IQALUIT WWTP UPGRADE/EXPANSION FEASIBILITY STUDY

City of Iqaluit

FEASIBILITY REPORT – FINAL REVISED

Prepared for:

City of Iqaluit
Building 901 (City Hall)
Nunavut Drive
Iqaluit, NU X0A OHO

Prepared by:

Nunami Stantec
4910 – 53 Street, PO Box 1777
Yellowknife, NT X1A 2p4
Tel: (867) 920-2882 Fax: (867) 920-4319

Project No.:

144902106

July 28, 2015

NUNAMI STANTEC

NUNAMI STANTEC

Sign-off Sheet

This document entitled Iqaluit WWTP Upgrade/Expansion Feasibility Study was prepared by Nunami Stantec for the account of the City of Iqaluit (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Nunami Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Nunami Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Nunami Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Nunami Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by D. Lycon
(signature)

David Lycon, Ph.d

REGISTERED PROFESSIONAL ENGINEER
Jul 27/15
G.A. PROSKO
LICENSEE
NWT/NU

Reviewed by ________________
(signature)

Glenn Prosko, P.Eng

EXECUTIVE SUMMARY

The City of Iqaluit's Wastewater Treatment Plant (WWTP) requires upgrading to service a growing population as well as to meet more stringent treatment objectives. The new WWTP upgrade will be subjected to territorial and federal requirements for effluent discharge. It is expected that the limits in the City's new Nunavut Water Board license will align with the federal Wastewater System Effluent Regulations (WSER). The existing WWTP provides primary treatment only and cannot achieve sufficient reduction of contaminants to meet proposed future effluent quality objectives. A secondary treatment process must be implemented to achieve compliance with proposed future effluent standards.

In accordance with the City's Request for Proposals, this Feasibility Report compares options for upgrading the existing WWTP against the possibility of building a new Greenfield WWTP. The four options presented and evaluated are:

- Option 1 – Re-use of existing facility in the form originally intended by the 1998 design-build project;
- Option 2A – Implementation of the secondary expansion concept developed in 2006 by Earth Tech;
- Option 2B – Implementation of other secondary treatment options utilizing the available infrastructure at the current WWTP; and
- Option 3 – Development of a new, Greenfield WWTP

Option 1 is not realistic as the inadequate capacity of the existing membrane treatment facility eliminates the possibility for remedial work and re-use. As designed, this facility would be unable to accommodate the proposed 2018 average day flow of 3,714 m3/day or future increases in wastewater flow without significant bypass events to the existing marine outfall. The facility is not suitable for commissioning in its current design state and will not be considered further in this Feasibility Report.

The Option 2A design is still relevant for the proposed regulatory environment, albeit at a reduced capacity. As it was designed for an ultimate population of 12,000, it will not have sufficient capacity to meet the 2038 design horizon of 16,500. For this reason, it is not being considered further in its conceived state. However, this design has been re-visited as Option 2B-3, and sized appropriately to meet the proposed 2038 design horizon.

Options 2B and 3 each examined four distinct secondary treatment options with common upgrades to the preliminary and primary treatment processes. The four secondary treatment options considered are:

- Membrane Bioreactor (MBR);
- Moving Bed Biofilm Reactor (MBBR);
- Conventional Activated Sludge (CAS); and
- Sequencing Batch Reactor (SBR)

Based on economic and non-economic factors, it is recommended that MBBR secondary treatment at the existing facility (Option 2B) be the secondary treatment option to be progressed to preliminary and detailed design. This option is advantageous because it produces high quality effluent within the smallest footprint, has reliable operation, is robust and avoids chemical use in secondary treatment. It is recommended to include septage receiving at the WWTP integrated with upgrades to the headworks.

Recommendation:

- Moving Bed Biofilm Reactor (MBBR) at the existing facility
- Capital Cost Estimate $26,500,000
- Annual Operating Cost Estimate $1,161,000

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

[File Ref: V:\1101\active\144902106_Iqaluit-WWTP\Feasibility Report\rpt_iqaluit_feasibility__body_2015_07_27_FINAL.docx]

ABBREVIATIONS

AAF	Annual Average Day Flow
AANDC	Aboriginal Affairs and Northern Development Canada
BFP	Belt Filter Press
BOD	Biochemical Oxygen Demand
CAS	Conventional Activated Sludge
cBOD	Carbonaceous Biochemical Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
DAF	Dissolved Air Flotation
DPS	Dewatered Primary Sludge
FE	Final Effluent
FOG	Fats, Oils, Grease
GR	Grit
MBR	Membrane Bioreactor
MBBR	Moving Bed Biofilm Reactor
ML	Mixed Liquor
MMF	Maximum Month Flow
NWB	Nunavut Water Board
PE	Primary Effluent
RAS	Return Activated Sludge
RFP	Request for Proposals
RS	Raw Sewage
SBR	Sequencing Batch Reactor
SCR	Screenings
SRS	Screened Raw Sewage
SRT	Solids Retention Time
TDH	Total Dynamic Head
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorous

TSS .... Total Suspended Solids

TWAS.. Thickened Waste Activated Sludge

UV ....Ultraviolet Disinfection

WAS...Waste Activated Sludge

WSER ....Wastewater System Effluent Regulations

WWTP... Wastewater Treatment Plant

1 INTRODUCTION

1.1 Background

The City of Iqaluit's Wastewater Treatment Plant (WWTP) requires upgrading to meet a growing population as well as to meet more stringent treatment objectives. This project has a particular urgency because, in March 2013, the City received an Inspector's direction from Aboriginal Affairs and Northern Development (AANDC) and Environment Canada that requires the City to complete the upgrades to the WWTP to bring the quality of effluent into compliance with applicable standards by December 2018. The existing WWTP only provides primary treatment and cannot achieve sufficient reduction of contaminants to meet proposed future effluent quality objectives. It is for this reason that secondary treatment processes must be added to the existing facility in order to achieve compliance with proposed future effluent standards.

Fifteen years ago, a number of circumstances left the City with an uncommissioned WWTP after investing over $7 million. To their credit, the City was able to regroup and advance remedial work on the facility to develop a design for an operating facility, however, funding limitations allowed only partial implementation of the work. After shelving the balance of the remedial work in 2006, the City is now in a position to advance the WWTP project to its completion with the implementation of secondary treatment.

1.2 Objective

The purpose of this Feasibility Report is to present and evaluate recommended secondary treatment options to identify the most appropriate upgrading option to provide a WWTP to meet proposed effluent discharge requirements in Iqaluit. The report will compare options for upgrading the existing WWTP against the possibility of building a new Greenfield WWTP. Specific objectives of this report include:

- Discussion of the regulatory framework for the project
- Establish flow and loading criteria for 20 year design horizon beginning in 2018.
- Compare the technical and economic feasibility of reuse of the existing facility, existing secondary design, alternative designs at the existing site, and alternative designs at a new Greenfield site.
- Order of magnitude construction and operation cost estimate for each option.
- Recommendation of a treatment option to be progressed to preliminary design.
- Discussion of detailed investigations that would be required to support detailed design.

2 DESIGN CRITERIA

2.1 Effluent Discharge Limits

The upgraded WWTP will be subject to territorial and federal requirements for effluent discharge. The Nunavut Water Board (NWB) licenses the use of water and the deposits of waste to water in Nunavut. The City's previous water license (#3AM-IQA611) issued by the NWB expired in 2012, and the City is currently undergoing a license renewal application process. It is assumed that the limits that will be proposed in the City's new NWB license will align with the federal Wastewater System Effluent Regulations (WSER).

At the federal level, the Canadian Council of Ministers of the Environment (CCME) have established the Wastewater Systems Effluent Regulations (WSER) under the Fisheries Act. The WSER are intended to provide harmonized wastewater effluent criteria across Canada. The Government of Nunavut has not formally adopted these limits, but as noted above, the proposed water license will likely follow these guidelines. **Table 1** displays a summary of the current WSER limits, limits from the expired Nunavut water license, and the proposed limits which have been used as a basis of design for this study. An area of note is the use of cBOD versus the BOD called for in the expired Nunavut water license. Again, this is meant to be an attempt to align the future water license with the federal WSER. It should be noted that the result of using either form of BOD in design is the same, as cBOD typically makes up approximately 80% of the total BOD. In this case, the design objective cBOD of 20 mg/L would equate to roughly 25 mg/L of total BOD.

Table 1 Summary of Treated Effluent Discharge Limits for the Iqaluit WWTP

Parameter	Federal Limit (WSER)	NWB License #3AM-IQA611 (expired 2012)		Proposed 2015 Design Objectives
		Average	Maximum Grab	
BOD	Not specified	30 mg/L	45 mg/L	N/A
cBOD	≤ 25 mg/L	Not specified	Not specified	20 mg/L
TSS	≤ 25 mg/L	30 mg/L	45 mg/L	20 mg/L
Un-Ionized Ammonia	≤ 1.25 mg/L	Not specified	Not specified	≤1.25 mg/L
Total Ammonia	Not specified	Not specified	Not specified	N/A
Total Residual Chlorine	≤ 0.02 mg/L	Not specified		N/A
pH	Not specified	6 to 9		6 to 9
Oil and Grease	Not specified	No visible sheen		No visible sheen
Toxicity	Not specified	Non Toxic		Non Toxic

NOTE:

(1) Federal Limits for cBOD and TSS are based on a quarterly arithmetic mean of biweekly composite samples for a facility of this size.

(2) Toxicity refers to non-acutely toxic undiluted effluent under the "Rainbow Trout, Oncorhynchus mykiss (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RN/13)". Samples are to be taken quarterly for a facility of this size.

2.1.1 Effluent Toxicity

One of the primary drivers for the AANDC and Environment Canada Inspector's direction revolves around effluent toxicity, or more specifically ammonia-based effluent toxicity. Total ammonia that is discharged at the outfall is comprised of two species in equilibrium; ionized ammonia and un-ionized ammonia. It is the un-ionized fraction that is acutely lethal, and predominates at higher pHs. Typical treatment plant effluent pH is around 6.5 to 7.2, which normally ensures that the un-ionized fraction will be well below levels that create the acutely lethal environment.

Historically, the City of Iqaluit's WWTP has failed the LC_{50} tests conducted on its effluent. These tests have been conducted using the Environment Canada test protocol EPS/1/RN/13. (*Biological Test Method - Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout).* The term "LC_{50}" is often used to describe the test, but in fact the test normally done for municipal wastewater is a single toxicity test conducted with 100% effluent. In this case, the test is considered a failure if more than 50% of the test organisms die after 96 hours. The LC_{50} test is a multi-concentration test done to determine the concentration of diluted effluent at which 50% or more of the test organisms die.

In past projects with other Northern communities, we have found that the failure of this test is often driven by an artifact of the test itself that is referred to as "pH drift". When the EPS/1/RN/13 protocol is used, the pH of the test solution artificially increases when it is aerated for the two hour period, which does not reflect the *in-situ* conditions at the WWTP's outfall. This increase in pH drives the ammonia equilibrium towards the un-ionized/more toxic fraction. If the effluent sample is tested using the Environment Canada protocol entitled *Procedure for pH Stabilization During the Testing of Acute Lethality of Wastewater Effluent to Rainbow Trout (EPS/1/RM/50)*, the pH remains near *in-situ* conditions, and the ionized / non-toxic fraction of ammonia will dominate in the test solution. This coupled with an effluent total ammonia concentration below approximately 30 mg/L (the maximum anticipated with the addition of secondary treatment) should readily be capable of passing the acute lethality testing requirement. For this reason, we are recommending that the future water license contain language indicating that either the EPS/1/RN/13 or EPS/1/RM/50 testing protocol can be used, depending on whether the City anticipates that pH stabilization in the test is required after the implementation of secondary treatment. Dawson City, Yukon has this same stipulation in their water license, and should their secondary treatment facility fail a non-pH stabilized toxicity test, they have the option of sending an additional sample to the testing facility to have a pH stabilized test conducted on their effluent. Prior to the implementation of secondary treatment Dawson City would routinely fail toxicity tests, but since implementation they have not failed any toxicity tests

This leads to the question as to whether or not an ammonia limit is necessary if the pH stabilized testing protocol can be used for compliance testing. Based on the information presented above, we feel that an ammonia limit will not be required for the new Iqaluit water license, and as such the plant will not be specifically designed to remove ammonia (nitrification).

2.2 Population Projections

There are two main sources for population projections related to the City of Iqaluit. The Nunavut Bureau of Statistics published population projections from 2010 to 2036 based on regional aggregates which are a representation of community aggregates. This report presents basic data at a high level. A more appropriate baseline for population projections related specifically to Iqaluit is the City of Iqaluit 2010 General Plan. The General Plan should be used for WWTP feasibility upgrade planning as it will directly correspond with other infrastructure planning projections in the City. Three population projection scenarios based on low, medium and high growth rates were used to project the population to the year 2030.

- High projection (3.38%) based the population change between 2001 and 2006 Census
- Medium projection (2.87%) based on the Government of Nunavut Bureau of Statistics community level population projections average annual rate
- Low projection (2.04%) based on annual growth rates for Nunavut from the 2008 Nunavut Economic Outlook developed by Statistics Canada

The 2011 census data for Iqaluit reported a population of 6,699, an 8.3% increase from the 2006 census figure of 6,184. In the General Plan, the Nunavut Bureau of Statistics in association with Statistics Canada corrected the census data to reflect the transient population which may not be accounted for in the census enumeration, with an adjusted 2007 population of 6,802. This population was used as a baseline to extend the population projections to a 20 year design horizon starting in 2018.**Table 2** and **Figure 1** provide a representation of the population projections for the three population projection scenarios.

Table 2 Population Projections to 2038

Year	Low Projection 2.04%	Medium Projection 2.87%	High Projection 3.38%
2007	6,802	6,802	6,802
2018	8,494	9,286	9,805
2023	9,396	10,697	11,578
2028	10,395	12,323	13,671
2033	11,499	14,195	16,143
2038	12,721	16,353	19,062

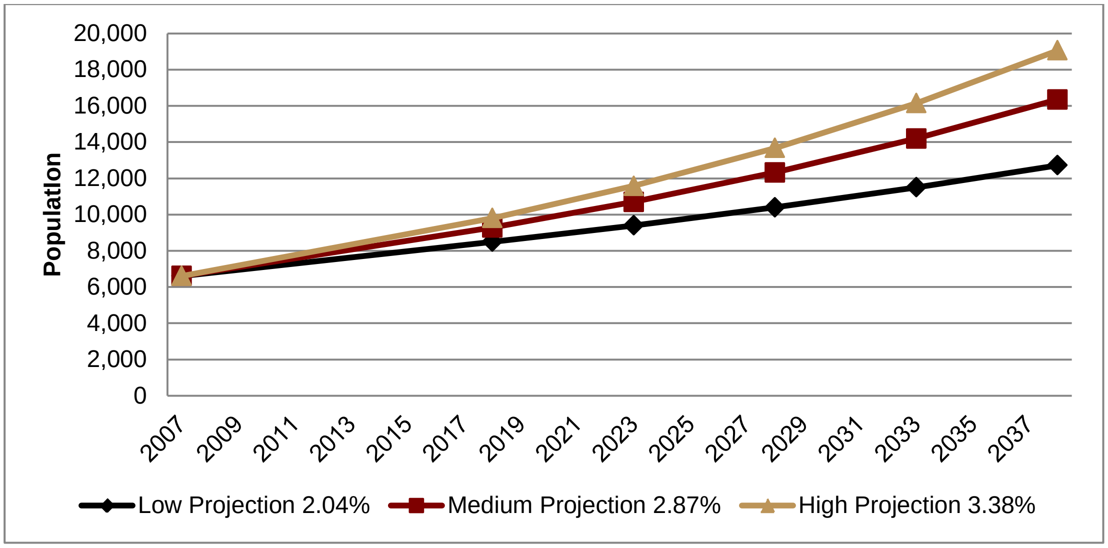


Figure 1 Population Projections to 2038

Consistent with the General Plan it is recommended that a medium growth projection be used for planning purposes, therefore the 2038 design population will be 16,353. The 2004 Conceptual Design Report used a Phase 1 population of 8,000 with considerations and provisions included in the design for a Phase 2 population of 12,000. The increased design population will require a review of existing equipment capacities and design elements based on the higher required WWTP capacity.

