

**Town of Okotoks Wastewater
Treatment Plant – Regional
Wastewater Pipeline
Feasibility Study**

Final Report



Prepared for:
Town of Okotoks

Prepared by:
Stantec Consulting Ltd.

April 13, 2016

Sign-off Sheet

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Hatim Fadlalla, Ph.D., P.Eng., PE

Reviewed by _____


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Chris Mountenay, P.Eng.



Sign-off Sheet

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Hatim Fadlalla, Ph.D., P.Eng., PE

Reviewed by  _____
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Chris Mountenay, P.Eng.

TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – REGIONAL WASTEWATER PIPELINE FEASIBILITY STUDY

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EXECUTIVE SUMMARY

The Town of Okotoks (The Town) has been growing rapidly towards the 30,000 persons. The Town is currently seeking a more reliable supplemental long-term water source from the City of Calgary. With additional growth, new stresses will be imposed on the Town wastewater treatment plant (WWTP).

Stantec Consulting Ltd. (Stantec) has been tasked by the Town to conduct a feasibility study that will assess the capacity and potential upgrade requirements of its existing WWTP and compare the feasibility of upgrading its WWTP to installing a regional wastewater pipeline to Pine Creek WWTP. Findings from the feasibility analyses were provided in the following Technical Memorandums (TMs):

1. TM# 1 Design Basis Definition
2. TM# 2 Capacity Assessment
3. TM# 3 Sanitary Forcemain Options
4. TM# 4 WWTP Upgrade Options
5. TM# 5 Evaluation Criteria and Weighting

1.1 TM #1 DESIGN BASIS DEFINITION

The Design Basis Memorandum (DBM) developed the design basis to evaluate the capacity of the existing WWTP and to determine future upgrade requirements to service future population load during the next 50-year planning period (2015 – 2065) as summarized in Table ES.1.

In addition, the DBM analyzed WWTP historical effluent quality data for the operating period from January 2010 through December 2014. Maximum month effluent discharge concentrations during the evaluation period were consistently below applicable discharge limits as summarized in Table ES.2. Okotoks WWTP has shown good performance and minor TP contributions to the Bow River as noted in Stantec's 2009 Downstream Users Study for the Municipality of Okotoks. This suggests that Okotoks WWTP effluent loadings are of minimal concern and most probably will not require adjustment from current discharge approval limits.

In addition, water quality at Carseland for parameters targeted by WWTPs (i.e., ammonia-N, TSS, and TP) generally meets South Saskatchewan Regional Plan (SSRP) triggers and is well below SSRP limits. However, high variability in open water TP concentrations and the fact that TP concentrations at Carseland are approaching trigger values suggest that future monitoring periods may demonstrate TP concentrations above triggers.

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Table ES.1 Summary of Design Basis

Process	Design Basis	Unit	Current	2039	2065
Population	1,271.5 capita/year	Capita	27,331	59,119	92,172
Screens	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Grit Tanks	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
EQ Tanks	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Primary Clarifier	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Aeration Tank	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
		kg TAN/d	176	381	594
		kg TP/d	54	117	182
Secondary Clarifier	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Tertiary Filtration	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
UV	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Aeration Blowers	Maximum Day Load	kg BOD ₅ /d	5,512	11,923	18,589
Pumps	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Piping	Peak Hour Flow	m ³ /h	1,081	2,336	3,642

Table ES.2 Effluent Flow and Quality

Parameter	Discharge Limit	Maximum Month	% above Limit	Notes
BOD₅ (mg/L)	20	6.4	0%	--
TSS (mg/L)	20	3.4	0%	Before 2012-01-01
	15	4.8	0%	After 2012-01-01
TP (mg/L)	1.0	0.7	0%	Before 2012-01-01
	0.5	0.2	0%	After 2012-01-01
NH₃-N (mg/L)	10	1.7	0%	Oct 1 to Jun 30
	5	1.3	0%	Jul 1 to Sep 30
TN (mg/L)	--	10.1	0%	Before 2012-01-01
	15	12.6	0%	After 2012-01-01
Total Coliform (#/100 mL)	1,000	552	0%	Geometric Mean
Fecal Coliform (#/100 mL)	200	125	0%	Geometric Mean

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The existing WWTP consists of influent screw pumps, grinder/spiral screens, vortex grit chamber, a flow equalization tank, an Activated Primary Clarifier (APC), a Biological nutrient Removal (BNR) bioreactor/secondary clarifier, tertiary disk filtration and UV disinfection. Primary and secondary solids are handled using Dissolved Air Floatation (DAF), centrifuge dewatering, and pug mill mixers.

1.2 TM #2 CAPACITY ASSESSMENT

In TM #2, Stantec completed a desktop capacity evaluation of the existing infrastructure at Okotoks WWTP based on historical monthly reports, design basis information from TM #1, supplemental sampling results, manufacturer data for installed equipment, or original design information through shop drawings and O&M manuals. In addition, Stantec developed a calibrated BioWinTM model using historical influent flows and loads and operational data to estimate the capacity of the secondary treatment and forecast the performance of the BNR process and effluent quality.

Figure ES.1 summarizes our findings from the capacity assessment effort. The figure illustrates the installed capacity and firm capacity (i.e. capacity with largest unit offline) of each unit process. Actual peak hour flow or maximum loading to each unit process in 2015 were also added and used to evaluate the status of each unit whether it is under capacity, at capacity, or over capacity based on the criteria listed in TM #2. The status of each critical unit process (i.e. the liquid train unit processes and DAF) was evaluated against their firm capacity. For less critical units including solids train unit processes and fermentation, the status of each unit was evaluated against their installed capacity assuming that the WWTP is able to dispose of thickened solids to an offsite facility when a solids handling unit is taken out of service for repair or maintenance until it is back online. For unit processes under design capacity, the Equivalent Population (EP) to reach full capacity was determined based on future flows projection as listed in TM #1.

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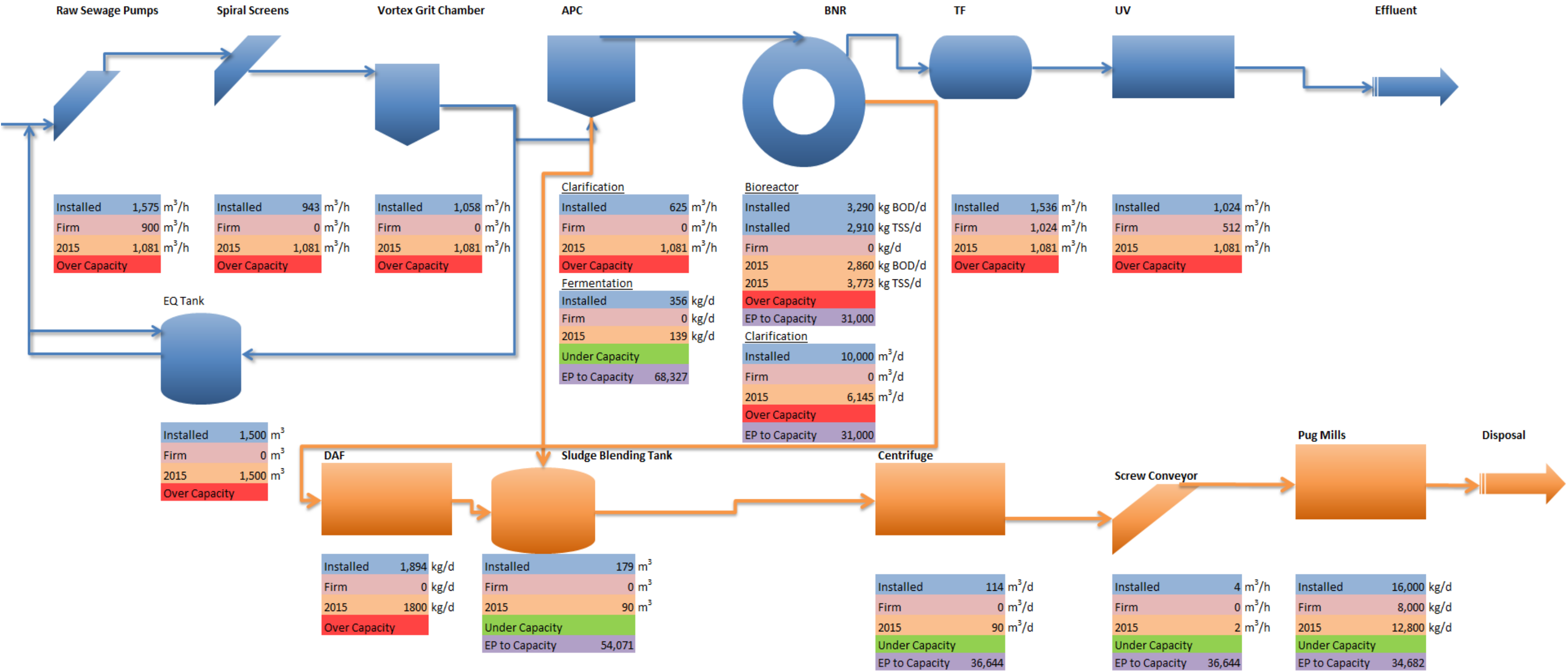


Figure ES.1 Capacity of the Existing Okotoks WWTP

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1.3 TM #3 SANITARY FORCEMAIN OPTIONS

TM#3 outlined various options to transfer wastewater from The Town to Pine Creek WWTP based on the population projections developed in TM#1 and projected wastewater generation rates. Stantec projected future development and sewage generation rates for both 25 year and 50 year planning periods as summarized in Table ES.3 using the following assumptions based on historical flow data and recommendations from "Town of Okotoks Sanitary Master Plan – 2012 Model Update & Existing and Future System Evaluation", Stantec, January 2014:

- Wastewater generation rate of 224.84 Lpcd calculated for current system (2014) flows was carried forward with the projected future population growth;
- A diurnal flow pattern was applied to the Average Dry Weather Flow (ADWF) rates to yield a Peak Dry Weather Flow (PDWF) of approximately 2.2 times the ADWF;
- Peak Wet Weather Flow (PWWF) parameters for all future areas were set to yield Inflow and Infiltration (I/I) rate of 0.28 L/s/ha as recommended by Alberta Environments & parks (AEP);
- The proposed future development and annexation areas for 30 year and 60 years projections in 2012 master plan were adopted in this study.

Table ES.3 System Wastewater Design Flow Projection

Year	Population	ADF (m3/d)	PDWF (L/s)	Land Area (ha)	I/I Allowance (L/s)	Total PWWF (L/s)
2039	59,119	13,292	341.54	1,718	322.62	664
2040	60,390	13,578	348.88	1,740	328.79	678
2065	92,172	20,725	532.52	2,290	482.90	1,012

Stantec evaluated two primary options as follow:

- Option #1: A pipeline and lift station designed to pump all of Okotoks' current and future sewage to Pine Creek WWTP;
- Option #2: A pipeline and lift station to pump to Pine Creek WWTP only the additional flows that exceed the current treatment capacity of the Town's WWTP;

The proposed pipeline route follows the preselected regional waterline along Hwy 2A until it diverge northeast onto Hwy 2 to connect to Pine Creek WWTP in Calgary with a total length of approximately 18.5 km.

Given the conceptual nature of this study and the lack of a topographic survey to verify the available contour information, Stantec recommends a cascade transmission system with a Mid-Lift Station (Mid-LS) along the alignment with a minimum pressure at Mid-LS. The proposed Mid-LS would be located at approximately Banister Gate, north of the Town. The Mid-LS would separate the proposed pipeline into two segments:

- Segment 1: Okotoks WWTP to the Mid-LS (~4.3 km);
- Segment 2: Mid-LS to Pine Creek WWTP (~14.2 km)

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For Option #1, Stantec recommends the following:

- Converting the existing WWTP into a peak shaving facility for the catchment area feeding the first segment;
- Installing a 650 mm pipeline with TDH of 81 m for Segment 1 and a 750 mm pipeline with TDH of 80 m for Segment 2 to convey wastewater from Okotoks to Calgary;
- For Option #2, Stantec recommends the following:
- Using the existing WWTP at its maximum capacity;
- Installing a pipeline and Mid-LS to pump additional wastewater flow that exceeds the existing capacity of the Town's WWTP to Pine Creek WWTP; and
- Installing a 650 mm pipeline with TDH of 82 m for Segment 1 and a 750 mm pipeline with TDH of 80 m for Segment 2 to convey wastewater from Okotoks to Calgary.
- For both options, Stantec recommends:
- Phasing the installation of the sewage pumps within the Mid-LS. In the first phase, sewage pumps that can accommodate the 25 year design scenario shall be installed with provisions for extra space for future (50 year) upgrades. In the second phase, the smaller pumps can be replaced with additional larger pumps with all associated electrical and ancillary equipment; and
- Considering a minimum pumping rate during pump selection and installation to make sure minimum pipe velocity is maintained at all times under current flow condition, 25 year and 50 year system.

The capital cost estimate indicated that there's nothing substantive to change the Opinion of Probable Cost (OPC) between the two options. For Option #1 the OPC is \$45.89 million and \$52.20 million for the 25 year and 50 year design horizons, respectively. For Option #2 the OPC is \$45.64 million and \$52.20 million for the 25 year and 50 year design horizons, respectively. However, for Option #2, the Town will have to keep the existing WWTP in operation with a high O&M cost. The provided OPCs do not include the portion of Pine Creek WWTP upgrade cost that the Town may have to pay to be able to tie in to Pine Creek WWTP.

1.4 TM #4 WWTP UPGRADE OPTIONS

In TM#4, Stantec conducted a desktop evaluation to determine process upgrade requirements at the Okotoks WWTP to be able to treat future flows and loadings for the 50-year design horizons. This Technical Memorandum (TM) builds on the regional pipeline feasibility study and information provided in Technical Memorandum #2 (TM #2) "Town of Okotoks WWTP – Treatment Capacity Assessment",

Stantec developed eight different alternatives to upgrade the existing WWTP to meet future treatment objectives through 2065. The different alternatives considered conventional BNR system, membrane bioreactor (MBR), effluent discharge options, and High Rate Clarification System (HRCS).

The HRCS would be designed as a parallel train to the main WWTP. During storm events, the HRCS would provide chemically enhanced primary treatment and disinfection to a portion of infrequent influent peak flows in excess of the projected capacity of the main WWTP. The HRCS

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partially treated and disinfected effluent would be blended with the effluent from the main WWTP prior to final discharge to Sheep River. The blended effluent would maintain good effluent water quality without negatively impacting the receiving waters. During average flow conditions, the HRCS would act as a standby primary clarifier. Effluent from the HRCS would be directed to the BNR system for further biological treatment.

In addition, Stantec evaluated two effluent discharge options that could be considered when the assimilative capacity of the Sheep River to accept additional nutrients loadings is exceeded. These options include discharging a portion of the treated effluent flow either to Highwood River or Bow River.

Stantec prepared a timeline and estimated an Opinion of Probable Cost (OPC) to upgrade the existing WWTP to meet future treatment objectives through 2065 considering the following alternatives:

- Alternative 1A uses an upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 1B uses an upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 2A uses an upgraded MBR in BNR configuration to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 2B uses an upgraded MBR in a BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 3A is the same as Alternative 1A with an effluent pump station that can discharge effluent to both the Sheep River and Highwood River to improve dilution.
- Alternative 3B is the same as Alternative 1B with an effluent pump station that can discharge effluent to both the Sheep River and Highwood River to improve dilution.
- Alternative 4A is the same as Alternative 1A with an effluent pump station that can discharge effluent to both the Sheep River and Bow River to improve dilution.
- Alternative 4B is the same as Alternative 1B with an effluent pump station that can discharge effluent to both the Sheep River and Bow River to improve dilution.

All costs were estimated in 2015 dollars and do not include GST.

Table ES.4 presents the cash flow of the OPC for the proposed upgrades over the next 50 years. While the OPC is presented during the year in which the upgrade is assumed to be online, sufficient time should be provided well in advance to allow for planning, design, engineering, and construction.

Stantec assumes the first potential year for expenditure is 2016 though this may not be feasible from a budget perspective. Upgrades noted for completion in 2016 typically relate to an identified capacity issue. Continued operation of the WWTP without upgrades may start to have an effect on treated effluent quality. Stantec recommends immediate commencement of design effort to plan for capacity upgrades as soon as budget is available.

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Table ES.4 Cash Flow of the OPC for the Proposed Upgrades through 2065 (in \$ Million)

Year	Alt. 1A	Alt. 1B	Alt. 2A	Alt. 2B	Alt. 3A	Alt. 3B	Alt. 4A	Alt. 4B
2016	\$15.71	\$7.61	\$23.18	\$14.26	\$15.71	\$7.61	\$15.71	\$7.61
2017	\$9.63	\$9.63	\$0	\$0	\$9.63	\$9.63	\$9.63	\$9.63
2019	\$0	\$5.92	\$0	\$5.92	\$0	\$5.92	\$0	\$5.92
2021	\$1.24	\$1.54	\$1.24	\$1.54	\$1.24	\$1.54	\$1.24	\$1.54
2024	\$0.87	\$0	\$0	\$0	\$0.87	\$0	\$0.87	\$0
2035	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16
2036	\$0	\$5.06	\$0	\$2.13	\$0	\$5.06	\$0	\$5.06
2037	\$5.87	\$0	\$5.87	\$0	\$5.87	\$0	\$5.87	\$0
2041	\$15.87	\$16.68	\$22.47	\$19.56	\$35.78	\$36.59	\$54.25	\$55.06
2042	\$0.33	\$0	\$0.33	\$0	\$0.33	\$0	\$0.33	\$0
2044	\$4.88	\$0	\$3.91	\$0	\$4.88	\$0	\$4.88	\$0
2057	\$0	\$0.97	\$0	\$0	\$0	\$0.97	\$0	\$0.97
Option Total	\$55.55	\$48.57	\$58.15	\$44.57	\$75.46	\$68.48	\$93.93	\$86.95

Figure ES.2 illustrates the Operations, Maintenance, & Replacement (OMR) cost estimates for the proposed alternatives. The figure indicates that while alternative 2B (MBR with HRCS) has the lowest O&M cost, alternative 2A (MBR without HRCS) has the highest O&M cost which indicates that the implementation of the HRCS would provide significant cost savings to the operations of the WWTP. The few spikes in the OMR cost curve for alternative 2A and alternative 2B represents membranes replacement costs. OMR cost for other alternatives is between Alternatives 2A and 2B.

Table ES.5 presents the Net Present Value (NPV) of the proposed upgrades which includes the total of OPC and OMR costs for each alternative with and without HRCS using a discount rate of 4% over the next 50 years. The NPV is color coded from dark green (lowest NPV) to dark orange (highest NPV). The table suggests that alternative 2B (MBR + HRCS) has the lowest NPV amongst all alternatives. In comparison, alternative 2A with no HRCS represent the highest NPV due to the additional infrastructure required to treat peak flows.

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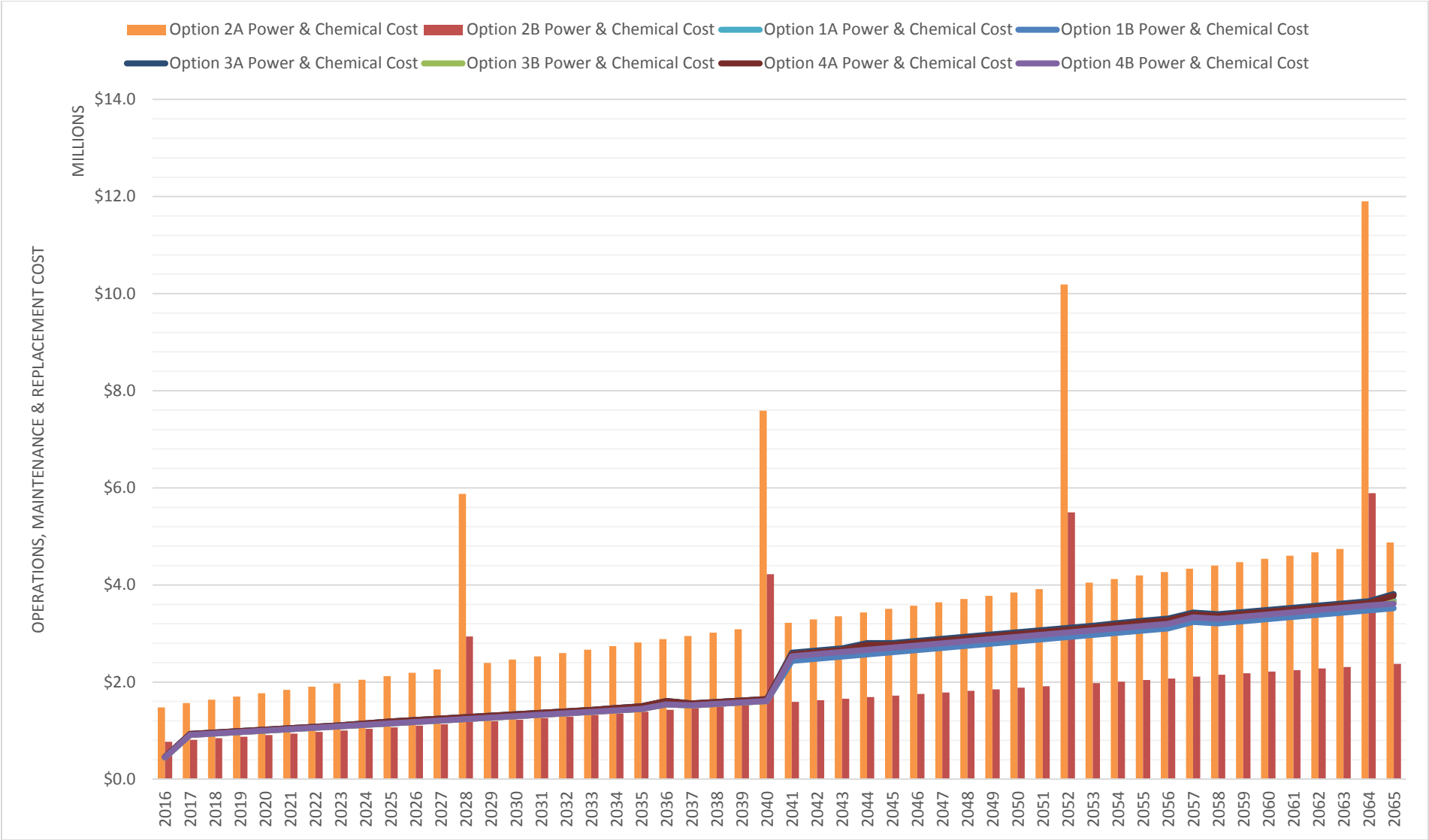


Figure ES.2 Operations, Maintenance, & Replacement Cost of the Proposed Alternatives

Table ES.5 Net Present Worth Value (NPV) for OPC and OMR (in \$ Million)

Year	Alt 1A	Alt 2A	Alt 3A	Alt 4A	Alt 1B	Alt 2B	Alt 3B	Alt 4B
2016	\$16.16	\$24.65	\$16.16	\$16.16	\$8.05	\$15.03	\$8.05	\$8.05
2017	\$10.16	\$1.51	\$10.16	\$10.16	\$10.13	\$0.78	\$10.13	\$10.13
2018	\$0.89	\$1.51	\$0.89	\$0.89	\$0.87	\$0.78	\$0.87	\$0.87
2019	\$0.88	\$1.51	\$0.88	\$0.88	\$6.12	\$6.04	\$6.12	\$6.12
2020	\$0.87	\$1.51	\$0.87	\$0.87	\$0.85	\$0.77	\$0.85	\$0.85
2021	\$1.88	\$2.53	\$1.88	\$1.88	\$2.11	\$2.04	\$2.11	\$2.11
2022	\$0.85	\$1.51	\$0.85	\$0.85	\$0.84	\$0.77	\$0.84	\$0.84
2023	\$0.84	\$1.50	\$0.84	\$0.84	\$0.83	\$0.76	\$0.83	\$0.83
2024	\$1.48	\$1.50	\$1.48	\$1.48	\$0.82	\$0.76	\$0.82	\$0.82
2025	\$0.84	\$1.49	\$0.84	\$0.84	\$0.81	\$0.75	\$0.81	\$0.81
2026	\$0.82	\$1.48	\$0.82	\$0.82	\$0.80	\$0.74	\$0.80	\$0.80
2027	\$0.81	\$1.47	\$0.81	\$0.81	\$0.79	\$0.74	\$0.79	\$0.79
2028	\$0.80	\$3.67	\$0.80	\$0.80	\$0.77	\$1.84	\$0.77	\$0.77
2029	\$0.79	\$1.44	\$0.79	\$0.79	\$0.76	\$0.72	\$0.76	\$0.76
2030	\$0.77	\$1.42	\$0.77	\$0.77	\$0.75	\$0.71	\$0.75	\$0.75
2031	\$0.76	\$1.40	\$0.76	\$0.76	\$0.74	\$0.70	\$0.74	\$0.74
2032	\$0.75	\$1.39	\$0.75	\$0.75	\$0.72	\$0.69	\$0.72	\$0.72
2033	\$0.73	\$1.37	\$0.73	\$0.73	\$0.71	\$0.68	\$0.71	\$0.71
2034	\$0.72	\$1.35	\$0.72	\$0.72	\$0.70	\$0.67	\$0.70	\$0.70
2035	\$1.26	\$1.89	\$1.26	\$1.26	\$1.24	\$1.21	\$1.24	\$1.24
2036	\$0.73	\$1.32	\$0.73	\$0.73	\$3.01	\$1.62	\$3.01	\$3.01
2037	\$3.26	\$3.87	\$3.26	\$3.26	\$0.67	\$0.64	\$0.67	\$0.67
2038	\$0.67	\$1.27	\$0.67	\$0.67	\$0.65	\$0.63	\$0.65	\$0.65
2039	\$0.66	\$1.25	\$0.66	\$0.66	\$0.64	\$0.62	\$0.64	\$0.64
2040	\$0.64	\$2.96	\$0.64	\$0.64	\$0.63	\$1.65	\$0.63	\$0.63
2041	\$6.88	\$9.64	\$14.40	\$21.31	\$7.17	\$7.94	\$14.69	\$21.60
2042	\$1.03	\$1.31	\$1.08	\$1.06	\$0.89	\$0.59	\$0.94	\$0.93
2043	\$0.89	\$1.16	\$0.93	\$0.92	\$0.88	\$0.58	\$0.92	\$0.91
2044	\$2.52	\$2.45	\$2.56	\$2.55	\$0.86	\$0.56	\$0.90	\$0.89
2045	\$0.86	\$1.12	\$0.90	\$0.89	\$0.84	\$0.55	\$0.88	\$0.87
2046	\$0.84	\$1.10	\$0.88	\$0.87	\$0.82	\$0.54	\$0.86	\$0.85
2047	\$0.82	\$1.08	\$0.86	\$0.85	\$0.80	\$0.53	\$0.84	\$0.83
2048	\$0.80	\$1.06	\$0.84	\$0.83	\$0.78	\$0.52	\$0.82	\$0.81
2049	\$0.78	\$1.04	\$0.82	\$0.81	\$0.77	\$0.51	\$0.80	\$0.79
2050	\$0.76	\$1.01	\$0.80	\$0.79	\$0.75	\$0.50	\$0.78	\$0.77
2051	\$0.74	\$0.99	\$0.78	\$0.77	\$0.73	\$0.49	\$0.76	\$0.75
2052	\$0.73	\$2.48	\$0.76	\$0.75	\$0.71	\$1.34	\$0.74	\$0.74
2053	\$0.71	\$0.95	\$0.74	\$0.73	\$0.70	\$0.46	\$0.73	\$0.72
2054	\$0.69	\$0.93	\$0.72	\$0.72	\$0.68	\$0.45	\$0.71	\$0.70
2055	\$0.68	\$0.91	\$0.71	\$0.70	\$0.66	\$0.44	\$0.69	\$0.68
2056	\$0.66	\$0.89	\$0.69	\$0.68	\$0.65	\$0.43	\$0.67	\$0.67
2057	\$0.66	\$0.87	\$0.69	\$0.68	\$0.84	\$0.42	\$0.87	\$0.86
2058	\$0.63	\$0.85	\$0.65	\$0.65	\$0.62	\$0.41	\$0.64	\$0.64
2059	\$0.61	\$0.83	\$0.64	\$0.63	\$0.60	\$0.40	\$0.63	\$0.62
2060	\$0.60	\$0.81	\$0.62	\$0.61	\$0.59	\$0.39	\$0.61	\$0.60
2061	\$0.58	\$0.79	\$0.60	\$0.60	\$0.57	\$0.38	\$0.59	\$0.59
2062	\$0.57	\$0.77	\$0.59	\$0.58	\$0.56	\$0.38	\$0.58	\$0.57
2063	\$0.55	\$0.75	\$0.57	\$0.57	\$0.54	\$0.37	\$0.56	\$0.56
2064	\$0.54	\$1.81	\$0.56	\$0.55	\$0.53	\$0.90	\$0.55	\$0.54
2065	\$0.54	\$0.71	\$0.56	\$0.55	\$0.52	\$0.35	\$0.53	\$0.53
NPV	\$74.70	\$103.07	\$82.96	\$89.68	\$69.06	\$62.75	\$77.33	\$84.05

TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – REGIONAL WASTEWATER PIPELINE FEASIBILITY STUDY

Executive Summary
April 13, 2016

1.5 TM #5 EVALUATION CRITERIA AND WEIGHTING

In this Technical Memorandum, Stantec conducted a pairwise comparison of multiple WWTP upgrade alternatives as presented in TM #3 and TM #4. Pairwise comparison is the method of ranking multiple proposed alternatives by assigning scores to each alternative based on the list of criteria generated by the Stantec understanding of the Town's objectives and priorities. Each described criterion is weighted through criteria pairwise weighting analysis. Based on the criteria weight and assigned score, each presented alternative acquires a normalized score which is used to rank the proposed alternatives. Table ES.6 summarizes the list of criteria developed for this analysis. Table ES.7 ranks the WWTP upgrade alternatives evaluated in TM#3 and TM#4.

Table ES.6 Evaluation Criteria

Item	Criteria	Description
1	Implementation	Date service could be available to meet Okotoks' needs
2	Cost Certainty	Confidence of cost estimate
3	NPV	The Net Present Worth of the total capital cost over the evaluation period
4	Short Term Capital Cost	Capital cost in the first five years
5	Medium Term Capital Cost	Capital cost between year 5 and 25
6	O&M Cost	Total value of operations and maintenance cost for selected option
7	Staging Flexibility	Ability to stage expenditure
8	Resiliency	Effect on operation following an extreme flow event
9	Permitting Requirements	Number of approvals and difficulty in obtaining them
10	Effluent Quality	Meet effluent discharge criteria and minimum impact on downstream receiving water quality

TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – REGIONAL WASTEWATER PIPELINE FEASIBILITY STUDY

Executive Summary
April 13, 2016

Table ES.7 Servicing Options

Rank	Upgrade alternative	Description	Normalized Score
1	Alternative 2B	Upgraded MBR in BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	73.6%
2	Alternative 1B	Upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	51.4%
3	Alternative 1A	Upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	38.9%
4	Alternative 3B	Same as Alternative 1B, but discharging to both the Sheep River and Highwood River.	37.5%
5	Alternative 2A	Upgrade membrane bioreactor (MBR) in a BNR configuration and discharge to Sheep River.	36.1%
6	Alternative 4B	Same as Alternative 1B, but discharging to both the Sheep River and Bow River.	31.9%
7	Alternative 3A	Same as Alternative 1A, but discharging to both the Sheep River and Highwood River.	20.8%
8	Alternative 4A	Same as Alternative 1A, but discharging to both the Sheep River and Bow River.	15.3%
N/A	Alternative 5	Shutdown Okotoks' WWTP and discharge to Pine Creek WWTP.	N/A
N/A	Alternative 6	Run the Okotoks' WWTP to its maximum capacity and discharge the additional flow to Pine Creek WWTP.	N/A

The ranks of the upgrade alternatives summarized in Table ES.5 indicate that all treatment alternatives with HRCS have higher normalized scores compared to the ones without HRCS. This suggests that the implementation of HRCS would be highly beneficial to the Town.

The implementation of MBR technology with a WWMF, and continued discharge to the Sheep River has achieved the highest normalized score of 73.67%, followed by a conventional upgrade with a WWMF, and continued discharge to the Sheep River.

However, the main challenge to proceed with HRCS is permitting requirements. Even though several facilities in the Edmonton area operate as HRCSSs, the Province of Alberta does not have specific regulations related to HRCSSs and their implementation. This means that each facility must be examined in detail through discussions with Alberta Environment and Parks (AEP). During consultative meetings with the City of Calgary, AEP has indicated a reluctance to give preliminary approval for HRCS treatment in southern Alberta without reviewing a complete, formal application package. No formal application for approval for HRCS has been attempted in southern Alberta. Because of uncertainty surrounding approvals for HRCS, Stantec assigned a "Poor" rating on permitting to all upgrade alternatives with HRCS.

TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – REGIONAL WASTEWATER PIPELINE FEASIBILITY STUDY

Executive Summary
April 13, 2016

In addition, the top three upgrade alternatives maintain effluent discharge to the Sheep River. Alternatives with partial discharge of treated effluent to either Highwood River or Bow River showed lower normalized scores with Alternative 4A as the lowest. This is mainly due to the extra capital and O&M costs associated with new pump stations and forcemains.

Alternatives 5 and 6 with full or partial discharges of sewage to the City of Calgary's Pine Creek WWTP were disqualified, as they could not be implemented in time to meet the Town of Okotoks' growth needs. This was confirmed by the City of Calgary during a meeting held on August 26, 2015 that the transfer of sewage from Okotoks to the Pine Creek WWTP is not possible until either the Pine Creek WWTP or Fish Creek WWTPs is expanded for more capacity. Both of the Pine Creek and Fish Creek WWTPs are operating above their firm capacity and currently cannot accept any unplanned-for sewage flows, such as from Okotoks.

The City of Calgary is currently studying options to upgrade the capacity of the Fish Creek WWTP and/or the Pine Creek WWTP. The capacity upgrade of either WWTP is not planned to be in service before 2025 which does not meet the Town's objectives. For this reason, upgrade alternatives 5 and 6 did not pass the implementation pass/fail test and are eliminated from further consideration.

Moreover, the Town would have to pay City of Calgary their share of the capital costs for upgrades at the Fish Creek WWTP and/or the Pine Creek WWTP either as a lump sum upfront payment or via installments included in the service rate charges. The Town will also be responsible for the cost of the construction, operation, and maintenance of the pump station and the sewer pipeline. Construction of a lift station and forcemain, and paying for upgrades to the City of Calgary's WWTPs is the highest cost option for treatment.

An upgrade of the Town's existing WWTP is likely able to be phased and constructed to meet growth requirements, unlike options that rely on a forcemain connection to the City of Calgary.

1.6 RECOMMENDATIONS

Based on OPC/NPV analysis and Pairwise comparisons, Stantec recommends the following:

- The Town should consider alternative 2B in their future upgrades planning;
- The Town should immediately initiate a follow-up study to analyze the frequency, severity, and duration of historical wet weather flow which would assist in sizing the proposed HRCS;
- The Town should immediately pursue the AEP approval of the proposed HRCS. Discussions with AEP indicated that the review period for any EPEA permit application could take up to one year which will push the completion date of any proposed upgrade; and

If HRCS is not approved, the Town should consider alternative 1A instead.

APPENDIX A – TM 1

TECHNICAL MEMORANDUM #1
Town of Okotoks Wastewater
Treatment Plant
Design Basis Memorandum



Prepared for:
The Town of Okotoks

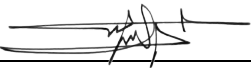
Prepared by:
Stantec Consulting Ltd.

November 16, 2015

Revision Record							
Revision	Description	Prepared By		Checked By		Approved By	
A	Issued for Review	Hatim Fadlalla	2015-06-18	Saibal Basu	2015-06-19	Chris Mountenay	2015-06-19
B	Issued for Approval	Hatim Fadlalla	2015-07-27	Saibal Basu	2015-08-13	Chris Mountenay	2015-08-14
C	Final	Hatim Fadlalla	2015-11-10			Chris Mountenay	2015-11-16

Sign-off Sheet

This document entitled TECHNICAL MEMORANDUM #1 Town of Okotoks Wastewater Treatment Plant Design Basis Memorandum was prepared by Stantec Consulting Ltd. ("Stantec") for the account of Town of Okotoks (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between 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, 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 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  _____
(signature)

Hatim Fadlalla, PhD, P.Eng., PE

Reviewed by  _____
(signature)

Chris Mountenay, P.Eng.

TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM

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TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
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**TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM**

EXECUTIVE SUMMARY

The Town of Okotoks (The Town) has been growing rapidly towards the 30,000 person population limit imposed by its limited raw water supply licenses. The Town is currently seeking a more reliable supplemental long-term water source from the City of Calgary. With additional raw water sources, new stresses will be imposed on the Town wastewater treatment plant (WWTP) due to potential development and population growth.

Stantec Consulting Ltd. (Stantec) has been tasked by the Town to conduct a feasibility study that will assess the capacity and potential upgrade requirements of its existing WWTP and compare the feasibility of upgrading its WWTP to other options including a regional wastewater pipeline to the City of Calgary Pine Creek (Pine Creek) WWTP.