2.3 Design Flows

The quantity of wastewater discharged monthly from the WWTP is recorded and reported in the City's annual report to the Nunavut Water Board. During periods of shutdowns flow is diverted to the back-up sewage lagoon. The diverted flow is not monitored so the City applies an average daily discharge rate during periods of shutdown to account for this unmeasured flow. Based on the available data, a summary of the annual and maximum monthly discharge volumes with calculated annual average day flow and maximum monthly flow is presented in **Table 3**.

Table 3 Annual and Monthly Quantity and Flows of Discharge from the Iqaluit WWTP

Year	Total Annual Flow (m^3)	Annual Average Day Flow AAF (m^3/d)	Maximum Month Flow (m^3)	Maximum Monthly Flow MMF (m^3/d)
2013	885,855	2,427	85,644	2,763
2012	848,994	2,326	79,255	2,642
2011	814,086	2,229	74,425	2,418
2010	831,311	2,278	76,287	2,461
2009	851,193	2,333	75,339	2,513
2008	942,795	2,583	88,794	2,864

NOTE:

(1) Data derived from 2008 flow monitoring study undertaken from July to December 2008 and supplemented with water treatment plant production flow rates.

The annual reported volumes were compared with the population projections for the City to determine if the per capita wastewater flows relate to acceptable design values. Examples include the following:

1. 2013 annual average flow of 2,427 m^3/d used in conjunction with an assumed, projected population of 8,000 yields an average per capita flow rate of 303 L/cap/d;
2. 2011 census value of 6,699 is used in conjunction with the 2011 annual average flow of 2,229 m^3/d to provide an average per capita flow of 333 L/cap/d; and
3. 2008 annual average flow of 2,583 m^3/d used with an assumed, projected population of 6,997 yields an average per capita flow rate of 369 L/cap/d.

In using these three examples of average effluent flow rates and population numbers, it can be seen how the per capita flow values range fairly significantly. In the absence of more definitive data, it is recommended that a per capita wastewater flow of 400 L/cap/d be used for feasibility design purposes; which is consistent with the 2004 Conceptual Design Report. In the later stages of design, the per capita flow numbers can be tightened up to determine if a less conservative number should be used as a basis of design.

The City provided data that allowed for an analysis of maximum month flows. The highest maximum month peaking factor found between 2009 and 2013 was determined to be 1.16. For the basis of design, this peaking factor is rounded up to 1.20. However, the City did not provide any recorded information from the existing wastewater treatment plant related to maximum day or peak hour flows. In the absence of this information assumptions have been made based on acceptable industry values for peaking factors for facilities of this size as listed in the Water Environment Federation, Manual of Practice 8- Design of Municipal Wastewater Treatment Plants (4th Ed., 1988). **Table 4** displays the design basis flow information that will be used for the feasibility level design work.

Table 4 Design Basis Flow Information

Parameter	Peaking Factor	Current 2018	Future 2038
Population	-	9,286	16,353
Per Capita Water Use, L/c/d		400	400
Average Day Flow, m^3/d	-	3,714	6,541
Maximum Month Flow, m^3/d	1.2	4,457	7,849
Maximum Day Flow, m^3/d	2.0	7,429	13,082
Peak Hour Flow, m^3/d	3.0	11,143	19,624
Peak Hour Flow, L/s	3.0	129	227

2.4 Design Constituent Loads

Based upon limited data provided by the City, an attempt has been made to develop per capita loading to be used for the design of the secondary treatment process. **Table 5** provides a summary of this data. These loading values are for the primary effluent that is derived from the outlet of the primary filter.

Table 5 Effluent Loading Data Results

Date of Sample	BOD (mg/L)	TSS (mg/L)	Ammonia (mg/L)	Total P (mg/L)
2014 December 16 Test D	191	180	37.5	6.12
2014 August 29 Test E	59	60	32.5	5.07
2014 April 29 Test C	712	860	31.6	9.36
2014 February 4 Test D	220	248	40.4	7.84
2013 December 17 Test D (1)	361	100	44	8.15
2013 December 17 Test D (2)	253	112	42.8	8.30
2013 November 5 Test C	88	204	35.9	6.44
2013 August 27 Test E	192	248	33	5.95
2013 June 18 Test D	213	204	39.4	7.53
2013 April 23 Test C	337	200	49.4	10.30
2013 February 27 Test D	208	N/A	36.5	7.64
2012 December 5 Test D	191	135	N/A	N/A
2012 September 19 Test E	169	N/A	42.8	6.89
2012 June 19 Test C	160	N/A	49.1	6.97
2012 July 25 Test D	163	N/A	42.9	7.32
Average	**200**	**169**	**40**	**7.4**

NOTE:

(1) April 29 Test C values for BOD and TSS were excluded from average calculations as they appear to be anomalous.

Based on historical loading data and best practices, the design basis information for average primary effluent constituent loading is provided in **Table 6**. In the absence of available maximum month loading data, a peaking factor of 1.2 will used for design purposes, as was used in the 2004 design report.

Table 6 Primary Effluent Design Basis Loading Information

Parameter	Derived Value(1)	Design Value
Biochemical Oxygen Demand (BOD)	61 g/cap/d	65 g/cap/d
Chemical Oxygen Demand (COD)	131 g/cap/d	135 g/cap/d
Total Suspended Solids (TSS)	51 g/cap/d	55 g/cap/d
Total Kjeldahl Nitrogen (TKN)(3)	16.2 g/cap/d	17 g/cap/d
Total Phosphorous (TP)	2.2 g/cap/d	2.5 g/cap/d
Influent Wastewater Temperature (winter)	N/A	12°C
Influent Wastewater Temperature (summer)	N/A	17°C

NOTE:

(1) Derived values calculated using an average annual flow of 2,427 m^3/d and an assumed population of 8,000.

(2) Assume COD:BOD is 2.15 for primary treated wastewater.

(3) Assume ammonia is 75% of TKN for primary treated wastewater.

2.5 Summary of Primary Effluent Flows and Loads

The design flows and loads to be used for the secondary treatment processes for the Iqaluit WWTP upgrade are summarized in **Table 7**.

Table 7 Summary of Design Flows and Loads

		2018 Current	2038 Future
Population			
Population	PE	9,286	16,353
Flows			
Average per Capita Flow	m^3/cap/d	0.4	0.4
Average Annual Flow	m^3/d	3,714	6,541
Maximum Month Flow (PF=1.2)	m^3/d	4,457	7,849
Maximum Day Flow (PF=2.0)	m^3/d	7,429	13,082
Peak Hour Flow (PF=3.0)	m^3/d	11,143	19,623
Peak Hour Flow (PF=3.0)	L/s	129	227
Biological Oxygen Demand (BOD)			
Average Day Per Capita Load	kg/cap/d	0.065	0.065
Average Annual Load	kg/d	604	1,063
Maximum Month Load (PF=1.2)	kg/d	725	1,276
Chemical Oxygen Demand (COD)			
Average Day Per Capita Load	kg/cap/d	0.135	0.135
Average Annual Load	kg/d	1,254	2,208
Maximum Month Load (PF=1.2)	kg/d	1,504	2,649
Total Suspended Solids (TSS)			
Average Day Per Capita Load	kg/cap/d	0.055	0.055
Average Annual Load	kg/d	511	899
Maximum Month Load (PF=1.2)	kg/d	613	1,079
Total Kjeldahl Nitrogen (TKN)			
Average Day Per Capita Load	kg/cap/d	0.017	0.017
Average Annual Load	kg/d	158	278
Maximum Month Load (PF=1.2)	kg/d	189	334
Total Phosphorus (TP)			
Average Day Per Capita Load	kg/cap/d	0.0025	0.0025
Average Annual Load	kg/d	23	41
Maximum Month Load (PF=1.2)	kg/d	28	49

2.6 Site Issues and Constraints

Options for upgrading the WWTP which involve re-use of the existing secondary building on site need to address issues and constraints that have been identified in past inspection reports. A comprehensive assessment of the original WWTP construction and building condition was completed in 2002 by Earth Tech. An updated inspection including commentary on the operating primary treatment system was completed in February 2015 by Stantec. These reports identify that the building appears to be in good condition and that the concrete tanks have been sufficiently repaired and upgraded to act as water retaining structures. This Feasibility Report will proceed on the basis that the infrastructure on site can be reused and repurposed, however the condition of the non-commissioned process equipment onsite is unknown. The reuse of this equipment will not be considered as part of this study, and for costing it is assumed that new process equipment which can be appropriately sized for new design conditions as well as properly certified and covered under warranty will be installed. During the detailed design phase, a more detailed assessment of process equipment re-use can be undertaken.

Portions of the existing plant that will experience additional structural loading under the proposed secondary expansion will require further investigation. The process tanks were re-furbished and tested for suitability, however some portions of the remaining structure may require additional reinforcement to ensure the new loadings can be accommodated.

Upgrades to the WWTP must adhere to the latest version of the National Fire Protection Association (NFPA) 820 standard Fire Protection in Wastewater Treatment and Collection Facilities. This standard outlines potential fire and explosion hazards in each process area and based on the ventilation and physical separation provided dictates the electrical classification, extent of the classified area, the required material of construction and the required fire protection measures. All preliminary treatment (headworks) areas will be ventilated at 12 air changes an hour to de-rate the classification from Class 1 Division 1 to Class 1 Division 2.

This Feasibility Report does not consider the ultimate disposal of wastes streams generated at the WWTP. It is assumed that the waste streams of screenings, thickened primary sludge and dewatered sludge will continue to be hauled to the City landfill in a trailer similar to the procedure in place now.

3 COMMON TREATMENT PROCESSES

3.1 Introduction

For the comparison of secondary treatment technology options it is practical to establish common treatment processes for preliminary treatment, primary treatment, disinfection and solids handling. During preliminary and detailed design these treatment processes will be refined based on the secondary treatment option selected.

3.2 Septage Receiving Station

The City provides septage hauling services to residences which are not connected to the piped wastewater collection system. Holding tanks are pumped out regularly and the septage is transported to a rudimentary dump station upstream of the WWTP. Trucks connect their transfer hoses to the discharge ports at the dump station manhole for unloading. Septage flows by gravity from the discharge manhole into the WWTP wetwell for treatment. Operating staff have expressed that they often experience a large amount of rags and cloths (assumed to originate from the septage station) entering the wet well and clogging the existing pumps. Additionally, operating staff noted that the septage receiving manhole frequently backs ups causing septage spills around the manhole. A new septage receiving station should be integrated with the WWTP upgrade. A new septage receiving station would considerably improve conditions for haulers as well as improve operational reliability at the WWTP. One final consideration is the management of fats, oils and grease (FOG) that occasionally makes up a portion of the septage being discharged at the facility. There are means of removing the FOG from the septage stream, but this then requires a dewatering step; which would then involve the implementation of additional unit processes. Consideration should be given to adding a hot water spray wash to any septage screening process that will allow the FOG to carry through to the primary or secondary treatment processes where it can managed more effectively.

Existing Equipment

- Dump station consisting of a discharge manhole with two hose connection ports

Recommended Improvements:

- Installation of two septage receiving stations integrated with the WWTP upgrade. The septage receiving stations will include a rock trap, grinder, perforated screen and auger for dewatering the screenings.
- Screened septage will be transferred to the wet well to be processed through the main treatment process.

3.3 Raw Wastewater Pumping

The existing raw wastewater pumping station receives flow from two lift stations in the City which have macerators, a gravity line which services downtown (including a connection to the jail) and from the septage receiving station. The flow is pumped to the screens from a deep, below grade wetwell by submersible solids handling pumps.

Existing Equipment

- Number of Pumps: 2 duty, 1 standby
- Capacity 56 L/s at 10 m TDH
- Type Submersible, centrifugal, solids passing (<75 mm diameter)

Recommended Improvements:

- City staff has noted that they have observed a large number of rags/cloth entering the pumping station. These materials clog the pumps and cause excessive wear and plant downtime. A macerator on the gravity pipe and septage receiving pipe upstream of the raw wastewater pumping station is recommended to solve this problem.
- The pumps do not have capacity to handle the ultimate design peak flow of 227 L/s in 2038. The pumping capacity will need to be increased to have two pumps operating as duty pumps with one pump as a standby. Each duty pump will be sized for 114 L/s (TDH to be confirmed).
- Solids handling chopper pumps could be installed in the existing pumping station to replace the existing pumps. This would eliminate the needs for grinding solids upstream of the WWTP. This concept should be examined during the preliminary design phase of the project.
- The addition of a septage receiving station would also greatly assist reliability of the system.

3.4 Preliminary and Primary Treatment

3.4.1 Screening

Screening equipment functions to remove coarse solids and other large materials in wastewater to enhance downstream treatment and protect equipment. The existing screening system at the WWTP consists of two screening channels with auger screens and one bypass screening channel with a manual screen.

Existing Equipment

- Number of Screens: 2 with 1 manual bypass
- Capacity 167 L/s total capacity, 84 L/s each screen
- Type 3 mm perforated screen basket with auger

Recommended Improvements:

- The existing screens do not have capacity to handle the ultimate design peak flow of 227 L/s in 2038. The screens are installed in a custom elevated, prefabricated stainless steel channel. It is unlikely that the screens can be replaced with a similar style of auger screen with increased capacity and still fit in the same prefabricated channel. A third auger screen with the same capacity (84 L/s) could be installed to replace the manual bypass to increase the capacity to handle peak hour flows. This option is not recommended as it does not allow for redundancy on a very critical piece of process equipment, and having three screens with their drive motors located side by side will create maintenance challenges.
- A new addition to the headworks building will be required for the secondary treatment options which will reuse the existing WWTP infrastructure. This new addition will house the septage receiving station and new fine screens. It is recommended that duty/standby drum screens each sized for the peak hour flow of 227 L/s be installed. Drum screens are advantageous to this application because they can easily receive piped flow from the wet well, screen the wastewater in a contained unit and transfer screened wastewater to the primary filter with piped flow. Drum screens have a small footprint and reduced headroom requirements and will be able to decrease the size of the headworks building addition. Screenings will be transferred from the screen to a disposal trailer using an integral screw press. During the transport and compaction of screening in the screw press solids are washed and compacted. It is also recommended that a hot water spray system be included with the drum screens to allow for the better management of fats, oils and grease that are present in the collection system.
- Greenfield plant options will consider two mechanical channel fine screens (6 mm opening) sized to meet peak hour flow (114 L/s each) with a manual bar screen bypass. Channel screens are recommended for the greenfield option because they are robust, and they readily allow for a simple bypass through a manual bar screen in the event of a mechanical screen being down for maintenance. Screenings will be collected and transferred to a disposal trailer via a shaftless screw unit.

3.4.2 Grit Removal

Grit removal is currently not included at the existing WWTP, as it is not a commonly used unit treatment process for smaller WWTPs. The benefit of grit removal is to remove sand and silt which can lead to wear and abrasion on downstream rotating equipment. A grit removal system was included as a provisional item in the 2004 Conceptual Design Report which would be able to be implemented if grit became a problematic in the future. The rationale for excluding grit removal at the time of construction was that the grit load in Iqaluit was expected to be low due to nominal infiltration to the sewer system and no significant grit contributing sources in the City.

However, discussions with operating staff as part of the 2015 Site Investigation revealed that grit is a problem at the WWTP. The WWTP is experiencing a large quantity of grit which collects in the wet well and screening channels and is carried downstream to the primary filters. The grit has been causing excessive wear and increased frequency of replacement of the primary filter mesh. It is understood that the grit being delivered to the WWTP originates from the septage receiving system and the City's collection system. The implementation of dedicated septage receiving stations with a large, enhanced rock trap and perforated screens upstream of the wet well is expected to alleviate a portion of the grit loading at the WWTP. However, in an effort to manage the grit from the City's collection system, a specific grit removal system is recommended as part of the WWTP upgrade.

Existing Equipment

- None

Recommended Improvements:

- A new compact grit removal system along with a grit washing / classification system. This system will be sized for a peak hourly flow of 227 L/s, and will be based on a stacked tray type of system. This system is capable of removing over 95% of the grit that is in excess of 300 microns in diameter and over 65% of the grit that is in excess of 150 microns.

3.4.3 Primary Filtration

A primary filter is used on site currently for ultra-fine screening and solids retention. Primary filters provide approximately the same level of treatment as conventional primary sedimentation tanks, but with a much smaller footprint. The primary filter removes a portion of the TSS and BOD loading by creating a filter mat on the rotating belt. Solids are thickened and dewatered then discharged through a chute to the same trailer as the screenings on the lower floor for final disposal.

Existing Equipment:

- Number of Filters 1 duty
- Capacity 167 L/s
- Type Salsnes primary filter

Recommended Improvements:

- The primary filter does not have capacity to handle the ultimate design peak flow of 227 L/s in 2038. A second primary filter will be required at the same capacity as the existing filter (167 L/s) to handle the peak hour flows.
- Currently there is no redundant primary filter unit. During times of maintenance on the primary filter, the WWTP bypasses flow directly to the sewage storage lagoon. Installation of a second primary filter will provide the redundancy required for normal operation and maintenance.
- Greenfield plant options will include two primary filters (duty/assist) sized at 167 L/s each to handle peak hour flows.

3.5 Disinfection

Disinfection of final effluent is not currently provided at the WWTP. Disinfection functions to reduce the number of waterborne pathogens to meet specific bacterial limits prior to discharge into receiving waters. As the WWTP's effluent discharges to a marine environment, the City does not have any specified limits for reduction of total or fecal coliform counts. This is the approach used in Canada for coastal facilities, unless there is a sensitive habitat located within the outfall's dispersion zone. Consistent with the 2004 Conceptual Design Report, disinfection will not be included in the WWTP upgrade, but sufficient footprint and hydraulic allowance will be provided if disinfection is required in the future. This allowance requires no additional infrastructure to be built and is considered a no cost item until implemented. If disinfection were required, it would be most appropriate for the City to implement a process such as an ultraviolet (UV) disinfection. UV disinfection eliminates the need to generate, handle, transport and store hazardous chemicals associated with chemical disinfection.

Existing Equipment

- None

Recommended Improvements:

- None

3.6 Solids Handling

3.6.1 Thickening

Thickening of waste activated/secondary sludge (WAS) is a process which concentrates the mixed liquor that is wasted from the secondary treatment process. The advantage of WAS wasting and thickening is that it provides a relatively simple means of controlling the solids retention time (SRT) of the secondary treatment process. Thickening also benefits the dewatering process by reducing the volume of water and increasing the concentration of solids to be dewatered, resulting in reduced sizing of dewatering equipment. The implementation of thickening is dependent on the characteristics of the WAS provided by the secondary treatment process.

The 2004 Conceptual Design Report compared dissolved air flotation, gravity belt and rotary drum thickening for application with a conventional activated sludge process at the WWTP. It was determined that dissolved air floatation (DAF) is most appropriate because of the high process simplicity and lower labor requirements.

Existing Equipment

- None

Recommended Improvements:

- If thickening of WAS is required, thickening will be accomplished using a dissolved air floatation system sized for 2038 flows of up to 450 m^3/d (depending on the secondary treatment process selected). Thickened WAS (TWAS) will be stored in an aerated tank prior to be dewatered.

3.6.2 Dewatering

Sludge dewatering reduces the volume of solids for disposal, which ultimately reduces costs of storage and transportation to final disposal. Dewatering produces a “cake” material which can vary in total solids content based on the type of sludge processed and the amount of polymer used.

The 2004 Conceptual Design Report compared centrifuge and belt filter press (BFP) dewatering for use at the WWTP. It was determined that given the complexity of the centrifuge in terms of mechanical, electrical and instrumentation equipment a trained specialist would be required to troubleshoot any problems as well as provide repairs and maintenance. A belt filter press was recommended because it is simpler to operate, less complex, robust and requires minimal repair and maintenance.

A belt filter press uses a perforated belt and mechanical compression to filter and separate the liquid fraction in the sludge from the solids fraction. To accomplish the filtering action under compression, a fabric belt is wound through a series of rollers and sludge is fed at the beginning of the belt and “squeezed” by successive rollers. Once the dewatered cake is scraped from the end of the press, the belt is washed with water to remove residual solids before the belt is returned to the first roller. Belt filter presses require polymer to aid in the dewatering process.

Existing Equipment

- None

Recommended Improvements:

- Belt filter press sized for flow up to 11 m^3/hour. The dewatering equipment will be sized to process three days’ worth of TWAS in 6 hours over a single day (18 hours total of dewatering per week). This operation schedule will avoid the BFP being operated on the weekend.
- A dry polymer system will be included with the dewatering process. Dry polymer has lower shipping costs, less stringent storage and longer shelf life compared to liquid polymer, which will be more suitable to a remote location such as the City of Iqaluit.

4 SECONDARY TREATMENT OPTIONS

As outlined in the work plan of our proposal and in accordance with the City's Request for Proposal (RFP), our intent is to look at the provision of secondary wastewater treatment for the City of Iqaluit using a four option approach. In summary, the four options are:

- Option 1 – Re-use of existing facility in the form originally intended by the 1998 design-build project;
- Option 2A – Implementation of the secondary expansion concept developed in 2006 by Earth Tech;
- Option 2B – Implementation of other secondary treatment options utilizing the available infrastructure at the current WWTP; and
- Option 3 – Development of a new, Greenfield wastewater treatment plant.

Options 2B and 3 will each examine four distinct secondary treatment options that are applicable for the City of Iqaluit. We also recognize that Options 1 and 2A are not feasible for implementation by the City, but as outlined in the RFP we have opted to describe the options and outline why they have been dropped from future consideration.

In the examination of the required size for the secondary treatment options suggested for Options 2B and 3, two approaches were used. For the more proprietary technologies (*i.e.* membrane bioreactor (MBR) and moving bed biofilm reactor (MBBR)), leading vendors were engaged to develop a required footprint and cost for each. For the conventional activated sludge (CAS) and sequencing batch reactor (SBR) processes, an industry standard process design software tool (BioWin) was used, along with in-house design spreadsheets. These tools allowed for the development of the required footprint for each process. Process equipment costing for these options was developed using an in-house database of wastewater treatment plant equipment costs.

4.1 Option 1: Re-Use of Existing Facility for Membrane Bioreactor (MBR) As-Is

Option 1 is the execution of remedial work on the existing secondary treatment membrane design completed by Hill-Murray in 1998 to provide a fully functional membrane bioreactor process for secondary treatment. The existing arrangement had the membranes installed in the main bioreactor tanks. Membranes would be removed from the bioreactor and transferred to an offline tank for cleaning. Membrane technology has advanced since this concept was originally proposed, where it is now common for most new installations to have the membrane cassettes installed externally to the bioreactor in a separate tank. In this configuration membranes remain in place in the separate tank for cleaning and soaking activities, as and when required. This eliminates operator requirements for manual cleaning of the membranes, and complications and operating costs associated with lifting membrane cassettes out of the main process tanks for cleaning. Discussions with GE Water and

Process Technologies (formerly Zenon Environmental- supplier of the process equipment for the 1998 design-build project) indicate that they still support the membrane technology originally proposed for the project, and as such it would be technically feasible to re-create the design originally envisioned in 1998.

However, the inadequate capacity of the existing membrane treatment facility eliminates the possibility for remedial work and re-use. The facility was designed for the 1998 average day flow of 1,800 m^3/day, and there were no provisions in the design to accommodate maximum month flows. The facility would be unable to accommodate the proposed 2018 average day flow of 3,714 m^3/day or future increases in wastewater flow without significant bypass events to the existing marine outfall. This type of plant operation would result in routine non-compliance of the facility.

The facility is not suitable for commissioning in its current design state and will not be considered further in this Feasibility Report.

4.2 Option 2A: 2006 Activated Sludge Design

Option 2A is the evaluation of the execution of remedial work on the existing facility in accordance with the detailed design for the conventional, nitrifying activated sludge secondary treatment facility that was completed in 2006 but never constructed. The 2011 Technical Memo *Technical Overview of 2005 Secondary Sewage Treatment Design* (AECOM) evaluated the drawings and specifications for this design to be at 80% completion for all disciplines excluding instrumentation and controls which was at a 20% complete level.

The secondary treatment process was designed to meet the WSER national guides for effluent concentrations of cBOD=25 mg/L, TSS= 25 mg/L and un-ionized ammonia= 1.25 mg/L while producing a non-toxic effluent.

The design was based on two population scenarios; Phase 1 population of 8,000 residents (3,200 m^3/d average day flow) and Phase 2 population of 12,000 (4,800 m^3/d average day flow). The design is undersized to meet the new population horizon in 2038 of a population of 16,353 (6,541 m^3/d average day flow). According to population projections the ultimate capacity of the 2006 design would be met in 2028 if this option were to be implemented. It is not recommended to proceed with the design as its capacity will be reached within 10 years of construction. A revised activated sludge design re-using the existing building infrastructure is presented under the Option 2B subsection.

The 2006 activated sludge design involved the use of a primary filter to remove suspended organic material similar to the results achieved by a primary clarifier. The existing two bioreactors were configured to have anoxic zones followed by aerobic zones for biological treatment. In this configuration, the plant could reduce the aeration requirements and recover alkalinity lost in the nitrification process. A new third bioreactor with an identical configuration was required to meet the Phase 2 flows. Three 16.2 meter diameter secondary clarifiers were proposed for Phase 2 (2 duty and 1 standby). Waste activated sludge (WAS) thickening was to be accomplished using a dissolved air floatation (DAF) process prior to dewatering by belt filter press.

A feasibility layout of Option 2A is presented in **Appendix A Figure 1**. It is noted that this option only brings the plant capacity up to a 10 year horizon of 2028.

Overall, this design is still relevant for the proposed regulatory environment, albeit at a reduced capacity. As noted above, this design will be re-visited as Option 2B-3, and sized appropriately to meet the proposed 2038 design horizon. Further discussion on the technology itself will also be provided in the subsection that outlines Option 2B-3.

4.3 Option 2B: Alternative Design for Existing WWTP

Option 2B is the evaluation of four secondary treatment options for remedial work on the existing facility to provide a fully functional process providing secondary treatment to meet the proposed effluent objectives. For this evaluation the secondary treatment options considered are:

- Option 2B-1 Membrane Bioreactor (MBR);
- Option 2B-2 Moving Bed Biofilm Reactor (MBBR);
- Option 2B-3 Conventional Activated Sludge (CAS); and
- Option 2B-4 - Sequencing Batch Reactor (SBR).

All of the alternative design options using the existing WWTP have common upgrades to the preliminary and primary treatment processes to integrate dedicated septage receiving stations, improve screening and increase primary filtration redundancy (as outlined in **Section 3** of this report).

4.3.1 Option 2B-1 Membrane Bioreactor (MBR)

Membrane Bioreactors (MBR) combine a suspended growth biological reactor with solids removal via micro or ultrafiltration. The membranes are submerged in the final tank of the secondary process and are in direct contact with the mixed liquor originating from the bioreactor. The membrane filtration equipment replaces the solids separation of secondary clarifiers in typical wastewater treatment. Vacuum pressure is applied to a header pipe connected to the membranes to draw the treated effluent through the hollow fibre membranes and into the pump which transfers the secondary effluent directly to the plant outfall. The external surface of the membrane is continuously scoured using airflow introduced at the bottom of the membrane module. The airflow may also provide a portion of the biological process oxygen requirements. Excess biological sludge is wasted directly from the MBR process tank to a thickening process such as DAF. New generation membranes are cleaned in place using sodium hypochlorite and citric acid, therefore no removal of the membrane cassettes is required. Figure 2 shows a process flow diagram for MBR secondary treatment.

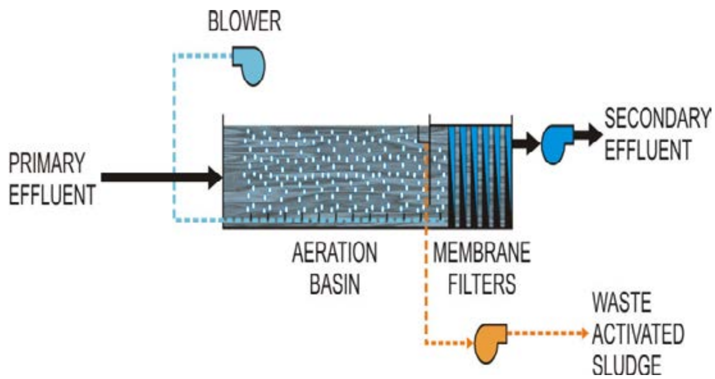


Figure 2 Membrane Bioreactor Process Diagram

MBR is known as a compact technology that is capable of producing a high quality effluent that is suitable for re-use. Membrane filtration allows for a higher biomass concentration to be maintained, reducing the required footprint for secondary treatment. However, this typically results in higher process air requirements, which in turn translates into higher energy consumption. MBR processes are also more energy intensive due to the pumping requirements and the energy required for backwashing and cleaning the membranes.

Operationally, the MBR process can be more complex and therefore somewhat more difficult to manage compared to conventional systems. However, process automation is a tool used for minimizing operator time and effort and if everything is operating properly minimal day to day intervention is required. Membrane bioreactors have proven to be a viable alternative to conventional treatment processes, and there are currently more than 100 WWTPs utilizing a MBR process in North America. One of the risks associated with the process is the chance that a membrane may fail while inside the reactor tank and draw in mixed liquor into the treated effluent. However, membrane failures can be detected by automated monitoring of the MBR effluent turbidity or monitoring the differential pressure across each membrane module to increase the system reliability. In addition to this, newer hollow fibre membranes are designed to reduce the risk of drawing in unfiltered mixed liquor.

A feasibility layout for the use of MBR for secondary treatment at the Iqaluit WWTP site is shown in **Appendix A Figure 2**. A third, additional aeration tank would be required to meet the design flows. A building extension is also required to house the MBR tanks, MBR chemical storage and dosing equipment, permeate pumps, backpulse tank and MBR blowers.

4.3.2 Option 2B-2 Moving Bed Biofilm Reactor (MBBR)

Moving Bed Biofilm Reactor (MBBR) technology is a submerged attached growth process which uses a conventional bioreactor filled with carrier media suspended in the tank. The carrier media provides a surface for attached growth to take place and is kept suspended and in continuous movement with aeration or mixers. The carrier media is shaped to have a high surface area per unit volume and protect the biofilm from shear forces. A sieve is used to retain the carrier media in the bioreactor tanks. The MBBR system is a single pass system with no return activated sludge (RAS) from the secondary clarifier. MBBR systems provide a small footprint fixed film process that can meet high effluent standards. **Figure 3** shows a process flow diagram for MBBR secondary treatment.