This Design Basis Memorandum (DBM) develops the design basis to evaluate the capacity of the existing WWTP and to determine future upgrade requirements to service future population load during the next 50-year planning period (2015 – 2065) using a multi-step approach.

The DBM presents the population and influent wastewater flow and load projections based on previous studies/reports and historical data provided by the Town. Population projections for the Town from 2014 to 2043 have been reproduced from the "Okotoks – Calgary Regional Potable Water Pipeline, Pre-design Study", Draft Report, The Town of Okotoks February 13, 2015. Population growth beyond 2043 through 2065 has been estimated using a linear population growth rate of 1,271.5 persons per year.

A per capita wastewater generation rates were estimated from historical population and wastewater data and used to project future wastewater flows and loads as summarized in Table ES.1 at 25- and 50-year design horizon.

**TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM**

Table ES.1 Summary of Design Basis

Process	Design Basis	Unit	Current	2039	2065
Population	1,271.5 capita/year	Capita	27,331	59,119	92,172
Screens	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Grit Tanks	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
EQ Tanks	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Primary Clarifier	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Aeration Tank	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
		kg TAN/d	176	381	594
		kg TP/d	54	117	182
Secondary Clarifier	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Tertiary Filtration	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
UV	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Aeration Blowers	Maximum Day Load	kg BOD ₅ /d	5,512	11,923	18,589
Pumps	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Piping	Peak Hour Flow	m ³ /h	1,080	2,336	3,642

In addition, the DBM analyzed WWTP historical effluent quality data for the operating period from January 2010 through December 2014. Maximum month effluent discharge concentrations during the evaluation period were consistently below applicable discharge limits as summarized in Table ES.2.

The WWTP has shown good performance and minor TP contributions to the Bow River as noted in Stantec's 2009 Downstream Users Study for the Municipality of Okotoks. This suggests that Okotoks WWTP effluent loadings are of minimal concern and should not require adjustment from current discharge approval limits.

**TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM**

Table ES.2 Effluent Flow and Quality

Parameter	Discharge Limit	Maximum Month	% above Limit	Notes
BOD₅ (mg/L)	20	6.4	0%	--
TSS (mg/L)	20	3.4	0%	Before 2012-01-01
	15	4.8	0%	After 2012-01-01
TP (mg/L)	1.0	0.7	0%	Before 2012-01-01
	0.5	0.2	0%	After 2012-01-01
NH₃-N (mg/L)	10	1.7	0%	Oct 1 to Jun 30
	5	1.3	0%	Jul 1 to Sep 30
TN (mg/L)	--	10.1	0%	Before 2012-01-01
	15	12.6	0%	After 2012-01-01
Total Coliform (#/100 mL)	1,000	552	0%	Geometric Mean
Fecal Coliform (#/100 mL)	200	125	0%	Geometric Mean

A review of the capacity of Pine Creek WWTP and conveyance capacity in the south catchment area in the City of Calgary is provided as well in this DBM. Pine Creek is almost nearing its design capacity. Therefore, the Town would not be able to tie in to the Pine Creek tributary catchment before an upgrade to the Pine Creek WWTP is completed. An upgrade to the Pine Creek WWTP, if initiated, would not be complete prior to 2025.

From a conveyance perspective, the Town could tie in to the West Pine Creek Sanitary Trunk near the intersection of Macleod Trail and 210th Avenue which connects directly to the Pine Creek WWTP. This sewer was recently constructed for a large future catchment area that does not include flow contributions from the Town of Okotoks and as such, the City may request additional compensation for a future upgrade to this trunk as a condition for allowing a tie-in to its system.

**TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM**

Background
November 16, 2015

1.0 BACKGROUND

The Town of Okotoks (The Town) is one of the fastest growing communities in Canada. Its populations as of June 2014 Municipal Census was 27,331 soaring from 19,996 in 2008. The Town had a 30,000 – population cap, which was enacted in 1998 as part of a sustainability plan to meet its water supply licensed limits from Sheep River aquifer. In 2012, the Town decided to eliminate its population cap and investigate alternatives for additional water supply sources and wastewater treatment upgrade options to meet its anticipated growing population demands. The Town is currently arranging to build a pipeline and tie in with the City of Calgary's water system. In addition, the Town has retained the services of Stantec Consulting Ltd. (Stantec) to assess the capacity and potential upgrade requirements of its current WWTP and to compare the feasibility of upgrading its WWTP to other options including a regional wastewater pipeline. Findings during this feasibility analyses will be provided in the following Technical Memorandums (TMs):

1. TM#1 Design Basis Definition (This TM)
2. TM# 2 Capacity Assessment (In progress)
3. TM# 3 Sanitary Forcemain Options (In progress)
4. TM# 4 WWTP Upgrade Options (In progress)
5. TM# 5 Evaluation Criteria and Weighting (In progress)
6. Final Feasibility Report (In progress)

**TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM**

Work Scope
November 16, 2015

2.0 WORK SCOPE

This Design Basis Memorandum (DBM) develops the design basis to evaluate the capacity of the existing WWTP and to determine future upgrade requirements to service future population load during the next 50-year planning period (2015 – 2065) using a multi-step approach.

First, Stantec extrapolated the population growth to the end of the 50-year design horizon based on “Okotoks – Calgary Regional Potable Water Pipeline, Pre-design Study”, Draft Report, The Town of Okotoks February 13, 2015.

Second, Stantec conducted an assessment of the historical influent flows and loads from January 2010 through December 2014. Stantec used the historical flows and loads data to establish a per capita wastewater generation rate that can be carried forward to predict future wastewater flows and loads. Historical loads were used to characterize influent wastewater and to determine daily and/or seasonal variations in flows and loads.

Future flows were then established based on population projections assuming steady per capita wastewater generation rates.

The last part of this DBM reviews current effluent discharge criteria and receiving water quality to predict future trends in effluent discharge criteria.

TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM

Population Projection
November 16, 2015

3.0 POPULATION PROJECTION

Population projections for the Town of Okotoks from 2014 to 2043 have been reproduced from the "Okotoks – Calgary Regional Potable Water Pipeline, Pre-design Study", Draft Report, The Town of Okotoks February 13, 2015. The draft report is based on two independent studies; "The Conceptual Water Servicing Review", BSEI July 28, 2013 and "The Town of Okotoks Growth Study and Financial Assessment", O2 Planning and Design February 2014. The draft report compared the two studies and assumed the more conservative growth projection of a linear population growth rate of 1,271.5 persons per year.

Based on the same linear population growth, Stantec extrapolated the population growth beyond 2043 through 2065, which represents the end of the 50-year feasibility study horizon as illustrated in Table 3.1.

Table 3.1 Town of Okotoks Population Projections (2014 – 2065)

Year	Population	Year	Population	Year	Population
2014	27,331	2032	50,218	2050	73,105
2015	28,603	2033	51,490	2051	74,377
2016	29,874	2034	52,761	2052	75,648
2017	31,146	2035	54,033	2053	76,920
2018	32,417	2036	55,304	2054	78,191
2019	33,689	2037	56,576	2055	79,463
2020	34,960	2038	57,847	2056	80,734
2021	36,232	2039	59,119	2057	82,006
2022	37,503	2040	60,390	2058	83,277
2023	38,775	2041	61,662	2059	84,549
2024	40,046	2042	62,933	2060	85,820
2025	41,318	2043	64,205	2061	87,092
2026	42,589	2044	65,476	2062	88,363
2027	43,861	2045	66,748	2063	89,635
2028	45,132	2046	68,019	2064	90,906
2029	46,404	2047	69,291	2065	92,178
2030	47,675	2048	70,562		
2031	48,947	2049	71,834		

**TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM**

Historical Wastewater Flows and Loads
November 16, 2015

4.0 HISTORICAL WASTEWATER FLOWS AND LOADS

Influent flows to the plant vary on an hourly, daily, and seasonal basis due to diurnal generation rates as well as seasonal variations in inflow and infiltration. This result in a number of important flow conditions to consider in this feasibility study including:

- Average Annual Daily Flow (AADF) – The average daily flow rate occurring over a 365 day period, which is used to develop flow rate ratios, establish long-term trends, and estimate pumping and chemical cost. However, AADF is typically not a limiting capacity criteria;
- Average Day Flow (ADF) – The time-weighted average of flow rate occurring over a 24-hour period;
- Maximum Day Flow (MDF) – The maximum flow rate occurring over a 24-hour period, which is used in sizing equalization basins and sludge pumping systems;
- Maximum Day Load (MDL) – The maximum load occurring over a 24-hour period, which is used in sizing aeration systems;
- Peak Hour Flow (PHF) – The peak flow sustained for a period of one hour during a 24-hour period, which is used for hydraulic sizing of pumping facilities, conduits, physical unit operations (grit systems, sedimentation tanks, and filters), and disinfection; and
- Maximum Month Load (MML) – The maximum daily loads sustained for one month, which is used to establish the sustained-load capacity requirements for the facility since effluent discharge limits are permitted based on a monthly arithmetic or geometric mean. The MML is also used for record keeping and reporting.

4.1 INFLUENT WASTEWATER FLOWS AND LOADS

Historical WWTP flows and loads, based on Monthly Wastewater Reports (MWRs) submitted to Alberta Environment and Parks (AEP) over a five year period from January 2010 through December 2014, are shown in Figure A.1 through Figure A.5.

No gaps were identified in ADF, BOD₅, and TSS data set. Total Ammonia Nitrogen (TAN) were measured 5 days a week year round. PHF measurements were provided for the periods from January 1, 2010 through June 17, 2010, from August 20, 2010 through March 16, 2011, and November 6, 2013 through November 7, 2014 only. A request was made to the plant operator, EPCOR Water Services Inc. (EPCOR), to provide the missing set of peak hourly flow data. No response was received so far. Nevertheless, EPCOR indicated that peak hour flow readings during June 2014 represent the highest measurement over the evaluation period.

Figure A.1 shows that AADFs have been steadily increasing from 5,405 m³/d in 2010 to 6,940 m³/d in 2014 with few peaks as high as 21,552 m³/d. Those peaks, which represent less than 1% of the reported daily flow values, occurred during May/June 2011, June 2013 (Alberta Flood), and June 2014.

Figure A.2 and Figure A.3 show the seasonal variations in influent BOD₅ and TSS concentrations and mass loadings to the WWTP based on daily flow conditions. Figure A.4 and Figure A.5 show



TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM

Historical Wastewater Flows and Loads
November 16, 2015

the seasonal variations in influent Total Ammonia Nitrogen (TAN) and Total Phosphorus (TP) concentrations and mass loadings to the WWTP, respectively.

Table 4.1 summarizes the average annual day, maximum month, maximum day, and peak hour measurements from January 2010 through December 2014. The flows and loads measurements in Table 4.1 are mutually exclusive (i.e. the flow and loads do not necessarily occur at the same time) and calculated from their respective dataset.

For the purpose of this feasibility study, maximum month sustained loads were selected as the design basis of the secondary treatment system to meet effluent discharge limits that are permitted based on a monthly arithmetic or geometric mean. Maximum day flow condition was selected as the design basis for sizing equalization basins, aeration blowers, and sludge pumping systems. Peak hourly flow was selected as the design basis for hydraulic sizing of pumping facilities, conduits, physical unit operations (grit systems, sedimentation tanks, and filters), and disinfection.

Table 4.1 Influent Flows and Loads – Jan 2010 through Dec 2014

Parameter	Flow	BOD ₅		TSS		TAN		TP	
	m ³ /d	mg/L	kg/d	mg/L	kg/d	mg/L	kg/d	mg/L	kg/d
Average Annual Day	6,145	329	2,005	291	1,786	31	133	7	39
Maximum Month	9,315	437	2,860	670	3,773	38	176	10	54
Maximum Day	21,552	797	5,512	3,228	24,287	51	312	25	158
Peak Hourly Flow	1,080 m ³ /h	--	--	--	--	--	--	--	--

It should be noted that maximum day BOD₅ and TSS loadings measured on June 24, 2013 and June 20, 2013, respectively, are most probably reflecting the “first flush” phenomenon during 2013 Alberta floods. Nevertheless, they were included in the statistical analysis of the reported data set since they account for less than 1% of the analyzed historical data set. Figure A.6 shows the frequency distribution of flow, BOD₅, and TSS loadings during the evaluation period.

TECHNICAL MEMORANDUM #1
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT
DESIGN BASIS MEMORANDUM

Future Wastewater Flows and Loads
November 16, 2015

5.0 FUTURE WASTEWATER FLOWS AND LOADS

5.1 PROJECTED WASTEWATER GENERATION RATES

To predict the per capita contribution to the total flows and loads, Stantec correlated the 2014 population data with flows and loadings during the evaluation period as summarized in Table 5.1.

Table 5.1 Wastewater Flows and Loads Generation Rates

Parameter	Unit	Value
Population	Capita	27,331
AADF	m ³ /d	6,145
	L/capita/d	224.84
MDF	m ³ /d	21,552
	L/capita/d	788.56
PHF	m ³ /h	1,080
	L/capita/h	39.52
MDL BOD ₅	kg/d	5,512
	g/capita/d	202
MML BOD ₅	kg/d	2,860
	g/capita/d	105
MML TSS	kg/d	3,773
	g/capita/d	138
MML TAN	kg/d	176
	g/capita/d	6
MML TP	kg/d	54
	g/capita/d	2

The resulting generation rates were carried forward in the planning process.

The "Okotoks – Calgary Regional Potable Water Pipeline, Pre-design Study", Draft Report estimated average and maximum water consumption rates of 266 L/capita/d and 450 L/capita/d during the period from 2010 through 2014. The 3-day moving average of water consumption during the same period is illustrated in Figure A.7.

Table 5.2 compares wastewater generation rates to water consumption rates during the period from 2010 through 2014. This information can assist in determining if there is a significant contribution of extraneous inflows or exfiltration in the wastewater collection system. From the data presented in Table 5.2, it is observed that WW:W ratio ranges from 0.83 to 1.01.

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Future Wastewater Flows and Loads
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Table 5.2 Annual Average Wastewater generation to Water Consumption

Year	Water Consumption*	Wastewater Generation	WW Generation/W Consumption
2010	274 Lpcd	233 Lpcd	0.85
2011	262 Lpcd	244 Lpcd	0.93
2012	288 Lpcd	239 Lpcd	0.83
2013	247 Lpcd	249 Lpcd	1.01
2014	260 Lpcd	254 Lpcd	0.98

*Source: "Okotoks – Calgary Regional Potable Water Pipeline – Pre-design Study – Draft" dated February, 2015

Table 5.3 shows the design basis of the 25-year and 50-year planning horizon based on projected population in Table 3.1 and estimated per capita generation rates in Table 5.1.

Table 5.3 Design Basis for the 25-year and 50-year planning horizon

Parameter	Unit	Year 2039	Year 2065
Population	Capita	59,119	92,172
AADF	m ³ /d	13,292	20,724
MDF	m ³ /d	46,619	72,683
PHF	m ³ /h	2,336	3,642
MDL BOD ₅	kg/d	11,923	18,589
MML BOD ₅	kg/d	6,186	9,645
MML TSS	kg/d	8,161	12,724
MML TAN	kg/d	381	594
MML TP	kg/d	117	182

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6.0 DISCHARGE LIMITS

6.1 RECEIVING WATER QUALITY BACKGROUND

The Sheep River originates in the mountain valleys of Elbow-Sheep Wildland Provincial Park. It passes through the Sheep River Provincial Park and provides drinking water for the towns of Turner Valley, Black Diamond, and Okotoks, before the confluence with the Highwood River about 8 km east of Okotoks. The Sheep River is the most significant of the Highwood River's tributaries and has a watershed area of approximately 1,500 km².

Historical water quality data for the Sheep River have demonstrated that with the exception of maximum total phosphorus concentrations, background water quality meets Alberta Surface Water Quality Guidelines (ASWQGs) and Canadian Water Quality Guidelines (CWQGs). Background water quality upstream of the WWTP outfall was evaluated from *in situ* measurements and sampling performed by Stantec staff in 2008 and 2009. The water quality monitoring program consisted of 24 days of water quality data collection and sampling over 12 months (March 10, 2008 to February 27, 2009). Average annual measured TP concentrations of 0.094 mg/L are above the ASWQG of 0.05 mg/L. However, this elevated average concentration was skewed by spring runoff concentrations, which attained levels as great as 2.31 mg/L. When the lower flow summer period was considered, mean measured TP concentrations fell to 0.006 mg/L, well below the ASWQG. Observed upstream water quality data demonstrated that spring runoff flows considerably alter the water quality of the Sheep River.

6.2 EPEA APPROVAL

Table 6.1 lists the current effluent discharge quality limits for the Okotoks WWTP as mandated by EPEA approval 1028-02-02 (effective January 01, 2012 through May 01, 2016).

Table 6.1 EPEA Approval Effluent Limits

Parameter	Unit	Discharge Limit	Calculation Notes
cBOD	mg/L	≤ 20	Monthly arithmetic mean of daily composite samples
TSS	mg/L	≤ 15	Monthly arithmetic mean of daily composite samples
TP	mg/L	≤ 0.5	Monthly arithmetic mean of daily composite samples
NH₃-N	mg/L	≤ 10	Monthly arithmetic mean of daily composite samples (October 1 to June 30)
NH₃-N	mg/L	≤ 5.0	Monthly arithmetic mean of daily composite samples (July 1 to September 30)
TN	mg/L	≤ 15	Calculated as monthly arithmetic mean of calculated weekly concentration
Total Coliform	#/100 mL	≤ 1,000	Monthly geometric mean of weekly samples
Fecal Coliform	#/100 mL	≤ 200	Monthly geometric mean of weekly samples



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6.3 EFFLUENT FLOW AND QUALITY

Table 6.2 summarizes the historical effluent quality data for Okotoks WWTP for the operating period from January 2010 through December 2014. The table shows the maximum month effluent concentration, maximum day effluent concentration, and the percentile of maximum month measurements above the discharge limit. Due to the amendment of EPEA Approval effective January 01, 2012, the parameters targeted with more stringent discharge limits were analyzed within two distinct periods; before 2012-01-01 and after 2012-01-01. Table 6.2 shows that the maximum month effluent discharge quality during the evaluation period was consistently below applicable discharge limit.

Figure A.8 through Figure A.12 depict the effluent discharge quality of BOD₅, TSS, TAN, TP, TC, and FC during the evaluation period from January 01, 2010 through December 31, 2014.

Table 6.2 Effluent Flow and Quality

Parameter	Discharge Limit	Maximum Month	Maximum Day	% above Limit	Notes
BOD ₅ (mg/L)	20	6.4	16.2	0%	--
TSS (mg/L)	20	3.4	9.0	0%	Before 2012-01-01
	15	4.8	31.4	0%	After 2012-01-01
TP (mg/L)	1.0	0.7	3.5	0%	Before 2012-01-01
	0.5	0.2	0.4	0%	After 2012-01-01
NH ₃ -N (mg/L)	10	1.7	8.6	0%	Oct 1 to Jun 30
	5	1.3	8.5	0%	Jul 1 to Sep 30
TN (mg/L)	--	10.1	17.5	0%	Before 2012-01-01
	15	12.6	16.8	0%	After 2012-01-01
Total Coliform (#/100 mL)	1,000	552	6,000	0%	Geometric Mean
Fecal Coliform (#/100 mL)	200	125	8,000	0%	Geometric Mean

6.4 EFFLUENT LIMITS AT MAJOR WWTPS ON THE BOW RIVER

The current treated effluent concentration limits for The City of Calgary's three treatment facilities established by Alberta Environment and Parks (AEP) in Approval No 17531-01-00 granted to The City of Calgary under the authority of the Environmental Assessment and Enhancement Act are provided in Table 6.3.

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Table 6.3 Summary of Current Treated Effluent Concentration Limits for Calgary WWTPs

Parameter	Bonnybrook WWTP	Fish Creek WWTP	Pine Creek WWTP	Calculation Notes
cBOD5 (mg/L)	≤ 15	≤ 20	≤ 15	Monthly arithmetic mean of daily composite samples
TSS (mg/L)	≤ 20	≤ 25	≤ 15	Monthly arithmetic mean of daily composite samples
TP (mg/L)	≤ 1.0	≤ 1.0	≤ 0.5	Monthly arithmetic mean of daily composite samples
NH₃-N (mg/L) (Oct 1 to Jun 30)	≤ 10	--	≤ 10	Monthly arithmetic mean of daily composite samples
NH₃-N (mg/L) (Jul 1 to Sep 30)	≤ 5.0	--	≤ 5.0	Monthly arithmetic mean of daily composite samples
TN (mg/L)	--	--	≤ 15	Calculated as monthly arithmetic mean of calculated weekly concentration
Fecal Coliform (#/100 mL)	≤ 200	≤ 200	≤ 200	Monthly geometric mean of daily grab samples

The Receiving Water Assessment (RWA) for the City of Calgary completed by Stantec in 2015 demonstrated that DO concentrations in the Bow River upstream of the confluence with the Highwood River are not expected to be sensitive to WWTP effluent cBOD₅, ammonia-N, and TSS loadings.

The majority of TSS loadings to the Bow River originates from non-point sources. Therefore, WWTP TSS loadings to the Bow River do not have a meaningful impact on Bow River TSS concentrations.

The City of Calgary is required to maintain total phosphorus loadings from its WWTPs below a 240 kg/day Total Loading Management Objective. The RWA for the City of Calgary demonstrated that the existing concentration limits for the Bonnybrook, Fish Creek, and Pine Creek WWTPs are sufficient to prevent DO impacts in the Bow River above the Highwood River. However, in order to maintain the Total Loading Management Objective, filtration of 40% of WWTP effluent flows from the Bonnybrook WWTP (including all flows from the Plant D expansion) will be required for 2025 and 2037 design horizons. Treated effluent quality for this portion of Bonnybrook WWTP flows will therefore be consistent with effluent requirements at the Pine Creek WWTP. This implies attaining average effluent TP concentrations of 0.2 mg/L although changes to effluent limits at the Bonnybrook WWTP have not been recommended at this time.

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6.5 SOUTH SASKATCHEWAN REGIONAL PLAN

The South Saskatchewan Regional Plan (SSRP) came into effect on September 1, 2014. It identifies surface water quality triggers and limits for the Bow River. Table 2 presents a comparison of Bow River water quality at Carseland to SSRP triggers.

Table 6.4 Comparison of Water Quality and SSRP Triggers at Carseland (2009-2012)

Indicator	Measured Surface Water Quality				Surface Water Quality Triggers				Surface Water Quality Limit
	Open Water (April to Oct.)		Winter (Nov. to March)		Open Water (April to Oct.)		Winter (Nov. to March)		
	Media n	90%- ile	Media n	90%- ile	Media n	90%- ile	Media n	90%- ile	
Total Ammonia (NH ₃ +4-N) mg/L	0.050	0.100	0.135	0.260	0.045	0.160	0.250	0.472	varies with pH and temp
Chloride (Cl-) mg/L	8.0	22.0	18.0	29.9	7.6	13.1	12.7	20.4	100
Nitrate (NO ₃ -N) mg/L	0.670	0.960	1.100	1.430	0.601	0.990	1.130	1.403	3
Total Nitrogen (TN) mg/L	1.05	1.60	1.40	1.79	1.02	1.72	1.68	2.17	-
TDP mg/L	0.005	0.020	0.011	0.016	0.007	0.016	0.017	0.028	-
Total Phosphorus (TP) mg/L	0.018	0.070	0.020	0.034	0.021	0.083	0.030	0.062	-
Sulphate (SO ₄ ⁻) mg/L	45.0	52.0	56.5	62.6	42.9	51.5	53.9	58.0	1000
Sodium Adsorption Ratio (SAR)	-	-	-	-	0.30	0.45	0.39	0.58	5
Specific Conductivity µS/cm	349	427	434	484	346	398	422	443	1000
Total Dissolved Solids mg/L	210	240	260	280	201	232	246	260	500
Total Organic Carbon mg/L	2.5	4.2	1.3	3.4	2.0	3.6	1.5	1.9	-
Total Suspended Solids mg/L	10	57	4	14	6	64	5	14	-
Turbidity NTU	7.0	43.0	2.7	11.0	4.0	48.4	2.6	9.3	-
pH	8.12	8.38	7.80	7.99	8.20	8.39	8.06	8.20	6.5-9.0
Escherichia coli cfu/100 mL	48	220	13	30	28	144	10	25	100

- indicates that value is not applicable

Bolded values indicate that measured surface water quality values are above SSRP triggers at Carseland

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Water quality at Carseland for parameters targeted by WWTPs (i.e., ammonia-N, TSS, and TP) generally meets SSRP triggers and is well below SSRP limits. However, high variability in open water TP concentrations and the fact that TP concentrations at Carseland are approaching trigger values suggest that future monitoring periods may demonstrate TP concentrations above triggers.

6.6 POTENTIAL OKOTOKS WWTP EFFLUENT REQUIREMENTS

Stantec's 2009 Downstream Users Study (DUS) for the Municipality of Okotoks demonstrated that the Municipality of Okotoks WWTP is expected to have a minimal, localized effect on Sheep River water quality. Plume characteristics predicted for the Town of Okotoks WWTP effluent discharge under average effluent quality and flow, as well as August 7Q10 river conditions generally complied with AENV mixing zone restrictions. However, predicted TP concentrations slightly exceeded the ASWQG of 0.05 mg/L at a downstream distance equivalent to 10 times the river width, or at 160 m downstream.

Increasing pressure to limit TP loadings to the Central Bow River suggests that AENV may require WWTP performance to match that of the City of Calgary's Pine Creek WWTP. Recent Okotoks WWTP effluent quality data show average TP levels below 0.2 mg/L, which implies very good WWTP performance and only minor TP loadings contributions to the Bow River. If required, lower TP limits should therefore be attainable given the Okotoks WWTP performance.

All other Okotoks WWTP effluent loadings are of minimal concern and should not require adjustment from current discharge approval limits.

The 2009 DUS calculated annual, July, and August 7Q10 flow rates to the Sheep River from Okotoks as 0.618 m³/s, 3.078 m³/s, and 2.548 m³/s, respectively. The calculated flows are not expected to limit average daily flows during the summer. However, winter flows could be an issue, especially with ammonia-N, as peak daily flows may be a large percentage of the Sheep River low flow rates. To minimize limitations on winter flows, the plant should ensure that the whole effluent is non-acutely toxic to the aquatic life in the Sheep River.

Effluent temperature should not be an issue since the annual low flow occurs during cold weather.

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City of Calgary Infrastructure
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7.0 CITY OF CALGARY INFRASTRUCTURE

The City of Calgary has three operating wastewater treatment facilities, Bonnybrook, Fish Creek, and the Pine Creek Wastewater Treatment Plant (Pine Creek). Combined, these three facilities service the City and a number of nearby municipalities, notably Airdrie, Cochrane, Chestermere, and the Tsuu T'ina Nation. Due to its proximity to the Town and future potential for expandability, Pine Creek would be the logical choice to service the Town should the Town and the City enter into an agreement for wastewater treatment by the City.

Pine Creek has a nominal design capacity of 250,000 Equivalent Population (EP) and treats flows from an upstream tributary gravity catchment as well as any flow that is transferred from the Fish Creek WWTP. Although Pine Creek was completed in 2008, it is our understanding that its capacity is almost 100% fully allocated as a result of growth within Calgary and the surrounding area.

Completion of a major WWTP expansion from the beginning of the conceptual design phase to the completion of construction is typically a 7 to 8 year process from beginning to end. Reviewing the City's 2015-2018 budget action plan, there is currently no mention of budget planned within the 2015-2018 budget cycle for the design of an expansion to Pine Creek. Based on this, it would seem unlikely that an expansion of the Pine Creek WWTP would be completed until at least 2025. Looking at the current approximate tributary population of these two facilities (based on census information) as well as recent growth trends, it would seem unlikely for the City to accept the addition of new regional customers within the Pine Creek tributary catchment before an upgrade to the Pine Creek WWTP is completed. If the Town would like to pursue a connection to the City's wastewater system, the timeline for a connection should be further discussed and confirmed with the City.

From a conveyance perspective, a logical tie in point to the City of Calgary's sanitary collection system would be to the West Pine Creek Sanitary Trunk near the intersection of Macleod Trail and 210th Avenue which connects directly to the Pine Creek WWTP. This sewer was recently constructed for a large future catchment area with a buildout timeframe of >25 years (likely well beyond this) and as such, should have sufficient capacity to convey flows to the Town of Okotoks for years to come. It is noted that the ultimate catchment for the design of this trunk sewer does not include flow contributions from the Town of Okotoks and as such, the City may request additional compensation for a future upgrade to this trunk as a condition for allowing a tie-in to its system.

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Summary of Design Conditions
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8.0 SUMMARY OF DESIGN CONDITIONS

Table 8.1 summarizes the design basis flows and loads used for sizing various unit operations at 0-, 25-, and 50-year design horizon.

Table 8.1 Summary of Design Basis

Process	Design Basis	Unit	Current	2039	2065
Population	1,271.5 capita/year	Capita	27,331	59,119	92,172
Screens	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Grit Tanks	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
EQ Tanks	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Primary Clarifier	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Aeration Tank	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
		kg TAN/d	176	381	594
		kg TP/d	54	117	182
Secondary Clarifier	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
	Peak Hourly Flow	m ³ /h	1,080	2,336	3,642
Tertiary Filtration	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
UV	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Aeration Blowers	Maximum Day Load	kg BOD ₅ /d	5,512	11,923	18,589
Pumps	Peak Hour Flow	m ³ /h	1,080	2,336	3,642
Piping	Peak Hour Flow	m ³ /h	1,080	2,336	3,642

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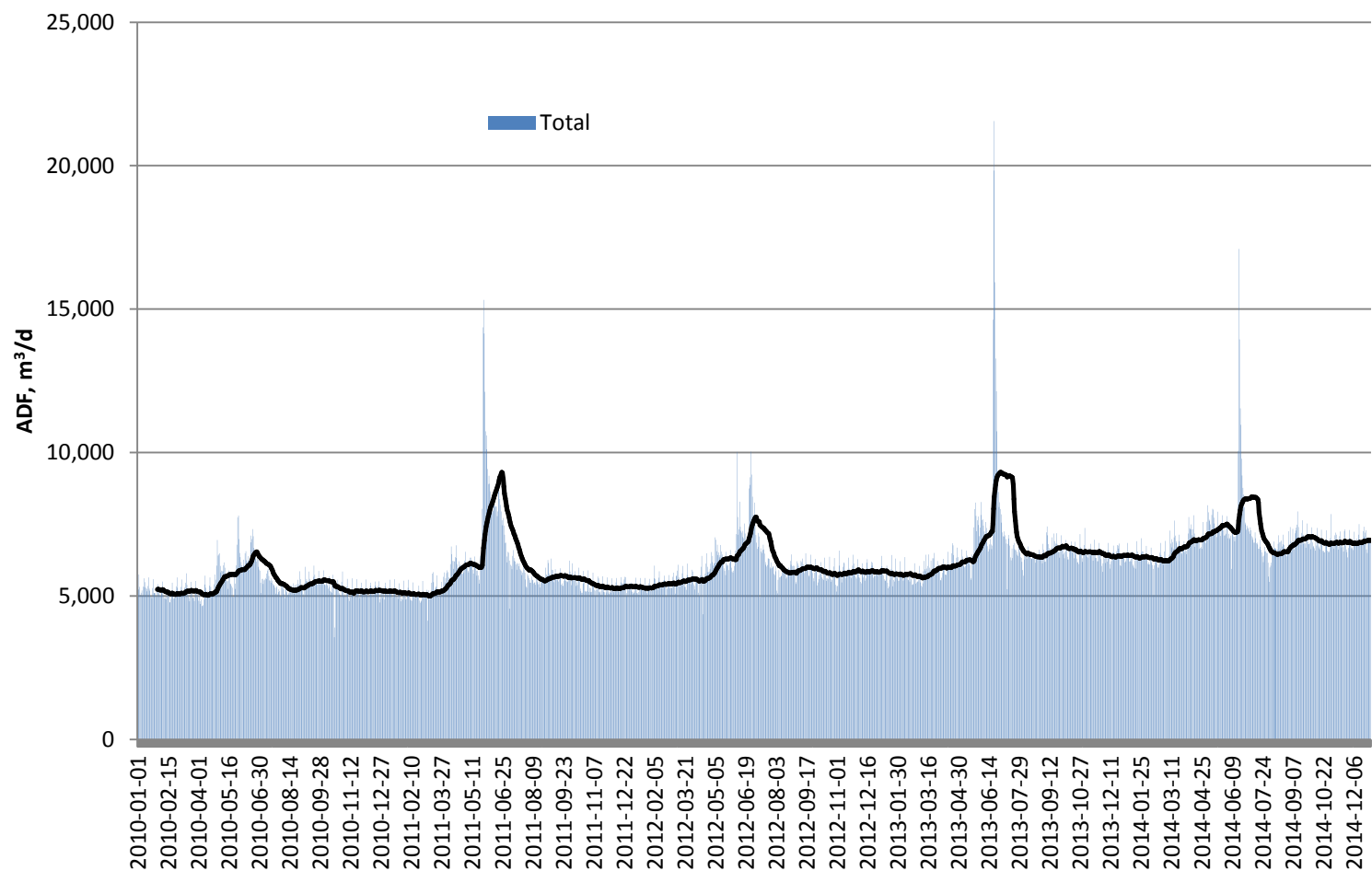


Figure A.1 Influent Average Daily Wastewater Flows – Jan 2010 through Dec 2014

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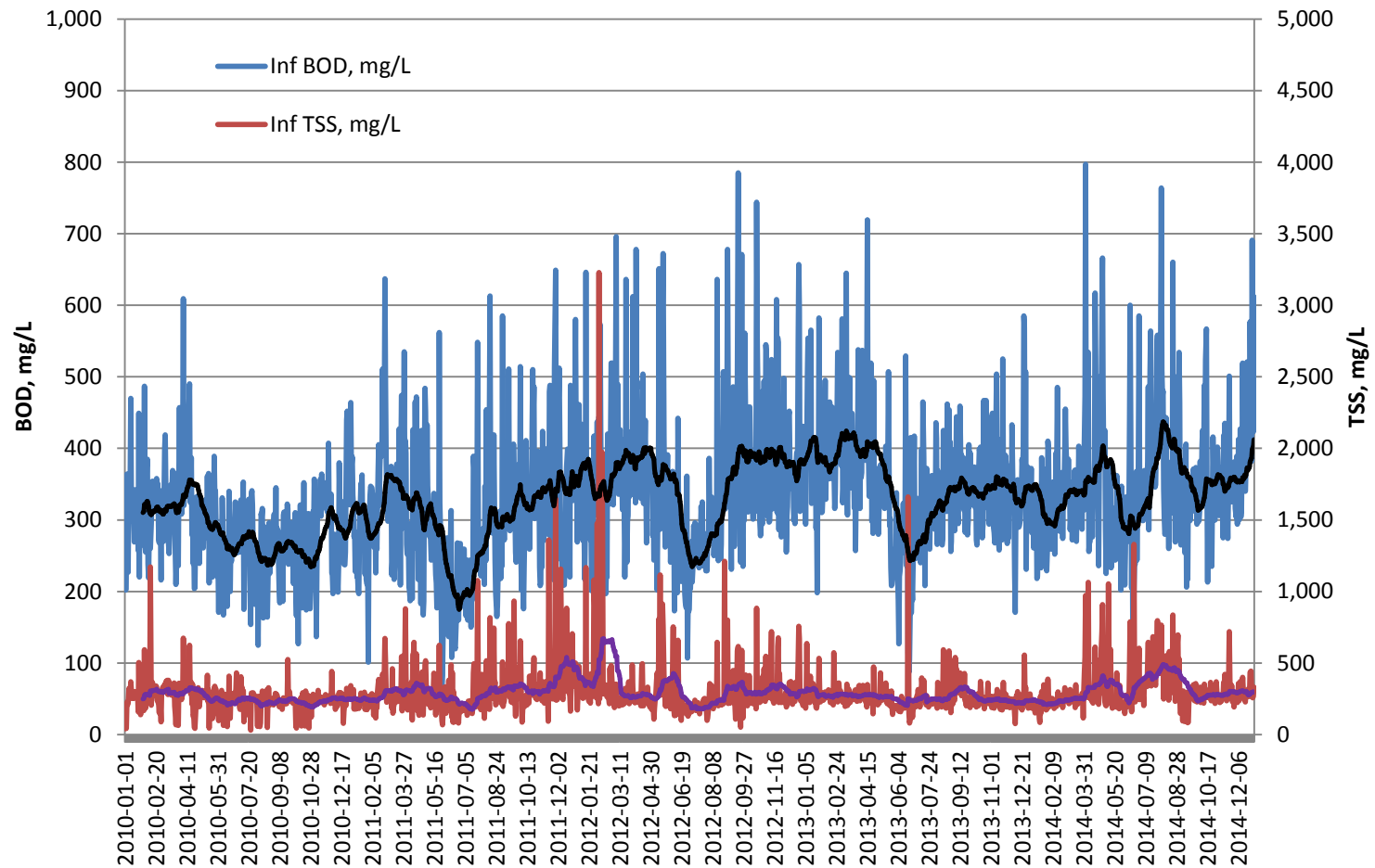