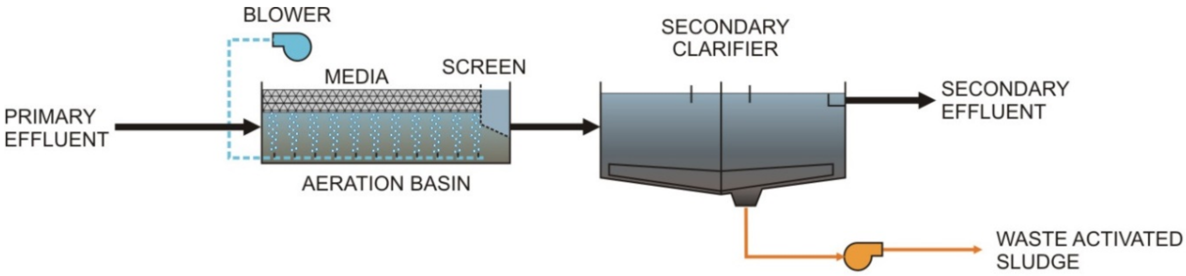


Figure 3 Moving Bed Biofilm Reactor Process Diagram

MBBR systems are resilient, simple to operate and tolerate variations in loading. The biomass is retained in the MBBR tanks protecting the treatment system from toxic shock and washout during hydraulic peaks.

This is a relatively simple to operate process, along the lines of conventional activated sludge. Maintenance requirements are fairly low for this technology as the aeration system utilized must be very robust. This is due mainly to the fact that tank dewatering for inspection is a time consuming process as all of the suspended media would have to be removed to inspect the aeration grid at the bottom of the tank. For this reason, suppliers of this technology recommend stainless steel, medium bubble aeration systems compared to the PVC systems normally used in conventional activated sludge processes. Though more robust, this type of aeration system does require a slightly higher energy input compared to fine bubble systems used for the other secondary treatment process options being considered in this report. Overall this technology is not as mature as conventional activated sludge, however there over 50 installations in North America; the majority of which are located in Quebec.

A feasibility layout for the use of MBBR for secondary treatment at the Iqaluit WWTP site is shown in **Appendix A Figure 3**. The MBBR layout fits well into the existing building footprint without a large expansion required. A building extension would be required to house a new electrical room, pumps and thickened waste activated sludge storage. The existing bioreactor tanks would be retrofitted to have separate aerobic zones for BOD and nitrification similar to the activated sludge design under Option 2A. The use of carrier media allows the capacity of the existing bioreactor tanks to be increased. With a media fill ratio of 65% (maximum allowable) the existing bioreactor tanks would be able to service the 2038 design population maximum day flow. The MBBR would be followed by high rate secondary clarification using a dissolved air flotation (DAF) clarifier. The solids thicken to approximately 3% prior to removal. The use of this clarification technology will also potentially eliminate the requirement for the thickening of waste activated/secondary sludge. The sludge from the DAF clarification process could be sent directly to the proposed dewatering process.

4.3.3 Option 2B-3 Conventional Activated Sludge (CAS)

The Conventional Activated Sludge (CAS) process is one of the most widely used secondary treatment processes. It is a suspended growth process that utilizes gravity solids separation. Primary effluent is directed to the aeration basin where it mixes with return activated sludge (clarifier underflow). The mixture – mixed liquor – is aerated and microbial activity occurs breaking down the BOD (and if applicable, oxidizing the ammonia to nitrates). The aeration basin effluent (mixed liquor) is discharged to a secondary clarifier where the solids and liquid fractions are separated. Most of the sludge is returned to the aeration basin to provide the microbial community needed to remove organic contaminants from the influent. A fraction of the underflow (return activated sludge) or a portion of the aeration basin's mixed liquor is wasted to offset biomass growth in the aeration basin and to control the solids retention time (SRT) in the system. **Figure 4** shows a process flow diagram for activated sludge treatment.

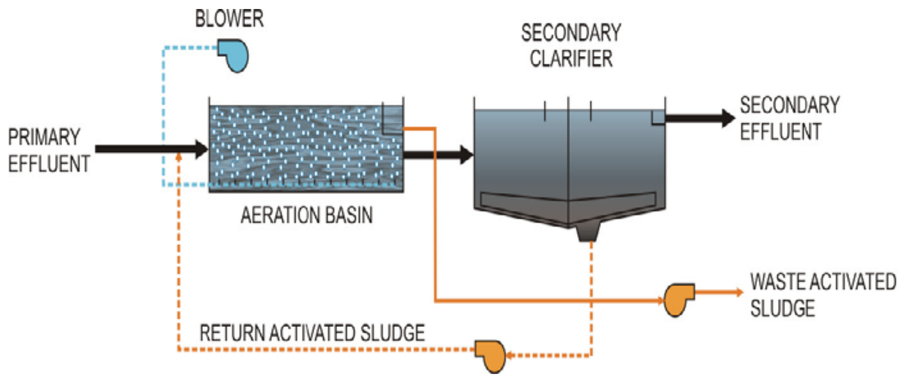


Figure 4 Activated Sludge Process Diagram

Activated sludge is one of the oldest secondary wastewater treatment technologies (over 100 years old) and has a wide base of use around the world, and in all climates. The process has low to average operating costs when compared to other processes due to moderate energy requirements, moderate level of operator attention, moderate solids yield, and low maintenance requirements. However, activated sludge requires a large footprint relative to the other technologies that are being examined in this report.

A key benefit of activated sludge is that there is the potential for future modification of the process if required to meet additional or more stringent effluent requirements (for example tanks could be retrofitted to include carrier media or re-configured to reduce phosphorus).

A feasibility layout for the use of activated sludge for secondary treatment at the Iqaluit WWTP site is shown in **Appendix A Figure 4**. Two new large aerobic tanks would be required for biological treatment of the design flows. A sizeable building extension is required to house two circular secondary clarifiers for sedimentation. This layout would result in a large volume of concrete required for construction of the process tankage. Our proposed design utilizes two secondary clarifiers that have been designed to accommodate a higher solids loading compared to those presented in Option 2A. For this reason they are similarly sized, though at a higher design flow. Further design development will have to examine the requirement for a redundant secondary clarifier and examine the risks associated with not building in this redundancy for the upgrades facility.

4.3.4 Option 2B-4 Sequencing Batch Reactor (SBR)

Sequencing batch reactors (SBRs) are similar to the conventional activated sludge reactors, however the treatment and clarification processes take place in one reactor in a fill-and-draw system. The first step of the process is the fill cycle, where the reactor tank is filled with screened and primary treated wastewater which mixes with the biomass that has settled during the previous cycle. Air is then added to the tank in the aeration cycle to aid in biological growth and biological treatment. The reactor then goes through a settle cycle where mixing and aeration stop so that solids are allowed to settle to the bottom of the tank. The length of the entire cycle normally takes four hours under normal flow conditions, or three hours during peak flow conditions. However, these cycle times are adjustable with the control system for the SBRs. The final cycle is the decant cycle where clarified effluent is discharged from the top of the reactor. **Figure 5** shows a process flow diagram for SBR secondary treatment.

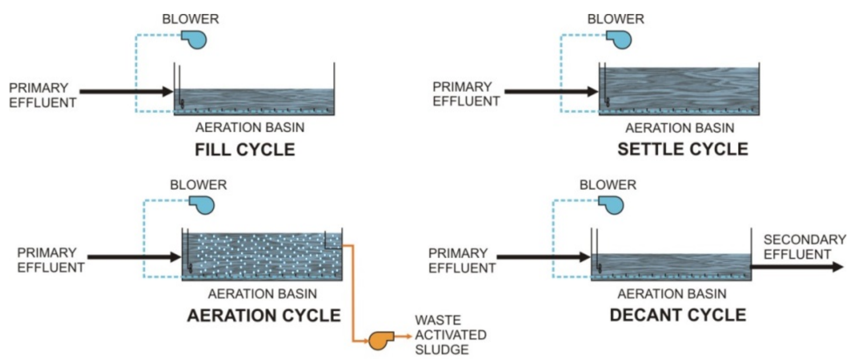


Figure 5 Sequencing Batch Reactor Process Diagram

SBRs can be advantageous over conventional activated sludge reactors as their reactors may require less space because treatment takes place in a single basin instead of multiple basins and dedicated clarifier units. In our review of the footprint requirements, SBR is roughly equal to activated sludge. However, the SBR was sized somewhat more conservatively than the activated sludge process. Regardless of the footprint, SBRs have a further advantage over activated sludge as the basins are all equally sized and common wall construction can be utilized. Operationally, the aeration and mixing devices are generally straight-forward to operate, however because of the sequencing nature of the process, the system is dependent upon automatic control to function. This is an increased level of complexity when compared to an activated sludge system. The complexity will also increase for larger systems with more parallel units, and additional sophistication for the control system. The process can handle wide variations in feed characteristics and flow rates by varying process parameters such as: mixed liquor suspended solids (MLSS), solids retention time (SRT), sludge wasting rates, sludge settling, dissolved oxygen and air flow rates. As well, the timing of the different cycles can be modified to optimize the process.

A feasibility layout for the use of SBR for secondary treatment at the Iqaluit WWTP site is shown in **Appendix A Figure 5**.The existing four process tanks on site would be used to make a single SBR train. Three new SBR tanks would be required to meet the design flow. This layout would result in a large volume of concrete required for construction of the process tankage.

4.4 Option 3: Greenfield Plant Design

Option 3 is the evaluation of four secondary treatment options for use at a Greenfield plant at a new location within the City. The same four secondary treatment options considered under Option 2B are carried forward for comparison purposes. **Figure 6** in **Appendix A** displays the identified potential location of a new Greenfield plant. The location has been selected to be placed over the existing sanitary line to avoid any complicated rerouting of the line to accommodate tie-in to the new facility. Locating the Greenfield plant near the existing lagoon continues to allow for the provision to overflow to the lagoon during emergency events. A key advantage of a Greenfield plant is that the existing plant can remain operational until the new plant is complete, i.e. no construction staging shutdowns are required.

All of the Greenfield plant options have identical headworks designs consisting of screening channels, in channel mechanical screens, dedicated septage receiving stations, primary filters and a pump well to allow for process tankage to be constructed mostly above ground where possible to minimize excavation.

4.4.1 Option 3-1 Membrane Bioreactor (MBR)

Option 3-1 is the construction of Greenfield MBR WWTP. A feasibility layout for the use of MBR for secondary treatment at the Greenfield site is shown in **Appendix A Figure 7**. This option requires single story building to house the biological treatment process tanks as well as a two story building to house the MBR process equipment and solids handling equipment.

4.4.2 Option 3-2 Moving Bed Biofilm Reactor (MBBR)

Option 3-2 is the construction of a Greenfield WWTP using MBBR for secondary treatment. A feasibility layout for the use of MBBR for secondary treatment at the Greenfield site is shown in **Appendix A Figure 8**. The MBBR layout is compact because the system uses DAF for clarification and thickening, a separate dedicated DAF for thickening is not required.

4.4.3 Option 3-3 Activated Sludge

Option 3-3 is the construction of a Greenfield WWTP using an activated sludge process for secondary treatment. A feasibility layout for the use of activated sludge secondary treatment at the Greenfield site is shown in **Appendix A Figure 9**. Two parallel process trains each consisting of an anoxic zone, swing zone and two aerobic zones are required for biological treatment.

4.4.4 Option 3-4 Sequencing Batch Reactor (SBR)

Option 3-4 is the construction of Greenfield SBR WWTP. A feasibility layout for the use of SBR for secondary treatment at the Greenfield site is shown in **Appendix A Figure 10**. Biological treatment and clarification takes place in four identically sized parallel SBR tanks.

5 CONSTRUCTION SCHEDULE

The most complex scenario for construction will be expanding the existing plant while a Greenfield plant can be constructed on its own, with less disruption to operations. In either case, the length of construction will be relatively similar. A more construction schedule is included **in Appendix B** and the major milestones are summarized as shown in **Table 8**. The estimated construction schedule should be refined further during detailed design.

Table 8 Estimated Construction Schedule

Critical Task	Start Date	End Date
Preliminary Design	July, 2015	October, 2015
Geotechnical and Additional Studies	August 2015	October 2015
Detailed Design	October 2, 2015	March, 2016
Tender	April, 2016	May, 2016
Tender Award	May, 2016	-
Pre-order Long Delivery Items	March, 2016	April, 2016
2016 Sea Lift Staging	Sept 2016	
Construction	May 2016	July 2018
Commissioning/Optimization	July 2018	August 2018
Project Complete	September 2018	-

Comments regarding the schedule analysis:

- It is estimated that the plant will take a minimum of two summer construction seasons to build. In the case that the project requires a large portion of the 2018 season, it is critical that the project meet the summer construction season of 2016. Therefore, the detailed design of the facility should commence as soon as possible. This will allow sufficient time to include appropriate reviews by the City at the various stages of design.
- It is anticipated that the local Contractors will have sufficient materials on hand to commence the construction in the spring of 2016 (i.e. concrete work can start without sealift).
- The main process treatment train and potentially some other equipment such as the generator, may require pre-purchase. Although the equipment may not be required for installation until the spring of 2017, to avoid air lift, the City may want to purchase the larger, long delivery items in time to be delivered by sea lift in the fall of 2016.
- Commissioning the expansion option will require some staging in construction as it will be more difficult to maintain operations while continuing to provide primary treatment. For example under the current options, a second Salsnes filter cannot be installed until the new screening system is in place and the existing screen can be demolished. Commissioning a

Greenfield plant will be much simpler as flow can be diverted from old to new and visa-versa to assist in the start-up and commissioning.

- Note that in the case of a Greenfield plant, the early siting of the plant is critical to allow a Geotechnical investigation to proceed this year in support of the detailed design. Geotechnical information currently exists for the existing plant and a desktop analysis may be sufficient to for its detailed design but this should be reviewed during detailed design.

6 CONSTRUCTION COST ESTIMATE

Construction cost estimates have been developed based on past experience from similar projects, rough quantity take offs and unit price estimating, as well as construction and constructability input from members of the design team. Construction cost estimates for the secondary treatment technologies presented in this feasibility report are presented in **Table 9**.

The building cost of constructing a Greenfield WWTP is higher than the cost of modifying and constructing new additions to the existing WWTP. The Greenfield WWTP options are more expensive because of the high cost of building materials (concrete and superstructure) in Iqaluit. The options re-using the existing WWTP have reduced costs because of the availability to re-use the four process tanks for treatment and existing building footprint.

In general, each section of costs includes the following:

1.0 General Requirements

- Bonding, insurance, safety and other general costs

2.0 Civil/Siteworks

- Demolition
- Excavation and backfill
- Roadwork
- Yard Piping
- Landscaping
- Temporary works

3.0 Buildings

- Foundations
- Building Concrete
- Building Superstructure
- Mechanical HVAC
- Decommissioning existing plant (greenfield)

4.0 Process

- Headworks
    - List station concrete
    - Primary wastewater pumps
    - Mechanical screens

    - Bar screen
    - Grit handling
    - Conveyors
    - Dump trailer
    - Primary filter
    - Bridge crane
    - Piping
    - Electrical and I&C
- Secondary Treatment
    - Process tank concrete
    - Blowers and diffusers
    - MBR process equipment
    - WAS pumps
    - Bridge crane
    - Piping and valving
    - Electrical and I&C
- Solids Handling
    - TWAS tank concrete
    - Dissolved air flotation units
    - TWAS pumps
    - Polymer system
    - Belt filter press
    - Solids dump trailer
    - Piping and valving
    - Electrical and I&C

5.0 Electrical Supply

- Utility and back-up power

6.0 Contingencies

- A contingency allowance of 30% is applied to Greenfield plant options while a higher contingency of 40% is applied to re-utilizing the existing plant as additional work may be required to revamp the structure to suit. Additional initial investigation into re-purposing portions of the structure is recommended and discussed further in Section 8.2.

7.0 Engineering and Administration

- 15% is applied to all options for engineering and project administration services.

The estimated construction cost of Option 1 Re-Use of Existing Facility for MBR As-Is and Option 2A- 2004 Activated Sludge are presented but not used in construction cost comparison because as specified in **Section 2** these options do not meet the required 2038 design capacity. The cost estimate for these options does not include any upgrades to the headworks to increase capacity, redundancy or include septage receiving stations.

The capital cost estimates for the options have similar costs for the common treatment processes used in this feasibility report (headworks and solids handling). Some of the main differentiating factors between the construction costs for the options are:

- The headworks upgrades at the existing building are less expensive than headworks construction at the Greenfield options because of the re-use of equipment on site such as the existing wet well structure, primary filter and existing headworks building structure.
- Activated sludge and SBR options require large process tanks for treatment. For this reason the building cost for these options is high due to higher superstructure costs associated with housing these tanks indoors. Also, the increased quantity of concrete required to construct the process tanks increases the secondary treatment option cost of these options, even though the cost of mechanical process equipment associated with these options is low.
- The secondary treatment cost of MBR is highest of all the secondary treatment options because of the equipment required to support treatment such as membrane filtration cassettes, permeate pumps, backpulse system and air scour blowers.
- Higher contingency is carried for options which re-use the existing facility, because portions of the existing facility may require further unidentified structural remediation.

The cost of Option 2B-2 MBBR at the existing facility is the lowest because:

- The process equipment associated with MBBR can fit within the existing process tanks, no additional process tankage required.
- The treatment system uses DAF for clarification; this means a separate DAF is not required for thickening solids prior to dewatering as is required for the other options.
- Only a small building addition is required to house an electrical/generator room and solids handling equipment.

Table 9 Construction Cost Estimates

		Existing Building Reused						Greenfield Plant			
		Option 1	Option 2a	Option 2b-1	Option 2b-2	Option 2b-3	Option 2b-4	Option 3-1	Option 3-2	Option 3-3	Option 3-4
Item	Description	Re-Use of Existing Facility Membrane Bioreactor (MBR) As-Is	2004 Activated Sludge	Membrane Bioreactor (MBR)	Moving Bed Biofilm Reactor (MBBR)	Activated Sludge	Sequencing Batch Reactor (SBR)	Membrane Bioreactor (MBR)	Moving Bed Biofilm Reactor (MBBR)	Activated Sludge	Sequencing Batch Reactor (SBR)
1.0	**GENERAL REQUIREMENTS**	$1,537,300	$1,298,800	$2,128,900	$1,550,600	$2,019,200	$1,514,600	$1,890,800	$2,331,400	$2,475,600	$2,358,700
2.0	**CIVIL/SITEWORKS**	$810,000	$810,000	$810,000	$810,000	$810,000	$810,000	$810,000	$810,000	$810,000	$810,000
3.0	**BUILDINGS**	$2,460,000	$5,647,000	$5,761,000	$4,541,000	$8,866,000	$8,017,000	$9,665,000	$8,310,000	$11,336,000	$10,946,000
4.0	**PROCESS**	-	-	-	-	-	-	-	-	-	-
4.1	**Headworks**	$0	$0	$4,027,000	$4,027,000	$4,027,000	$4,027,000	$4,958,000	$4,993,000	$4,993,000	$4,993,000
4.2	**Secondary Treatment**	$9,830,000	$4,258,000	$8,418,000	$4,250,000	$4,216,000	$4,046,000	$9,218,000	$7,323,000	$5,344,000	$4,565,000
4.3	**Solids Handling**	$1,573,000	$1,573,000	$1,573,000	$1,178,000	$1,573,000	$1,573,000	$1,573,000	$1,178,000	$1,573,000	$1,573,000
5.0	**ELECTRICAL**	$700,000	$700,000	$700,000	$700,000	$700,000	$700,000	$700,000	$700,000	$700,000	$700,000
	Subtotal - Construction	**$17,000,000**	**$14,300,000**	**$23,500,000**	**$17,100,000**	**$22,300,000**	**$20,700,000**	**$28,900,000**	**$25,700,000**	**$27,300,000**	**$26,000,000**
	Contingencies	$6,800,000	$5,700,000	$9,400,000	$6,800,000	$6,700,000	$8,300,000	$8,700,000	$7,700,000	$8,200,000	$7,800,000
	Engineering and Administration Services (15% of Subtotal)	$2,600,000	$2,100,000	$3,500,000	$2,600,000	$3,300,000	$3,100,000	$4,300,000	$7,700,000	$4,100,000	$3,900,000
	Total	**$26,400,000**	**$22,100,000**	**$36,400,000**	**$26,500,000**	**$32,300,000**	**$32,100,000**	**$41,900,000**	**$37,300,000**	**$39,600,000**	**$37,700,000**
	Cost difference	**N/A**	**N/A**	**$9,900,000**		**$5,800,000**	**$5,600,000**	**$15,400,000**	**$10,800,000**	**$13,100,000**	**$11,200,000**

7 OPERATING AND NPV COST ESTIMATES

Operating cost estimates have been based on feasibility sizing of equipment and initial consultations with suppliers. The operating cost estimates for the secondary treatment technologies compared in this feasibility report are presented in **Table 10**.

Similar to the capital costs, the operating costs for the options have similar costs for the common treatment processes used in this feasibility report (headworks and solids handling). Operating costs have not been calculated for the options which would not meet the 2038 design criteria. The secondary treatment cost for all of the options encompasses the electrical demand associated with high rate aeration to service the biological treatment in the bioreactor tanks.

The operating cost for MBR secondary treatment is the highest because the process requires a separate air supply for scouring the membrane modules, the process is based on vacuum pressure pumping to extract treated water from the membrane fibres, and the system requires chemical supply and dosing for periodic maintenance cleaning of the modules.

Detailed discussions with the City will be required to confirm assumptions used for feasibility operating cost estimates to create a more refined estimate during detailed design.

As a further review of the economic evaluation for the various options, a net present value (NPV), or life cycle cost evaluation has been conducted for each option. In full cost accounting, it is often useful to see how the combination of capital and operating cost over the life cycle of the facility compares. The results of this analysis are presented in **Table 11**. For this analysis, a life cycle of thirty years and a rate of inflation of 3% were used.

For the Greenfield options, the MBBR, conventional activated sludge and SBR were all fairly comparable for net present value. However, in looking at the retrofit options, the MMBR was readily the most attractive option based on NPV.

Table 10 Annual Operating Cost Estimates

		Existing Building Reused				Greenfield Plant			
		Option 2b-1	Option 2b-2	Option 2b-3	Option 2b-4	Option 3-1	Option 3-2	Option 3-3	Option 3-4
Item	Description	Membrane Bioreactor (MBR)	Moving Bed Biofilm Reactor (MBBR)	Activated Sludge	Sequencing Batch Reactor (SBR)	Membrane Bioreactor (MBR)	Moving Bed Biofilm Reactor (MBBR)	Activated Sludge	Sequencing Batch Reactor (SBR)
1.0	**LABOUR**	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000	$350,000
2.0	**PROCESS**	-	-	-	-	-	-	-	-
	Headworks	$124,000	$124,000	$124,000	$124,000	$124,000	$124,000	$179,000	$124,000
	Secondary Treatment	$819,000	$489,000	$480,000	$468,000	$1,090,000	$489,000	$447,000	$468,000
	Solids Handling	$15,000	$11,000	$15,000	$15,000	$15,000	$11,000	$15,000	$15,000
3.0	**CHEMICAL**	$28,000	$28,000	$28,000	$28,000	$28,000	$28,000	$28,000	$28,000
4.0	**HEATING AND LIGHTING**	$140,000	$140,000	$190,000	$190,000	$140,000	$140,000	$190,000	$190,000
	TOTAL	**$1,494,000**	**$1,161,000**	**$1,204,000**	**$1,193,000**	**$1,765,000**	**$1,161,000**	**$1,228,000**	**$1,193,000**
	Difference	$333,000		$43,000	$32,000	$604,000		$67,000	$32,000

Table 11 Net Present Value Analysis

	Existing Building Reused				Greenfield Plant			
	Option 2b-1	Option 2b-2	Option 2b-3	Option 2b-4	Option 3-1	Option 3-2	Option 3-3	Option 3-4
Description	Membrane Bioreactor (MBR)	Moving Bed Biofilm Reactor (MBBR)	Activated Sludge	Sequencing Batch Reactor (SBR)	Membrane Bioreactor (MBR)	Moving Bed Biofilm Reactor (MBBR)	Activated Sludge	Sequencing Batch Reactor (SBR)
Capital Cost	$36,400,000	$26,500,000	$32,300,000	$32,100,000	$41,900,000	$37,300,000	$39,600,000	$37,700,000
NPV of Operating Cost	$29,284,000	$22,757,000	$23,599,000	$23,384,000	$34,595,000	$22,757,000	$24,070,000	$23,384,000
TOTAL NET PRESENT VALUE	**$65,684,000**	**$49,257,000**	**$55,899,000**	**$55,484,000**	**$76,495,000**	**$60,057,000**	**$63,670,000**	**$61,084,000**
Percent difference	33%	0%	13%	13%	55%	22%	29%	24%

8 RECOMMENDATION AND NEXT STEPS

8.1 Recommendation

Feasibility work has been completed evaluating a variety of secondary treatment options to identify the most appropriate option to provide a WWTP to meet the proposed effluent discharge requirements in Iqaluit. This report has compared options for upgrading the existing WWTP against the possibility of building a new Greenfield WWTP. Based on mainly economic and some non-economic factors, it is recommended that Option 2B-2 MBBR secondary treatment at the existing facility is the secondary treatment option to be progressed to preliminary and detailed design. A process flow diagram for the use of MBBR for secondary treatment at the Iqaluit WWTP site is shown in **Appendix C Figure 1.** This option is advantageous because it produces high quality effluent within the smallest footprint, has reliable operation, is robust and avoids chemical use in secondary treatment. Aside from the aeration system and the wasting pumps, there are no other mechanical devices associated with this process. One disadvantage relates to the floating media within the tank. In the unlikely event of basin maintenance, the basin would have to be dewatered and the media would have to be removed and stored onsite to allow free access to the tank. This can be accomplished by plant staff with a portable pump that can be used to remove the media, and either add it to the other duty basin, or remove to an area adjacent to the dewatered tank where the media can be allowed to drain to the duty basin. This risk is manageable given the significant cost benefit associated with process' small footprint.

Figure 6 illustrates what the basin would look like without the media, and **Figure 7** shows a basin in operation. Note the mesh screens at the effluent end that allow treated wastewater to leave the basin, while retaining the floating plastic media (**Figure 6**). **Figure 8** shows what the media looks like, both in its new form and once the biomass has formed.

Figure 6 Empty MBBR Basin

Figure 7 Full MBBR Basin

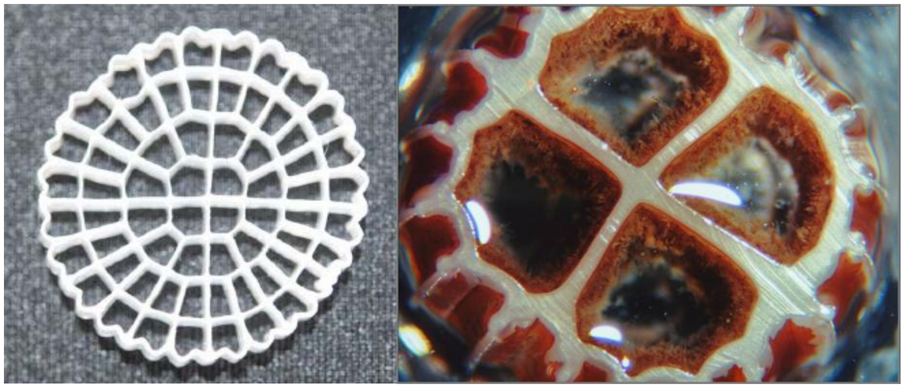


Figure 8 MBBR Media

As part of the general contract for this work, the contractor will arrange for various key equipment vendors to come to the site and provide training to the plant staff on how to operate, maintain and troubleshoot the equipment. We also recommend that the City carry an annual training budget to allow staff to take general or specialty courses that are offered by various training organizations. This will allow the City to develop a group of operators that have a sufficiently high enough qualification to run the facility without having to rely on outside contract operations staff. The level required to operate the facility will be determined during the design phase of the project in consultation with the authority having jurisdiction.

It is also recommended to include septage receiving at the WWTP integrated with upgrades to the headworks presented in Section 3. It would be economical to include this construction as part of the main WWTP project and it would result in significantly improved conditions for septage haulers in the future. Moving forward with MBBR treatment, in concert with the supporting processes described in the report will provide the City with a compact plant.

Recommendation:

- Option 2B-2 Moving Bed Biofilm Reactor at the existing facility
- Capital Cost Estimate $26,500,000
- Annual Operating Cost Estimate $1,161,000

The information presented in this report provides a sufficient basis for the initiation of preliminary design. The preliminary design effort will revolve around confirming process equipment layouts, refining the capital and operating costs to higher level of certainty and initiation additional investigations that will help form the basis of design.

8.2 Potential Required Investigations

It is recommended that the City complete some investigation work to confirm the basis of design and minimize risk throughout the detailed design and construction process. Recommended investigation work includes:

Geotechnical Investigation and Site Survey

Review of existing information will be required to determine if sufficient information is available for the area where the secondary treatment building will be extended. A desktop geotechnical study could potentially meet the requirements for the detailed design depending on the layout and requirements of the expansion.

Structural Evaluation

Previous work has been completed to confirm the process tanks are suitable for use, however the associated CH2M Hill final report and the record drawings have not been located. Nevertheless, Stantec are confident that the tanks can be utilized as is without further remedial efforts. This is based on:

- Stantec team members recalling reviewing the CH2M Hill report approximately 13 years ago
- Subsequent reports (Earth Tech Sewage Treatment Plant Investigation, December 2002) refer to work being completed as per the CH2M Hill recommendations
- The remedial work appears in place and in sound condition
- Reviewing the tender drawings for the remedial work (record drawings were not located)

Therefore, it is not anticipated that further remedial efforts will be necessary. Should the City still retain serious concerns, a more minor engineering investigation and possibly hydrostatic testing the tanks again, could be performed initially and the need for further efforts evaluated.

For the remainder of the building, detailed structural evaluation and possibly destructive testing should be completed to confirm the building is capable of withstanding the new loading requirements of process equipment. The main area which will require investigation is the second floor of the secondary treatment building as this area will be housing new dissolved air floatation units and the belt filter press. The condition of the concrete floor and supporting walls in this area for loading by mechanical equipment is unknown but is assumed to be poor. Stantec recommends the City proceed with a structural review of the area once the design scope and general layout for the project is established.

Redundancy Evaluation

If requested by the City, a redundancy evaluation can be completed to determine the preferred level of standby equipment. Standby equipment for critical processes in the headworks has been included in this feasibility work. Standby equipment in the secondary and solids handling areas has not been included as they are non-critical processes and can significantly increase construction costs while providing no value under normal operating conditions.

Environmental Assessment

The footprint required for upgrading the WWTP is small and adjacent to the existing facility so it is not expected than any environmental assessment will be required. The City is to confirm if baseline information exists for this area as part of the original WWTP construction, and if any additional environmental assessments would be required.