Figure A.2 Influent BOD5 and TSS Concentrations – Jan 2010 through Dec 2014

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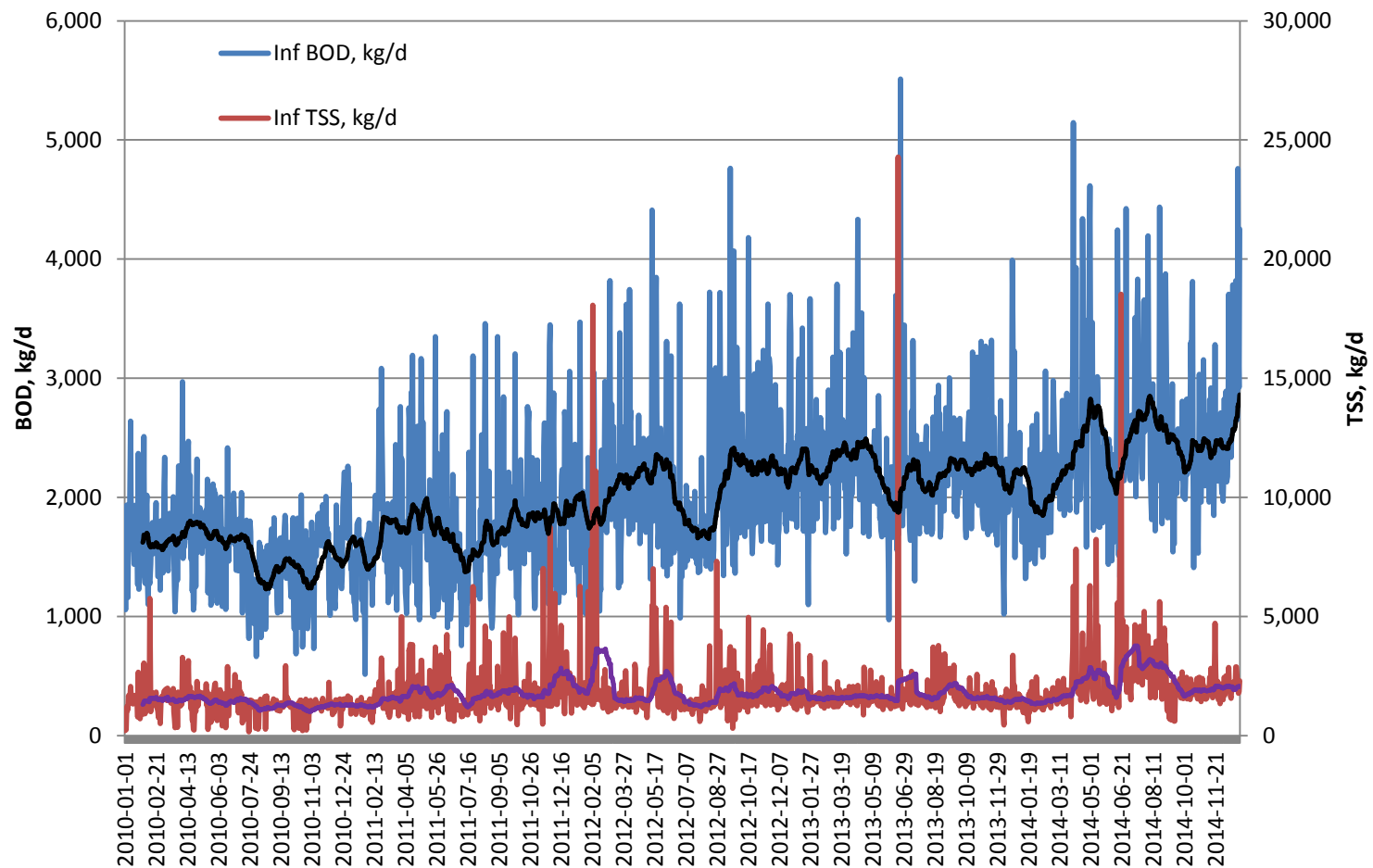


Figure A.3 Influent BOD5 and TSS Loads – Jan 2010 through Dec 2014

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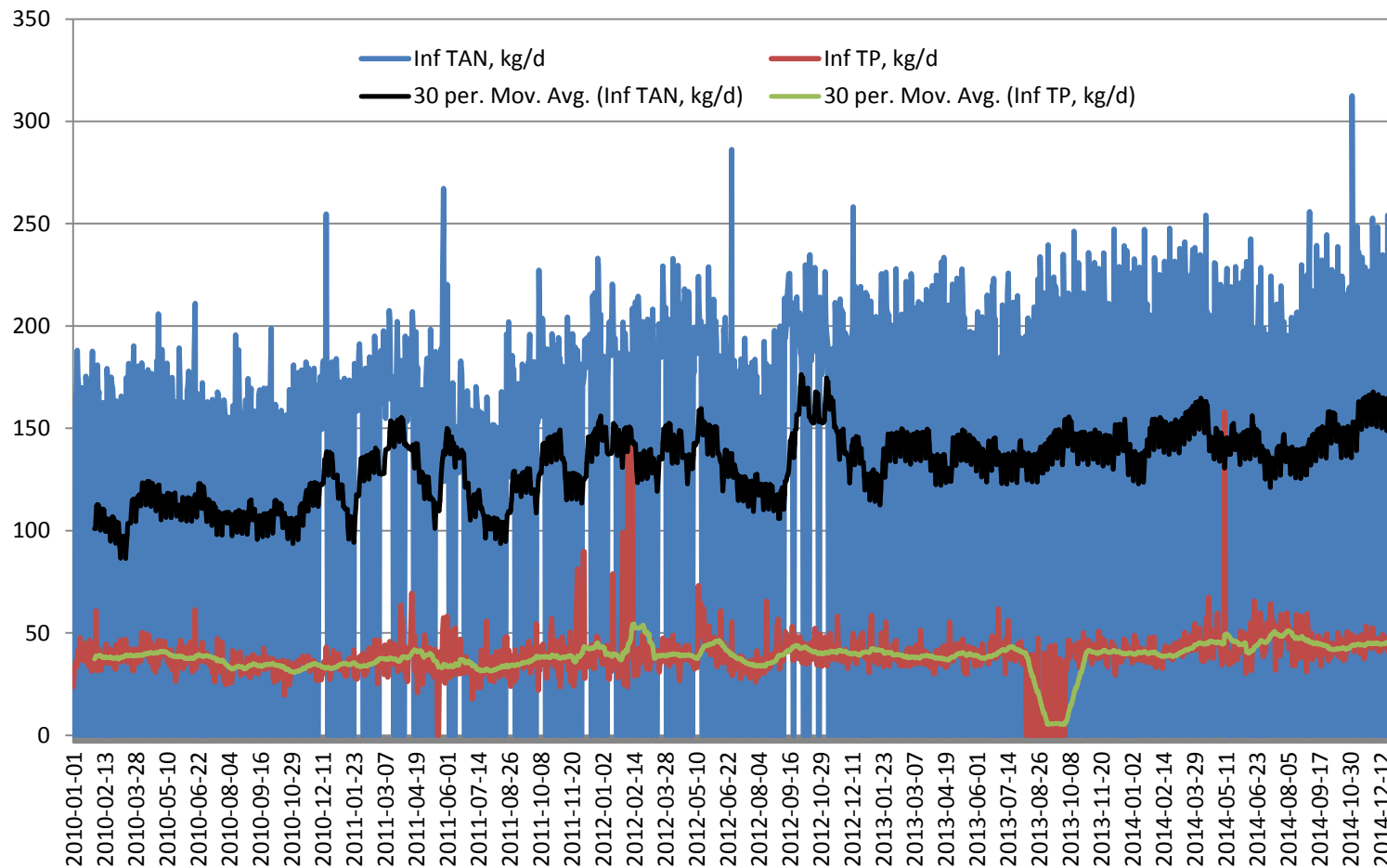


Figure A.4 Influent TAN and TP Concentrations – Jan 2010 through Dec 2014

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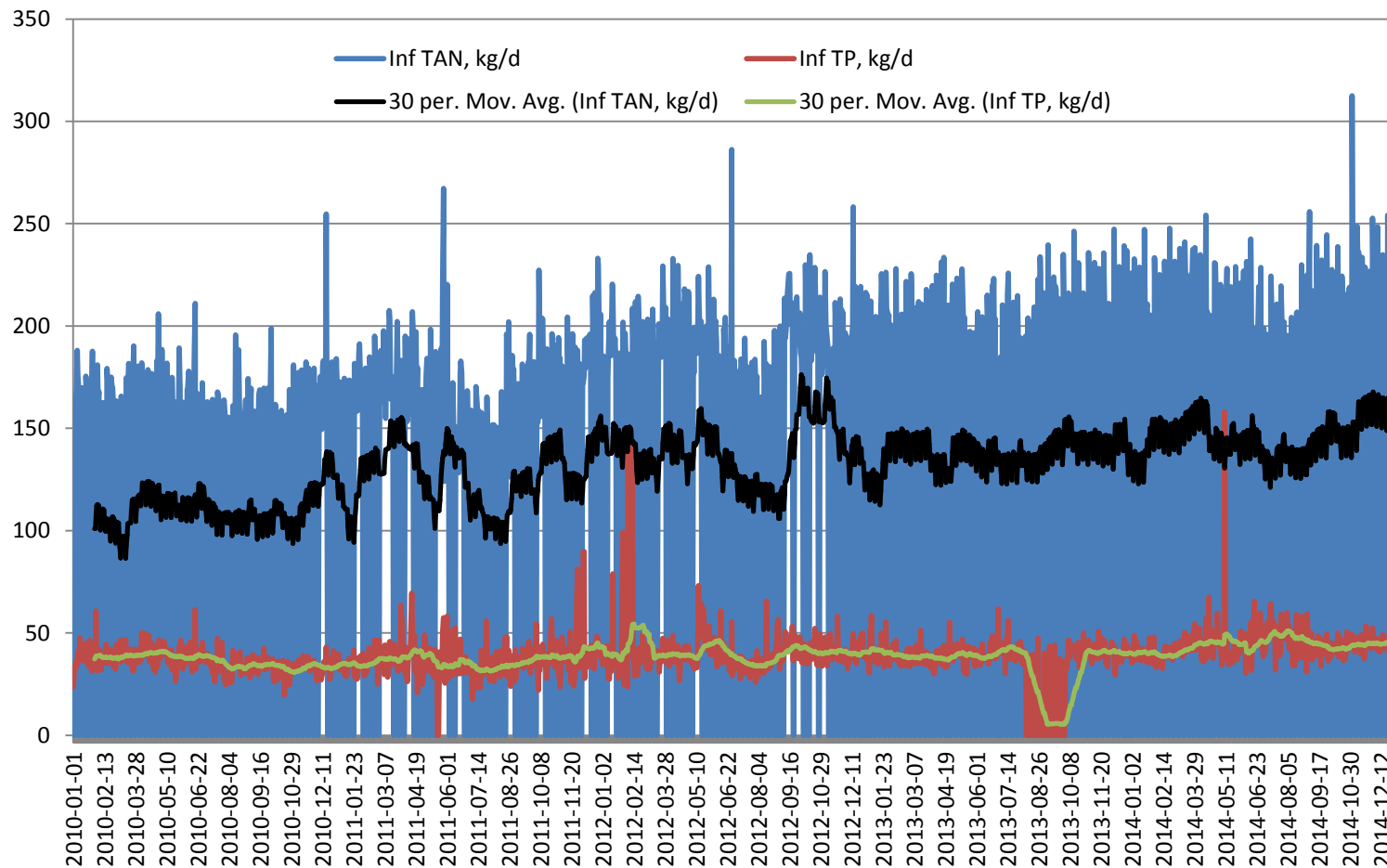


Figure A.5 Influent TAN and TP Loads – Jan 2010 through Dec 2014

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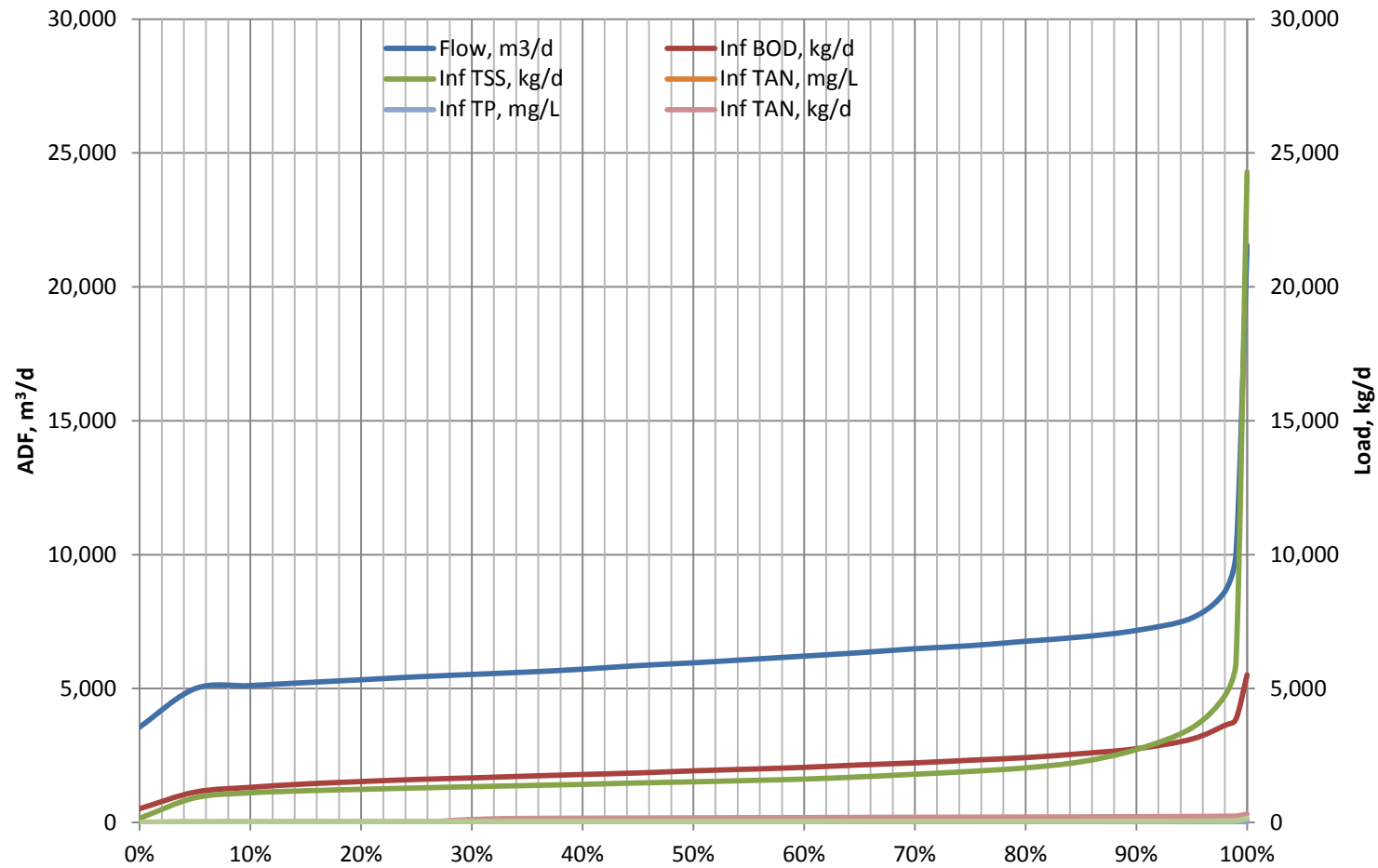
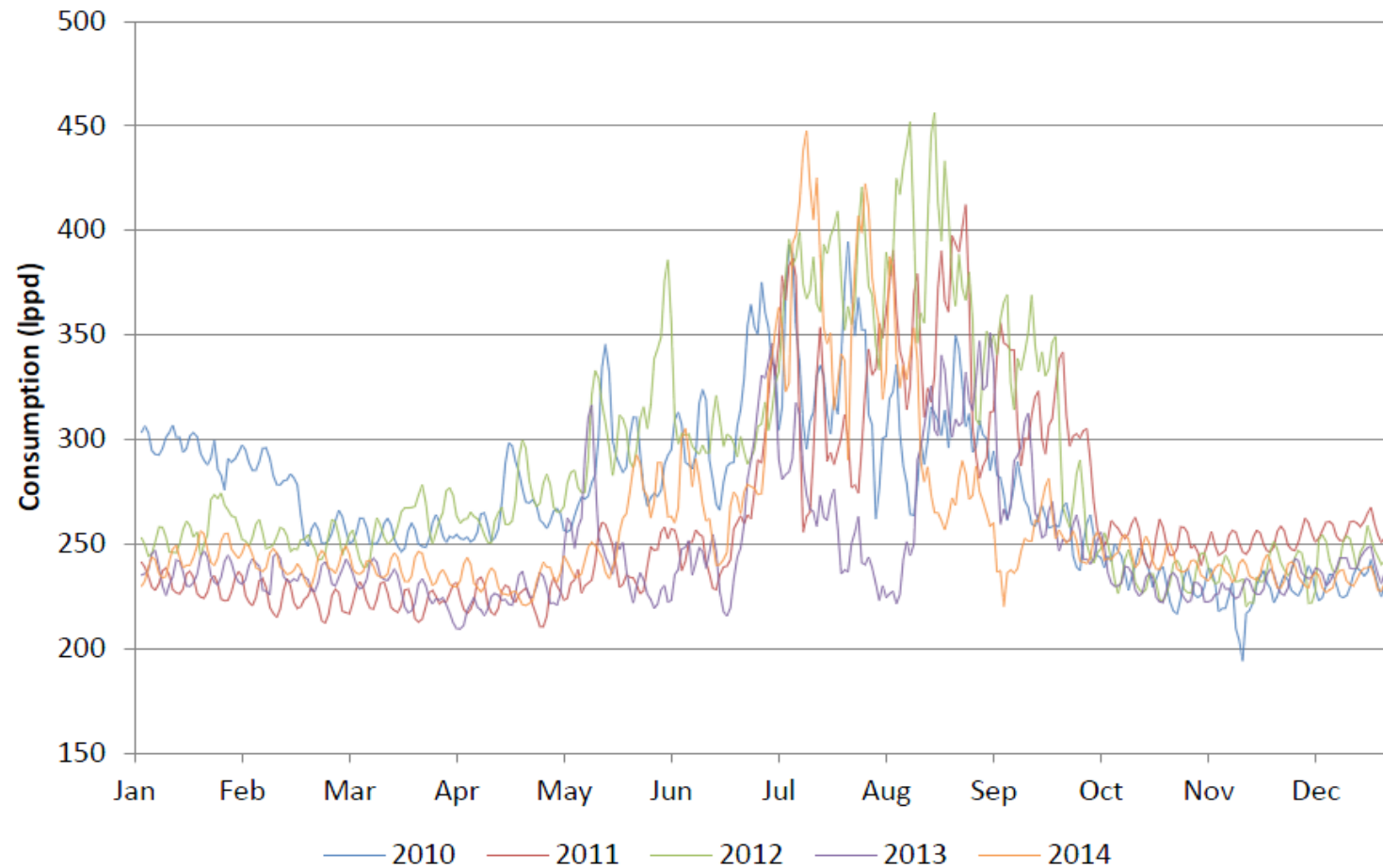


Figure A.6 Influent Flows and Loads Frequency Distribution – Jan 2010 through Dec 2014

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Source: "Okotoks – Calgary Regional Potable Water Pipeline – Pre-design Study – Draft" dated February, 2015

Figure A.7 Town of Okotoks 3-day Moving Average Water Consumption

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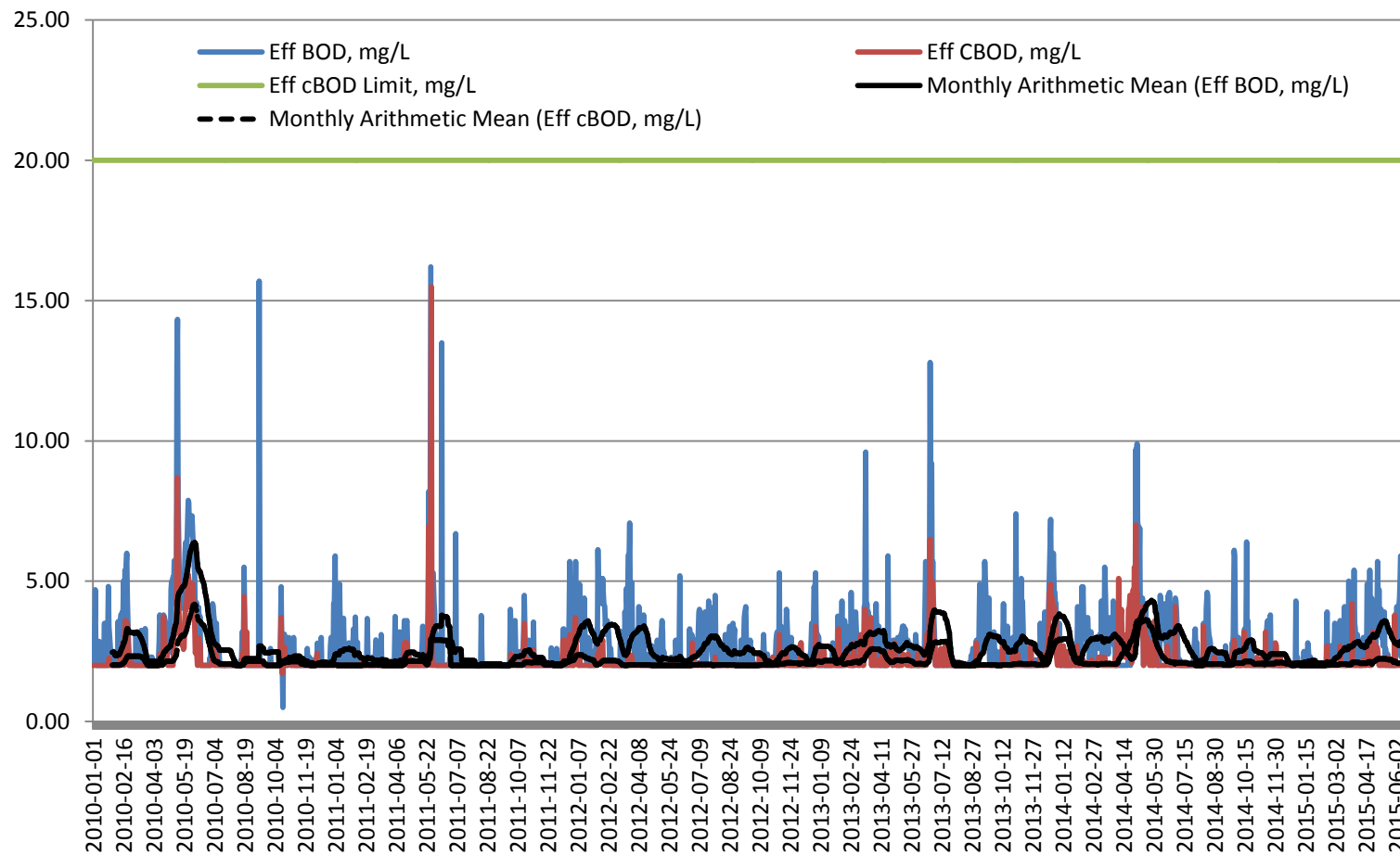


Figure A.8 Effluent BOD Concentrations – Jan 2010 through Dec 2014

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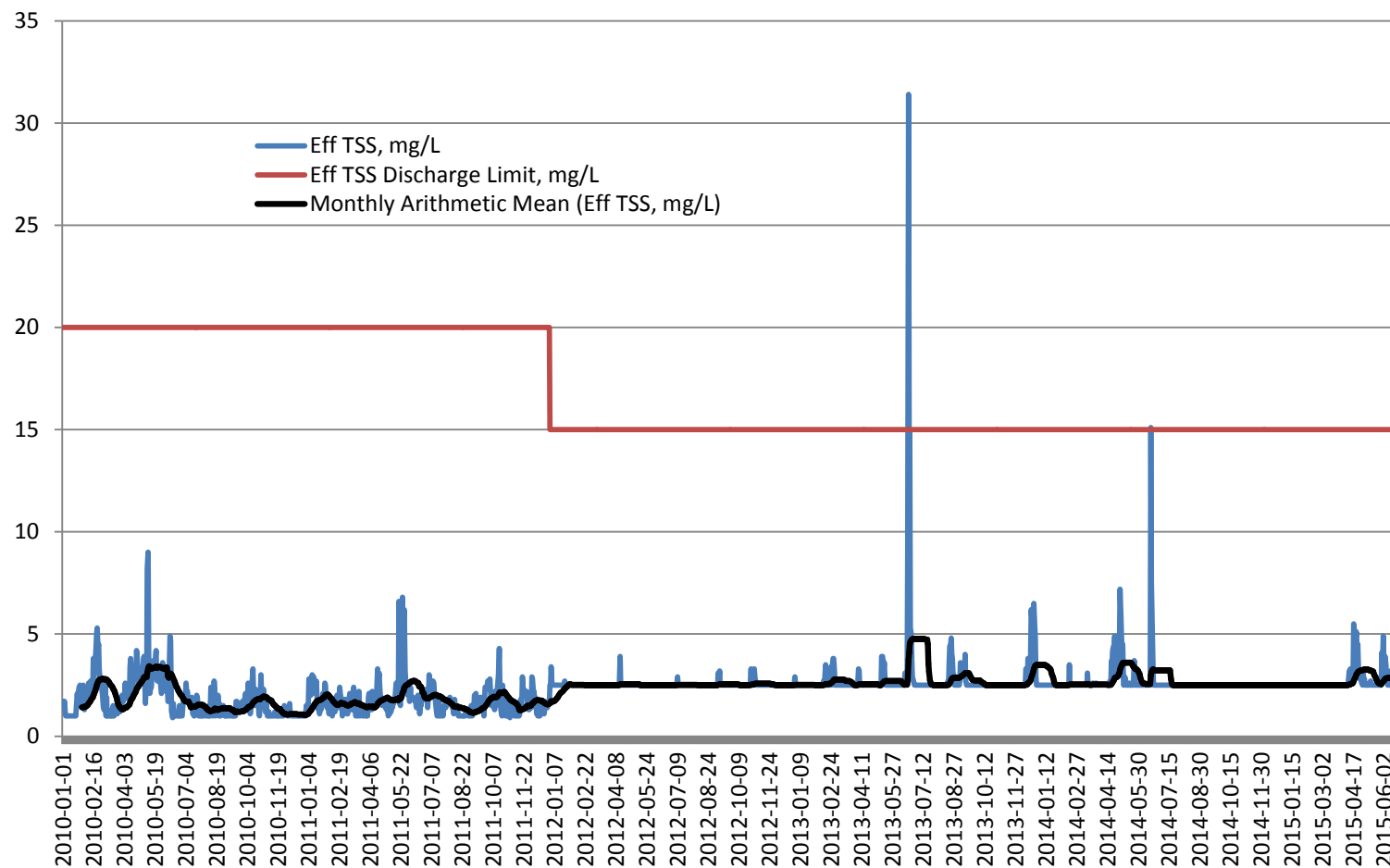


Figure A.9 Effluent TSS Concentrations – Jan 2010 through Dec 2014

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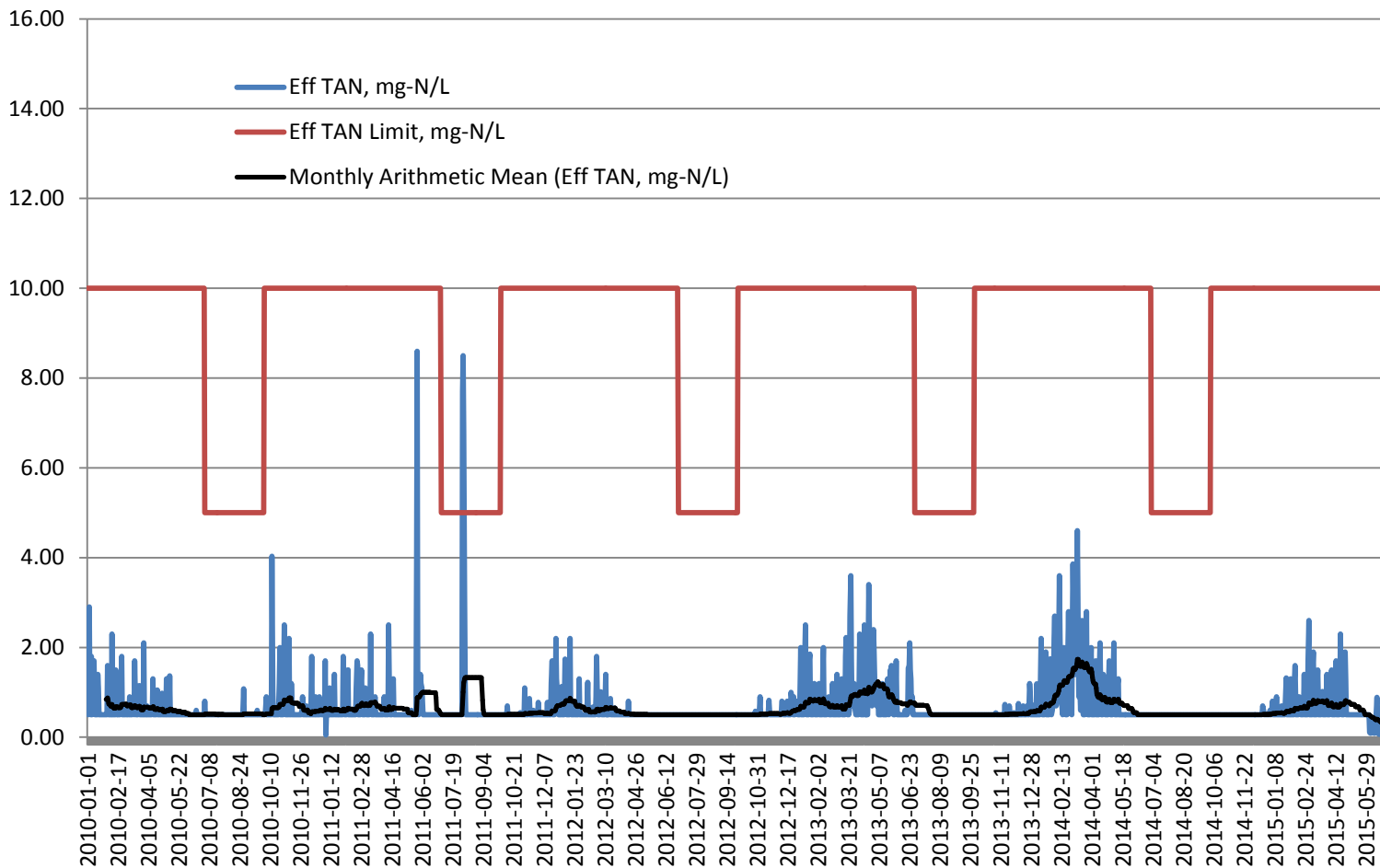


Figure A.10 Effluent TAN Concentrations – Jan 2010 through Dec 2014

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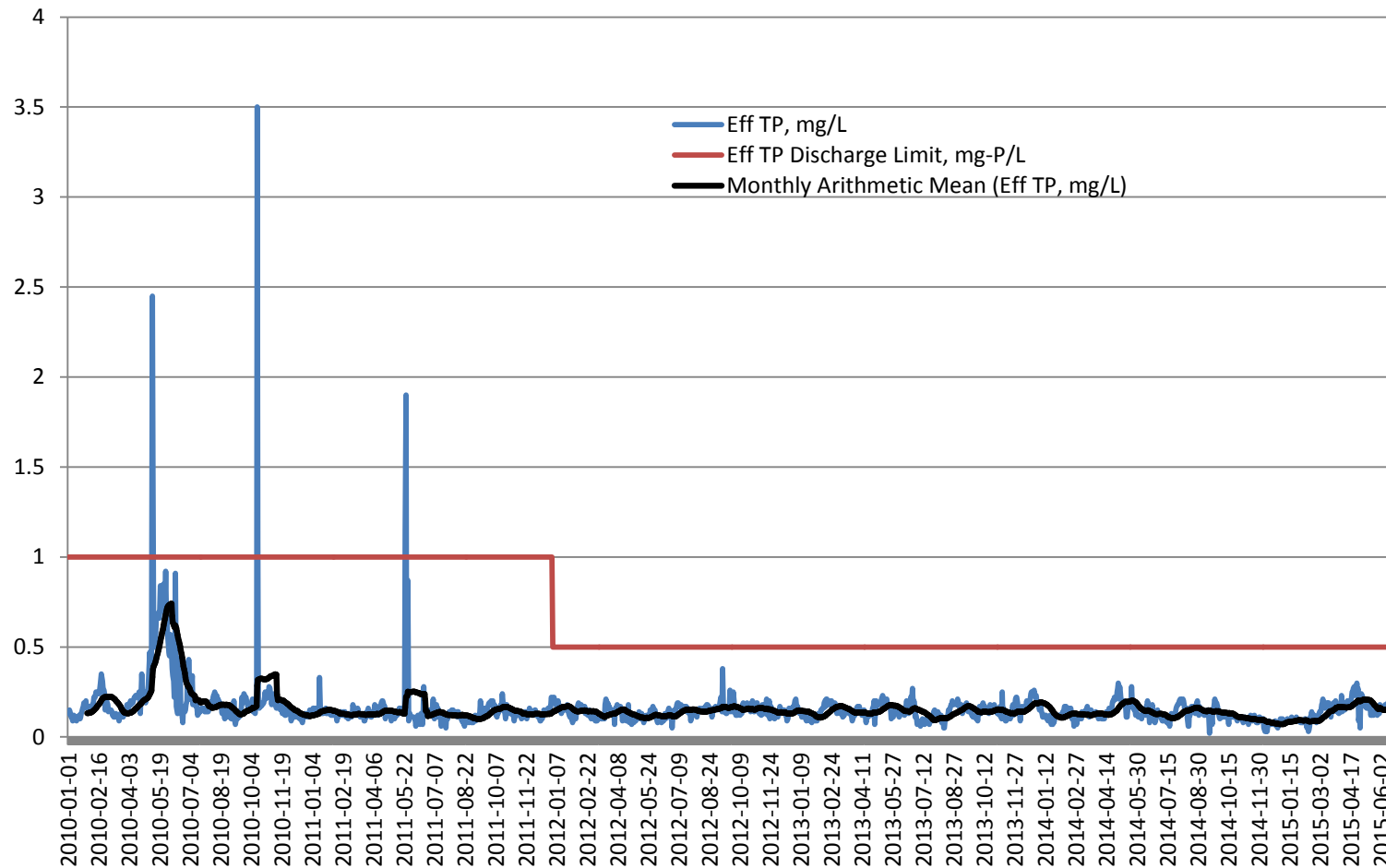


Figure A.11 Effluent TP Concentrations – Jan 2010 through Dec 2014

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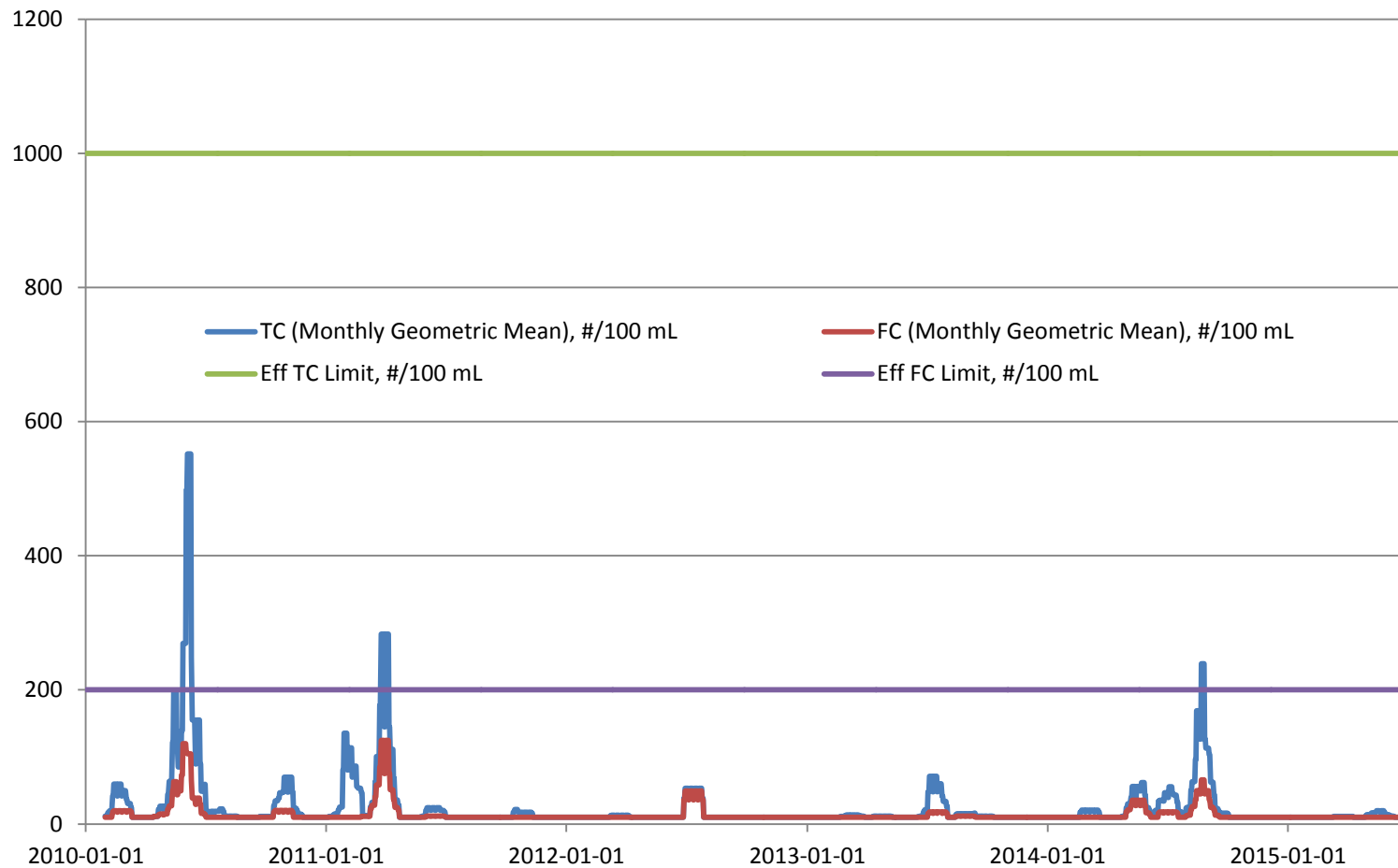


Figure A.12 Effluent Monthly Geometric Mean Total Coliform and Fecal Coliform Counts – Jan 2010 through Dec 2014

APPENDIX B – TM 2

TECHNICAL MEMORANDUM #2
Town of Okotoks Wastewater
Treatment Plant –
Treatment Capacity
Assessment



Prepared for:
The Town of Okotoks

Prepared by:
Stantec Consulting Ltd.

September 25, 2015

Revision Record							
Revision	Description	Prepared By		Checked By		Approved By	
A	Issued for Review	Hatim Fadlalla	2015-08-10	Saibal Basu	2015-08-11	Chris Mountenay	2015-08-14
B	Final	Hatim Fadlalla	2015-09-23	Nick Szoke	2015-09-25	Chris Mountenay	2015-09-25

Sign-off Sheet

This document entitled TECHNICAL MEMORANDUM #2 Town of Okotoks Wastewater Treatment Plant – Treatment Capacity Assessment was prepared by Stantec Consulting Ltd. ("Stantec") for the account of The Town of Okotoks (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between 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, 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 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 _____
(signature)

Hatim Fadlalla

Reviewed by _____
(signature)

Nick Szoke

**TECHNICAL MEMORANDUM #2
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT –
TREATMENT CAPACITY ASSESSMENT**

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TREATMENT CAPACITY ASSESSMENT

Executive Summary

As part of the regional pipeline feasibility study, Stantec conducted a desktop evaluation of the hydraulic and treatment capacity of the existing Wastewater Treatment Plant (WWTP) based on manufacturer data for installed equipment; and/or original design information through design reports, record drawings, shop drawings, and O&M manuals. The capacity evaluation assessed headworks, primary treatment, secondary treatment, tertiary treatment, and disinfection unit processes.

In addition, Stantec developed a calibrated BioWin™ model using historical influent flows and loads and operational data to estimate the capacity of the secondary treatment and forecast the performance of the biological nutrient removal (BNR) process and effluent quality.

Table 1.1 summarized the design basis for the current, 25-, and 50- year design horizon as estimated in TM#1.

Table ES.1 Summary of Design Basis

Process	Design Basis	Unit	Current	2039	2065
Population	1,271.5 capita/year	Capita	27,331	59,119	92,172
Screens	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Grit Tanks	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
EQ Tanks	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Primary Clarifier	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Aeration Tank	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
		kg TAN/d	176	381	594
		kg TP/d	54	117	182
Secondary Clarifier	Maximum Month Load	kg BOD ₅ /d	2,860	6,186	9,645
		kg TSS/d	3,773	8,161	12,724
	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Tertiary Filtration	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
UV	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
	Maximum Day Flow	m ³ /d	21,552	46,619	72,683
Aeration Blowers	Maximum Day Load	kg BOD ₅ /d	5,512	11,923	18,589
Pumps	Peak Hour Flow	m ³ /h	1,081	2,336	3,642
Piping	Peak Hour Flow	m ³ /h	1,081	2,336	3,642

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Table 1.2 summarizes our findings from the capacity assessment effort. The table lists the total number of installed unit processes, installed capacity, firm capacity, and excess capacity. The excess capacity was determined based on the design basis listed in Table 1.1. The Equivalent Population (EP) and the year by which each existing unit process reaches its full capacity was determined based on future flows projected in Table 3.1 in TM #1.

Table ES.2 Capacity Assessment of Okotoks WWTP

Process	Qty	Installed Capacity	Firm Capacity	Excess Firm Capacity	EP (Year) to Capacity
Influent Screw Pumps	3	1,575 m ³ /h	900 m ³ /h	-181 m ³ /h	Reached
Grinder/Spiral Screens	1	943 m ³ /h	0 m ³ /h	-1,081 m ³ /h	Reached
Vortex Grit Chamber	1	1,058 m ³ /h	0 m ³ /h	-1,081 m ³ /h	Reached
EQ Tank	1	1,500 m ³	0 m ³	Not Applicable	Not Applicable
Primary Clarifier	1	15,000 m ³ /d (Limited by inlet piping hydraulics)	0 m ³ /d	-15,000 m ³ /d	Reached
Bioreactor/Secondary Clarifier	1	3,290 kg/d BOD 2,910 kg/d TSS	0 kg/d	-3,290 kg/d BOD -2,910 kg/d TSS	Reached
Tertiary Filtration	3	1,536 m ³ /h	1,024 m ³ /h	-57 m ³ /h	Reached
UV Disinfection	2	1,024 m ³ /h	512 m ³ /h	-569 m ³ /h	Reached
Fermentation	1	356 kg/d VFA	0 kg/d VFA	-356 kg/d VFA	68,327 (2046)
Dissolver Air Flotation	1	1,894 kg/d Solids	0 kg/d Solids	-1,894 kg/d Solids	28,765 (2015)
Blend Tank	1	178.6 m ³	0 m ³	-178.6 m ³	54,071 (2035)
Centrifuge	1	114.4 m ³ /d	0 m ³ /d	-114.4 m ³ /d (21%)	36,644 (2021)
Screw Conveyor	1	4 m ³ /h	0 m ³ /h	-4 m ³ /h	
Pug Mill Mixers	2	4 Batches / Day (16,000 kg/d wet sludge)	2 Batches / Day (8,000 kg/d wet sludge)	1 – 1.5 Batches / Day (4,000 – 6,000 kg/d wet sludge)	49,715 (2031) – Average Conditions 34,682 (2019) – Max Month Conditions

* The negative values indicates that the firm capacity is exceeded.

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Abbreviations

Acronym	Description
ADF	Average Day Flow
AEP	Alberta Environment and Parks
APC	Activated Primary Clarifier
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
DAF	Dissolved Air Flotation
EBPR	Enhanced Biological Phosphorus Removal
EP	Equivalent Population
EQ	Equalization Tank
LSI	Lockerbie Stanley Inc.
MLSS	Mixed Liquor Suspended Solids
MSBR	Modified Sequencing Batch Reactor
NML	Nitrified Mixed Liquor
PHF	Peak Hour Flow
PLC	Programmable Logic Controller
PS	Primary Sludge
RAS	Return Activated Sludge
SRT	Solids Retention Time
SWD	Side Water Depth
TSS	Total Suspended Solids
TWAS	Thickened Waste Activated Sludge
UV	Ultra Violet
VFA	Volatile Fatty Acid
WAS	Waste Activated Sludge
WWTP	Wastewater Treatment Plant

**TECHNICAL MEMORANDUM #2
TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT –
TREATMENT CAPACITY ASSESSMENT**

Introduction
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1.0 INTRODUCTION

1.1 BACKGROUND

The Town of Okotoks (The Town) is one of the fastest growing communities in Canada. Its populations as of June 2014 Municipal Census was 27,331 soaring from 19,996 in 2008. It had a 30,000 – population cap, which was eliminated in 2012. The Town is investigating alternatives for additional water supply sources and wastewater treatment upgrade options to meet its anticipated growing population demands. The Town has retained the services of Stantec Consulting Ltd. (Stantec) to assess the capacity and potential upgrade requirements of its current wastewater treatment plant (WWTP) and to compare the feasibility of upgrading its WWTP to other options including a regional wastewater pipeline. Findings during this feasibility analyses will be provided in the following Technical Memorandums (TMs):

1. TM#1 Design Basis Definition (Completed)
2. TM# 2 Capacity Assessment (This TM)
3. TM# 3 Sanitary Forcemain Options (A draft submitted to the Town)
4. TM# 4 WWTP Upgrade Options (In progress)
5. TM# 5 Evaluation Criteria and Weighting (In progress)
6. Final Feasibility Report (In progress)

1.2 EXISTING WWTP

The existing WWTP has a design capacity of 30,000 Equivalent Population (EP). It is bounded by North Railway Street to the north, 32 Street E. to the west, the Sheep River to the south and the proposed highway 2A by-pass to the east.

The existing WWTP consists of influent screw pumps, grinder/spiral screens, vortex grit chamber, a flow equalization tank, an Activated Primary Clarifier (APC), a Biological nutrient Removal (BNR) bioreactor with a secondary clarifier, tertiary disk filtration and effluent UV disinfection. Primary and secondary solids are handled using dissolved air floatation, centrifuge dewatering, and pug mill mixers. Emergency/balancing sludge storage is provided using the decommissioned Modified Sequencing Batch Reactor (MSBR).

Figure 1.1 shows a schematic diagram of the existing WWTP.

TECHNICAL MEMORANDUM #2 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – TREATMENT CAPACITY ASSESSMENT

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September 25, 2015

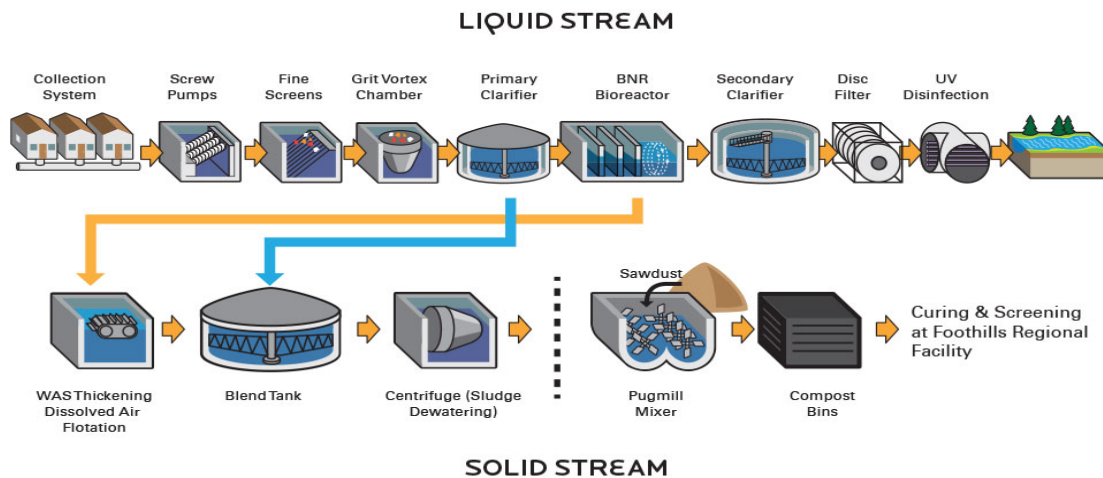


Figure 1.1 Okotoks WWTP Schematic Diagram

1.3 WORK SCOPE

This Technical Memorandum #2 (TM #2) summarizes the result of the baseline hydraulic and process treatment capacity evaluation of the existing WWTP based on historical monthly reports, design basis information from TM #1, supplemental sampling results, manufacturer data for installed equipment, or original design information through shop drawings and O&M manuals. The goals of this assessment are:

- to determine the flow and load conditions for which the current facility reaches full capacity;
- to indicate which specific equipment is limiting the operating capacity of the WWTP; and
- to determine when major infrastructure upgrades are required to service the future population.

Stantec estimated the installed capacity of equipment or tanks based on manufacturer data or original design information. The firm capacity of equipment is estimated with the largest unit offline. The firm capacity of tanks or reactors is equivalent to its installed capacity. The excess capacity of an equipment was estimated based on its firm capacity.

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WWTP Hydraulics
September 25, 2015

2.0 WWTP HYDRAULICS

2.1 HYDRAULIC ANALYSIS

Stantec developed a new hydraulic profile of Okotoks WWTP an Average Day Flow (ADF) of 10,000 m³/d and Peak Hour Flow (PHF) of 26,500 m³/d. The hydraulic profile was based on record drawings and manufacturers design information as illustrated in Figure 2.1. It reflects the existing liquid stream of the WWTP including headworks, APC, bioreactor, secondary clarifier, filtration and UV facility, and outfall diffuser to the Sheep River. Elevations used to create hydraulic profile were taken from record drawings.

For the purpose of this hydraulic analysis, the hydraulic limitations for each system were based on the level which would cause a channel, tank, or process to overflow and spill to the ground.

2.2 HYDRAULIC ASSESSMENT

Based on the hydraulic analysis, the headworks would be limited by the flow through the 600mm inlet channel of the Grit Tank. This channel has sufficient capacity to pass more than 30,000 m³/d. The flow rate which would cause this channel to overflow greatly exceeds that of the recommended flow rate through the Grit Tank and process capacity of the fine screen. Therefore, the analysis was only completed for a flow rate of 30,000 m³/d.

Due to the hydraulic capacity limitation of the 500 mm inlet pipe to the APC, a maximum flow of 15,000 m³/d can be transferred from primary influent channel to APC. WWTP operators reported that flows in excess of 14,000 m³/d are usually diverted directly to the bioreactors to prevent spillover from the primary influent channel.

Similar to APC, the hydraulic limitation through the bioreactor is the result of the headloss within the secondary influent pipe. At a flow rate of 30,000 m³/d, with an additional 11,500 m³/d of RAS, there is approximately 775mm of headloss through the secondary clarifier inlet pipe. At these flow conditions, the bioreactor would overflow and submerge the APC effluent weirs as well.

Aside from the bottleneck in the inlet piping to the secondary clarifier, the clarifier itself still maintains freefall conditions over its weir at a flow rate of 30,000 m³/d. This indicates that there is sufficient hydraulic capacity in the effluent pipe to accommodate more flow. However, due to the process limitations of the secondary clarifier, further hydraulic analysis was not completed.

The filtration system has sufficient hydraulic capacity to pass 30,000 m³/d before the filter tanks would overflow.

The hydraulic analysis of the existing UV channel showed that there is significant hydraulic capacity at 30,000 m³/d. Flow rates could approach 60,000 m³/d within this channel before causing an overflow condition.

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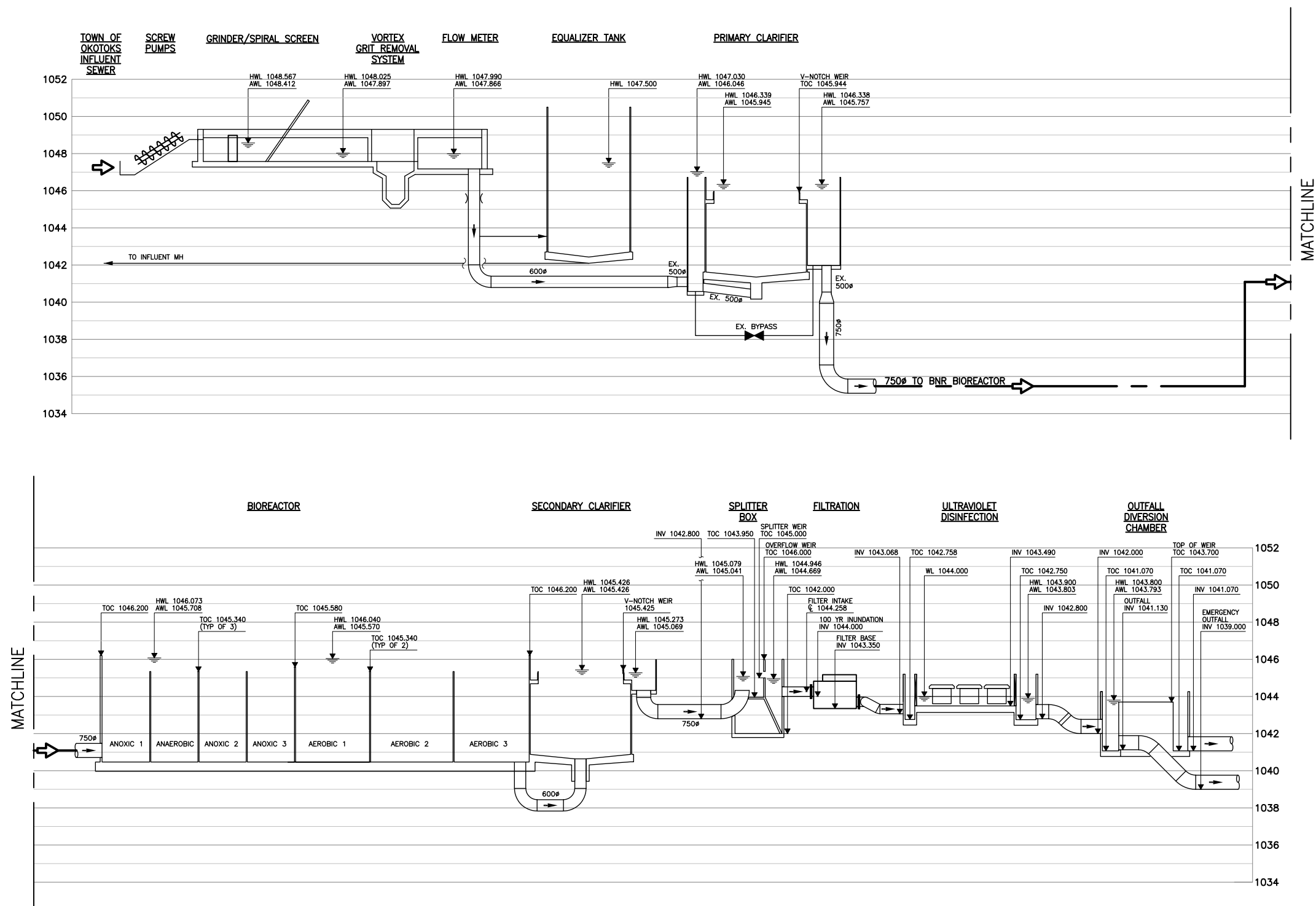
HWL LIQUID LEVEL AT PEAK HYDRAULIC FLOW (26,500 m³/d)
AWL LIQUID LEVEL AT ANNUAL AVERAGE DAILY FLOW (10,000 m³/d)

Notes

1. AT PEAK HYDRAULIC LEVELS IN RIVER (1043.73m)

Scale: NO SCALE

Client/Project
EPCOR
TOWN OF OKOTOKS WWTP
REGIONAL WASTEWATER PIPELINE FEASIBILITY STUDY
Figure No.
2.1
Title
Hydraulic Profile



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3.0 TREATMENT CAPACITY ASSESSMENT

3.1 PRELIMINARY TREATMENT

3.1.1 Influent Screw Pumps

Three (3) influent Archimedes screw pumps transfer influent raw sewage to the channel grinder/spiral screen. The pumps operate as lead/lag/lag pumps. Current WWTP operations rely mostly on the SP-103 as the main lift pump with SP-102 and SP-101 as support pumps to lift additional flows during PHF conditions.

For the purpose of this analysis, Stantec assumed that the installed capacity of the pumps is equal to the rated capacity times screw pumps' efficiency. Pump efficiencies were based on information supplied by WWTP operators. The firm capacity was estimated as the total installed capacity with the largest pump offline.

Based on historical PHF measurements of 1,081 m³/h, the firm capacity of the screw pumps is exceeded by 181 m³/h at PHF condition (i.e. -181 m³/h). Table 3.1 summarizes the basis of design of the influent screw pumps.

Table 3.1 Influent Screw Pumps Basis of Design

Item	Unit	Basis of Design
Installed Capacity		
Pump 1 (SP-101)	m ³ /h	450
Pump 2 (SP-102)	m ³ /h	450
Pump 3 (SP-103)	m ³ /h	675
Total Installed Capacity	m ³ /h	1,575
Firm Capacity	m ³ /h	900
Historical PHF	m ³ /h	1,081
Excess Firm Capacity	m ³ /h	-181
Time to Reach Firm Capacity		Reached

3.1.2 Grinder/Spiral Screens

Pumped raw sewage passes through one (1) JWC Environmental Auger Monster channel grinder/spiral screens that consists of two sets of counter-rotating, intermeshing cutters that trap and shear wastewater solids into a consistent particle size followed by spiral screens. The grinder/spiral screen combination grinds coarse solids into finer solids up to 6 mm in size and screens out trash, rags, and large particulates from the liquid stream.

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Based on historical PHF measurements of 1,081 m³/h, the firm capacity of the existing system is exceeded at PHF condition. Table 3.2 summarizes the basis of design of the grinder/spiral screens system.

Table 3.2 Grinder/Spiral Screens Basis of Design

Item	Unit	Basis of Design
Tag		CG-104/SCR-105
Spiral Screen Configuration		45° Inclined with Lifting Eyes
Channel Width	m	1.2
Channel Depth	m	1.51
Installed Capacity	m ³ /h	943
Firm Capacity	m ³ /h	0
Historical PHF	m ³ /h	1,081
Excess Firm Capacity	m ³ /h	-1,081
Time to Reach Firm Capacity		Reached

Although the use of the channel grinder can minimize handling issues associated with screenings, their use in WWTPs is becoming less desirable due to the potential accumulation of shredded rags on air diffusers and deteriorating quality of digested biosolids.

3.1.3 Vortex Grit Chamber

The existing Mabarex vortex grit separator was installed in 2005 and operates with one (1) grit chamber and one (1) grit classifier. From spiral fine screen, screened influent enters tangentially and flows around the upper chamber. The adjustable, rotating paddles augment the spiraling flow to create a mechanically induced vortex which settles grit, transports it to the center opening of the fixed floor plate for collection in the lower chamber, and lifts and returns the lighter organic particles to the main flow. The grit solids are removed from the lower chamber by an air lift pump for further washing and dewatering on the grit classifier.

Based on historical PHF measurements of 1,081 m³/h, the firm capacity of the existing system is exceeded at PHF condition. Table 3.3 summarizes the basis of design of the vortex grit removal system.

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Table 3.3 Vortex Grit Removal System Basis of Design

Item	Unit	Basis of Design
Tag		VG-106, GC-107
Grit Chamber Upper Diameter	m	3.0
Grit Chamber Lower Diameter	m	1.2
Installed Capacity	m ³ /h	1,058
Firm Capacity	m ³ /h	0
Historical PHF	m ³ /h	1,081
Excess Capacity	m ³ /h	-1,081
Time to Reach Firm Capacity		Reached

3.2 EQUALIZATION (EQ) TANK

The main purpose of flow equalization at Okotoks WWTP is to provide a normalized feed to the biological process during the diurnal low flow periods at nights. During the day, a portion of the screened, degritted sewage is diverted from the existing 400 mm primary influent line within the headworks building to the EQ tank via a 150 mm connection piping. One (1) chopper pump is used for recirculation (mixing) of screened sewage detained in the EQ tank. During low flow periods, the pump is used to bleed the stored sewage into the main WWTP liquid stream.

Table 3.5 summarizes the basis of design of the EQ tank and EQ pumps.

Table 3.4 EQ Tank/EQ Pumps Basis of Design

Item	Unit	Basis of Design
<u>EQ Tank:</u>		
Quantity		1
Tag		TK-125
Capacity	m ³	1,500
Maximum Water Level	m	1,047.5
<u>EQ Pumps:</u>		
Tag		P-122
Installed Capacity	m ³ /h (L/s)	187 – 226 (52 – 63)
Firm Capacity	m ³ /h	0
Head	m	10 – 12
Power	kW	14.9

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3.3 PRIMARY TREATMENT

Primary clarification is the process where readily settleable solids and floating material is physically removed from the liquid stream. This settling is achieved by using tanks with sufficient detention time that allows suspended solids to settle down to the bottom of the clarifier. Floating materials are routinely skimmed off the wastewater surface. Efficiently designed and operated primary clarifiers typically remove 50 – 70 percent of influent suspended solids and 35 – 45 percent of influent BOD and maintain a surface overflow rate of 52 m³/m²/d and 80 – 120 m³/m²/d at average and peak flow conditions, respectively¹.

The Okotoks WWTP has one (1) circular primary clarifier, which is operated as an APC fermenter. In this mode of operation, the APC settles out solids (sludge) and stores it long enough to induce fermentation. Two (2) recycle pumps (1 duty/1 standby) continuously recycle a portion of primary sludge (PS) to APC inlet so that a fermenting sludge blanket is allowed to build up on the clarifier floor. PS fermentation produces volatile fatty acids (VFAs), chiefly in the form of acetic acid, which is used in the bioreactor to facilitate biological phosphorus removal and excess for denitrification. The generated VFAs are elutriated through mixing with the influent wastewater and PS recycle, and conveyed by gravity with primary effluent over the effluent weir to the bioreactor.

A sludge blanket of 1 – 2 m is maintained at the bottom of the clarifier at all times. The sludge retention time is controlled by wasting a portion of sludge each day to a single Sludge Blend Tank. Operations waste approximately 34 m³/d of sludge (2015), with the wasting occurring in the morning during periods of low flow. A detailed discussion of PS storage and fermentation process is discussed in Section 3.7.1.

The APC contains a scum box, which discharges to scum pit. The scum pit has a mixer to keep solids in suspension, and a submersible pump which discharges scum to the sludge blend tank.

Table 3.5 and Table 3.6 summarize the existing APC design basis and criteria, respectively.

Table 3.5: Activated Primary Clarifier Basis of Design

Parameter	Unit	Value
Dimensions		
Diameter	m	16.6
Depth (Side Water Depth)	m	4.0
Nominal Area	m ²	190
Volume	m ³	760
Clarifier Mechanism Power	kW	0.37
Recycle Pump Power	kW	3.7
Primary Scum Pump Power	kW	2.22
Scum Pit Mixer Power	kW	1.5

¹ Wastewater Engineering: Treatment and Reuse (4th Edition). Metcalf and Eddy. 2003.

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Table 3.6: Primary Clarifier Design Criteria

Parameter	Unit	Value
WWTP Design Flow	m ³ /d	10,000
Overflow Rate (Average Flow)	m ³ /m ² /d	52
Hydraulic Retention Time (Average Flow)	h	1.8
Sludge Blanket Depth	m	1 – 2
Solids Retention Time (SRT)	d	5 – 10

3.3.1.1 Process Evaluation

Stantec evaluated the performance of the existing APC system using historical data provided by the WWTP (2010 to Present) as summarized in Table 3.7.

Table 3.7: Primary Clarifier System Performance

Parameter	Unit	Design	2010 - 2015
Surface Overflow Rate (Average Flow = 6,193 m ³ /d)	m ³ /m ² /d	52	32.6
Surface Overflow Rate (PHF = 25,946 m ³ /d)	m ³ /m ² /d	100	136
Retention Time (Average Flow = 6,193 m ³ /d)	h	1.8	3.0
Solids Removal	%	N/A	55%
BOD Removal	%	N/A	40%

Table 3.7 indicates that the existing APC has sufficient primary treatment process capacity. The surface overflow rate of the existing APC is below the design overflow rate of 52 m³/m²/d. In addition, the APC maintains a good TSS and BOD removal rates of 55% and 40%, respectively.

At peak flow conditions, the analysis indicated that the existing APC could accommodate peak flows up to 950 m³/h while meeting industry standards of 120 m³/m²/d surface overflow rate. At PHF, BOD and TSS removal efficiencies across the APC are expected to drop to approximately 25% and 45%, respectively.

3.3.1.2 Future Upgrade Requirements

The existing APC fermenter still has significant process capacity. Table 3.8 summarizes the required APC expansions based on the existing systems design parameters.

Table 3.8: Future APC Upgrade Requirements

Parameter	Flow	Surface Overflow Rate	EP (Year)
Current Conditions	6,193 m ³ /d	32 m ³ /m ² /d	27,331 (2014)
Design Conditions: One APC	9,880 m ³ /d	52 m ³ /m ² /d	43,943 (2027)
Design Conditions: Two APCs	19,760 m ³ /d	52 m ³ /m ² /d	87,886 (2061)

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In order to maintain a maximum surface overflow rate of $52 \text{ m}^3/\text{m}^2/\text{d}$ at ADF conditions, a second APC will be required after 2027. Using the same tank dimensions, this APC would have sufficient capacity through 2061 at ADF conditions.

Given that current peak flow conditions exceed the suggested surface overflow rate of $80 - 120 \text{ m}^3/\text{m}^2/\text{d}$, additional peak flow shaving (attenuation via storage) or diversion to a wet weather management facility which could treat a portion of the influent flow would help to reduce the impact of peak flow on the APC.

3.4 SECONDARY TREATMENT

The secondary system at the Okotoks WWTP was constructed in 2006 based on Modified Johannesburg Process consisting of a single seven-zone aeration tank surrounding a single Hi-Tech secondary clarifier for solids separation with a 5.5 m side water depth (SWD). The aeration tank consist of a small pre-anoxic zone, followed by an anaerobic zone, two anoxic zones, and three aerobic zones as shown in Figure 3.1. One (1) submersible direct drive ABS pump returns a portion of the nitrified mixed liquor (NML) from the end of the third aerobic zone to the beginning of the first anoxic zone for denitrification. The remaining NML flows from the third aerobic zone to the secondary clarifier for solids separation. The system has two (2) integral submersible ITT Flygt pumps the direct the Return Activated Sludge (RAS) from the bottom of the secondary clarifier to the head of the pre-anoxic zone to eliminate dissolved oxygen and nitrates entering the anaerobic zone, which could otherwise affect the biological phosphorus removal process.

To regulate the biomass concentration in the bioreactor, two (2) submersible ITT Flygt pumps waste a portion of the NML from the surface of the bioreactor to the dissolved air flotation (DAF) unit for thickening. The thickened Waste Activated Sludge (TWAS) from the DAF then goes through the blend tanks to the centrifuge for further dewatering. The liquid subnatant is sent back to the APC inlet.

Table 3.9 summarizes the design information of the secondary system.

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Table 3.9 Secondary System Basis of Design

Item	Unit	Basis of Design		
<u>Aeration Tank</u>				
No. of Tanks	--	1		
No. of Zones per Tank	--	7		
Pre-Anoxic Volume	m ³	311		
Anaerobic Volume	m ³	265		
Anoxic 1 Volume	m ³	518		
Anoxic 2 Volume	m ³	576		
Aerobic 1 Volume	m ³	1,210		
Aerobic 2 Volume	m ³	634		
Aerobic 3 Volume	m ³	634		
Total Volume	m ³	4,147		
Un aerated Volume	% of PE Flow	40%		
Internal Recycle	% of PE Flow	300%		
<u>Aeration Blowers</u>				
Type		Positive Displacement		
Manufacturer		Aerzen	Aerzen	Roots
Model		GM 60S	GM 35S	86P 5546
Quantity		2 (duty)	1 (duty)	1 (standby)
Inlet Capacity (each)	Nm ³ /min	28.6 – 50.9	28.6	N/A
Blower Speed	RPM	1,658 – 2,685	2,906	N/A
<u>Internal Recycle Pumps</u>				
Tag		P-310		
Duty Flow	m ³ /d	30,240		
Duty head	m	0.525		
<u>Secondary Clarifier</u>				
Tag		SC-350		
Diameter	m	28		
Surface Area	m ²	616		
SWD	m	5.5		
<u>RAS Pumps</u>				
Tag		P-361 & P-362		
Duty Flow	m ³ /d	10,109		
Duty head	m	8.7		
<u>WAS Pumps</u>				
Tag		P-321 & P-322		
Duty Flow	m ³ /d	674		
Duty head	m	9.0		

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3.4.1 BioWin™ Model Development

Stantec used BioWin™ version 4.1.1 to model the activated sludge system at Okotoks and to determine the maximum process loading capacity, operating characteristics, and sludge production values of the existing secondary treatment processes. Figure 3.1 illustrates the process flow diagram of the BioWin™ model. The presented configuration was developed based on the facility's actual configuration and physical characteristics. Certain features which were determined to have little to no impact on the net results such as polymer addition, screw conveyors, mask-o-zoll, pug mills, tertiary filtration, and disinfection are not included in the model set-up. In addition, the current APC bypass practice to the MSBR and subsequent bleeding of stored wastewater from the MSBR to the bioreactor were not considered as part of the main process and, therefore, were excluded from the model. Stantec then used the available WWTP operating conditions to calibrate/verify the model before using it in subsequent evaluations.

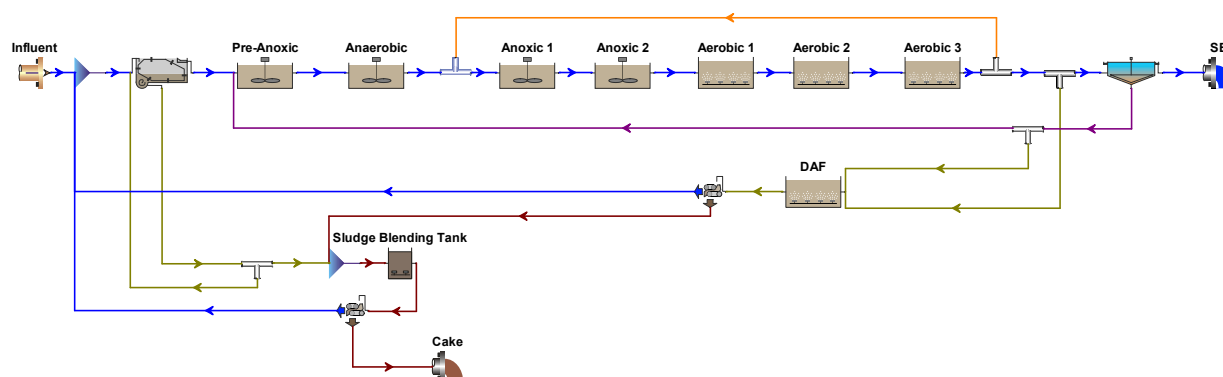


Figure 3.1 BioWin Model Process Flow Diagram

3.4.1.1 Supplemental Sampling

The next step in developing the BioWin™ process model was to evaluate the historical characterization of the influent wastewater and the operating parameters of the liquid and solids streams at the WWTP. The evaluation identified certain data gaps that were communicated to EPCOR and used as a basis to conduct a series of supplemental sampling events. Supplemental sampling was conducted for 3 weeks from May 26, 2015 through June 15, 2015. Table 3.10 through Table 3.13 list the results of the collected samples.