Respectfully submitted,

Nunami Stantec Limited

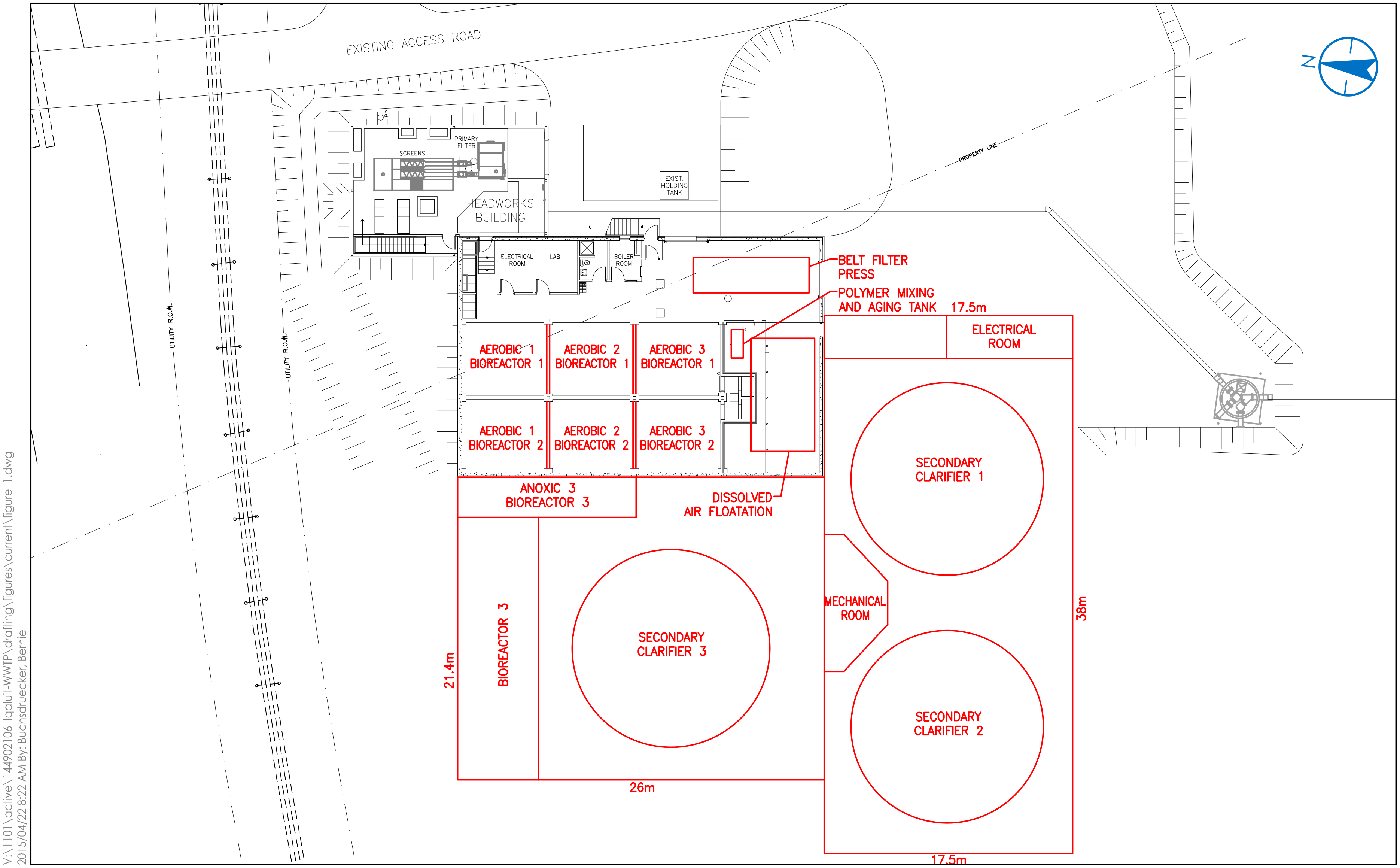
REGISTERED PROFESSIONAL ENGINEER
G.A. PROSKO
LICENSEE
NWT/NU

Reviewed by:

Original signed by:	***Original signed by:***
David Lycon, Ph.D, P.Eng.	Glenn Prosko, P.Eng
Process Specialist	Senior Project Manger

APPENDIX A

Feasibility Site Layouts



Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

EXISTING INFRASTRUCTURE

NEW ADDITION

Note:

BIOREACTOR BLOWERS, TWAS PUMPS, TWAS STORAGE, RAS PUMPS, WAS PUMPS, MECHANICAL ROOM LOCATED ON LOWER FLOOR

Scale

1:400 (0, 4, 12, 20m)

Client/Project

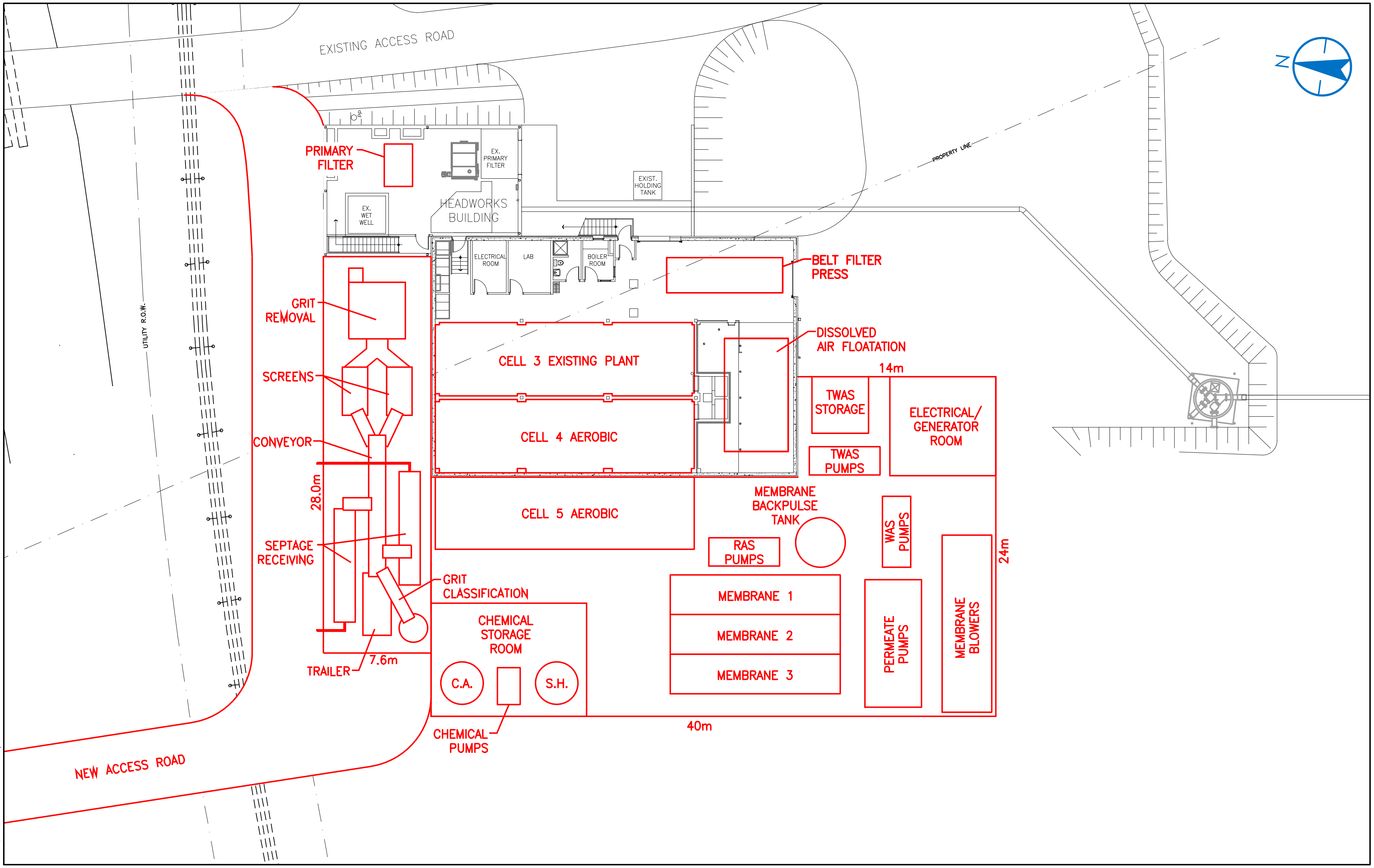
CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES
FEASIBILITY STUDY

Figure No.

1

Title

Option 2A
2006 Activated Sludge Design



V:\1101\active\144902106_Iqaluit-WWTP\drafting\figures\current\figure_2.dwg
2015/05/11 11:25 AM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

EXISTING INFRASTRUCTURE

NEW ADDITION

Note:

BIOREACTOR BLOWERS AND MECHANICAL ROOM LOCATED ON LOWER FLOOR

Scale

0 4 12 20m

1:400

Client/Project

CITY OF IQALUIT, NUNAVUT

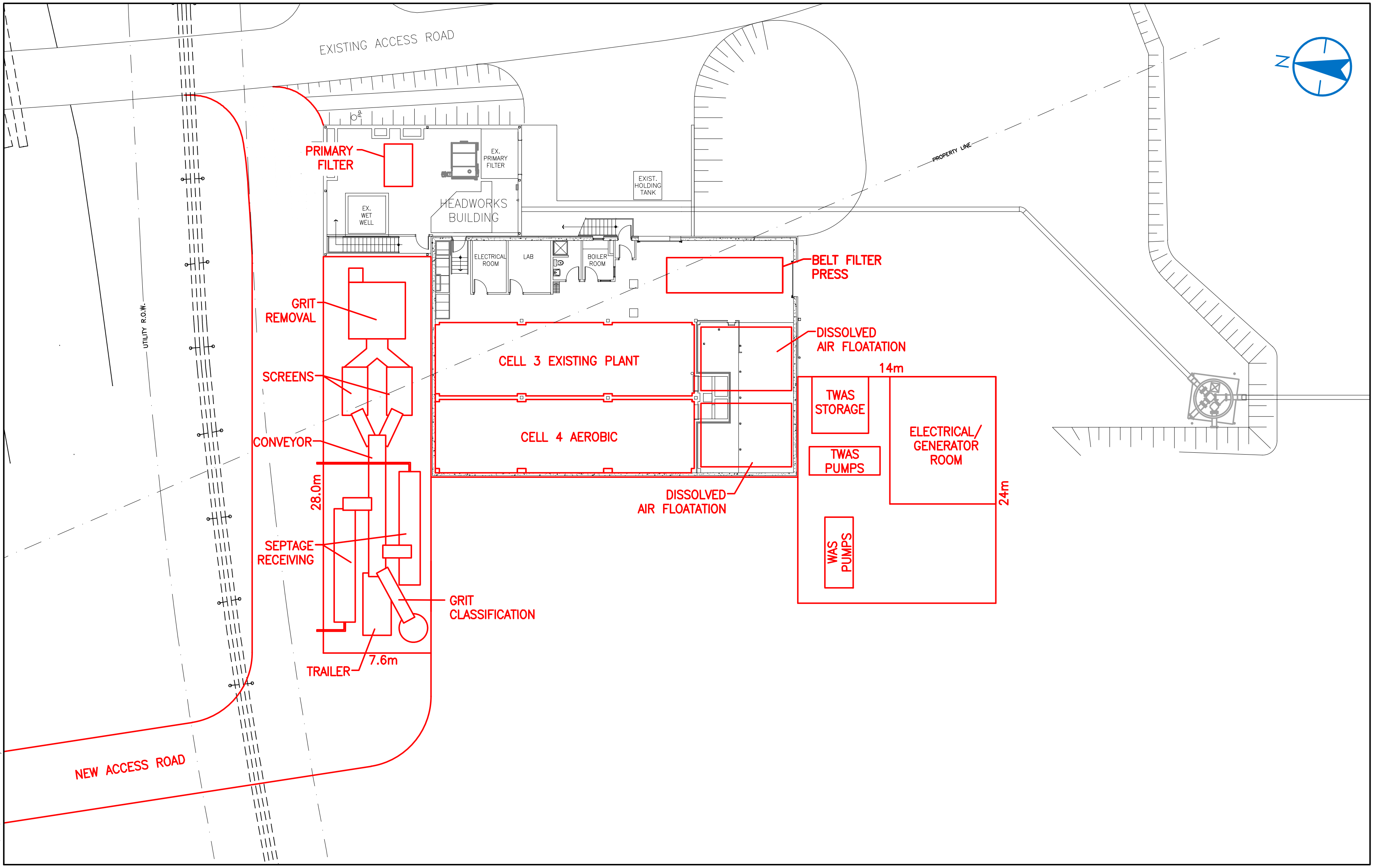
WASTEWATER TREATMENT PLANT UPGRADES FEASIBILITY STUDY

Figure No.

2

Title

Option 2B-1
Membrane Bioreactor (MBR)



Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

EXISTING INFRASTRUCTURE
NEW ADDITION

Note:

BIOREACTOR BLOWERS AND MECHANICAL ROOM LOCATED ON LOWER FLOOR

Scale

0 4 12 20m

1:400

Client/Project

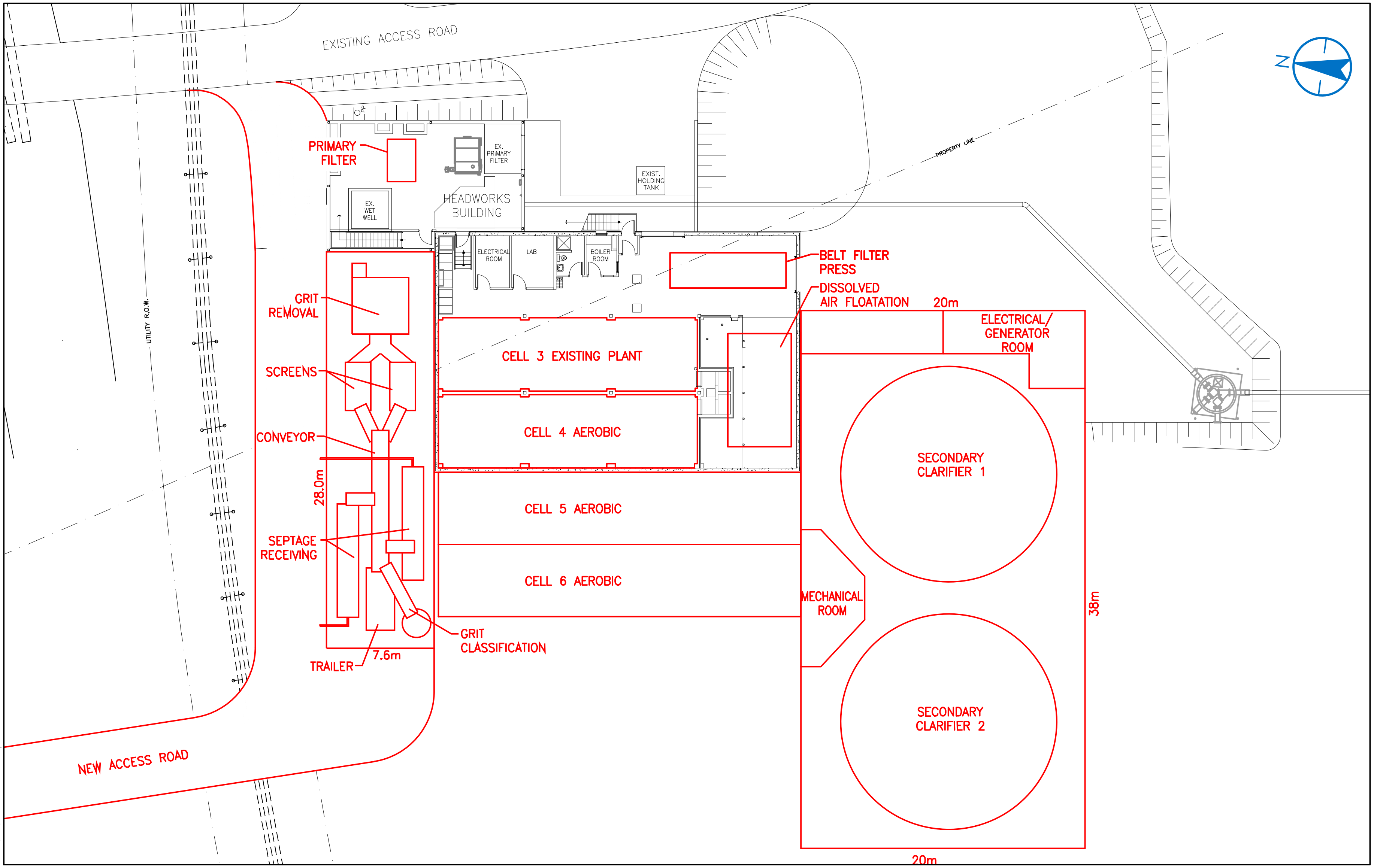
CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES
FEASIBILITY STUDY

Figure No.