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Table 3.10 Supplemental Sampling Results – Raw Influent/Final Effluent

Date	Raw Influent								FE	
	BOD _{Inhibited} mg/L	COD mg/L	TSS mg/L	FSS mg/L	VSS mg/L	TKN mg- N/L	Ortho-P mg- P/L	Total Alkalinity mg/L as CaCO ₃	pH	COD mg/L
2015-05-26	173	620	242	38	204	47.3	2.5	375	7.64	33
2015-05-28	327	496	290	76	214	50.1	2.4	369	7.63	32
2015-05-31	290	586	108	<10	108	50.6	2.1	363	7.57	36
2015-06-02	288	620	416	31	384	48.8	2.9	385	7.55	37
2015-06-04	191	495	279	35	244	44.1	3.1	383	7.66	38
2015-06-07	289	618	230	38	192	47.7	4.1	407	7.57	38
2015-06-09	244	526	271	26	245	48.9	3.1	641	7.40	34
2015-06-11	202	532	292	40	252	42.6	3.1	364	7.37	25
2015-06-14	230	581	302	22	280	45.5	3.0	363	7.54	35

Table 3.11 Supplemental Sampling Results – Primary/Secondary Effluent

Date	Primary Effluent						Secondary Effluent						
	BOD _{Inhibited} mg/L	TSS mg/L	TAN mg- N/L	TKN mg- N/L	BOD ₅ mg/L	COD mg/L	TSS mg/L	VSS mg/L	TAN mg- N/L	TKN mg- N/L	NO ₃ mg- N/L	TP mg- P/L	Ortho- P mg-P/L
2015-05-27	190	105	40.3	63.6	<4	32	3	3	<0.05	1.03	4.71	0.13	0.01
2015-05-29	172	98	43.9	62.2	<4	24	27	4	0.05	1.70	5.15	0.17	0.01
2015-06-01	239	154	35.2	60.0	<4	36	7	7	0.05	1.19	3.96	0.17	<0.01
2015-06-03	208	76	34.3	49.8	<4	41	6	6	0.08	0.90	4.52	0.22	0.02
2015-06-05	148	95	32.6	46.6	<4	37	38	11	0.10	0.83	4.71	0.22	0.02
2015-06-08	206	127	35.7	61.2	<4	35	6	6	0.06	1.23	3.80	0.19	<0.01
2015-06-10	167	93	35.7	57.5	<4	34	3	3	0.08	2.19	3.90	0.22	0.01
2015-06-12	158	124	41.4	62.0	<4	44	36	11	0.08	1.34	4.17	0.23	0.02
2015-06-15	224	168	36.4	55.5	<4	32	3	3	0.10	1.15	3.55	0.17	0.04

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Table 3.12 Supplemental Sampling Results – DAF

Date	DAF Supernatant								TWAS			
	BOD ₅ mg/L	COD mg/L	TSS mg/L	VSS mg/L	TAN mg-N/L	TKN mg-N/L	TP mg-P/L	Ortho-P mg-P/L	Total Alkalinity mg/L as CaCO ₃	pH	TS mg/L	VS mg/L
2015-05-27	11	58	20	17	0.14	1.75	0.85	0.02	240	8.07	No Data	No Data
2015-05-29	5	47	50	20	0.06	2.05	1.21	0.02	240	7.75	22,500	5,600
2015-06-01	14	65	32	27	0.26	2.39	1.89	0.64	243	7.63	20,100	4,900
2015-06-03	25	92	57	41	0.77	3.90	5.50	2.92	236	7.50	18,400	3,500
2015-06-05	6	59	29	24	0.15	1.29	1.33	0.10	235	7.83	25,600	6,100
2015-06-08	135	254	270	270	0.13	4.89	8.50	0.09	244	7.70	17,600	3,700
2015-06-10	27	80	43	40	0.74	4.21	6.17	3.69	248	7.67	18,200	4,200
2015-06-12		77	54	30	0.08	2.18	0.89	0.02	206	7.85	20,500	4,600
2015-06-15	29	99	44	44	1.34	4.38	7.44	5.40	237	7.54	16,500	3,700

Table 3.13 Supplemental Sampling Results – Centrate

Date	BOD ₅ mg/L	BOD Inhibited mg/L	COD mg/L	TSS mg/L	FSS mg/L	VSS mg/L	TAN mg-N/L	TKN mg-N/L	TP mg-P/L	Ortho-P mg-P/L	Total Alkalinity mg/L as CaCO ₃	pH
2015-05-27	512	483	990	353	33	320	51.9	106.0	194	214	487	6.96
2015-05-29	459	399	1,060	416	<16	416	40.0	91.9	261	183	453	6.77
2015-06-01	420	360	1,150	417	<22	417	38.0	89.9	288	183	460	6.72
2015-06-03	390	357	1,180	435	<25	435	37.1	84.0	206	160	463	6.76
2015-06-05	347	367	1,150	677	205	473	38.0	75.2	196	174	455	6.91
2015-06-08	639	520	1,650	232	<13	232	49.0	103.0	616	248	496	6.56
2015-06-10	390	393	1,260	414	24	390	38.0	84.8	247	189	473	6.74
2015-06-12	344	210	1,270	525	325	200	43.0	83.2	181	163	326	6.61
2015-06-15	468	483	1,410	395	<25	395	45.0	92.7	220	212	467	6.59

Stantec used the supplemental sampling program results to supplement influent wastewater and solids handling facilities recycle streams characterization; and to estimate solids removal efficiency across the APC as summarized in Table 3.14.

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Table 3.14 Wastewater Characterization based on Supplemental Sampling Program

Parameter	Unit	Range	Average
<u>Raw Influent</u>			
COD/BOD ₅	--	1.6 – 2.2	1.9
VSS/TSS	--	0.74 – 1.00	0.88
Ortho-P/TP	--	0.33 – 0.69	0.48
TAN/TKN	--	0.54 – 0.74	0.60
Total Alkalinity	mg/L as CaCO ₃	363 – 641	406
<u>Primary Effluent</u>			
BOD Removal	%	3% – 65%	41%
TSS Removal	%	29% – 74%	58%

3.4.1.2 Calibration/Verification

Stantec used influent loadings from November 24, 2012 through December 23, 2012 as well as wastewater characterization parameters listed in Table 3.14 to calibrate the BioWin™ model. The model was initially evaluated by simulating and comparing results using model default kinetic and stoichiometric parameters with observed biological solids production, Mixed Liquor Suspended Solids (MLSS) concentrations, and activated sludge wasting rates. Kinetic and stoichiometric parameters were then adjusted until reasonable fit was achieved between the model and the WWTP data. Table 3.15 lists the adjustments made to these parameters.

Table 3.15 Adjusted BioWin™ Parameters

	Unit	Default	Adjusted
<u>Kinetic Parameters</u>			
Ammonia Oxidizing Bacteria (AOB) Max. Specific Growth Rate	1/d	0.90	0.75
<u>Stoichiometric Parameters</u>			
Particulate Substrate COD:VSS Ratio	mg COD/ mg VSS	1.60	1.63
Particulate Inert COD:VSS Ratio	mg COD/ mg VSS	1.60	1.63

To verify the applicability of the model, Stantec modeled a separate set of influent loadings during a warmer weather condition from July 16, 2013 through August 15, 2013. A reasonable fit was achieved between the model and the WWTP data without further adjustments beyond what is listed in Table 3.15.

Table 3.16 summarizes the results of the calibration/verification model simulations as compared to WWTP data.

Based on the calibration/verification model response, Stantec assumed that the model can reasonably predict WWTP operating conditions and effluent concentrations and is applicable for further use. The kinetic and stoichiometric parameters determined during the calibration phase became the basis for all subsequent computer simulations.



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Table 3.16 BioWin™ Model Calibration and Verification Responses

Parameter	Unit	Calibration			Verification		
		2012-11-24 to 2014-12-23		Model Response	2013-07-16 to 2013-08-15		Model Response
		Range	Average		Range	Average	
Raw Influent							
ADF	m³/d	5,446 – 6,442	5,882	5,882	5,709 – 6,851	6,442	6,442
COD	mg/L	--	--	739	--	--	689
BOD ₅	mg/L	255 – 498	358	358	208 – 436	313	313
TSS	mg/L	192 – 428	268	268	184 – 364	236	236
VSS	mg/L	--	--	236	--	--	208
TKN	mg-N/L	--	--	52	--	--	50
TAN	mg-N/L	30 – 47	34	34	28 – 32	30	30
TP	mg-P/L	5.8 – 9.0	6.7	6.7	5.6 – 7.3	6.1	6.1
Ortho-P	mg-P/L	--	--	3.2	--	--	2.9
Alkalinity	mM as CaCO ₃	--	--	8.1	--	--	8.1
pH		7.9 – 8.6	8.4	8.4	7.9 – 8.5	8.3	8.3
Temperature	°C	7.9 – 16.3	13.9	13.9	14.8 – 18.3	16.6	16.6
Activated Primary Clarifier							
Surface Area	m²		882	882		882	882
SWD	m		4.18	4.18		4.18	4.18
Blanket Depth	m	--	--	1.5	0.9 – 1.5	1.2	1.2
COD _{PE}	mg/L	--	--	543	--	--	528
BOD _{5PE}	mg/L	--	--	299	--	--	278
TSS _{PE} *	mg/L	108 – 140	124	118	106 – 116	111	116
VSS _{PE}	mg/L	--	--	103	--	--	102
TKN _{PE}	mg-N/L	--	--	44	--	--	39
TAN _{PE}	mg-N/L	--	--	34	--	--	30
TP _{PE}	mg-P/L	--	--	5	--	--	5
Ortho-P _{PE}	mg-P/L	--	--	4	--	--	3
VFA _{PE} *	mg/L	52 – 73	60	67	35 – 48	45	56
PS	m³/d	--	--	26	--	--	19
PS*	%	2.5% – 3.1%	2.8%	2.8%	3.1% – 3.8%	3.5%	3.3%
Bioreactor							
MLVSS	mg/L	--	--	2,619	2,030 – 2,570	2,287	2,498
MLSS	mg/L	2,870 – 3,345	3,050	3,056	2,515 – 3,750	2,978	2,856
Solids	kg	--	--	12,707	--	--	11,808
HRT	h	--	--	17	--	--	15
SRT	d	9.8 – 17.9	11	11	7.4 – 25.6	9	9
Sludge Yield	g VSS/g BOD ₅	--	--	0.45	--	--	0.53
Internal	%	--	--	300%	--	--	300%



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Parameter	Unit	Calibration			Verification		
		2012-11-24 to 2014-12-23	Model Response	Range	Average	Range	Model Response
		Range					
Recycle							
Oxygen Requirements	kg-O ₂ /h	--	--	84	--	--	85
<u>Secondary Clarifier</u>							
RAS	m ³ /d	--	--	5,882		7,040	7,040
RAS	mg/L	--	--	6,104	--	--	5,429
WAS	m ³ /d	226 – 417	363	362	151 – 534	429	429
WAS	mg/L	2,870 – 3,300	3,045	3,056	2,670 – 3,940	3,109	2,838
WAS	kg/d	705 – 1,231	1,105	1,105	548 – 1,869	1,327	1,218
<u>Effluent Quality</u>							
BOD ₅	mg/L	2.0 – 2.8	2.1	2.2	2.0 – 2.8	2.1	2.3
TSS	mg/L	2.5	2.5	3.8	2.5	2.5	4.2
TAN*	mg-N/L	0.5 – 1.0	0.6	0.7	0.5	0.5	0.6
NO _x *	mg-N/L	6.1 – 8.7	7.6	5.6	4.8 – 5.8	5.2	4.6
TKN*	mg-N/L	1.1 – 2.5	1.7	2.8	0.6 – 2.8	1.6	2.6
TN*	mg-N/L	8.6 – 10.1	9.4	8.4	5.9 – 8.6	6.8	7.2
TP	mg-P/L	0.09 – 0.17	0.1	0.1	0.05 – 0.15	0.1	0.2
<u>DAF</u>							
<u>TWAS</u>							
Flow	m ³ /d	--	--	40	--	--	32
Solids*	%	2.3% – 3.1%	2.7%	2.7%	3.7% – 4.1%	3.9%	3.8%
<u>Subnatant</u>							
Flow	m ³ /d	--	--	322	--	--	397
Solids*	mg/L	14 – 24	19	51	19 – 28	24	23
<u>Centrifuge Feed</u>							
Solids*	%	2.7% – 2.9%	2.8%	2.8%	3.2%	3.2%	3.6%
<u>Cake</u>							
Solids*	%	19.8% – 20.5%	20.2%	20.4%	22.3% – 22.7%	22.5%	22.6%
<u>Centrate</u>							
Flow	m ³ /d	--	--	57	--	--	43
TSS*	mg/L	260 – 300	280	281	170 – 240	205	200
VSS	mg/L	--	--	239	--	--	172
TKN	mg-N/L	--	--	194	--	--	296
TAN	mg-N/L	--	--	173	--	--	281
TP	mg-P/L	--	--	83	--	--	95
Ortho-P	mg-P/L	--	--	77	--	--	91

* Based on less than 5 data points

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3.4.2 Capacity Evaluation

Stantec used the annual average loading condition as a basis for the capacity evaluation of the secondary system as summarized in Table 3.18.

Table 3.17 Annual Average (AA) and Maximum Month (MM) Loading Condition

Parameter	Unit	AA	MM
BOD ₅	kg/d	2,022	2,860
TSS	kg/d	1,788	3,773
TAN	kg-N/d	170	176
TP	kg-P/d	43	54

For the purpose of this evaluation, Stantec used the calibrated BioWin™ model and incrementally increased loadings to the bioreactors. The models were run under winter (@ 12 °C) and summer conditions (@ 20 °C). The model outputs were monitored and compared against the following boundary limits whichever is reached first:

- Available blower capacity of 130 Nm³/min;
- Effluent discharge limits as stipulated in the WWTP Approval to Operate;
- Secondary Clarifier Surface Overflow Rate (SOR) of 29 m³/m²/d (WEF MOP, 2010); and
- Secondary Clarifier Solids Loading Rate (SLR) of 176 kg/m²/d (WEF MOP, 2010).

Table 3.18 shows the performance of the existing process configuration under current influent loadings and compares it to potential maximum loadings that the bioreactors can handle. Summer conditions were used to determine maximum air requirements while winter conditions were used to estimate the treatment capacity of the bioreactors.

Table 3.18 Bioreactors Treatment Capacity

Parameter	Unit	Current – Winter	Current – Summer	Capacity – Winter	Capacity – Summer
Raw Influent					
COD	kg/d	4,448	4,448	7,238	7,238
BOD ₅	kg/d	2,022	2,022	3,290	3,290
TSS	kg/d	1,788	1,788	2,910	2,910
VSS	kg/d	1,574	1,574	2,561	2,561
TKN	kg-N/d	289	289	470	470
TAN	kg-N/d	170	170	310	310
TP	kg-P/d	43	43	70	70
Ortho-P	kg-P/d	21	21	34	34
Alkalinity	mM as CaCO ₃	8.1	8.1	8.1	8.1
pH		8.1	8.1	8.1	8.1
Temperature	°C	12	20	12	20

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Parameter	Unit	Current – Winter	Current – Summer	Capacity – Winter	Capacity – Summer
Activated Primary Clarifier					
Surface Area	m ²	882	882	882	882
SWD	m	4.18	4.18	4.18	4.18
Blanket Depth	m	1.5	1.5	1.5	1.5
COD _{PE}	mg/L	516	507	514	512
BOD _{5PE}	mg/L	275	269	273	271
TSS _{PE}	mg/L	125	123	125	124
VSS _{PE}	mg/L	109	107	109	109
TKN _{PE}	mg-N/L	40	39	40	40
TAN _{PE}	mg-N/L	31	31	31	31
TP _{PE}	mg-P/L	6	6	5	6
Ortho-P _{PE}	mg-P/L	4	4	4	4
VFA _{PE}	mg/L	75	69	67	60
PS	m ³ /d	24	24	40	40
PS	%	3.5%	3.5%	3.6%	3.6%
Bioreactor					
MLVSS	mg/L	2,926	1,993	3,807	3,187
MLSS	mg/L	3,452	2,406	4,418	3,831
Solids	kg	14,322	9,982	18,334	15,894
HRT	h	16	16	10	10
SRT	d	12	9	9	9
Sludge Yield	g VSS/g BOD ₅	0.49	0.44	0.51	0.43
Internal Recycle	%	250%	250%	250%	250%
Oxygen Requirements	kg-O ₂ /h	75	79	113	128
	Nm ³ /min*	40	42	60	68
Secondary Clarifier					
RAS	m ³ /d	6,145	6,145	10,000	10,000
RAS	mg/L	6,895	4,804	8,823	7,649
WAS	m ³ /d	336	448	443	442
WAS	mg/L	3,452	2,406	4,418	3,831
WAS	kg/d	1,161	1,079	1,957	1,693
SOR	m ³ /m ² /d	10	10	16	16
SLR	kg/m ² /d	85	60	176	152
Effluent Quality					
BOD ₅	mg/L	2.1	2.3	3.8	3.6
TSS	mg/L	4.0	3.9	7.5	7.3
TAN	mg-N/L	1.3	0.2	4.5	0.2
NO _x	mg-N/L	5.3	5.7	4.2	5.7
TKN	mg-N/L	3.2	2.4	6.6	2.6

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Parameter	Unit	Current – Winter	Current – Summer	Capacity – Winter	Capacity – Summer
TN	mg-N/L	8.4	8.1	10.8	8.3
TP	mg-P/L	0.1	0.2	0.2	0.3
DAF					
<u>TWAS</u>					
Flow	m ³ /d	34	29	55	44
Solids	%	3.4%	3.6%	3.5%	3.7%
<u>Subnatant</u>					
Flow	m ³ /d	303	419	388	398
Solids	mg/L	57	38	75	63
<u>Centrifuge</u>					
<u>Feed</u>					
Solids	%	3.4%	3.6%	3.5%	3.7%
<u>Cake</u>					
Solids	%	22.2%	22.8%	23.1%	22.4%
<u>Centrate</u>					
Flow	m ³ /d	50	46	81	71
TSS	mg/L	573	590	597	626
VSS	mg/L	486	496	511	528
TKN	mg-N/L	206	231	171	194
TAN	mg-N/L	167	191	132	153
TP	mg-P/L	113	177	68	136
Ortho-P	mg-P/L	100	163	55	122

* Oxygen capacity in Nm³/min was calculated assuming WWTP elevation of 1,045 m; wastewater temperature of 20 °C; diffusers submergence of 6 m; α of 0.65; β of 0.90; and oxygen transfer efficiency of 27%.

Table 3.18 suggests that the existing secondary system is almost at capacity at the maximum month BOD₅ loading conditions. At this condition, the secondary system is capable of treating wastewater for an EP of 31,440 which is expected to be reached by year 2017. Solids loading to the secondary clarifier appears to be the factor limiting the capacity of the secondary system.

The solids loading analysis was based on literature-recommended maximum solids loading rates to the secondary clarifiers. Site-specific determination of secondary sludge settling characteristics is highly recommended to evaluate the true performance capacity of the secondary clarifiers and when upgrades are required.

3.4.3 Alum Trim

Okotoks WWTP uses alum to trim effluent phosphorus concentration to approximately 0.2 mg-P/L. The alum trim system consists of one (1) alum tote and two (2) diaphragm metering pumps (1 duty and 1 standby). Alum is dosed into the 600-mm bioreactor effluent line going to the secondary clarifier.

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Table 3.20 summarizes the basis of design of the alum trim system.

Table 3.19 Alum Trim Basis of Design

Item	Unit	Basis of Design
<u>Alum Tank:</u>		
Tag		TK-315
Capacity	L	1,000
<u>Alum Feed Pumps:</u>		
Tag		P-391/P-392
Installed Capacity	L/h	58.4
Firm Capacity	L/h	29.2
Head	m	71

3.5 TERTIARY FILTRATION

Three (3) Kruger/Hydrotech disc filtration units (2 duty + 1 standby) provide tertiary filtration to the secondary effluent prior to disinfection. The filter units were designed to allow for filtration rates of 194 L/min/m² at PHF.

Based on disk filters configuration (2 duty + 1 standby) and allowable filtration rate, the firm capacity was calculated and compared to historical flow information to determine the available capacity for the filtration system. Results show that the firm capacity of the existing filtration systems with two units in operation is exceeded by 57 m³/h (i.e. -57 m³/h), or by 6% at PHF conditions.

Based on these results, PHF capacity has already been reached at the current population.

Table 3.20 summarizes the basis of design of the tertiary filtration system.

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Table 3.20 Tertiary Filtration Basis of Design

Item	Unit	Basis of Design
Model		HSF2212-IF
Quantity		3 (2 Duty + 1 Standby)
No. of Discs per Unit		12
Submerged Area/Unit	m ²	44
Allowable Filtration Rate @ PHF	L/min/m ²	194
Installed Capacity	m ³ /h	1,536
Firm Capacity	m ³ /h	1,024
Historical PHF	m ³ /h	1,081
Excess Capacity	m ³ /h	-57
Time to Reach Firm Capacity		Reached

3.6 UV DISINFECTION

Two (2) banks of Wedeco Ultra Violate (UV) disinfection system are installed downstream of the tertiary filtration units. The UV disinfection system operates with a total of 112 UV lamps located along one (1) channel with 2 banks in series per channel.

Based on existing UV configuration and flow rate, the firm capacity was estimated assuming one bank is out of service and compared to historical flow information to determine the available capacity for the UV system. Results show that the capacity of the existing UV systems with one bank offline is exceeded by 569 m³/h (i.e. -569 m³/h).

Table 3.21 summarizes the basis of design of the UV system.

Table 3.21 UV Basis of Design

Item	Unit	Basis of Design
No. of UV Channels		1
No. of Banks per UV Channel		2
No. of Modules per Banks		7
No. of Lamps per Module		8
Total No. of Lamps		112
Approach Channel Width	mm	1,030
UV Channel Width	mm	770
Outlet Channel Width	mm	1,524
Channel Depth	mm	915
Cross Sectional Area	m ²	0.705

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Item	Unit	Basis of Design
Target Fecal Coliform	MPN/mL	100
UV Dose	μWs/cm ²	40,000
UV Transmittance @ 253.7 nm	%	65%
Design Loading Rate	L/min/lamp	152
Installed Capacity	m ³ /h	1,024
Firm Capacity	m ³ /h	512
Historical PHF	m ³ /h	1,081
Excess Capacity (one unit offline)	m ³ /h	-569
Time to Reach Firm Capacity		Reached

A more thorough evaluation of the UV system is recommended using UV Bioassay Validation procedure to determine the most efficient UV dose at various flow rates and water qualities.

3.7 SOLIDS HANDLING

3.7.1 Primary Sludge (PS)

The APC system is also used to produce a sufficient and steady supply of short chain VFAs by way of PS fermentation. These VFAs are required for biological phosphorus removal mechanism within the bioreactors. Excess VFAs not consumed in the biological phosphorus removal process can also be used as an internal carbon source to enhance the denitrification process in the anoxic zone.

The fermentation process of the settled PS typically occurs over a period of 4 to 8 days of storage in anaerobic conditions depending on temperature. A sludge blanket of 1-2 m is required within the clarifier to provide sufficient SRT. Hydrolysis along with naturally occurring micro-organisms will break down organics and produce VFAs, such as acetic, propionic and butyric acids.

Recirculation pumps recirculate fermented sludge from underflow of the APC and back to APC inlet channel. This process helps to ensure proper mixing of the microorganisms with organics in the sludge to optimize the fermentation process and help liberate VFA into solution.

The existing APC equipment was summarized in Table 3.5 as part of the liquid stream evaluation.

3.7.1.1 Process Evaluation

Table 3.22 summarizes the fermentation performance in the APC based on historical data (2010 – 2014).

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Table 3.22: APC System Fermentation Performance

Parameter	Unit	Design	2010 - 2015
Average Daily Flow Rate	m ³ /d	10,000	6,193
Solids in APC Influent	mg/L	--	332 ¹
Solids in APC Effluent	mg/L	--	199 ¹
Total Primary Solids	kg/d	--	1,032 ²
Sludge Blanket	m	1 – 2	0.6 – 3.0
Solids Inventory	kg	6,840 ³	--
Sludge Retention Time	d	5 – 10	5.6 ⁴
VFA Production	mg/L (kg/d)	--	58 (356) @ average flow
VFA Production	mg/L (kg/d)	--	48 (329) @ maximum month flow
VFA Required	mg/L (kg/d)	--	21 (130) @ average flow
Average Condition			
Influent Total Phosphorus	kg/d	--	39 ⁵
Total P for Cell Synthesis	kg/d	--	12.2 ⁶
Total P in Effluent	kg/d	--	3.0 ⁷
Total P Available for EBPR	kg/d	--	23.7 ⁸
VFA Required	mg/L (kg/d)	--	17.3 (106.6) @ average flow ⁹
Maximum Month Condition			
Influent Total Phosphorus	kg/d	--	54 ⁵
Total P for Cell Synthesis	kg/d	--	18.6 ⁶
Total P in Effluent	kg/d	--	4.7 ⁷
Total P Available for EBPR	kg/d	--	30.8 ⁸
VFA Required	mg/L (kg/d)	--	14.9 (138.5) @ average flow ⁹

1. From operations data (2010 – 2014). BOD in APC effluent assumed to be 40% of BOD in influent.

2. Calculated based on (solids in – solids out) x average flow rate.

3. Calculated based on APC area of 190 m² and assuming a sludge blanket of 2 m.

4. Calculated as solids inventory/total primary solids wasted.

5. From TM # 1 – Design Basis Memorandum.

6. Assumes 1kg P is used per 100 kg BOD (199 mg/L BOD to Bioreactor – from data).

7. Assuming Effluent TP of 0.5 mg/L.

8. Calculated as Influent Total P – Total P for Cell Synthesis – effluent Total P

9. Calculated based on 4.5 kg VFA/ kg P.

Table 3.22 indicates that the existing APC is operating sufficiently as a fermenter at average flow and maximum month flow conditions. Stantec estimated the historical average and maximum month VFA productions as 356 kg/d and 329kg/d, respectively. The enhanced biological phosphorus removal (EBPR) process at the WWTP requires approximately 106 kg/d and 138 kg/d of VFA at average and maximum month conditions, respectively.

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Therefore, based on the liquid and solids assessments, the APC's process capacity is limited by the liquid stream clarification capacity as illustrated in Table 3.7.

3.7.1.2 Future Upgrade Requirements

Based on the performance of the existing fermentation system, phosphorous load to the WWTP could increase 2.5 times before additional fermentation capacity is required. This is expected to occur in 2046 at an equivalent population of 68,327 people.

3.7.2 WAS Thickening – Dissolved Air Flotation (DAF)

A single DAF unit is used to thicken Waste Activated Sludge (WAS) to about 3.0 to 4.0% solids concentration. The DAF process consists of a single tank and a pressurization system consisting of two recycle pumps, saturation tank, and two compressors. The arrangement does not provide any standby capacity for when the DAF tank is taken offline.

WAS is typically pumped from aerobic zone 3 of the bioreactor to the DAF unit. It can also be wasted from the RAS line serving the secondary clarifier. DAF tank effluent (subnatant) is recycled back to the APC. A portion of the subnatant is sent to a compressed air tank before it is recycled back to the DAF inlet. The air-saturated mixture is then released into the WAS feed piping through a flow control valve just ahead of DAF tanks inlet. As the air-saturated mixture returns to near atmospheric pressure in the feed piping and tank, the depressurized air is released as fine bubbles throughout the liquid volume. These fine bubbles attach to the sludge particles, causing them to float to the water surface. The float, or thickened sludge, is removed by a surface skimmer. Thickened sludge is discharged to the Sludge Blend Tank for blending with PS prior to being fed to the centrifuge.

Table 3.23 and Table 3.24 summarize the design basis and criteria of the existing DAF system, respectively.

Table 3.23: DAF Equipment Basis of Design

Parameter	Unit	Value
Dimensions		
Length	m	6.9
Width	m	2.6
Depth	m	2.9
Area	m ²	17.9
Volume	m ³	52
Skimmer Power	kW	0.37
Compressor Power	kW	3.7
Recycle Pump Power	kW	18.5

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Table 3.24: DAF Design Criteria

Parameter	Unit	Value
Water Temperature	°C	10 – 20
WAS Loadings (Max Month)		
@2,600 mg/L (summer)	kg/d	1,650
	m ³ /d	635
@4,200 mg/L (summer)	kg/d	1,165
	m ³ /d	278
Surface Solids Loading Rate (without polymer)	kg/m ² /h	4.4
Air to Solids Ratio		0.02 to 0.04
Performance Criteria		
TWAS Concentration (without polymer)	%	3.0% min
Solids Capture (without polymer)	%	85% min

3.7.2.1 Process Evaluation

Table 3.25 summarizes the DAF system performance based on historical data (2010 – 2014).

Table 3.25: DAF System Performance

Parameter	Unit	Design	2010 - 2015
Maximum WAS Solids (Max Month)	kg/d	1,894 ¹	1,800 ²
WAS Volume (Max Month)	m ³ /d	Not Specified	490
Tank Solids Loading	kg/m ² /d	4.4	4.2
Hydraulic Loading	L/m ² /s	1.4 ³	0.3
TWAS concentration	%	3.0 – 4.0%	3.3%
Solids Capture	%	85%	99% ⁴

1. Calculated based on Area of DAF x 4.4 kg/m²/hr (max loading rate without polymer)
2. From data collected between 2010 and 2015 (not including data during flood 2013 flood event).
3. Water Environment Federation (WEF) Manual Of Practice No. 8
4. Calculated based on average TSS in DAF subnatant of 30.4 mg/L and average WAS solids concentration of 3,273 mg/L (0.33%) from operations data.

Comparing the design criteria to the actual operating data from 2010 to 2015, the existing DAF system is operating more efficiently than the original design expectation but is close to its process capacity. At current DAF operation, the DAF has sufficient capacity to accommodate a solids loading rate up to 4.2 kg/m²/d while producing a TWAS of 3.3% solids at an estimated average solids capture rate of 99% without polymer addition. Typical DAF solids loading rates found in literature² state that without chemical addition the solids loading rate should be between 2 – 5 kg/m²/h.

² WEF Manual of Practice No. 8. Design of Municipal Wastewater Treatment Plants (5th Edition)

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Polymer addition to DAF could also be implemented to increase process efficiency. This would have to be confirmed with bench testing.

3.7.2.2 Future Upgrade Requirements

The existing DAF system is nearing the recommended design capacity of 4.4 kg/m²/d. It may be possible to increase the process capacity by adding polymer. However, it is recommended that an additional DAF system be installed to add redundancy to the system. Table 3.26 summarizes the DAF system capacity and required expansions based on the existing systems design parameters.

Table 3.26: Future DAF Expansion Requirements

Parameter	Solids Loading Rate	Total Solids Processed	Service Population
Current System – 1 DAF	4.2 kg/m ² /d	1,800 kg/d	27,331 (2014)
Total System Capacity - 1 DAF	4.4 kg/m ² /d	1,894 kg/d	28,765 (2015)
Total System Capacity - 2 DAFs	4.4 kg/m ² /d	3,788 kg/d	57,630 (2037)
Total System Capacity - 3 DAFs	4.4 kg/m ² /d	5,683 kg/d	86,296 (2060)

As seen from Table 3.26, the service population (and subsequent WAS generation rate) will exceed the existing design capacity for the DAF around 2015 – 2016 at maximum month conditions. It is possible to continue to exceed the recommended solids loading rate to the DAF, but this will result in decreased process efficiency. A second DAF system would provide sufficient process capacity until 2037 and a third system would provide sufficient capacity until 2060.

Furthermore, polymer addition could be evaluated (bench testing) to help increase service capacity of the DAF system, and could delay future expansion requirements.

3.7.3 Blend Tank

One (1) sludge blend tank is used to mix and store TWAS and PS before it is pumped to the centrifuge system for dewatering. Within the sludge blend tank, there are two submersible horizontal propeller mixers which thoroughly mix the sludge. Two sludge feed progressive cavity pumps (duty/standby) transfer blended sludge to the centrifuge and are started manually by an operator. The pumps will automatically stop on a preset low liquid level or if the centrifuge has stopped. The flow rate is set by the centrifuge system and controlled via variable frequency drives on the pumps.

Table 3.27 summarizes the existing Blend Tank basis of design.

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Table 3.27: Blend Tank Basis of Design

Parameter	Unit	Value
Dimensions		
Diameter	m	8.3
Depth	m	3.3
Tank Area	m ²	27.4
Tank Volume	m ³	178.6
Mixer Power	kW	2.96
Sludge Pump Power	kW	5.55
Pump Capacity	L/s	4.2
Pump TDH	m	9
Solids Concentration	%	2.3 – 4

3.7.3.1 Process Evaluation

Table 3.28 summarizes the capacity of the existing Sludge Blend Tank based on historical data (2010 – 2014).

Table 3.28: Sludge Blend Tank Capacity

Parameter	Unit	Value
Total Sludge Storage Volume	m ³	178.6
PS Volume	m ³ /d	34
TWAS Volume	m ³	56 ¹
Total Sludge Volume	m ³	90 m3
Storage Capacity	d	1.98
Current Population	capita	27,331
Daily Sludge Production/Capita	m ³ /d/capita	0.0033
Population Service Capacity	capita	54,071

1. Calculated based on a WAS of 1,800 kg/d at an average solids concentration of 3.3%

Based on current storage capacity and sludge production rate, the Sludge Blend Tank can store TWAS and PS for up to 2 days. The Sludge Blend Tank would be able to accommodate all sludge produced at the WWTP until population exceeds 54,071 people (in 2035).

Discussions with WWTP staff have stated that they do not draw the tank down below 40% of total tank volume. Below this set point the existing mixers will be exposed and will not be able to maintain adequate sludge mixing. In order to utilize the entire tank capacity, modifications to the mixing system are recommended. This could include changing the type of mixers and their location or the addition of a submersible mixing pump.

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3.7.3.2 Future Upgrade Requirements

Table 3.29 summarizes the future upgrade requirements.

Table 3.29: Future Sludge Blend Tank Requirements

Parameter	Unit	Value
Total Sludge Storage Volume	m ³	178.6
Daily Sludge Production/Person	m ³ /d/capita	0.0033
Ultimate Population (2065)	capita	92,178
Total Storage Required	m ³	304.4
Existing Storage	m ³	178.6
Additional Storage Required	m ³	125.8

In order to blend PS and TWAS past the year 2035 a second blend tank will be required. To accommodate the total volume of sludge generated at the ultimate design population an additional 125.8 m³ of storage is required.

3.7.4 Centrifuge

The centrifuge system is used to dewater the blended sludge prior to being mixed with woodchips and sent for composting. Sludge is fed into the a single Alfa Laval centrifuge via the blended sludge pumps, mixed with polymer, and then accelerated using rotational forces. The solids separate to the wall of the bowl and are removed from the centrifuge by the internal scroll. Dewatered sludge is collected by a screw conveyor where it is then transported to the Pug Mill Mixers. The separated liquid (i.e. centrate) discharges back to the APC.

Table 3.30 summarizes the basis of design of the existing centrifuge.

Table 3.30: Centrifuge Basis of Design

Parameter	Unit		Value
Diameter	mm	353	
Length	mm	1,460	
Centrifuge Capacity			
Volume	m ³ /h	14.3	
Solids	kg/h	526	
Sludge Blend			
TWAS	%	60% to 65%	
Undigested Primary Solids	%	35% to 40%	
Operational Mode		8 hr/d - 7 days a week	
Design Feed Solids Concentration	%	3 – 4%	
Sludge Cake Concentration	%	25%	
Solids Capture Rate	%	95%	
Main Drive Power	kW	14.8	
Backdrive Power	kW	5.55	



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3.7.4.1 Process Evaluation

Table 3.31 summarizes the centrifuge capacity based on historical data (2010 – 2014).

Table 3.31: Centrifuge Process Evaluation

Parameter	Unit	Value
Centrifuge Capacity (by Volume) @ 8 h operation	m ³ /d	114.4
Centrifuge Capacity (by Solids) @ 8 h operation	kg/d	4,208
Blended Sludge Volume (current)	m ³ /d	90
Excess Capacity	m ³ /d	24.4 (21%)
Volume of Sludge per capita	m ³ /d/capita	0.003
Blended Sludge Solids (current)	kg/d	2,6101
Excess Capacity	kg/d	1,598 (38%)
Volume of Sludge per capita	kg/d/capita	0.96

1. Average blended solids concentration of 2.9% (operations data 2010-2014)

Based on the current process capacity, the existing centrifuge system is limited by the volume of sludge that it can process and not by solids processing capacity. From the current sludge volume production per capita, the existing centrifuge system will be able to process sludge until the population exceeds 36,644 people (in 2021).

3.7.4.2 Future Upgrade Requirements

The centrifuge has sufficient capacity to process the blended sludge until 2021. Table 3.32 summarizes the future upgrade requirements for this system assuming similar sized centrifuges are installed.

Table 3.32: Future Centrifuge Capacity

Parameter	Unit	Value
Daily Sludge Production/Person (m ³ /d/capita)	m ³ /d/capita	0.0033
Ultimate Population (2065)	capita	92,178
Total Sludge Production in 2065 (m ³)	m ³	304.4
Capacity of Centrifuge by Volume (operated 8 hours/ day)	m ³ /d	114.4
Process Capacity 2 Centrifuges	m ³ /d	228.8
Service Population	capita	69,289 (2047)
Process Capacity 3 Centrifuges	m ³ /d	343.2
Service Population	capita	103,933 (2065+)

In order to thicken blended sludge past the year 2021 and the WWTP will either require a second centrifuge, or modified operations to run the centrifuge system longer than 8 hours a day. Since there is no standby centrifuge capacity, Stantec recommends to install a second centrifuge

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prior to modifying operations. With a second centrifuge, the WWTP would be able to process blended sludge through to 2047.

3.7.5 Screw Conveyor

Dewatered sludge from the centrifuge discharges to a single screw conveyor which transfers the sludge to the Pug Mill Mixers. The conveyor has two discharge ports equipped with pneumatic gates, one to each mixer, to allow operators to select which mixer receives dewatered sludge. Control of the conveyor is interlocked with the centrifuge Programmable Logic Controller (PLC). Once the centrifuge shuts down, the conveyor continues to run of a preset time to remove the sludge before it shuts down.

Table 3.33 summarizes the design information of the existing dewatered sludge conveyor system.

Table 3.33: Dewatered Sludge Conveyor

Parameter	Unit	Value
Conveyor Capacity @ 50% trough loading	m ³ /h	4.0
Drive Power	kW	2.22

3.7.5.1 Process Evaluation

The process evaluation for the dewatered Sludge Conveyor is summarized in Table 3.34.

Table 3.34: Sludge Conveyor Process Evaluation

Parameter	Unit	Value
Blended Sludge Volume @2.9% solids	m ³ /d	90
Dewatered Sludge Solids Concentration	%	20.7% ¹
Dewatered Sludge Volume	m ³ /d	12.6 ²
Conveyor Loading (8 hours/day)	m ³ /h	1.6
Maximum Conveyor Loading (based on maximum capacity of centrifuge)	m ³ /h	2.0
Conveyor Loading – Design	m ³ /h	4.0

1. Average dewatered sludge solids concentration from operations data (2010-2014)
2. Conservative assumption that solids have the same density of water. Higher solids densities will result in less sludge volume after dewatered.

Based on the current process capacity the existing screw conveyor will have sufficient capacity for the maximum output from the existing centrifuge.

3.7.5.2 Future Upgrade Requirements

Due to the existing configuration, it is recommended to install a second conveyor at the same time as the new centrifuge.

3.7.6 Pug Mill Mixers

Two (2) Helm Welding Luck/Now Mixer Feeder S M.R 425 Pug Mill Mixers are used to mix dewatered sludge with woodchips prior to composting. When the compost system was originally



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designed by Engineered Compost Solutions, the WWTP was mixing, storing and processing compost onsite, however, the WWTP now only mixes the sludge and woodchip before shipping the mixture to a compost facility.

The WWTP has two Pug Mill Mixers, each contain 4 mixing augers, electronic weigh scales, and discharge conveyor. Table 3.35 summarizes the basis of design of the Pug Mill Mixers.

Table 3.35: Pug Mill Mixer Basis of Design

Parameter	Unit	Value
Dimensions	m	5 x 2.3 x 3.3 (LxWxH)
Total Working Volume	m ³	12.0
Pug Mill Capacity	m ³ /batch	8.0 ¹
	batch/d	2 ¹
Drive Power	kW	22.2
Conveyor Dimensions	m	8.5 x 0.6 x 1.8 to 3.6 (LxWxH)
Conveyor Power	kW	11.1

1. Engineering Compost System – Compost Facility Drawings.

3.7.6.1 Process Evaluation

Table 3.36 summarizes the process evaluation for the existing Pug Mill Mixers.

Table 3.36: Pug Mill Process Evaluation

Parameter	Unit	Value
Pug Mill Capacity	m ³ /batch	8
Sludge Loading/batch	kg/batch	4,000
Maximum Batches / Day (Design)		4
Maximum Sludge Process/Day	kg	16,000
Sludge Volume/batch	m ³	4.3
Dewatered Sludge Volume	m ³ /d	12.6 ²
Dewatered Sludge Mass (@ 20.7% solids)	kg/d	8,796 (wet) ¹ 1,820 (dry) ²
Sludge Volume (Average Day)	m ³ /d	8.80 ³
Sludge Volume (Max Day)	m ³ /d	12.6 ⁴
Woodchip Loading/batch	kg	2,000
Woodchip Volume/batch	m ³	3.7 ⁵
Batches/day (Average Day)		2.2
Batches/day (Maximum Day)		3.2
Service Population (Average Day)		49,715
Service Population (Maximum Day)		34,682

1. Average from Operations Data
2. Based on 20.7% solids (average from centrifuge)
3. Calculated using average mass to pug mill and density of 998 kg/m³
4. Based on volume from Centrifuge at max month WAS loading
5. Average woodchip density from BC agriculture (selected based on woodchip volumes anecdotally reported by operations staff)

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With the current process capacity of the Pug Mills, the WWTP should process 2 to 3 batches per day. From conversation with WWTP Staff for a typical day the WWTP process 2 to 2.5 batches through the Pug Mills. Based on the design parameters for these units, the WWTP should be able to process up to 4 batches a day (2 per Pug Mill), or 16,000 kg/d of sludge (wet). This is the equivalent of approximately 49,715 people (at average conditions or 34,682 (at max month conditions).

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4.0 SUMMARY

As part of the regional pipeline feasibility study, Stantec conducted a desktop evaluation of the treatment capacity of the existing WWTP based on manufacturer data for installed equipment; and/or original design information through design reports, record drawings, shop drawings, and O&M manuals. The capacity evaluation assessed headworks, primary treatment, secondary treatment, tertiary treatment, and disinfection unit processes.

Table 4.1 summarizes our findings from the capacity assessment effort. The table lists the total number of installed unit processes, firm capacity, and excess firm capacity. Negative values in the excess firm capacity indicate insufficient firm capacity at design flow. The Equivalent Population (EP) and the year by which each existing unit process reaches its full capacity was determined based on future flows projected in Table 3.1 in TM #1. The negative capacities indicate that there is no excess capacity if the respective equipment is offline for any reason.

Table 4.1 Capacity Assessment of Okotoks WWTP

Process	Qty	Installed Capacity	Firm Capacity	Excess Firm Capacity	EP (Year) to Capacity
Influent Screw Pumps	3	1,575 m ³ /h	900 m ³ /h	-181 m ³ /h	Reached
Grinder/Spiral Screens	1	943 m ³ /h	0 m ³ /h	-1,081 m ³ /h	Reached
Vortex Grit Chamber	1	1,058 m ³ /h	0 m ³ /h	-1,081 m ³ /h	Reached
EQ Tank	1	1,500 m ³	0 m ³	Not Applicable	Not Applicable
Primary Clarifier	1	15,000 m ³ /d (Limited by inlet piping hydraulics)	0 m ³ /d	-15,000 m ³ /d	Reached
Bioreactor/Secondary Clarifier	1	3,290 kg/d BOD 2,910 kg/d TSS	0 kg/d	-3,290 kg/d BOD -2,910 kg/d TSS	Reached
Tertiary Filtration	3	1,536 m ³ /h	1,024 m ³ /h	-57 m ³ /h	Reached
UV Disinfection	2	1,024 m ³ /h	512 m ³ /h	-569 m ³ /h	Reached
Fermentation	1	356 kg/d VFA	0 kg/d VFA	-356 kg/d VFA	68,327 (2046)
Dissolver Air Flotation	1	1,894 kg/d Solids	0 kg/d Solids	-1,894 kg/d Solids	28,765 (2015)
Blend Tank	1	178.6 m ³	0 m ³	-178.6 m ³	54,071 (2035)
Centrifuge	1	114.4 m ³ /d	0 m ³ /d	-114.4 m ³ /d (21%)	36,644 (2021)
Screw Conveyor	1	4 m ³ /h	0 m ³ /h	-4 m ³ /h	
Pug Mill Mixers	2	4 Batches / Day (16,000 kg/d wet sludge)	2 Batches / Day (8,000 kg/d wet sludge)	1 – 1.5 Batches / Day (4,000 – 6,000 kg/d wet sludge)	49,715 (2031) – Average Conditions 34,682 (2019) – Max Month Conditions

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References
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5.0 REFERENCES

1. Stantec Consulting Ltd., 2015, "Technical Memorandum #1 – Town of Okotoks Wastewater Treatment Plant – Design Basis Memorandum", Calgary, AB.

APPENDIX C – TM 3

TECHNICAL MEMORANDUM #3
Regional Wastewater Pipeline
Feasibility Study – Hydraulic
Analysis for Sanitary
Forcemain Options



Prepared for:
Town of Okotoks

Prepared by:
Stantec Consulting Ltd.

October 9, 2015


Revision Record							
Revision	Description	Prepared By		Checked By		Approved By	
A	Issued for Review	Maggie Fu		Liang Liu			

Sign-off Sheet

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TECHNICAL MEMORANDUM #3
REGIONAL WASTEWATER PIPELINE FEASIBILITY STUDY – HYDRAULIC ANALYSIS FOR SANITARY
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Introduction
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1.0 INTRODUCTION

1.1 BACKGROUND

The Town of Okotoks (The Town) is currently experiencing rapid economic and population growth that is increasing demand for wastewater collection and treatment services. Stantec Consulting Ltd. (Stantec) has been tasked by The Town to conduct a feasibility study to assess the capacity and potential upgrade requirements of its existing WWTP and compare the feasibility of upgrading its WWTP to other options including a regional wastewater pipeline to the City of Calgary Pine Creek (Pine Creek) WWTP.

Further to Technical Memorandum #2, this memorandum considers the feasibility of a regional wastewater transmission system to Pine Creek WWTP as an alternative option to service future population growth over the 25 and 50 year design horizons.

1.2 OBJECTIVE

The objective of the regional transmission system is to provide an efficient, reliable system to transfer wastewater from The Town to Pine Creek WWTP. This technical memorandum outlines various options for forcemain sizing and pumping requirements relative to the design horizons.

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Design Basis
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2.0 DESIGN BASIS

Stantec developed the design criteria for the regional sanitary forcemain to reflect the level of service and standards typical for regional transmission systems in Alberta. The design criteria are intended to ensure security of service and reasonable capital and operation and maintenance costs.

2.1 POPULATION PROJECTION

As mentioned Section 3.0 in Technical Memorandum #1, population projections were estimated using a linear population growth rate of 1,271 persons per year, which results in a total population of 59,119 and 92,178 for the 25 and 50 year design horizon, respectively.

2.2 RECENT FLOW DATA REVIEW

The previous Technical Memorandum #1 has determined the Average Annual Daily Flow, Maximum Day and Peak Hour Flow from monthly reports submitted to Alberta Environment and Parks (AEP) during the period from 2010 through 2014 as summarized in Table 2.1, which reflects the existing condition of Town's sanitary sewer system.

Table 2.1 Flow Data Summary for Current Sanitary System

Parameter	Flow
Average Annual Daily Flow	6,145 m ³ /d
Maximum Month	9,315 m ³ /d
Maximum Day	21,552 m ³ /d
Peak Hourly Flow	1,080 m ³ /h

2.3 SYSTEM DESIGN FLOW

The Sanitary Master Plan technical report entitled "Town of Okotoks Sanitary Master Plan – 2012 Model Update & Existing and Future System Evaluation", Stantec, January 2014, analyzed historical wastewater flows for primary service areas to be collected by the Town's WWTP and developed future conceptual servicing plans for both 30 year and 60 year growth scenarios. The intent of that technical report was to use the flow records collected from the Town's flow monitoring program and the correlated rainfall data to provide an update to the 2009 Sanitary Master Plan.

Based on the recommendations adopted from 2012 Master Plan and the previous Technical Memorandum #1, the following assumptions were applied as a basis for future design flow projections in this study.



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- The wastewater generation rate of 224.84 Lpcd calculated for current system (2014) flows was carried forward with the projected future population growth;
- A diurnal flow pattern was applied to the Average Dry Weather Flow (ADWF) rates to yield a Peak Dry Weather Flow (PDWF) of approximately 2.2 times the ADWF;
- Peak Wet Weather Flow (PWWF) parameters for all future areas were set to yield Inflow and Infiltration (I/I) of 0.28 L/s/ha as recommended by AEP;
- The proposed future development and annexation areas for 30 year and 60 years projections in 2012 master plan were adopted in this study with an assumption of approximately 70% development areas to reflect 25 year and 50 year population design horizon for the regional transmission system.

Stantec developed the projected future development and sewage generation rates for both 25 year and 50 year planning periods including average dry weather flow (ADWF), peak dry weather flow (PDWF), inflow and infiltration (I/I) and peak wet weather flow (PWWF) as summarized in Table 2.2.

Table 2.2 System Wastewater Design Flow Projection

Year	Population	ADF (m3/d)	PDWF (L/s)	Land Area (ha)	I/I Allowance (L/s)	Total PWWF (L/s)
2017	31146	7003	179.93	1162	166.90	347
2018	32417	7289	187.28	1187	173.98	361
2019	33689	7575	194.62	1212	181.05	376
2020	34960	7860	201.97	1238	188.13	390
2021	36232	8146	209.31	1263	195.21	405
2022	37503	8432	216.66	1288	202.29	419
2023	38775	8718	224.01	1314	209.37	433
2024	40046	9004	231.35	1339	216.45	448
2025	41318	9290	238.70	1364	223.52	462
2026	42589	9576	246.04	1389	230.60	477
2027	43861	9862	253.39	1415	237.68	491
2028	45132	10147	260.73	1440	244.76	505
2029	46404	10433	268.08	1465	251.84	520
2030	47675	10719	275.43	1490	258.92	534
2031	48947	11005	282.77	1516	266.00	549
2032	50218	11291	290.12	1541	273.07	563
2033	51490	11577	297.46	1566	280.15	578
2034	52761	11863	304.81	1592	287.23	592
2035	54033	12149	312.15	1617	294.31	606
2036	55304	12435	319.50	1642	301.39	621
2037	56576	12720	326.84	1667	308.47	635



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Year	Population	ADF (m3/d)	PDWF (L/s)	Land Area (ha)	I/I Allowance (L/s)	Total PWWF (L/s)
2038	57847	13006	334.19	1693	315.55	650
2039	59119	13292	341.54	1718	322.62	664
2040	60390	13578	348.88	1740	328.79	678
2041	61662	13864	356.23	1762	334.95	691
2042	62933	14150	363.57	1784	341.12	705
2043	64205	14436	370.92	1806	347.28	718
2044	65476	14722	378.26	1828	353.45	732
2045	66748	15008	385.61	1850	359.61	745
2046	68019	15293	392.96	1872	365.78	759
2047	69291	15579	400.30	1894	371.94	772
2048	70562	15865	407.65	1916	378.11	786
2049	71834	16151	414.99	1938	384.27	799
2050	73105	16437	422.34	1960	390.43	813
2051	74377	16723	429.68	1982	396.60	826
2052	75648	17009	437.03	2004	402.76	840
2053	76920	17295	444.37	2026	408.93	853
2054	78191	17580	451.72	2048	415.09	867
2055	79463	17866	459.07	2070	421.26	880
2056	80734	18152	466.41	2092	427.42	894
2057	82006	18438	473.76	2114	433.59	907
2058	83277	18724	481.10	2136	439.75	921
2059	84549	19010	488.45	2158	445.92	934
2060	85820	19296	495.79	2180	452.08	948
2061	87092	19582	503.14	2202	458.24	961
2062	88363	19868	510.49	2224	464.41	975
2063	89635	20153	517.83	2246	470.57	987
2064	90906	20439	525.18	2268	476.74	1000
2065	92178	20725	532.52	2290	482.90	1012

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3.0 SYSTEM HYDRAULICS

Two primary options are evaluated in this section to provide potential alternatives to meet the Town's future developments:

- Option #1: A pipeline and lift station designed to pump all of Okotoks' current and future sewage to Calgary WWTP;
- Option #2: A pipeline and lift station to pump to Pine Creek WWTP only the additional flows that exceed the current treatment capacity of the Town's WWTP;

3.1 SYSTEM OVERVIEW

3.1.1 Transmission Line Alignment

The proposed pipeline route was suggested to be adhering to the preferred potable water main alignment along Hwy 2A, which was adopted from the Okotoks-Calgary Regional Potable Water Pipeline. Some modifications were made to have the pipeline to proceed northeast onto Hwy 2 and then tie into Pine Creek WWTP in Calgary to reflect the proposed regional wastewater transmission line, with a total length of approximately 18.5 km as demonstrated in Figure 3.1 - Conceptual Pipeline Alignment.

3.1.2 Topography

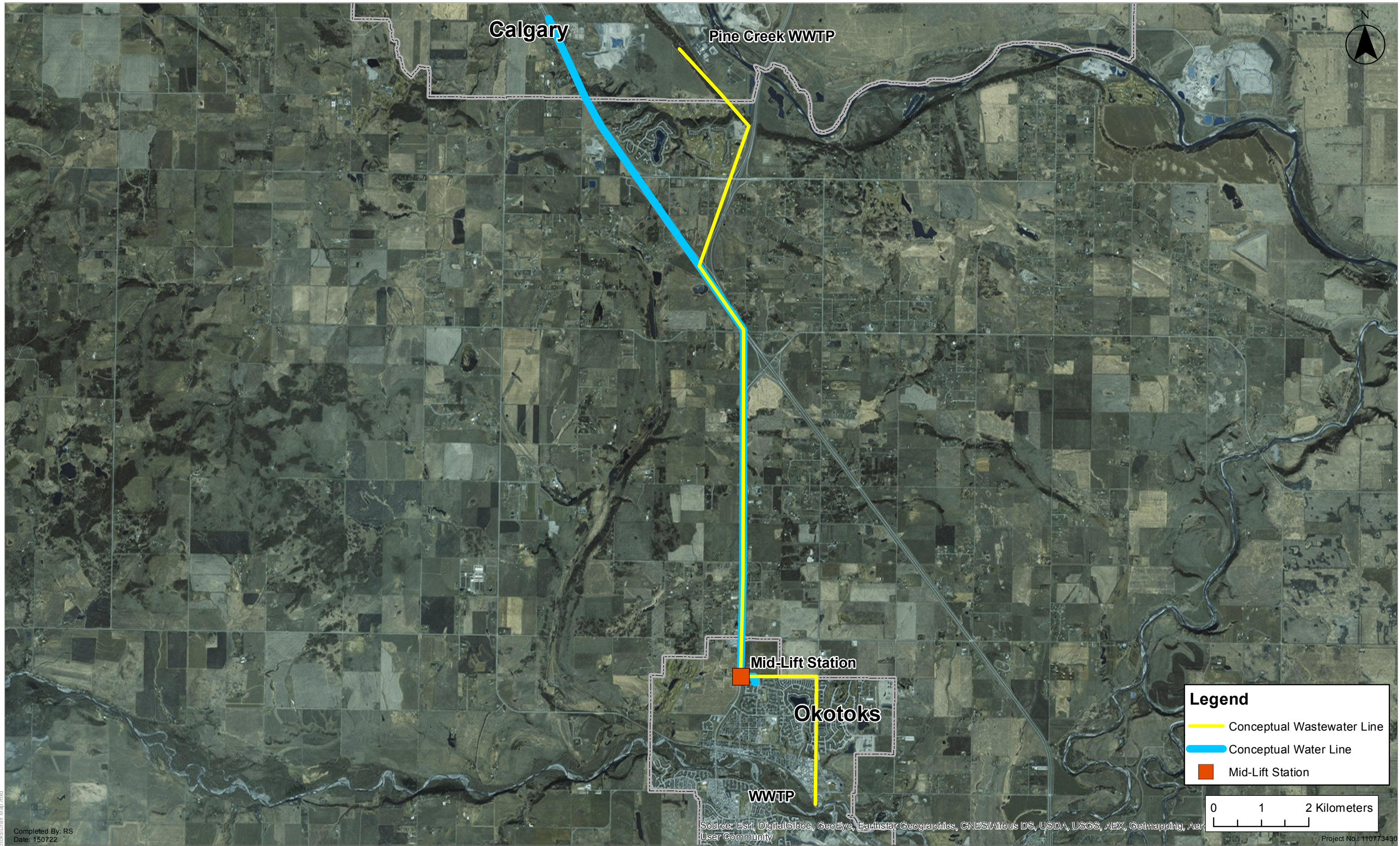
Line topography, system pressure, and total design flow are major factors influencing a wastewater forcemain's hydraulic performance. The following characterizes the topography along the proposed alignment.

The beginning of the proposed transmission system (at the Okotoks WWTP) is at 1,045 m above sea level; the end of the line (Tie-in Point to Pine Creek Sanitary Trunk) is situated at 1,045 m above sea level. The route distance is estimated at 18.5 km. The pipeline alignment crosses a couple of high hills en route to Pine Creek WWTP. Given the conceptual nature of this study and the lack of a topographic survey to verify the available contour information, Stantec assumed a minimum pressure at the highest point to ensure that the flow can be pumped over the estimated highest point (1,142 m) of the alignment.

Considering pump availability and energy saving strategy, Stantec recommends a cascade transmission system with a Mid-Lift Station (Mid-LS) along the alignment. The proposed Mid-LS would be located at approximately Banister Gate, north of the Town with an elevation of 1,099 m. The Mid-LS would separate the line into two segments:

- Segment One: Okotoks WWTP to the Mid-LS (~4.3 km);
- Segment Two: Mid-LS to Pine Creek WWTP (~14.2 km)





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3.1.3 Flow Collection Strategy

Given the Town's natural topography, wastewater from the existing collection system and the new development area located south of the Town will continue to be collected at the site of the Okotoks WWTP, from which it will be pumped to the Mid-LS. Wastewater flows generated from new development located north of the Town will be directed to the proposed Mid-LS directly. The combined total flow including wastewater from both catchments will be pumped and conveyed to Pine Creek WWTP.

3.1.4 Pipe Material

Because of their resistance to corrosion, their relative low capital cost, and local prevalence and availability, thermoplastic pipes, such as HDPE, are typically considered during the conceptual hydraulic analysis of a major wastewater forcemain system. During the Preliminary Design stage, other materials may be considered.

3.1.5 Line Velocities

It is important to try to maintain wastewater flows in a forcemain system within an optimal range of velocities. Ideally, the flow velocity in the forcemain should be maintained so that the minimum average flow is not less than 0.6 m/s, and the maximum velocity at the peak design flow is not greater than 3.0 m/s to minimize turbulence and erosion.

If line velocities are too low, solids deposition will become a maintenance challenge for system operators, the wastewater will be more odours and more difficult to treat. Capital costs per unit rate of flow will be higher than optimal, as well.

If velocities are too high, the transient conditions in the pipeline will hasten pump wear out as well as pipeline fatigue and failure. Power costs will become prohibitive, as well.

Therefore, for the purpose of this memorandum, the forcemain shall be sized to maintain wastewater velocities less than 3.0 m/s during future peak flow conditions while maintaining wastewater self-cleansing velocities greater than 0.6 m/s during current peak flow conditions.

3.1.6 Line Pressure

Due to sewage pump total dynamic head (TDH) limitations, it is generally not feasible to obtain wastewater pumps with maximum discharge pressure higher than 850 kPa. Therefore, to size the proposed pumping system, Stantec assumed a maximum TDH (system pressure) of 850 kPa for the hydraulic analysis of the Okotoks regional transmission system.



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3.2 HYDRAULIC ANALYSIS

3.2.1 Option #1 System Sizing

The analysis of Option #1, a pipeline and lift station designed to pump all of Okotoks' current and future sewage to Calgary WWTP, considers two design scenarios:

1. The system is sized to meet projected sanitary flow 25-years into the future
2. The system is sized to meet projected sanitary flow 50-year into the future

3.2.1.1 System Design Capacity

From an energy savings perspective, Stantec evaluated two delivery approaches for both segments from Okotoks WWTP to Mid-LS and from Mid-LS to Calgary.

Approach #1: Pumping peak wet weather flow (PWWF) throughout the entire system from Okotoks WWTP to Pine Creek WWTP, Calgary with design PWWF as summarized in Table 3.1 for each segment.

Table 3.1 System Design Flow Summary for Approach #1

Scenario	Design Flow (L/s)	
	Okotoks WWTP to Mid-LS	Mid-LS to Pine Creek WWTP
25 Year	561	664
50 Year	697	1012

Approach #2: Converting the Town's existing WWTP into a peak shaving storage volume to trim peak diurnal wastewater flows for the first segment from Okotoks WWTP to Mid-LS. The utilization of the existing facilities as the off-line storage will enable the system to accommodate short periods of high flows without oversizing the associated pumping, piping and appurtenances.

With this approach, Stantec sized the first segment to handle peak dry weather flow (PDWF) collected and pumped to the Mid-LS from Okotoks WWTP catchment area, and the second segment to pump the combined flow to Calgary, including PDWF from first segment and PWWF from the northern catchment area. System design flows for Approach #2 is provided in Table 3.2.

Table 3.2 System Design Flow Summary for Approach #2

Scenario	Design Flow (L/s)	
	Okotoks WWTP to Mid-LS	Mid-LS to Pine Creek WWTP
25 Year	296	399
50 Year	394	709

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3.2.1.2 Analysis Results and Recommendations

Both design scenarios (25 year and 50 year) have been simulated based on the proposed cascade regional transmission system from Okotoks to Calgary.

25 Year Design Scenario:

As part of the system hydraulic analysis, Stantec evaluated various pipe sizes and compared them for both delivery approaches. Detailed results are attached in Appendix A.

Table 3.3 illustrates the system parameters including pipe length, preferred pipe diameter, associated line velocities and required pumping head.

Table 3.3 Analysis Results for both delivery approaches (25 year)

Approach	Length (m)		O. Diameter (mm)		Pipe Velocity (m/s)		TDH Requirement (m)	
	Segment One	Segment Two	Segment One	Segment Two	Segment One	Segment Two	Segment One	Segment Two
Appro. #1	4,304	14,165	750	750	1.73	2.04	81	75
Appro. #2			600	600	1.42	1.92	80	81

With similar attainable pumping heads, Approach #1 will require a 750 mm pipeline to convey the PWWF design flow through the proposed cascade transmission system to Pine Creek WWTP. Using Approach #2, a 600 mm pipeline will be sufficient to pump the sewerage from Okotoks WWTP to the Mid-LS and to Pine Creek WWTP.

Stantec recommends Delivery Approach #2 for the 25-year design scenario with 600 mm HDPE pipe from Okotoks to Pine Creek WWTP. Wastewater will be from Okotoks WWTP to Mid-LS and Mid-LS to Pine Creek WWTP at a pumping heads of 80 m and 81 m, respectively. Table 3.4 presents the recommendations for the 25 year horizon with pipe design parameters and estimated pumping HP (60% pumping efficiency).

Table 3.4 Recommendations for Design Option #1 (Based on 25 Year Horizon)

Segments	Design Flow (L/s)	Length (m)	Pipe Material	O. D (mm)	I.D (mm)	Velocity (m/s)		TDH (m)	Estimated HP
						2039	Current		
Segment One	296	4,304	HDPE DR 13.5	600	515	1.42	0.76	80	513
Segment Two	399	14,165	HDPE DR 13.5	600	515	1.92	0.76	81	700

50 Year Design Scenario:

Stantec simulated different pipe sizes for both delivery approaches under the 50 year design scenario. Detailed results are attached in Appendix A.



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Table 3.5 illustrates the system parameters including pipe length, preferred pipe diameter, associated line velocities and required pumping head.

Table 3.5 Analysis Results for both delivery approaches (50 year)

Approach	Length (m)		O. Diameter (mm)		Pipe Velocity (m/s)		TDH Requirement (m)	
	Segment One	Segment Two	Segment One	Segment Two	Segment One	Segment Two	Segment One	Segment Two
Appro. #1	4,304	14,165	800	850	1.89	2.4	82	82
Appro. #2			650	750	1.61	2.2	81	80

Approach #1 will require an 800mm and 850 mm pipelines to convey the PWWF design flow through the proposed cascade transmission system to Pine Creek WWTP. Using Approach #2, a 650 mm and 750 mm pipelines, along with the off-site storage, will be sufficient to pump the sewerage from Okotoks WWTP to the Mid-LS and to Pine Creek WWTP.

Stantec recommends Delivery Approach #2 for the 50-year design scenario with 650 mm HDPE pipe from Okotoks the Mid-LS and 750 mm HDPE pipe from the Mid-LS to Pine Creek WWTP at a pumping heads of 81 m and 80 m, respectively. Table 3.6 presents the recommendations for the 50-year horizon with pipe design parameters and estimated pumping HP (60% pumping efficiency).

Table 3.6 Recommendations for Design Option #1 (Based on 50 Year Horizon)

Segments	Design Flow (L/s)	Length (m)	Pipe Material	O. D (mm)	I.D (mm)	Velocity (m/s)		TDH (m)	Estimated HP
						2065	Current		
Segment One	394	4,304	HDPE DR 13.5	650	558	1.61	0.65	81	695
Segment Two	709	14,165	HDPE DR 13.5	750	643	2.2	0.49	80	695

As noted in the Table 3.6, system sizing based on 50 year design horizon cannot provide line velocity greater than the minimum required scouring velocity during current system operation. Therefore, a minimum pumping rate of 195 L/s will be considered for the pump selection to achieve the self-cleansing velocity of 0.6 m/s and avoid solids deposition within the pipeline.

3.2.2 Option #2 System Sizing

The analysis of Option #2, a pipeline and lift station designed to pump only additional flows that exceed the current treatment capacity of Town's WWTP to Calgary, considers two design scenarios:

1. The system is sized to meet projected sanitary flow 25-years into the future
2. The system is sized to meet projected sanitary flow 50-years into the future



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3.2.2.1 System Design Capacity

Table 1.1 from Technical Memorandum #2 determined that the existing WWTP is reaching its capacity limit either due to process or hydraulic limitations. Therefore, wastewater generated from all future areas will be conveyed from Okotoks to Pine Creek WWTP. As the existing facilities will be in operation, Stantec considered PWWF as the design base to ensure that the regional transmission system will be capable of handling peak flows when needed. Design PWWF for future areas are provided in Table 3.7.

Table 3.7 System Design Flow Summary for Option #2

Scenario	Design Flow (L/s)	
	Okotoks WWTP to Mid-LS	Mid-LS to Pine Creek WWTP
25 Year	261	364
50 Year	397	712

3.2.2.2 Analysis Results and Recommendations

System simulation and analysis were conducted for both growth scenarios (25 year and 50 year) based on the proposed cascade regional transmission system from Okotoks to Calgary.

25 Year Design Scenario:

Detailed analysis results are attached in Appendix A, including various pipe sizes simulation and the associated pumping head requirements.

Table 3.8 displays the system parameters including pipe length, preferred pipe diameter and the associated line velocity & required pumping head for 25 year design scenario.

Table 3.8 System Sizing Recommendation for Option #2 (25 year)

Segments	Design Flow (L/s)	Length (m)	Pipe Material	O. D (mm)	I.D (mm)	Velocity (m/s)	TDH (m)	Estimated HP
Segment One	261	4,304	HDPE DR 13.5	550	472	1.49	82	466
Segment Two	364	14,165	HDPE DR 13.5	600	515	1.8	74	587

A 550 m pipeline with an 82 m pumping head will be selected for Segment One from Okotoks WWTP to Mid-LS. A 600 m pipeline with a 74 m pumping head will be selected for Segment Two from Mid-LS to Pine Creek. The associated pumping HP was estimated assuming 60% pumping efficiency.

50 Year Design Scenario:



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Detailed analysis results are attached in Appendix A, including various pipe sizes simulation and the associated pumping head requirements.

The recommended pipe size and pumping head are presented in Table 3.9 with system parameters including pipe length, pipe diameter and the line velocity & required pumping head for 50 year design scenario.

Table 3.9 System Sizing Recommendation for Option #2 (50 year)

Segments	Design Flow (L/s)	Length (m)	Pipe Material	O. D (mm)	I.D (mm)	Velocity (m/s)	TDH (m)	Estimated HP
Segment One	397	4,304	HDPE DR 13.5	650	558	1.62	82	705
Segment Two	712	14,165	HDPE DR 13.5	750	643	2.19	80	1241

A 650 m pipeline with an 82 m TDH will be needed to pump the flow from Okotoks WWTP to the Mid-LS. A 750 m pipeline with an 80 m pumping head will be selected for Segment Two from Mid-LS to Pine Creek. The Estimated HPs were 705 HP and 1,241 HP for Segment One and Segment Two assuming 60% pump efficiency.

3.2.3 System Design Consideration

In order to optimize the system design for 25 year and 50 year growth scenarios, the following suggestions shall be taken into consideration:

- Stantec recommended to install a larger size pipeline to accommodate the 50 year design flow;
- Stantec recommends phasing the installation of sewage pumps within the Mid-LS. In the first phase, sewage pumps that can accommodate the 25 year design scenario will be installed with provisions for extra space for future (50 year) upgrades. In the second phase, the smaller pumps can be replaced and additional pumps can be installed with all associated electrical and ancillary equipment.
- A minimum pumping rate shall be considered during the pump selection to make sure the minimum pipe velocity will be achieved under current flow condition, 25 year and 50 year design horizon.

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Opinion of Probable Cost
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4.0 OPINION OF PROBABLE COST

Due to the conceptual nature of the system design, especially with respect to items such as lift station features, odour control facilities, forcemain alignment and drilling lengths, it is important to consider the listed costs in comparative terms between the various options. These comparative capital costs representing the lift station construction and pipeline installation are summarized in Table 4.1. To prepare these costs, Stantec referenced several recently completed projects with similar nature to determine the opinion of probable cost of this regional wastewater transmission system project. All costs have been estimated in 2015 dollars and do not include GST.

Table 4.1 Opinion of Probable Cost

NO.	DESCRIPTION	Option #1		Option #2	
		25 year	50 year	25 year	50 year
1	GENERAL	\$ 3,483,000	\$ 3,483,000	\$ 3,483,000	\$ 3,483,000
2	SITE WORK	\$ 1,295,000	\$ 1,295,000	\$ 1,295,000	\$ 1,295,000
3	PIPELINE	\$ 20,920,000	\$ 22,970,000	\$ 20,719,000	\$ 22,970,000
4	LIFT STATIONS	\$ 10,000,000	\$ 13,000,000	\$ 10,000,000	\$ 13,000,000
5	ROAD RESTORATION	\$ 35,000	\$ 35,000	\$ 35,000	\$ 35,000
6	SURFACE RESTORATION	\$ 965,000	\$ 965,000	\$ 965,000	\$ 965,000
7	MISCELLANEOUS ITEMS	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000
SUBTOTAL		\$ 36,710,000	\$ 41,760,000	\$ 36,509,000	\$ 41,760,000
Engineering and Contingency - (25%)		\$ 9,177,500	\$ 10,440,000	\$ 9,127,250	\$ 10,440,000
TOTAL (not including GST)		\$ 45,887,500	\$ 52,200,000	\$ 45,636,250	\$ 52,200,000

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Conclusions and Recommendations
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5.0 CONCLUSIONS AND RECOMMENDATIONS

Two primary options were evaluated as potential servicing alternatives for the Okotoks regional wastewater transmission system. This section summarizes conclusions and recommendations base on system hydraulic analysis.

- The proposed alignment following the preselected regional waterline is recommended for the Okotoks regional wastewater transmission system, which will tie in to the West Pine Creek Sanitary Trunk and connects directly to Pine Creek WWTP in Calgary. The total length is approximately 18.5 km.
- Given the nature of the topography along the proposed Okotoks regional wastewater line, a cascade transmission system with Mid-LS was suggested.
- Option #1: A pipeline and lift station designed to pump all of Okotoks' current and future sewage to Pine Creek WWTP;
 - Stantec recommends Approach #2 (based on PDWF for Segment One) for the 25 year design horizon per Table 3.4. A 600 mm pipeline with TDH of 80 m for Segment One and a 600 mm pipeline with TDH of 81 m for Segment Two will be used to convey wastewater from Okotoks to Calgary.
 - Stantec recommends using Approach #2 for the 50 year design horizon as per Table 3.6. A 650 mm pipeline with TDH of 81 m for Segment One and a 750 mm pipeline with TDH of 80 m for Segment Two will be used to convey wastewater from Okotoks to Calgary.
- Option #2: A pipeline and lift station to pump only additional flows exceeds the current treatment capacity of Town's WWTP to Calgary;
 - For the 25 year design horizon, Stantec recommends a 550 mm pipeline with TDH of 82 m for Segment One and a 600 mm pipeline with TDH of 74 m for Segment Two to convey wastewater from Okotoks to Calgary as summarized in Table 3.8.
 - For the 50 year design horizon, Stantec recommends a 650 mm pipeline with TDH of 82 m for Segment One and a 750 mm pipeline with TDH of 80 m for Segment Two to convey wastewater from Okotoks to Calgary as summarized in Table 3.9.