3

Title

Option 2B-2
Moving Bed Biofilm Reactor (MBBR)



V:\1101\active\144902106_Iqaluit-WWTP\drafting\figures\current\figure_4.dwg
2015/05/11 11:27 AM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

EXISTING INFRASTRUCTURE

NEW ADDITION

Note:

BIOREACTOR BLOWERS, TWAS PUMPS, TWAS STORAGE, RAS PUMPS, WAS PUMPS, MECHANICAL ROOM LOCATED ON LOWER FLOOR

Scale

0 4 12 20m

1:400

Client/Project

CITY OF IQALUIT, NUNAVUT

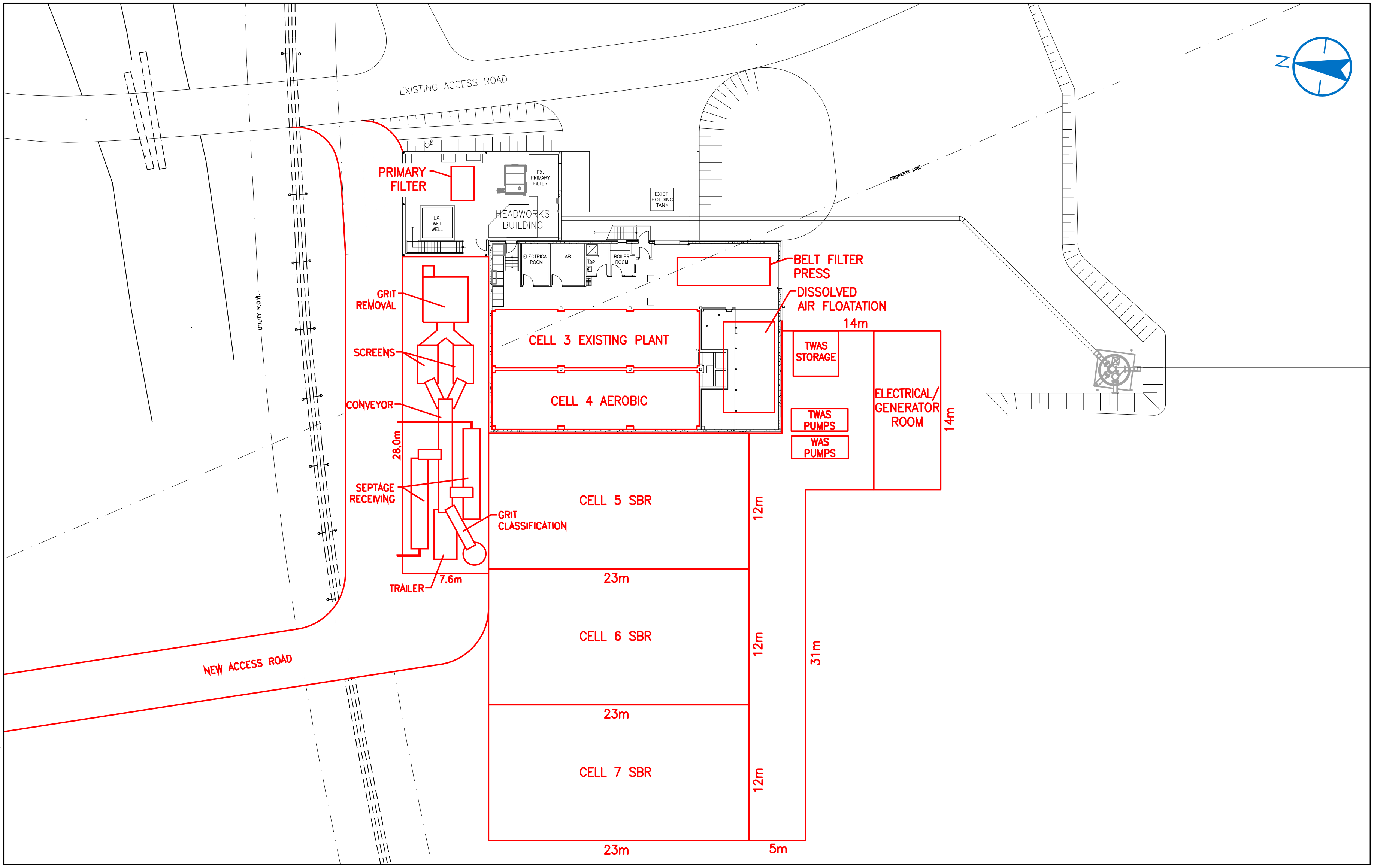
WASTEWATER TREATMENT PLANT UPGRADES FEASIBILITY STUDY

Figure No.

4

Title

Option 2B-3
Activated Sludge



V:\1101\active\144902106_iqaluit-WWTP\drafting\figures\current\figure_5.dwg
2015/05/11 11:27 AM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

EXISTING INFRASTRUCTURE

NEW ADDITION

Scale

0 5 15 25m

1:500

Client/Project

CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES
FEASIBILITY STUDY

Figure No.

5

Title

Option 2B-4
Sequencing Batch Reactor (SBR)

V:\1101\active\144902106_Iqaluit-WWTP\drafting\figures\current\figure_6.dwg
2015/04/22 8:28 AM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Scale

1:2000 — 0, 20, 60, 100m

Client/Project

CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES
FEASIBILITY STUDY

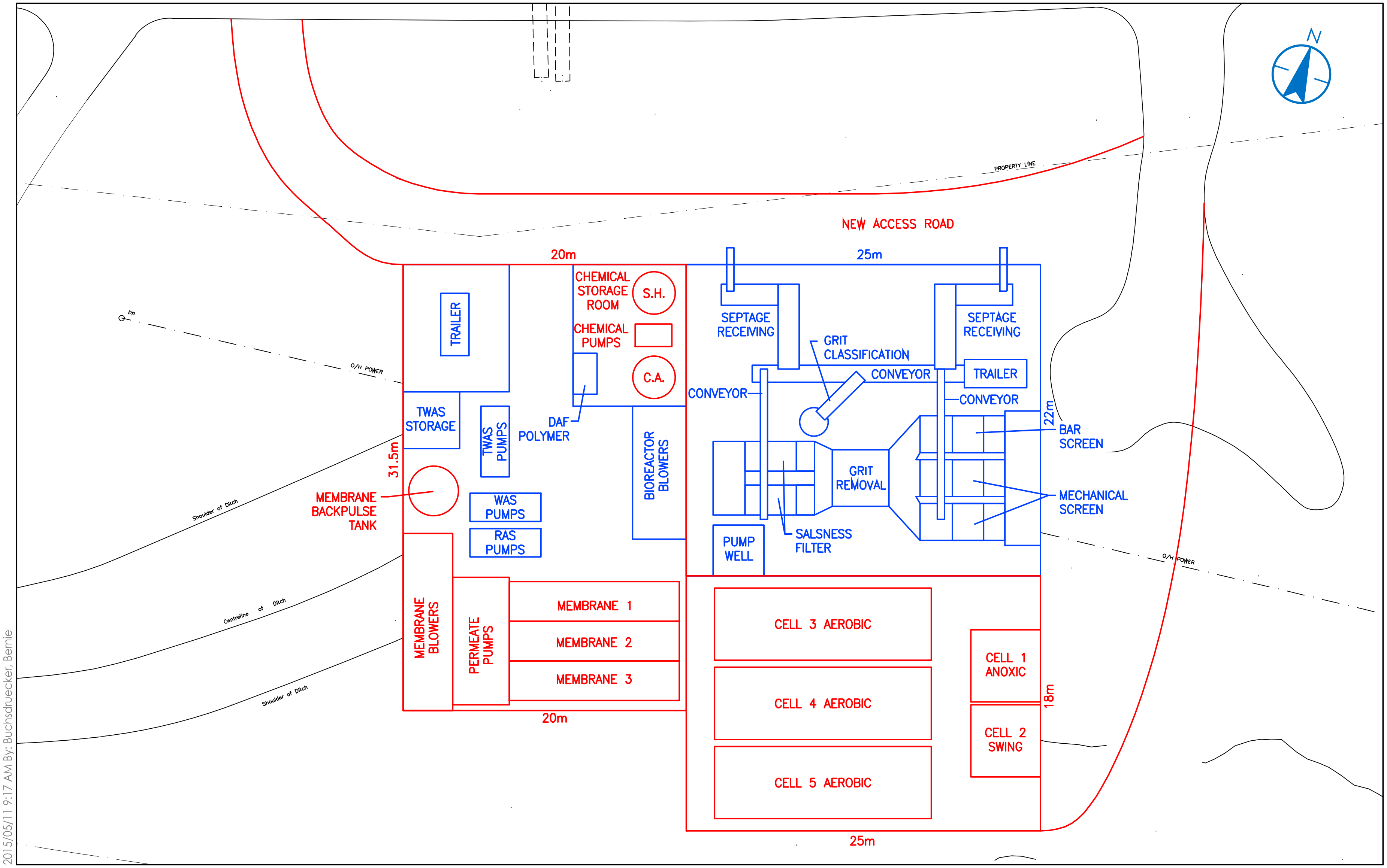
Figure No.

6

Title

Greenfield Site Plan

V:\1101\active\144902106_Iqaluit-WWTP\drafting\figures\current\figure_7.dwg
2015/05/11 9:17 AM By: Buchsdruecker, Bernie



Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

COMMON TREATMENT PROCESS BETWEEN GREENFIELD OPTIONS

SECONDARY TREATMENT EQUIPMENT

Scale

1:400 (0, 4, 12, 20m)

Note:

DISSOLVED AIR FLOATATION, BELT FILTER, ADMIN/LAB AND ELECTRICAL/MECHANICAL ROOM LOCATED ON SECOND FLOOR (31.5m x 20m)

Client/Project

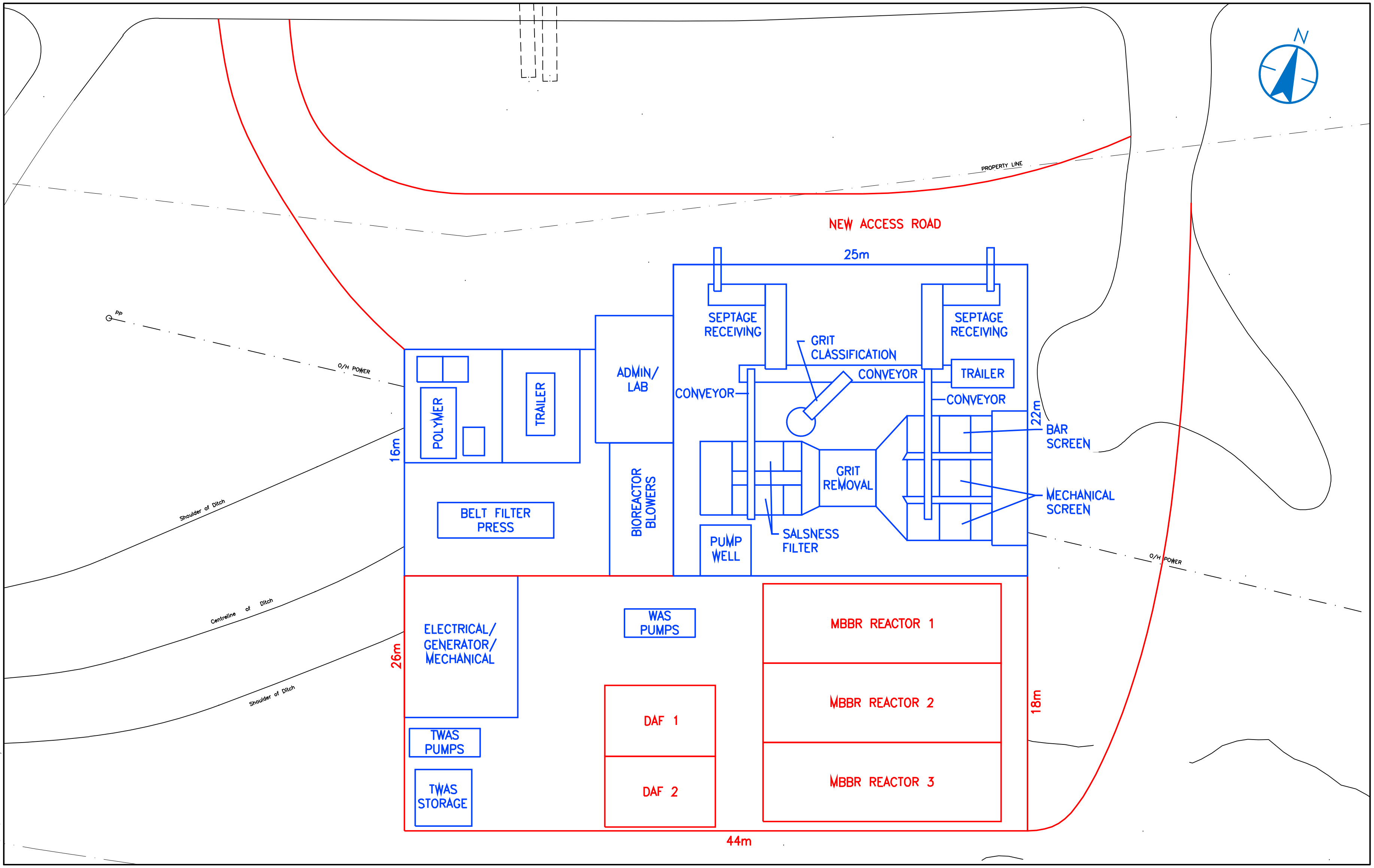
CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES FEASIBILITY STUDY

Figure No.