Appendix A HYDRAULIC ANALYSIS RESULTS

Option #1: Model Results Based on Flow Projection Scenario - 25 year

18469

Regional Wastewater Transmission Line from Town of Okotoks to City of Calgary (Approach #1)														
Segment One - WWTP to Mid Lift Station														
Locations	Elevation (m)	PDWF (L/s)	PDWF (m3/d)	Pipe Material	Pressure Rating (psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 750 mm														
WWTP	1045	561	48465	DR 13.5	160	130	4304	643	11.6	1.73	115	81	984	1125.5
J-84	1106										12			1113.9
MID LS	1099										14			1109.5
Sub-total		561	48465				4304		16.00			81		
Pipe Size Opt #2 HDPE 700 mm														
WWTP	1045	561	48465	DR 13.5	160	130	4304	600	23.0	1.98	123	86	1051	1131.0
MID LS	1099										12			1108.0
Sub-total		561	48465				4304		23.04			86		
Pipe Size Opt #3 HDPE 650 mm														
WWTP	1045	561	48465	DR 13.5	160	130	4304	558	32.8	2.29	136	96	1167	1140.5
MID LS	1099										12			1107.7
Sub-total		561	48465				4304		32.81			96		
Segment Two - MID LS to Calgary WWTP														
Locations	Elevation (m)	PWWF (L/s)	PWWF (m3/d)	Pipe Material	Pressure Rating (psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 750 mm														
MID LS	1099			DR 13.5	160	130	2821	643	14.8	2.0	107	75	1085	1174.0
J-18	1142										25			1159.2
J-103	1033										111			1111.0
Pine Creek	997			DR 11	200		2102	616	11.0	2.2	146			1100.0
Total		664	57383				14165		74.01			75		
Pipe Size Opt #2 HDPE 800 mm														
MID LS	1099			DR 13.5	160	130	2821	686	10.8	1.8	99	70	1006	1168.5
J-18	1142										23			1157.7
J-103	1033										128			1122.5
Pine Creek	997			DR 11	200		2102	657	9.9	2.0	164			1112.7
Total		664	57383				14165		55.82			70		

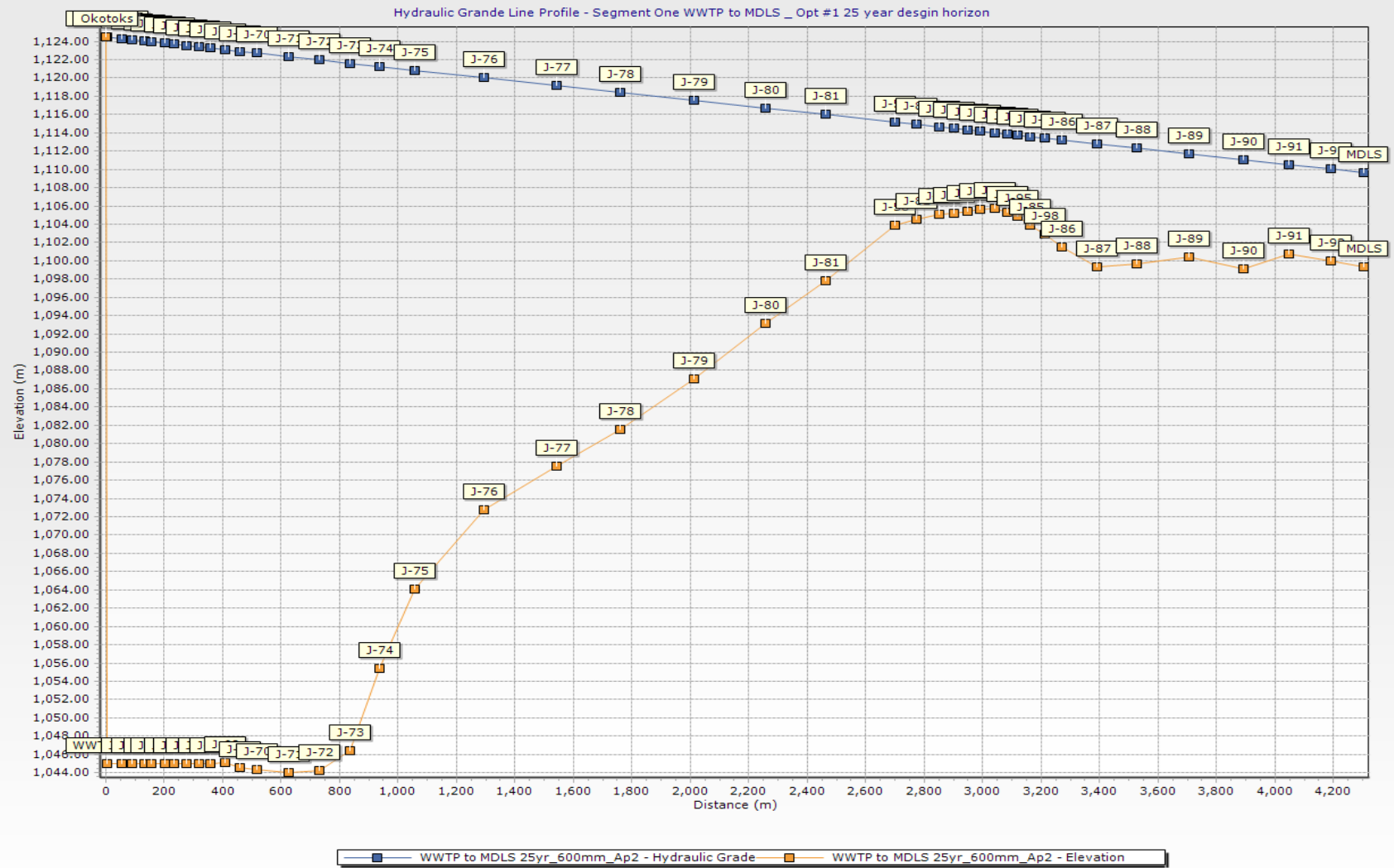
Regional Wastewater Transmission Line from Town of Okotoks to City of Calgary (Approach #2)

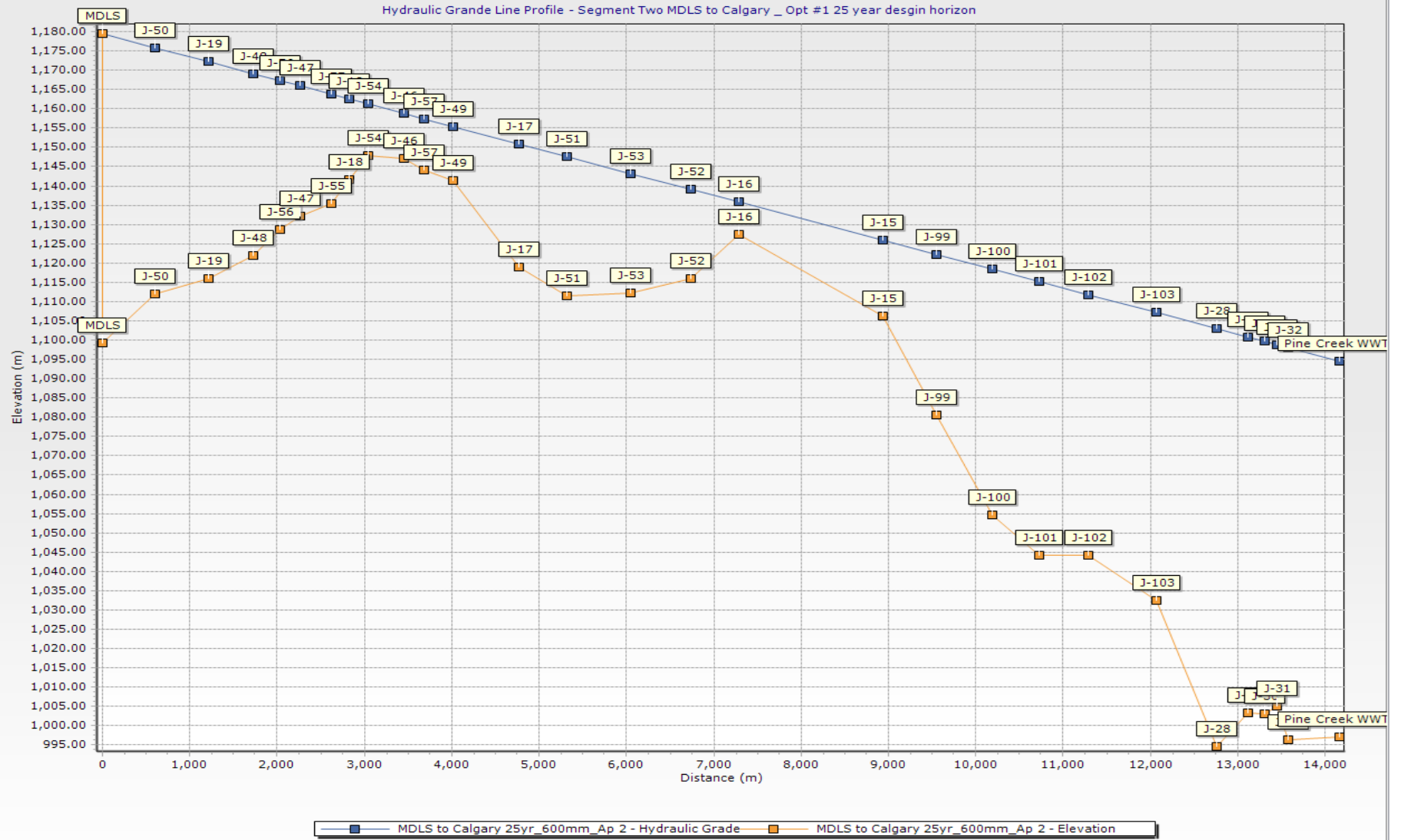
Segment One - WWTP to Mid Lift Station

Locations	Elevation (m)	PDWF (L/s)	PDWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 600 mm														
WWTP	1045	296	25589	DR 13.5	160	130	4304	515	10.5	1.42	114	80	513	1124.5
J-84	1106										12			1114.0
MID LS	1099										15			1109.7
Sub-total		296	25589				4304		14.84			80		
Current Dry Peak		158	13651							0.76				
Pipe Size Opt #2 HDPE 550 mm														
WWTP	1045	296	25574	DR 13.5	160	130	4304	472	22.7	1.69	122	86	552	1130.5
MID LS	1099										12			1107.8
Sub-total		296	25574				4304		22.69			86		
Current Dry Peak		158	13651							0.90				

Segment Two - MID LS to Calgary WWTP

Locations	Elevation (m)	PWWF (L/s)	PWWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 600 mm														
MID LS	1099			DR 13.5	160	130	14165	515	17.0	1.9	115	81	700	1179.5
J-18	1142										30			1162.6
Pine Creek	997										138			1094.6
Total		399	34507				14165		84.92			81		
Current Dry Peak		158								0.76				
Pipe Size Opt #1 HDPE 550 mm														
MID LS	1099			DR 13.5	160	130	14165	472	25.9	2.3	149	104	905	1203.0
J-18	1142										50			1177.1
Pine Creek	997										108			1073.2
Total		399	34507				14165		129.85			104		
Current Dry Peak		158								0.90				





Option #1: Model Results Based on Flow Projection Scenario - 50 year

Regional Wastewater Transmission Line from Town of Okotoks to City of Calgary (Approach #1)														
Segment One - WWTP to Mid Lift Station														
Locations	Elevation (m)	PDWF (L/s)	PDWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 750 mm														
WWTP	1045	697	60226	DR 13.5	160	130	4304	643	17.4	2.15	125	88	1329	1132.5
J-84	1106										13			1115.1
MID LS	1099										12			1107.9
Sub-total		697	60226				4304		24.59					
Current		300	60226				4304			0.92				
Current Dry Peak		158	13651							0.49				
Pipe Size Opt #2 HDPE 800 mm														
WWTP	1045	697	60226	DR 13.5	160	130	4304	686	12.7	1.89	116	82	1238	1126.5
J-84	1106										12			1113.8
MID LS	1099										13			1108.6
Sub-total		697	60226				4304		17.94			82		
Current		300	25920				4304			0.81				
Current Dry Peak		158	13651							0.43				
Segment Two - MID LS to Calgary WWTP_ Scenario 50 year														
Locations	Elevation (m)	PWWF (L/s)	PWWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 850 mm														
MID LS	1099			DR 13.5	160	130	14165	729	17.5	2.4	117	82	1808	1181.0
J-18	1142										31			1163.5
Pine Creek	997										137			1093.4
Total		1012	87437				14165		87.59			82		
Current		300								0.72				
Current Dry Peak		158								0.38				
Pipe Size Opt #1 HDPE 800 mm														
MID LS	1099			DR 13.5	160	130	14165	686	23.5	2.7	139	98	2150	1196.5
J-18	1142										44			1173.0
Pine Creek	997										116			1078.7
Total		1012	87437				14165		117.78			98		

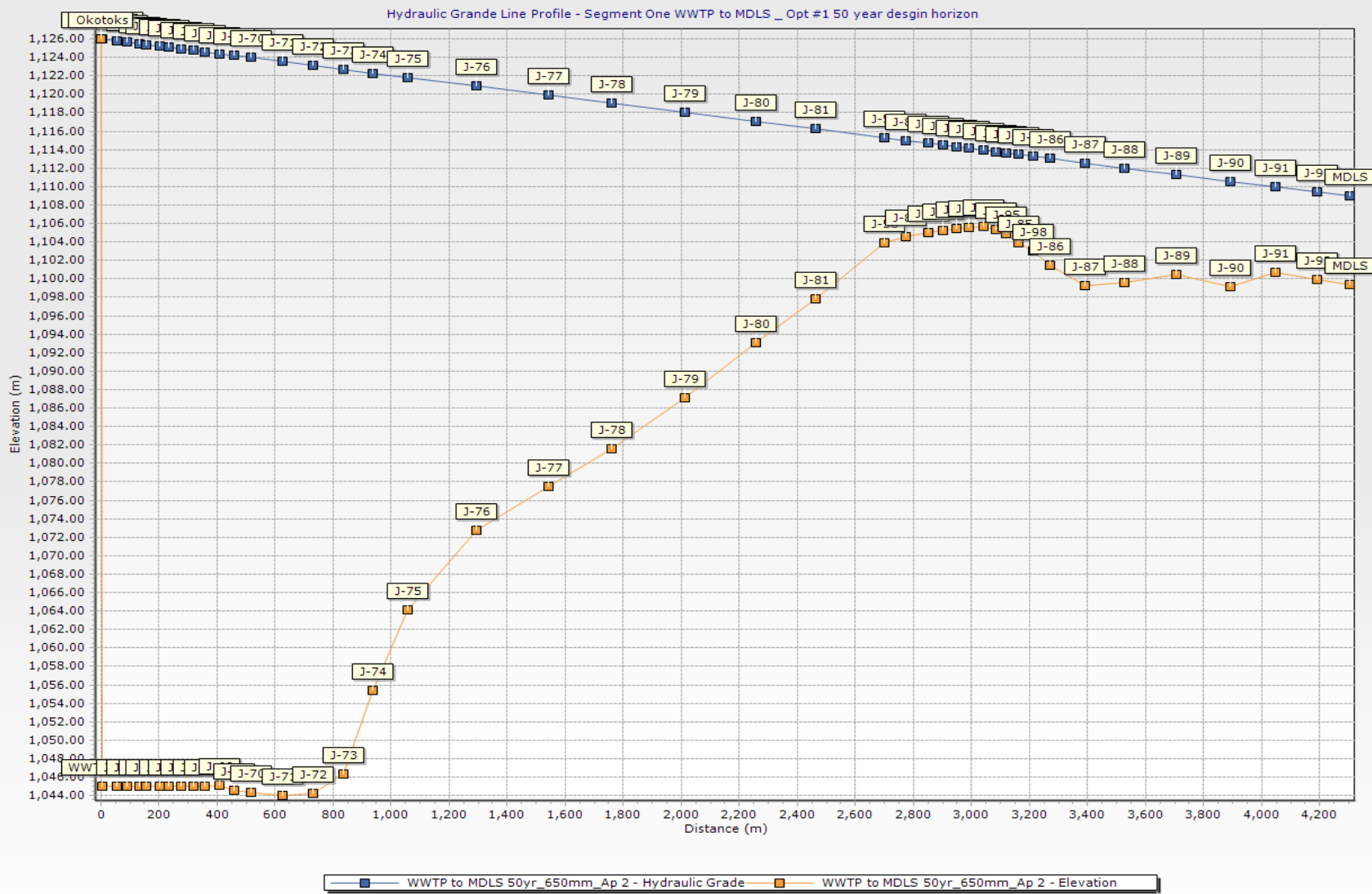
Regional Wastewater Transmission Line from Town of Okotoks to City of Calgary (Approach #2)

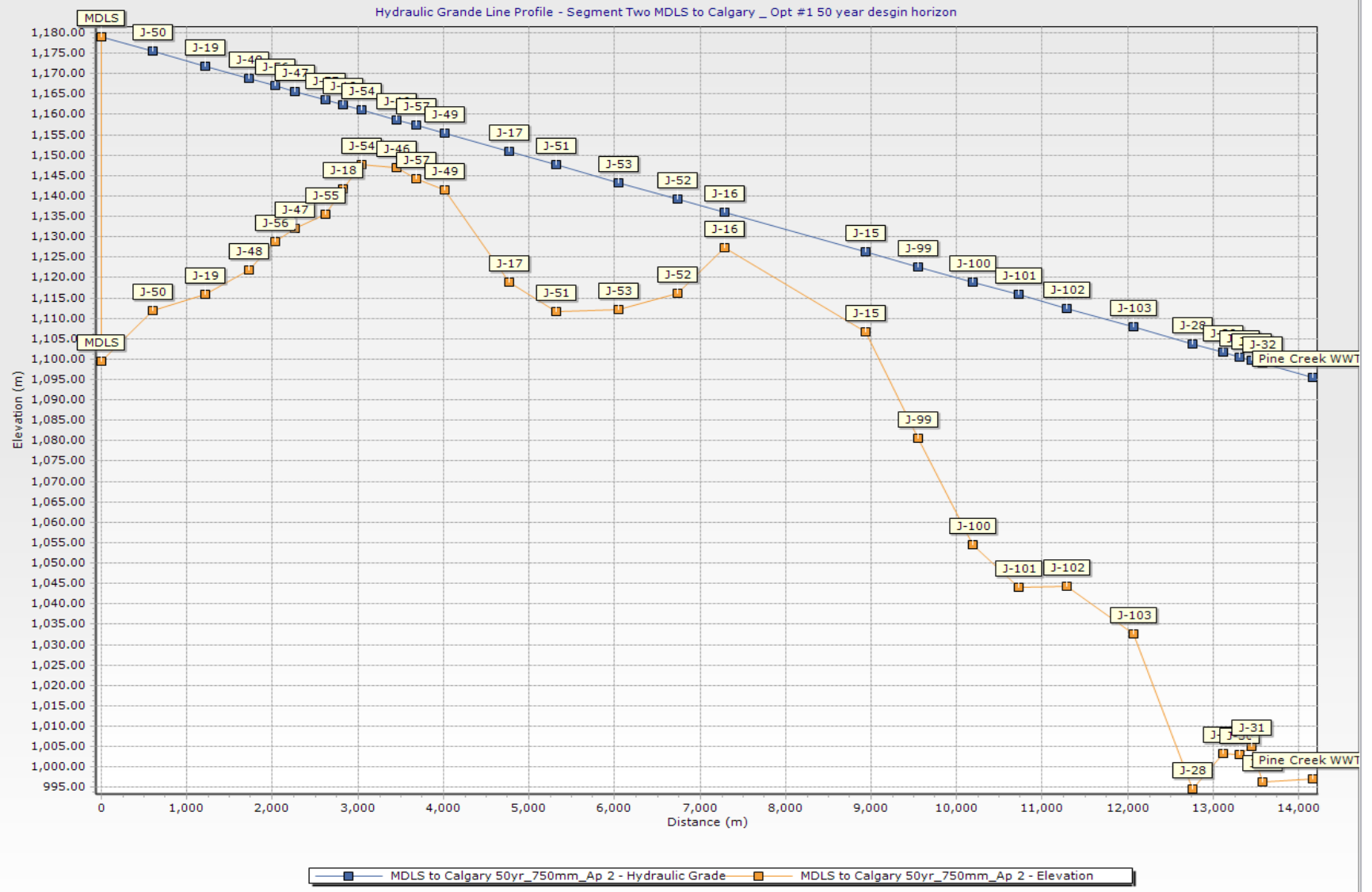
Segment One - WWTP to Mid Lift Station

Locations	Elevation (m)	PDWF (L/s)	PDWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 600 mm														
WWTP	1045	394	34051	DR 13.5	160	130	4304	515	17.8	1.89	126	88	756	1133.0
J-84	1106										13			1115.2
MID LS	1099										12			1107.8
Sub-total		394	34051				4304		25.20			88		
Current Dry Peak		158	13651							0.76				
Pipe Size Opt #2 HDPE 650 mm														
WWTP	1045	394	34051	DR 13.5	160	130	4304	558	12.1	1.61	116	81	695	1126.0
J-84	1106										12			1114.0
MID LS	1099										14			1109.0
Sub-total		394	34051				4304		17.05			81		
Current Dry Peak		158	13651							0.65				

Segment Two - MID LS to Calgary WWTP

Locations	Elevation (m)	PWWF (L/s)	PWWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	Estimated HP	HGL (m)
Pipe Size Opt #1 HDPE 750 mm														
MID LS	1099			DR 13.5	160	130	14165	643	16.7	2.2	114	80	695	1179.0
J-18	1142										29			1162.3
Pine Creek	997										140			1095.5
Total		709	61262				14165		83.53			80		
Current Dry Peak		158								0.49				
Pipe Size Opt #1 HDPE 700 mm														
MID LS	1099			DR 13.5	160	130	14165	600	23.4	2.5	139	97	843	1196.0
J-18	1142										44			1172.6
Pine Creek	997										116			1079.0
Total		709	61262				14165		117.01			97		





Model Results Based on Option #2

Regional Wastewater Transmission Line from Town of Okotoks to City of Calgary - 25 Year														
Segment One - WWTP to Mid Lift Station														
Locations	Elevation (m)	PDWF (L/s)	PDWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size Opt #1 HDPE 500 mm														
WWTP	1045	261	22550	DR 13.5	160	130	4304	429	20.2	1.81	131	92	1136.5	520
J-84	1106										15		1116.3	
MID LS	1099										12		1107.9	
Sub-total		261	22550				4304		28.63			92		
Pipe Size Opt #2 HDPE 550 mm														
WWTP	1045	261	22550	DR 13.5	160	130	4304	472	12.7	1.49	117	82	1127.0	466
J-84	1106										12		1114.3	
MID LS	1099										14		1109.0	
Sub-total		261	22550				4304		17.98			82		
Segment Two - MID LS to Calgary WWTP														
Locations	Elevation (m)	PWWF (L/s)	PWWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size Opt #1 HDPE 600 mm														
MID LS	1099			DR 13.5	160	130	2821	515	14.3	1.8	24	74	1173.0	587
J-18	1142						9242		46.7	1.8	113		1158.7	
J-103	1033						2102		3.5	1.8	162		1112.0	
J-28	995			DR 11	200				11.8	1.8	148		1108.4	
Pine Creek	997												1096.7	
Total		364	31463				14165		76.32			74		
Pipe Size Opt #2 HDPE 550 mm														
MID LS	1099			DR 13.5	160	130	14165	472			133	93	1192.0	738
J-18	1142								21.9	2.1	40		1170.1	
Pine Creek	997								87.7	2.1	121		1082.5	
Total		364	31463				14165		109.55			93		

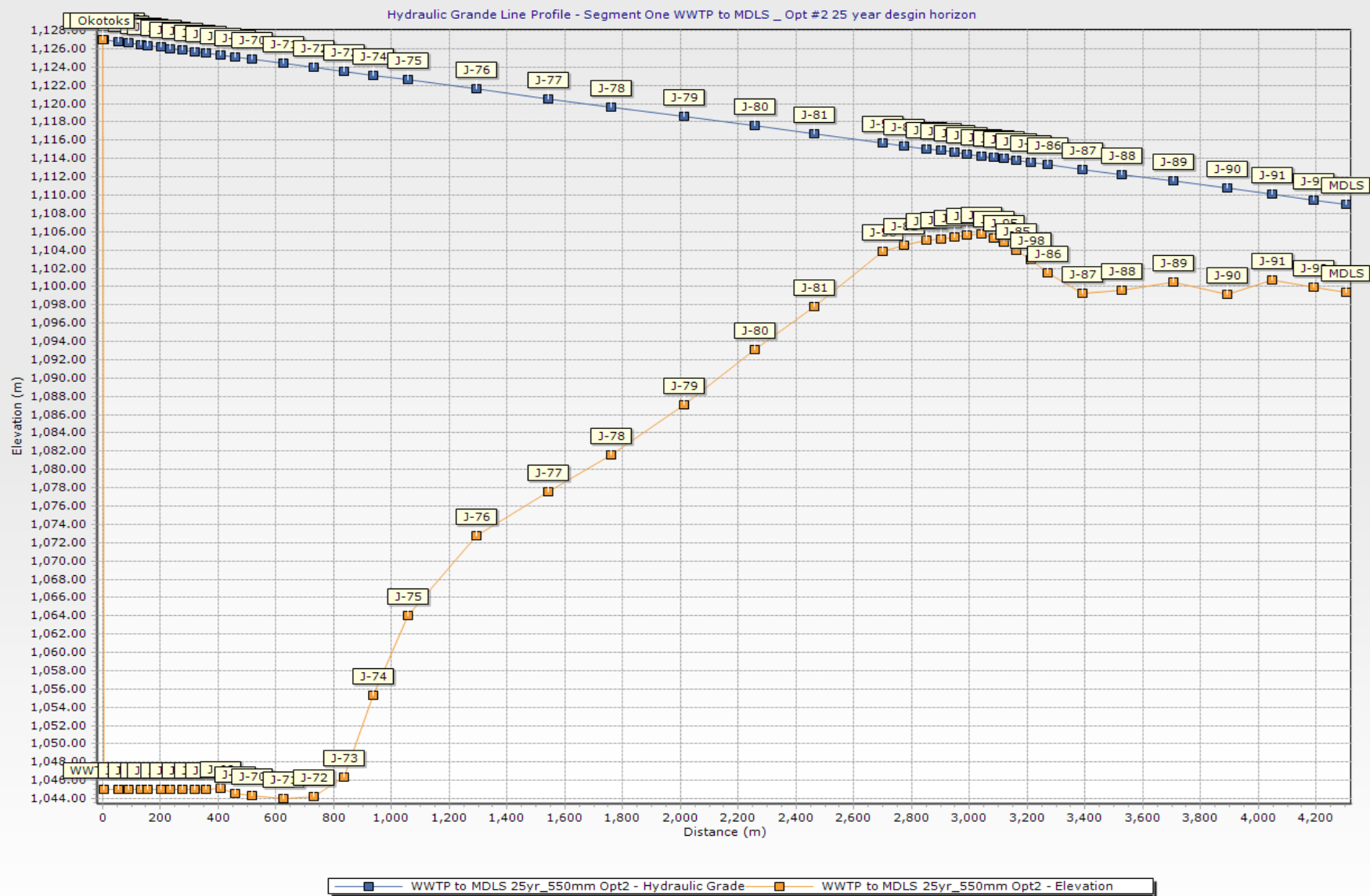
Regional Wastewater Transmission Line from Town of Okotoks to City of Calgary- 50 Year

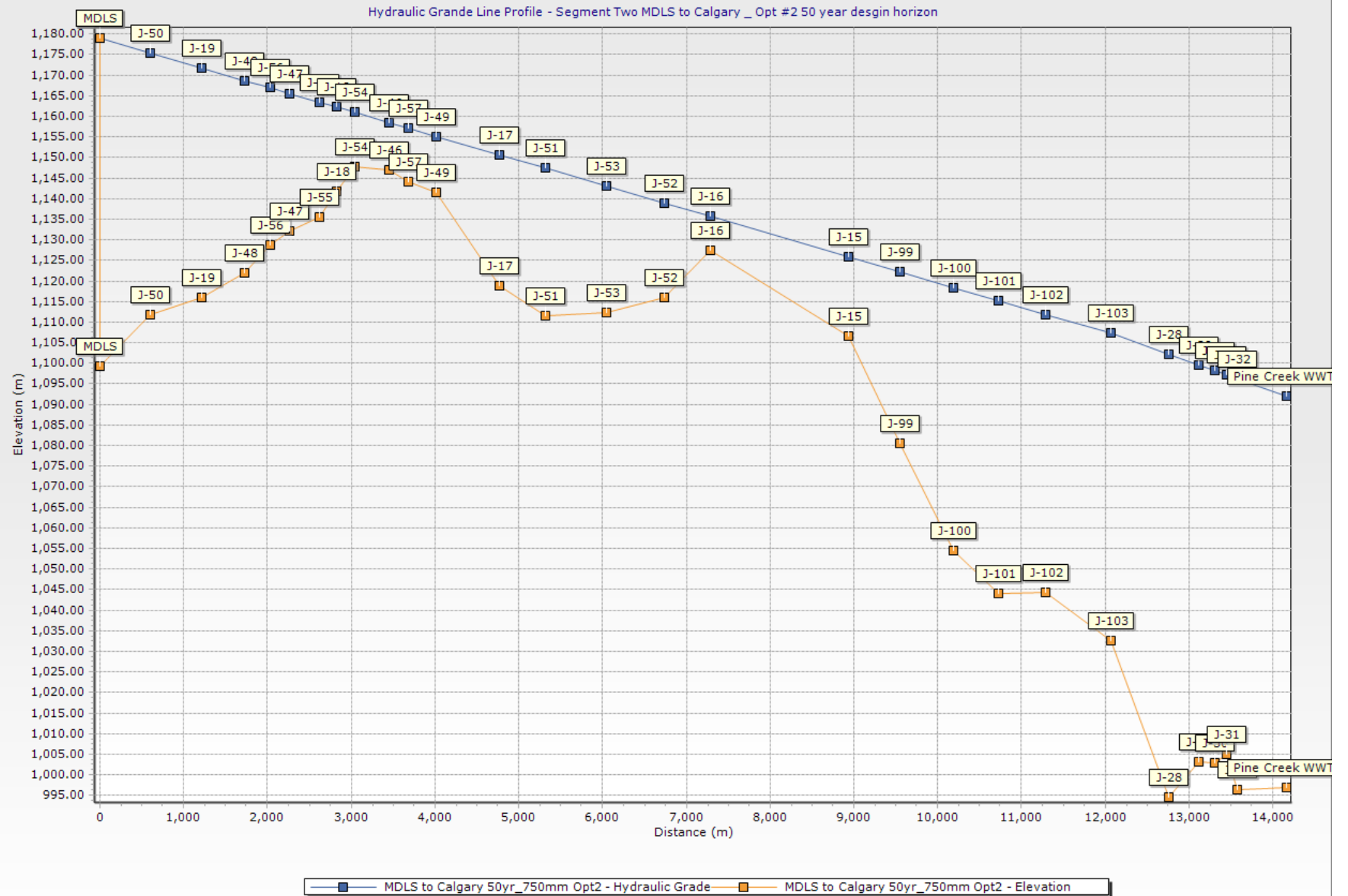
Segment One - WWTP to Mid Lift Station

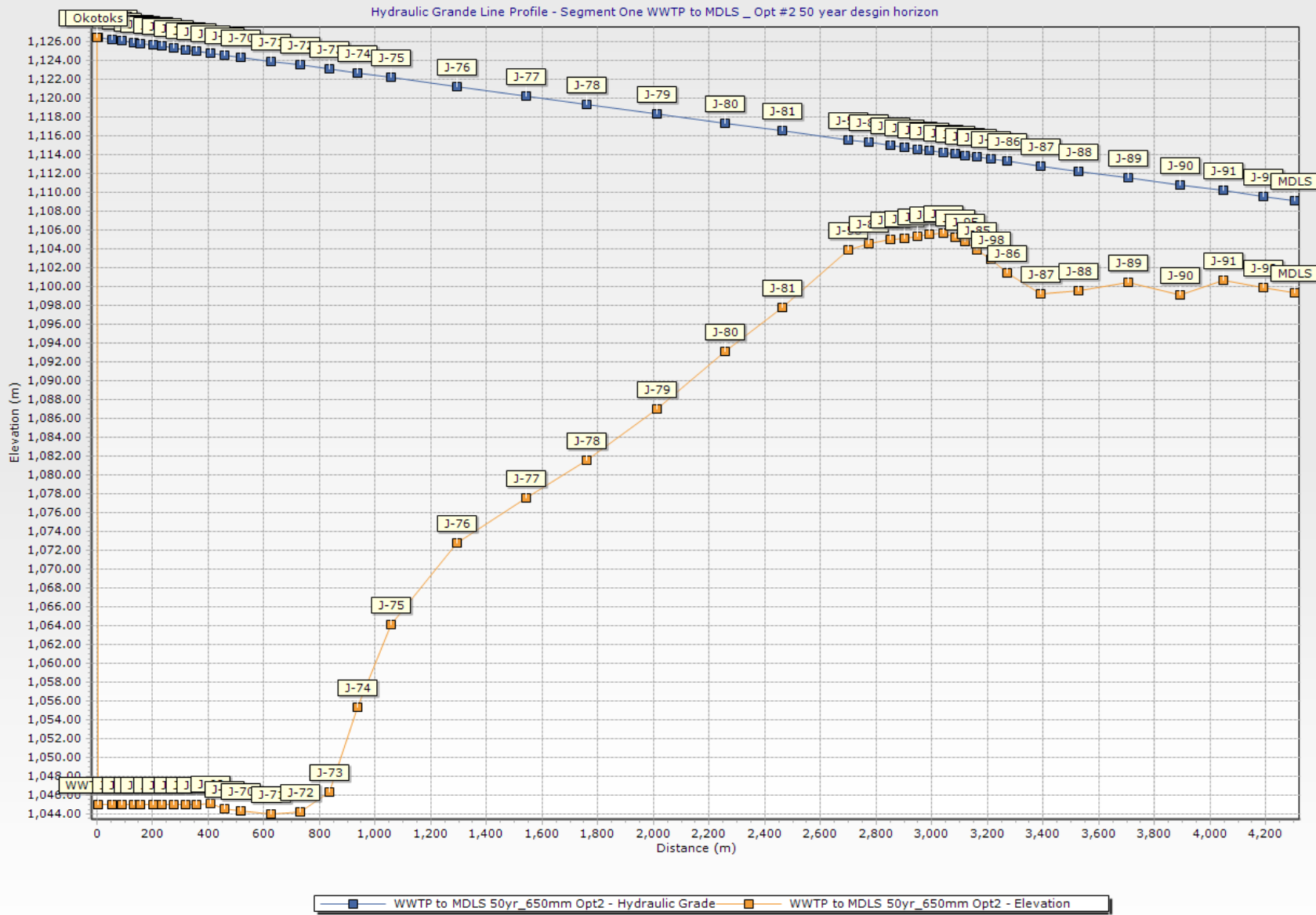
Locations	Elevation (m)	PDWF (L/s)	PDWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size Opt #1 HDPE 650 mm														
WWTP	1045	397	34301	DR 13.5	160	130	4304	558	12.2	1.62	116	82	1126.5	705
J-84	1106										12		1114.3	
MID LS	1099										14		1109.2	
Sub-total		397	34301				4304		17.30			82		
Pipe Size Opt #2 HDPE 600 mm														
WWTP	1045	397	34301	DR 13.5	160	130	4304	515	18.1	1.91	126	89	1133.5	765
J-84	1106										14		1115.4	
MID LS	1099										12		1107.9	
Sub-total		397	34301				4304		25.56			89		
Pipe Size Opt #3 HDPE 550 mm														
WWTP	1045	397	34301	DR 13.5	160	130	4304	472	39.0	2.27	146	102	1147.0	882
MID LS	1099										12		1108.0	
Sub-total		397	34301				4304		38.96			102		

Segment Two - MID LS to Calgary WWTP

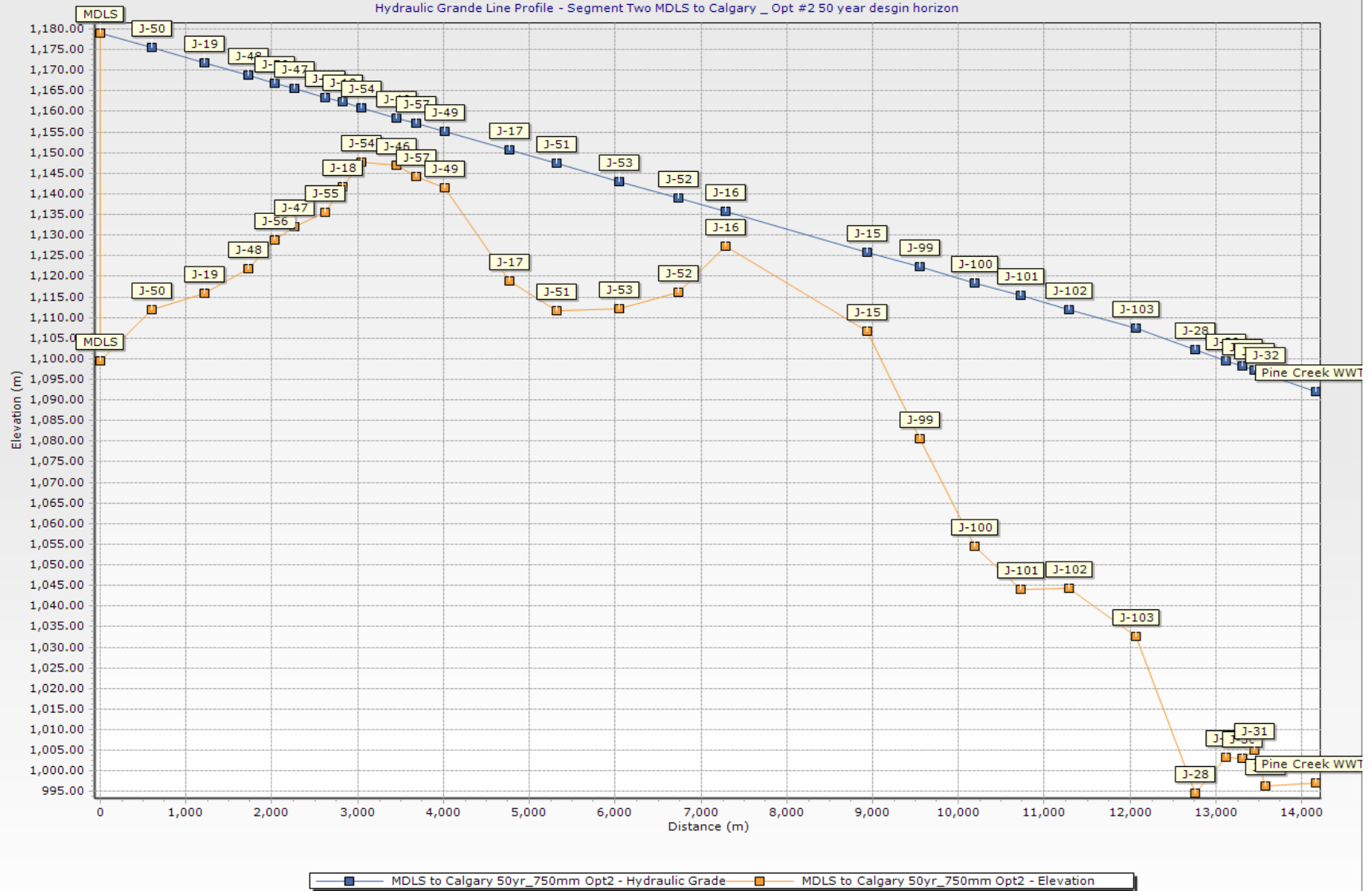
Locations	Elevation (m)	PWWF (L/s)	PWWF (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size Opt #1 HDPE 750 mm														
MID LS	1099			DR 13.5	160	130					114	80	1179.0	1241
J-18	1142						2821	643	16.8	2.2	29		1162.2	
J-103	1033						9242		54.9	2.2	106		1107.3	
J-28	995			DR 11	200				5.1	2.4	153		1102.2	
Pine Creek	997						2102	616	10.2	2.4	135		1091.9	
Total		712	61517				14165		87.07			80		
Pipe Size Opt #1 HDPE 800 mm														
MID LS	1099			DR 13.5	160	130					102	72	1170.5	1109
J-18	1142						2821	686	12.2	1.9	19		1158.3	
J-103	1033						9242		40.1	1.9	122		1118.2	
J-28	995			DR 11	200				3.8	2.1	170		1114.4	
Pine Creek	997						2102	657	7.5	2.1	156		1107.0	
Total		712	61517				14165		63.55			72		







Hydraulic Grande Line Profile - Segment Two MDLS to Calgary _ Opt #2 50 year desgin horizon



APPENDIX D – TM 4

**TECHNICAL MEMORANDUM #4
Town of Okotoks Wastewater
Treatment Plant – WWTP
Upgrade Options**



Prepared for:
The Town of Okotoks

Prepared by:
Stantec Consulting Ltd.