7

Title

Option 3-1
Greenfield Membrane Bioreactor (MBR)



V:\1101\active\144902106_Iqaluit-WWTP\drafting\figures\current\figure_8.dwg
2015/05/11 9:19 AM By: Buchsdruecker, Bernie

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Legend

COMMON TREATMENT PROCESS BETWEEN GREENFIELD OPTIONS

SECONDARY TREATMENT EQUIPMENT

Scale

1:400 — 0, 4, 12, 20m

Client/Project

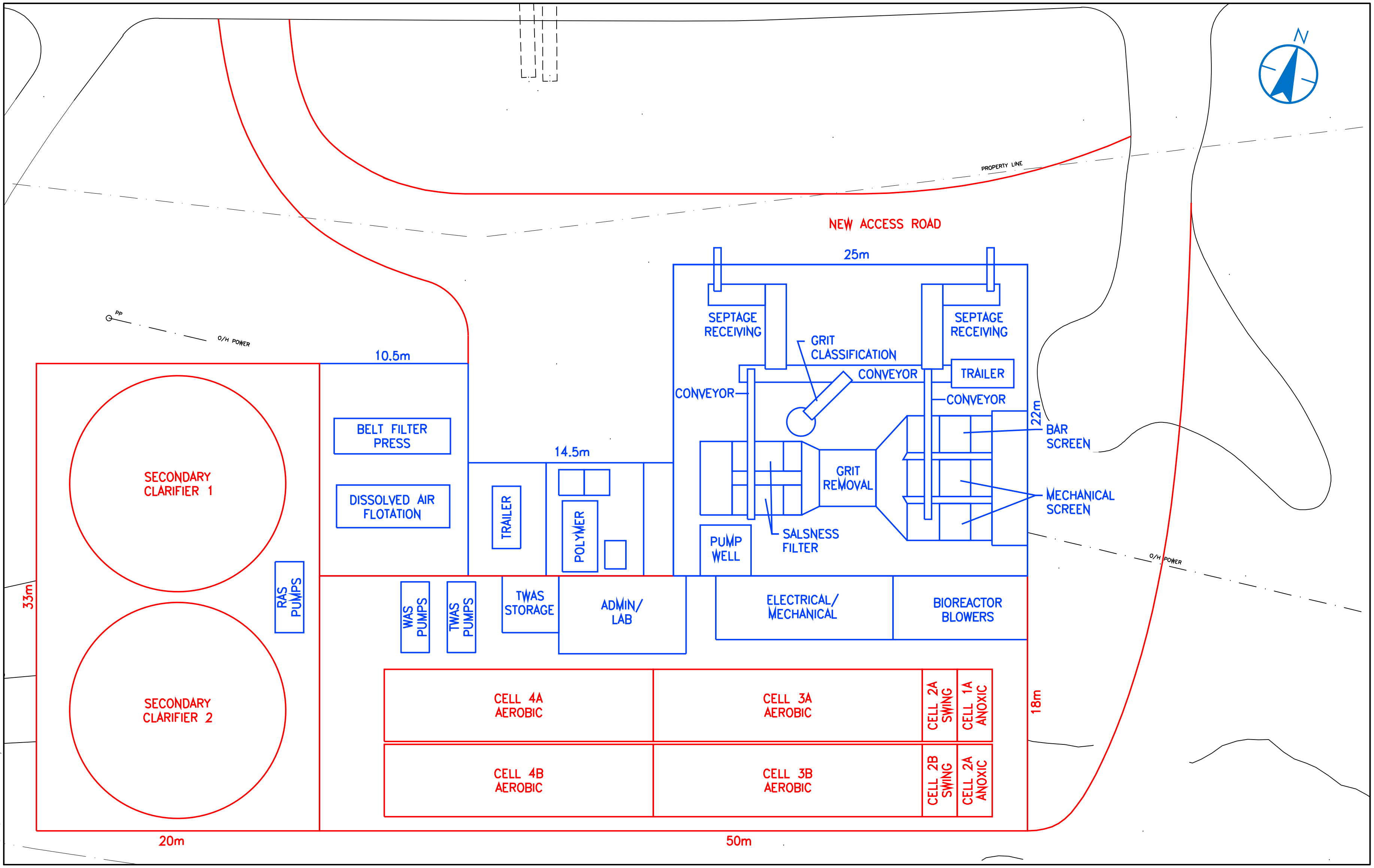
CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES FEASIBILITY STUDY

Figure No.

8

Title

Option 3-2
Greenfield Membrane Bioreactor (MBBR)



Legend

COMMON TREATMENT PROCESS BETWEEN GREENFIELD OPTIONS

SECONDARY TREATMENT EQUIPMENT

Scale

0 4 12 20m

1:400

Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

Client/Project

CITY OF IQALUIT, NUNAVUT

WASTEWATER TREATMENT PLANT UPGRADES FEASIBILITY STUDY

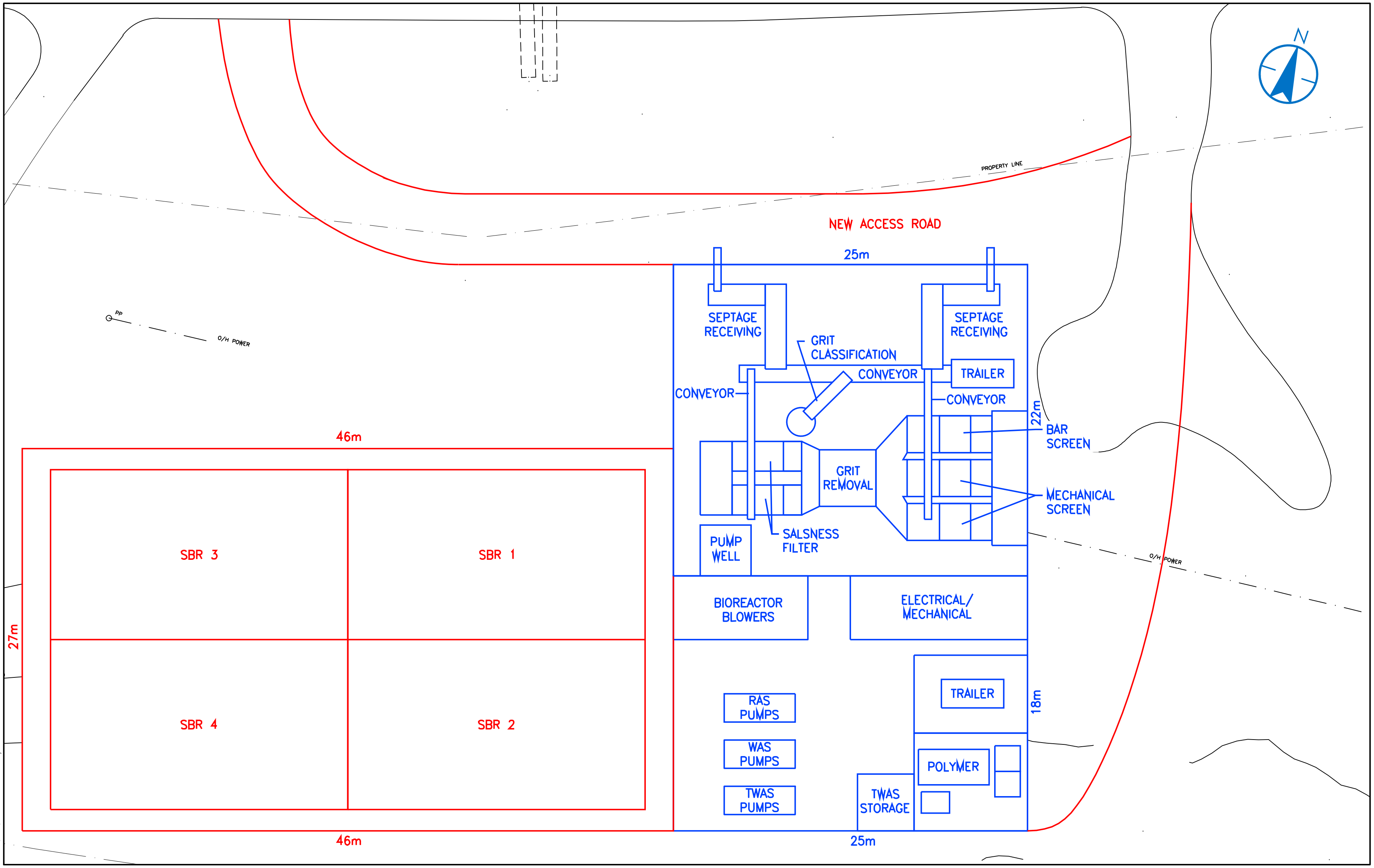
Figure No.

9

Title

Option 3-3
Greenfield Activated Sludge

V:\1101\active\144902106_Iqaluit-WWTP\drafting\figures\current\figure_10.dwg
2015/05/11 9:19 AM By: Buchsdruecker, Bernie



Stantec

10160 - 112 Street
Edmonton AB
www.stantec.com

COMMON TREATMENT PROCESS BETWEEN GREENFIELD OPTIONS
SECONDARY TREATMENT EQUIPMENT

Scale

1:400 (0, 4, 12, 20m)

Client/Project

CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES
FEASIBILITY STUDY

Figure No.

10

Title

Option 3-4
Greenfield Sequencing Batch Reactor (SBR)

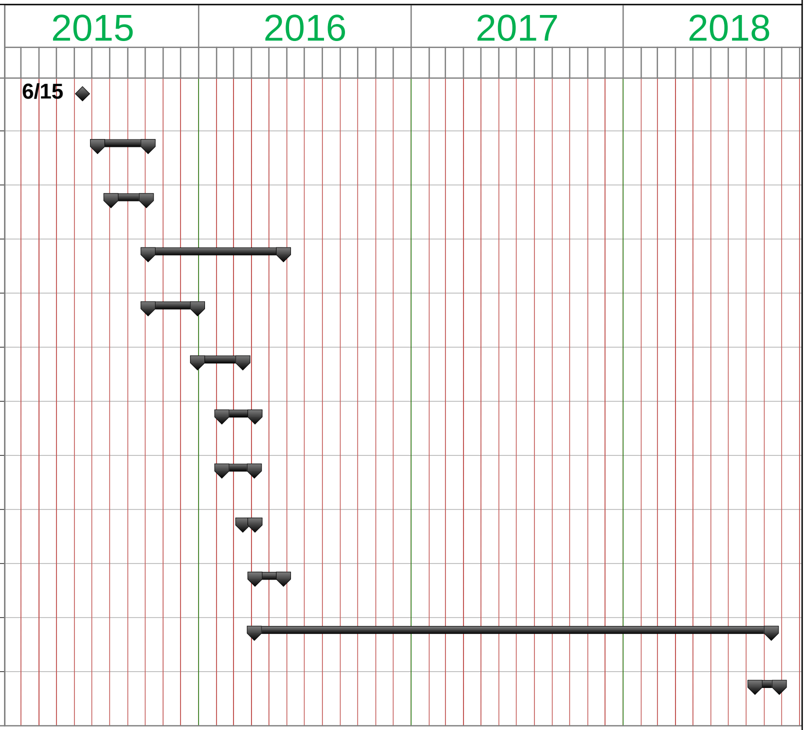
APPENDIX B

Estimated Construction Schedule

City of Iqaluit - WWTP Upgrade/Expansion

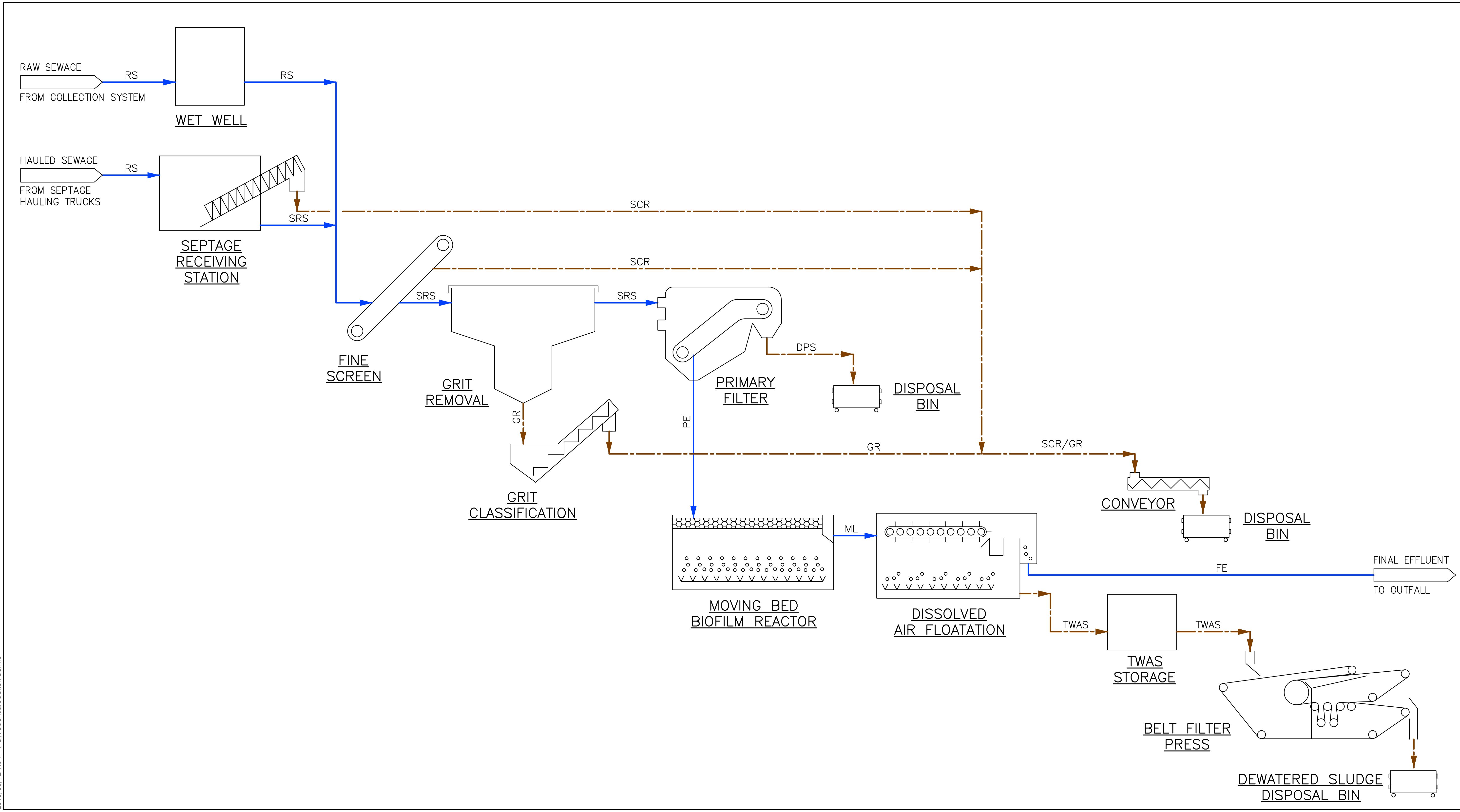
Project Implementation Schedule

ID	Task Name	Duration	Start	Finish
1	Feasibility Study Complete	0 days	Jun 15 '15	Jun 15 '15
2	**Preliminary Design**	**61 days**	**Jul 10 '15**	**Oct 5 '15**
18	**Geotechnical and Additional Studies**	**45 days**	**Aug 3 '15**	**Oct 2 '15**
25	**Detailed Design**	**167 days**	**Oct 6 '15**	**May 25 '16**
26	**50% Submittal**	**61 days**	**Oct 6 '15**	**Dec 29 '15**
37	**90% Submittal**	**56 days**	**Dec 30 '15**	**Mar 16 '16**
57	**Tender Documents**	**41 days**	**Feb 10 '16**	**Apr 6 '16**
58	**Pre-purchase Equipment Packages**	**40 days**	**Feb 10 '16**	**Apr 5 '16**
63	**WWTP Upgrades**	**15 days**	**Mar 17 '16**	**Apr 6 '16**
67	**Tendering Assistance**	**35 days**	**Apr 7 '16**	**May 25 '16**
74	**Construction Phase Assistance**	**636 days**	**Apr 6 '16**	**Sep 12 '18**
96	**Post Construction Services**	**30 days**	**Aug 16 '18**	**Sep 26 '18**



APPENDIX C

Moving Bed Biofilm Process Flow Diagram



Legend
- LIQUID STREAM
- SOLID STREAM

Stantec
10160 - 112 Street
Edmonton AB
www.stantec.com

Client/Project
CITY OF IQALUIT, NUNAVUT
WASTEWATER TREATMENT PLANT UPGRADES
FEASIBILITY STUDY

Figure No.
1

Title
Option 2B-2
Moving Bed Biofilm Reactor (MBBR)
Process Flow Diagram