April 12, 2016

Sign-off Sheet

This document entitled TECHNICAL MEMORANDUM #4 Town of Okotoks Wastewater Treatment Plant – WWTP Upgrade Options was prepared by Stantec Consulting Ltd. ("Stantec") for the account of The Town of Okotoks (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between 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, 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 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.

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**TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP
UPGRADE OPTIONS**

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Executive Summary

Stantec conducted a desktop evaluation to determine process upgrade requirements at the Okotoks WWTP to be able to treat future flows and loadings for the 50-year design horizons. This Technical Memorandum (TM) builds on the regional pipeline feasibility study and information provided in Technical Memorandum #2 (TM #2) "Town of Okotoks WWTP – Treatment Capacity Assessment",

Stantec developed eight different alternatives to upgrade the existing WWTP to meet future treatment objectives through 2065. The different alternatives considered conventional BNR system, membrane bioreactor (MBR), effluent discharge options, and High Rate Clarification System (HRCS).

The HRCS would be designed as a parallel train to the main WWTP. During storm events, the HRCS would provide chemically enhanced primary treatment and disinfection to a portion of infrequent influent peak flows in excess of the projected capacity of the main WWTP. The HRCS partially treated and disinfected effluent would be blended with the effluent from the main WWTP prior to final discharge to Sheep River. The blended effluent would maintain good effluent water quality without negatively impacting the receiving waters. During average flow conditions, the HRCS would act as a standby primary clarifier. Effluent from the HRCS would be directed to the BNR system for further biological treatment.

In addition, Stantec evaluated two effluent discharge options that could be considered when the assimilative capacity of the Sheep River to accept additional nutrients loadings is exceeded. These options include discharging a portion of the treated effluent flow either to Highwood River or Bow River.

Stantec prepared a timeline and estimated an Opinion of Probable Cost (OPC) to upgrade the existing WWTP to meet future treatment objectives through 2065 considering the following alternatives:

- Alternative 1A uses an upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 1B uses an upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 2A uses an upgraded MBR in BNR configuration to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 2B uses an upgraded MBR in BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
- Alternative 3A is the same as Alternative 1A with an effluent pump station that can discharge effluent to both the Sheep River and Highwood River to improve dilution.
- Alternative 3B is the same as Alternative 1B with an effluent pump station that can discharge effluent to both the Sheep River and Highwood River to improve dilution.



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- Alternative 4A is the same as Alternative 1A with an effluent pump station that can discharge effluent to both the Sheep River and Bow River to improve dilution.
- Alternative 4B is the same as Alternative 1B with an effluent pump station that can discharge effluent to both the Sheep River and Bow River to improve dilution.

All costs were estimated in 2015 dollars and do not include GST.

Table ES.1 presents the cash flow of the OPC for the proposed upgrades over the next 50 years. While the OPC is presented during the year in which the upgrade is assumed to be online, the Town should provide sufficient time well in advance to allow for planning, design, engineering, and construction.

Table ES.1 Cash Flow of the OPC for the Proposed Upgrades through 2065 (in \$ Million)

Year	Alt. 1A	Alt. 1B	Alt. 2A	Alt. 2B	Alt. 3A	Alt. 3B	Alt. 4A	Alt. 4B
2016	\$15.71	\$7.61	\$23.18	\$14.26	\$15.71	\$7.61	\$15.71	\$7.61
2017	\$9.63	\$9.63	\$0	\$0	\$9.63	\$9.63	\$9.63	\$9.63
2019	\$0	\$5.92	\$0	\$5.92	\$0	\$5.92	\$0	\$5.92
2021	\$1.24	\$1.54	\$1.24	\$1.54	\$1.24	\$1.54	\$1.24	\$1.54
2024	\$0.87	\$0	\$0	\$0	\$0.87	\$0	\$0.87	\$0
2035	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16	\$1.16
2036	\$0	\$5.06	\$0	\$2.13	\$0	\$5.06	\$0	\$5.06
2037	\$5.87	\$0	\$5.87	\$0	\$5.87	\$0	\$5.87	\$0
2041	\$15.87	\$16.68	\$22.47	\$19.56	\$35.78	\$36.59	\$54.25	\$55.06
2042	\$0.33	\$0	\$0.33	\$0	\$0.33	\$0	\$0.33	\$0
2044	\$4.88	\$0	\$3.91	\$0	\$4.88	\$0	\$4.88	\$0
2057	\$0	\$0.97	\$0	\$0	\$0	\$0.97	\$0	\$0.97
Option Total	\$55.55	\$48.57	\$58.15	\$44.57	\$75.46	\$68.48	\$93.93	\$86.95

Figure ES.1 Illustrates the Operations, Maintenance, & Replacement (OMR) cost estimates for the proposed alternatives. The figure indicates that while alternative 2B (MBR with HRCS) has the lowest O&M cost, alternative 2A (MBR without HRCS) has the highest O&M cost which indicates that the implementation of the HRCS would provide significant cost savings to the operations of the WWTP. The few spikes in the OMR cost curve for alternative 2A and alternative 2B represents membranes replacement costs. OMR cost for other alternatives is between Alternatives 2A and 2B.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

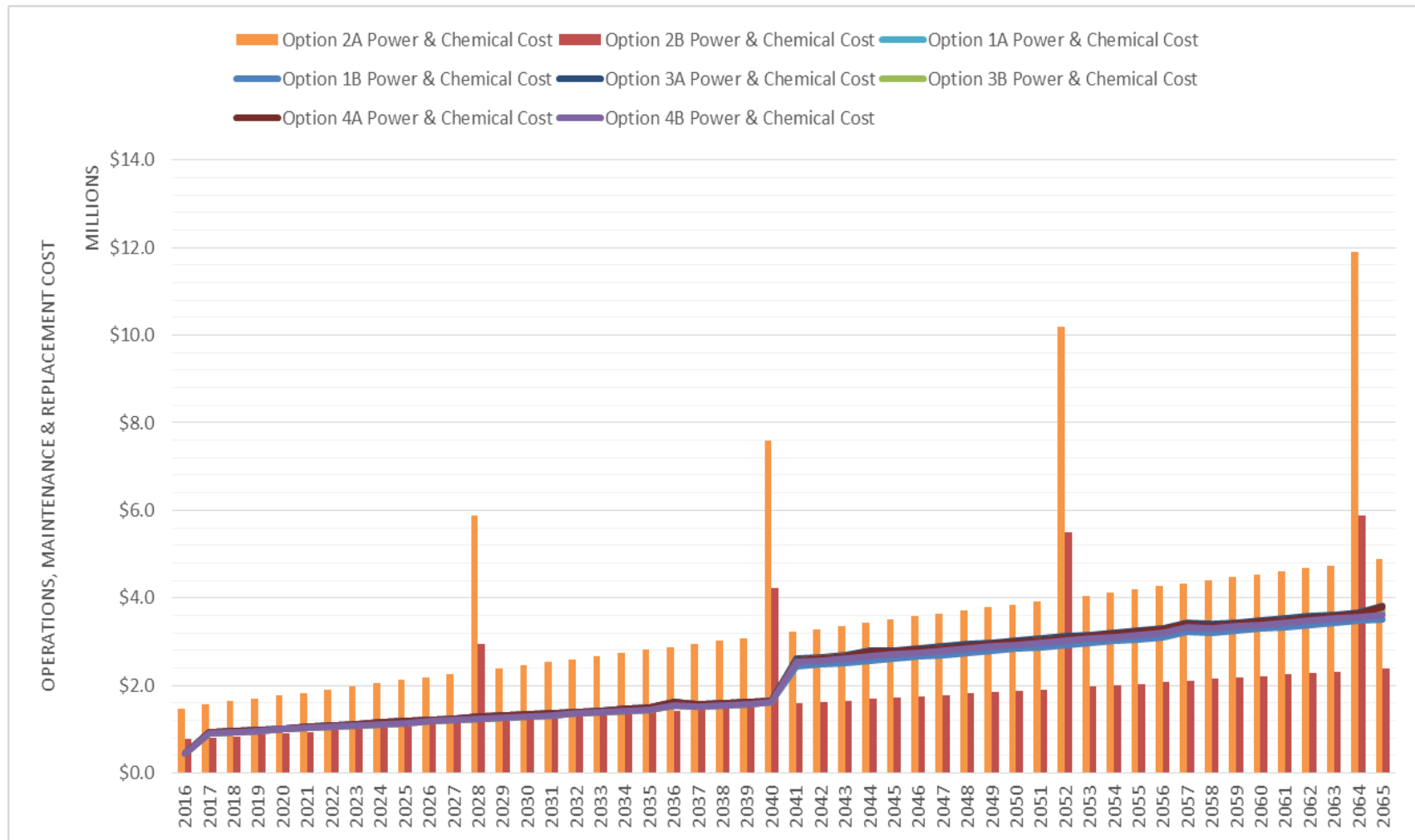


Figure ES.1 Operations, Maintenance, & Replacement Cost of the Proposed Alternatives

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Table 1.2 presents the Net Present Value (NPV) of the proposed upgrades which includes the total of OPC and OMR costs for each alternative with and without HRCS using a discount rate of 4% over the next 50 years. The NPV is color coded from dark green (lowest NPV) to dark orange (highest NPV). The table suggests that alternative 2B (MBR + HRCS) has the lowest NPV amongst all alternatives. In comparison, alternative 2A with no HRCS represent the highest NPV due to the additional infrastructure required to treat peak flows.

Based on this analysis, Stantec recommends the following:

- The Town should consider alternative 2B in their future upgrades planning;
- The Town should immediately initiate a follow-up study to analyze the frequency, severity, and duration of historical wet weather flow which would assist in sizing the proposed HRCS;
- The Town should immediately pursue the Alberta Environments & parks (AEP) approval of the proposed HRCS. Discussions with AEP indicated that the review period for any EPEA permit application could take up to one year which will push the completion date of any proposed upgrade; and
- If HRCS is not approved, the Town should consider alternative 1A instead.

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Table 1.2 Net Present Worth Value (NPV) for OPC and OMR (in \$ Million)

Year	Alt 1A	Alt 2A	Alt 3A	Alt 4A	Alt 1B	Alt 2B	Alt 3B	Alt 4B
2016	\$16.16	\$24.65	\$16.16	\$16.16	\$8.05	\$15.03	\$8.05	\$8.05
2017	\$10.16	\$1.51	\$10.16	\$10.16	\$10.13	\$0.78	\$10.13	\$10.13
2018	\$0.89	\$1.51	\$0.89	\$0.89	\$0.87	\$0.78	\$0.87	\$0.87
2019	\$0.88	\$1.51	\$0.88	\$0.88	\$6.12	\$6.04	\$6.12	\$6.12
2020	\$0.87	\$1.51	\$0.87	\$0.87	\$0.85	\$0.77	\$0.85	\$0.85
2021	\$1.88	\$2.53	\$1.88	\$1.88	\$2.11	\$2.04	\$2.11	\$2.11
2022	\$0.85	\$1.51	\$0.85	\$0.85	\$0.84	\$0.77	\$0.84	\$0.84
2023	\$0.84	\$1.50	\$0.84	\$0.84	\$0.83	\$0.76	\$0.83	\$0.83
2024	\$1.48	\$1.50	\$1.48	\$1.48	\$0.82	\$0.76	\$0.82	\$0.82
2025	\$0.84	\$1.49	\$0.84	\$0.84	\$0.81	\$0.75	\$0.81	\$0.81
2026	\$0.82	\$1.48	\$0.82	\$0.82	\$0.80	\$0.74	\$0.80	\$0.80
2027	\$0.81	\$1.47	\$0.81	\$0.81	\$0.79	\$0.74	\$0.79	\$0.79
2028	\$0.80	\$3.67	\$0.80	\$0.80	\$0.77	\$1.84	\$0.77	\$0.77
2029	\$0.79	\$1.44	\$0.79	\$0.79	\$0.76	\$0.72	\$0.76	\$0.76
2030	\$0.77	\$1.42	\$0.77	\$0.77	\$0.75	\$0.71	\$0.75	\$0.75
2031	\$0.76	\$1.40	\$0.76	\$0.76	\$0.74	\$0.70	\$0.74	\$0.74
2032	\$0.75	\$1.39	\$0.75	\$0.75	\$0.72	\$0.69	\$0.72	\$0.72
2033	\$0.73	\$1.37	\$0.73	\$0.73	\$0.71	\$0.68	\$0.71	\$0.71
2034	\$0.72	\$1.35	\$0.72	\$0.72	\$0.70	\$0.67	\$0.70	\$0.70
2035	\$1.26	\$1.89	\$1.26	\$1.26	\$1.24	\$1.21	\$1.24	\$1.24
2036	\$0.73	\$1.32	\$0.73	\$0.73	\$3.01	\$1.62	\$3.01	\$3.01
2037	\$3.26	\$3.87	\$3.26	\$3.26	\$0.67	\$0.64	\$0.67	\$0.67
2038	\$0.67	\$1.27	\$0.67	\$0.67	\$0.65	\$0.63	\$0.65	\$0.65
2039	\$0.66	\$1.25	\$0.66	\$0.66	\$0.64	\$0.62	\$0.64	\$0.64
2040	\$0.64	\$2.96	\$0.64	\$0.64	\$0.63	\$1.65	\$0.63	\$0.63
2041	\$6.88	\$9.64	\$14.40	\$21.31	\$7.17	\$7.94	\$14.69	\$21.60
2042	\$1.03	\$1.31	\$1.08	\$1.06	\$0.89	\$0.59	\$0.94	\$0.93
2043	\$0.89	\$1.16	\$0.93	\$0.92	\$0.88	\$0.58	\$0.92	\$0.91
2044	\$2.52	\$2.45	\$2.56	\$2.55	\$0.86	\$0.56	\$0.90	\$0.89
2045	\$0.86	\$1.12	\$0.90	\$0.89	\$0.84	\$0.55	\$0.88	\$0.87
2046	\$0.84	\$1.10	\$0.88	\$0.87	\$0.82	\$0.54	\$0.86	\$0.85
2047	\$0.82	\$1.08	\$0.86	\$0.85	\$0.80	\$0.53	\$0.84	\$0.83
2048	\$0.80	\$1.06	\$0.84	\$0.83	\$0.78	\$0.52	\$0.82	\$0.81
2049	\$0.78	\$1.04	\$0.82	\$0.81	\$0.77	\$0.51	\$0.80	\$0.79
2050	\$0.76	\$1.01	\$0.80	\$0.79	\$0.75	\$0.50	\$0.78	\$0.77
2051	\$0.74	\$0.99	\$0.78	\$0.77	\$0.73	\$0.49	\$0.76	\$0.75
2052	\$0.73	\$2.48	\$0.76	\$0.75	\$0.71	\$1.34	\$0.74	\$0.74
2053	\$0.71	\$0.95	\$0.74	\$0.73	\$0.70	\$0.46	\$0.73	\$0.72
2054	\$0.69	\$0.93	\$0.72	\$0.72	\$0.68	\$0.45	\$0.71	\$0.70
2055	\$0.68	\$0.91	\$0.71	\$0.70	\$0.66	\$0.44	\$0.69	\$0.68
2056	\$0.66	\$0.89	\$0.69	\$0.68	\$0.65	\$0.43	\$0.67	\$0.67
2057	\$0.66	\$0.87	\$0.69	\$0.68	\$0.84	\$0.42	\$0.87	\$0.86
2058	\$0.63	\$0.85	\$0.65	\$0.65	\$0.62	\$0.41	\$0.64	\$0.64
2059	\$0.61	\$0.83	\$0.64	\$0.63	\$0.60	\$0.40	\$0.63	\$0.62
2060	\$0.60	\$0.81	\$0.62	\$0.61	\$0.59	\$0.39	\$0.61	\$0.60
2061	\$0.58	\$0.79	\$0.60	\$0.60	\$0.57	\$0.38	\$0.59	\$0.59
2062	\$0.57	\$0.77	\$0.59	\$0.58	\$0.56	\$0.38	\$0.58	\$0.57
2063	\$0.55	\$0.75	\$0.57	\$0.57	\$0.54	\$0.37	\$0.56	\$0.56
2064	\$0.54	\$1.81	\$0.56	\$0.55	\$0.53	\$0.90	\$0.55	\$0.54
2065	\$0.54	\$0.71	\$0.56	\$0.55	\$0.52	\$0.35	\$0.53	\$0.53
NPV	\$74.70	\$103.07	\$82.96	\$89.68	\$69.06	\$62.75	\$77.33	\$84.05

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Introduction
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1.0 INTRODUCTION

1.1 BACKGROUND

The Town of Okotoks (The Town) is one of the fastest growing communities in Canada. Its populations as of June 2014 Municipal Census was 27,331 rapidly increasing from 19,996 in 2008. The Town had a 30,000 person population cap, which was eliminated in 2012.

The Town is investigating water supply and wastewater treatment upgrade options to meet projected populations for the 25-year (2040) and 50-year (2065) design horizons of 59,119 and 92,172, respectively.

Stantec Consulting Ltd. (Stantec) is comparing the costs, capacity, and upgrade requirements of treating wastewater locally at Okotoks' Wastewater Treatment Plant (WWTP) or connecting to the City of Calgary through a regional wastewater pipeline. Water supply options are being investigated by others.

The feasibility analyses are provided in the following Technical Memorandums (TMs):

1. TM#1 Design Basis Definition (Completed)
2. TM# 2 WWTP Capacity Assessment (Completed)
3. TM# 3 Sanitary Forcemain Options (DRAFT under review)
4. TM# 4 WWTP Upgrade Options (This TM)
5. TM# 5 Evaluation Criteria and Weighting (In progress)
6. Final Feasibility Report (Pending)

1.2 EXISTING WWTP CAPACITY

The existing WWTP consists of influent screw pumps, grinder/spiral screens, vortex grit chamber, a flow equalization tank, an Activated Primary Clarifier (APC), a Biological nutrient Removal (BNR) bioreactor/secondary clarifier, tertiary disk filtration and UV disinfection. Primary and secondary solids are handled using Dissolved Air Floatation (DAF), centrifuge dewatering, and pug mill mixers. In TM #2, Stantec completed a desktop capacity evaluation of the existing infrastructure at Okotoks WWTP based on historical monthly reports, design basis information from TM #1, supplemental sampling results, manufacturer data for installed equipment, or original design information through shop drawings and O&M manuals.

Figure 1.1 summarizes our findings from the capacity assessment effort. The figure illustrates the installed capacity and firm capacity (i.e. capacity with largest unit offline) of each unit process. Actual peak hour flow or maximum loading to each unit process in 2015 were also added and used to evaluate the status of each unit whether it is under capacity, at capacity, or over capacity based on the criteria listed in TM #2. The status of each critical unit process (i.e. the liquid train unit processes and DAF) was evaluated against their firm capacity. For less critical units including solids train unit processes and fermentation, the status of each unit was evaluated against their installed capacity assuming that the WWTP is able to dispose of thickened solids to



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an offsite facility when a solids handling unit is taken out of service for repair or maintenance until it is back online. For unit processes under design capacity, the Equivalent Population (EP) to reach full capacity was determined based on future flows projection as listed in TM #1.

1.3 WORK SCOPE

This Technical Memorandum #4 (TM #4) summarizes costs and options for WWTP upgrades to treat the projected flows and loadings for the 25-year (2040) and 50-year (2065) design horizons. Upgrade options address:

- Process upgrade requirements;
- Effluent outfall upgrade requirements; and
- Optional process upgrades.

All upgrade alternatives incorporate critical equipment redundancy to enable the WWTP to operate at a firm capacity in excess of population needs when the largest capacity unit is removed from service. For less critical components, regular maintenance can be scheduled during low flow periods to enable the WWTP to take one unit offline while relying on the other unit(s) to achieve treatment objectives.

1.4 COST ESTIMATES

Stantec provided cost estimates at a Class 4 level of accuracy according to ACEI Recommended Practice 18R-97, "Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries".

Class 4 estimates are used for projects developed to between 1% and 15% and are suitable for feasibility reports. The accuracy is considered valid within +50% and -30% of the noted value.

Stantec did not include taxes in cost estimates.

All estimates were based on projected market pricing for the described work scope using 2015 dollars at existing market conditions in Southern Alberta.

For net present value (NPV) calculations, Stantec applied a discount rate of 4%.

Stantec assumes the first potential year for expenditure is 2016 though this may not be feasible from a budget perspective. Upgrades noted for completion in 2016 typically relate to an identified capacity issue. Continued operation of the WWTP without upgrades may start to have an effect on treated effluent quality. Stantec recommends immediate commencement of design effort to plan for capacity upgrades as soon as budget is available.

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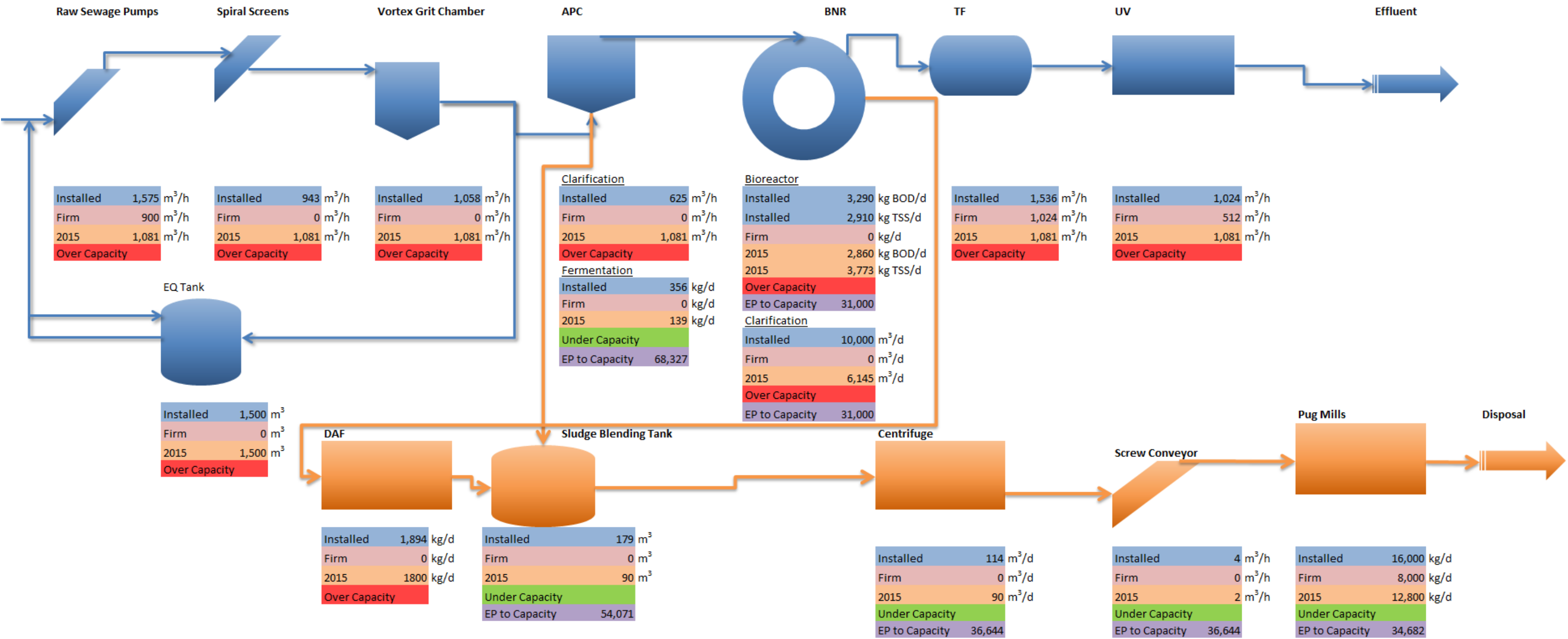


Figure 1.1 Capacity of the Existing Okotoks WWTW

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Receiving Water Conditions
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2.0 RECEIVING WATER CONDITIONS

The potential for increased discharge from the WWTP as Okotoks' population grows is limited by the assimilative capacity of the Sheep River to absorb additional nutrients in the treated effluent. Nutrients released by surface runoff and from Black Diamond's WWTP are assumed to remain constant for this analysis.

Stantec used upstream and downstream water quality data (Carter & Ryan, 2010; Stantec Consulting Ltd., 2009) to estimate the downstream Sheep River concentrations of phosphorous and nitrogen as Okotoks' WWTP effluent flow rates increase with growth in the service population.

Allowable water quality nutrient limits were based on the Alberta Surface Water Quality Guidelines (ASWQG).

2.1 TOTAL PHOSPHOROUS

2.1.1 Background Phosphorous

Phosphorous loading to Sheep River results from both point sources (Turner Valley, Black Diamond, and Okotoks) and non-point sources (agricultural surface run-off). Turner Valley and Black Diamond operate an aerated lagoon treatment process that does not include provisions for nutrient removal. Stantec assumes that no significant phosphorous removal is currently achieved at the Black Diamond WWTP. Though the service population is low compared to Okotoks, the relative contribution of Total Phosphorus (TP) from the Black Diamond WWTP to Sheep River background concentration is significant.

Stantec assumes there will be no change in background TP concentrations through the study period. To decrease the background TP concentration in the Sheep River, improvements to phosphorous management for all point and non-point sources should be implemented.

Phosphorus concentration is the most important constraint on potential service population growth within the Sheep River watershed. The effect of TP in the river is especially important during the summer season when river flows are low, water temperature is elevated, and algae growth is prevalent.

2.1.2 Average Phosphorous Conditions

At an average background TP levels of 0.0086 mg-P/L and August 7Q10 river flows of 2.548 m³/s, Stantec estimated that Okotoks WWTP is able to continue discharging its treated effluent with TP level of 0.2 mg-P/L to Sheep River until 2040 without exceeding ASWQG of 0.05 mg-P/L.

To comply with the ASWQG requirements beyond 2040 until 2065 at average background TP levels of 0.0086 mg-P/L and August 7Q10 river flows of 2.548 m³/s, Okotoks' WWTP has to maintain effluent TP concentrations below 0.125 mg-P/L using enhanced chemical phosphorus precipitation with tertiary filtration.



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Receiving Water Conditions
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The existing technology with additional chemical use would enable Okotoks to meet the TP effluent limit under average background loading conditions.

2.1.3 Maximum Phosphorous Conditions

At the maximum background TP concentration of 0.0199 mg-P/L and August 7Q10 river flow of 2.548 m³/s, effluent TP concentration has to be reduced to 0.14 mg-P/L or less to meet the ASWQG by 2040.

To comply with the ASWQG requirements beyond 2040 until 2065 at maximum background TP levels of 0.0199 mg-P/L and August 7Q10 river flows of 2.548 m³/s, Okotoks WWTP has to maintain treated effluent TP concentrations below 0.09 mg-P/L using enhanced chemical phosphorus precipitation with tertiary filtration.

The existing technology with additional chemical use would enable Okotoks to meet the TP effluent limit under average background loading conditions.

2.1.4 Phosphorus Loading to Bow River

Discussion with Alberta Environment and Parks (AEP) indicated that future upgrades of the Okotoks WWTP should consider the effect of TP loadings on Bow River at Carseland. However, while effluent loadings from Okotoks WWTP at 2040 and 2065 flows and effluent TP level of 0.2 mg-P/L are approximately 9.5 kg/day and 14.5 kg/d, respectively, the City of Calgary is allowed to release an average of 340 kg/day of TP (240 kg/day from the three WWTPs and 100 kg/day from non-point sources) into Bow River.

Though the impact of Okotoks' TP releases on Bow River at Carseland will be small, input from AEP will be required to determine if additional treatment is necessary to mitigate the effect.

A regional discussion for all municipalities contributing TP to Sheep River will also be required to be able to meet the TP trigger point at Carseland.

2.2 AMMONIA

Assuming the nitrogen removal performance of the WWTP remains constant, and using seasonal pH and temperatures to calculate the fraction of un-ionized ammonia in the river, Okotoks is able to continue discharging its treated effluent to Sheep River until 2065 without exceeding ASWQG in-stream limits of 0.016 mg-N/L.

During the warm summer months, residual effluent ammonia-N entering the Sheep River will likely be fully nitrified by the time it gets to Carseland. Thus the effect of un-ionized ammonia-N releases on Bow River reported at Carseland is not likely to be a concern for operation of the Okotoks WWTP.

During low flow winter months, effluent dilution is reduced and nitrogen removal efficiency at the WWTP may need to be improved.

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Receiving Water Conditions
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Modification of the nutrient removal process to increase capacity in nitrification and denitrification sections of the bioreactor, or to modify operational procedures (recirculation rates and sludge age), may be required to meet Carseland ammonia limits during cold winter months.

No innovative technology is required to meet the effluent ammonia limits for Sheep River or Bow Rivers, though additional detailed analysis of the winter effects of ammonia on Bow River will be required as part of future EPEA approval processes.

2.3 SHEEP RIVER FLOWS

If the Sheep River 7Q10 flow remains constant, the analysis results in this TM for TP and ammonia are acceptable. However, due to concerns about recurring droughts and decline in river flows over time, Okotoks must consider another effluent discharge location other than the Sheep River.

Regulatory changes may also result in more stringent discharge limits or impose dilution ratios that will be difficult to meet with any technology.

Partial discharge of treated effluent to Highwood River or Bow River would improve the dilution ratio and may be necessary to allow Okotoks to treat additional flow.

Though a change in the effluent discharge location may improve local dilution and local nutrient concentration, it will not affect the mass load at the Carseland monitoring station.

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Wet Weather Management
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3.0 WET WEATHER MANAGEMENT

Due to the substantial capital investment required to provide a WWTP capable of fully treating peak flow rates, and the infrequent occurrences of these high flows, budget-limited municipalities are considering wet weather management strategies to treat relatively infrequent peak flow events.

Wet weather management strategies typically divert a portion of peak flow away from the main WWTP processes, treat it through a lower intensity side stream physical/chemical treatment process followed by disinfection, and then blend the partially treated effluent with the effluent from the main WWTP prior to discharge.

3.1 REGULATORY REVIEW

Wet weather management strategies are gaining attention within Canada and the United States. There has been significant debate regarding the quality and effect of blended effluent on the environment. Few jurisdictions have explicit prohibition against wet weather flow side-stream treatment to achieve effluent quality limits during peak flow events.

The Province of Alberta does not currently have specific regulations related to wet weather treatment strategies. Discussions with provincial regulators will be required to obtain approval for side stream processes.

Gold Bar WWTP in Edmonton operates a 600 ML/d High Rate Clarification System (HRCS) consisting of screening and chemically enhanced primary clarification followed by disinfection. Effluent from this facility is directly discharged to the North Saskatchewan River through a dedicated outfall.

Within Canada, the British Columbia Environmental Management Act: Municipal Wastewater Regulation includes requirements, summarized in Table 3.1, for municipal effluent quality for flows above and below 2.0 x annual average day flow (AAF). The act recognizes that during periods of high inlet WWTP flow and substantial effluent dilution in the receiving watercourse, a fixed effluent quality is not necessarily required.

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Wet Weather Management
April 12, 2016

Table 3.1: BC Municipal Effluent Quality Requirements If Maximum Daily Flow > 50 m³/d

Parameter	Dilution Ratio > 40:1	Dilution Ratio > 10:1
Daily Flow < 2 x AAF: TSS & BOD ₅ (mg/L)	≤ 45	≤ 10
Daily Flow < 2 x AAF: pH	6 - 9	6 – 9
Daily Flow < 2 x AAF: TP (mg/L)	≤ 1.0	≤ 1.0
Daily Flow < 2 x AAF: Ortho-P (mg/L)	≤ 0.5	≤ 0.5
Daily Flow > 2 x AAF (interim): TSS & BOD ₅ (mg/L)	≤ 130	≤ 10

In March 2013 a US federal appellate court ruled that Environmental Protection Agency (EPA) cannot regulate wastewater treatment processes within the boundaries of publically owned utilities. More specifically, the court ruled that EPA cannot restrict the blending of treated and partially treated wastewater within a WWTP if the resulting effluent still meets the required discharge criteria. While the judgment is specific to the United States, it supports the validity of using wet weather management facilities to balance budget constraints against environmental concerns, especially when permit requirements are still being satisfied.

3.2 PROCESS DESCRIPTION

HRCS provides primary treatment for a portion of the total influent wastewater that is diverted away from the main WWTP processes during high flow events. Diversion of flow protects the slow growing biomass in the bioreactors from washout, allowing the WWTP to continue normal operation, even during peak flow conditions.

HRCS for Okotoks would divert all inflow above a target set to a bypass channel upstream of the current headworks facility. Bypass flow would be screened and chemically treated to form primary sludge as part of the high rate clarification step. If permitted (or required) by the regulator, HRCS clarifier effluent could be disinfected prior to discharge to the existing effluent channel. The combined effluents from the HRCS and WWTP would meet approval discharge limits without affecting the biology of the WWTP, allowing it to continue normal operation throughout the high flow event. Sludge collected in the high rate clarifier would be pumped to the sludge blend tank.

High rate clarification processes require coagulants (aluminum or ferric salts), polymer, and usually micro-sand or magnetite particles as ballasts to increase particle settling velocities. The high overflow rates achieved with the ballasts reduce the required footprint while the chemical treatment step results in enhanced chemical pollutant removal.

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3.3 PROCESS CAPACITY

Stantec recommends constructing HRCS to enable the WWTP to bypass flows in excess of 2.0 x average annual flow away from the main treatment processes. The proposed HRCS would be sized to ultimately treat up to 45,000 m³/d; the peak flow in excess of 2.0 x average annual flows in 2065. Two 15,000 m³/d high rate clarifiers must be constructed immediately by 2016 to handle peak flows in excess of 2.0 x average annual flows until 2040. To accommodate the proposed clarifiers, a new HRCS building with all associated piping and ancillary components is required by 2016. In 2041, a third high rate clarifier with a capacity of 15,000 m³/d must be installed within the same building to handle peak flows in excess of 2.0 x average annual flows until 2065.

The approximate cost of the 45,000 m³/d HRCS at Okotoks is \$5.25 Million including 22% contingency and 15% engineering fee allocations.

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WWTP Upgrade Alternatives
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4.0 WWTP UPGRADE ALTERNATIVES

To meet sewage generation projections for the study period, Stantec developed eight different alternatives for wastewater treatment and release. The treatment alternatives considered the following options:

1. Conventional biological nutrient removal (BNR) using the existing technologies with effluent discharge to Sheep River
2. Membrane Bioreactor (MBR) treatment with effluent discharge to Sheep River
3. Conventional BNR with effluent releases to Sheep River and Highwood River
4. Conventional BNR with effluent releases to Sheep River and Bow River

For each of the treatment alternatives, Okotoks may select to employ HRCS to treat peak flows. The HRCS would be designed as a parallel train to the main WWTP. During storm events, the HRCS would provide chemically enhanced primary treatment and disinfection to a portion of infrequent influent peak flow in excess of 2.0 x average annual flow of the WWTP. The HRCS partially treated and disinfected effluent would be blended with the effluent from the main WWTP prior to final discharge to Sheep River. The blended effluent would maintain good effluent water quality without negatively impacting the receiving waters. During average flow conditions, the HRCS would act as a standby primary clarifier. Effluent from the HRCS would be directed to the BNR system for further biological treatment.

Alternatives without HRCS are annotated with an A and those with HRCS with a B.

4.1 ALTERNATIVE 1

4.1.1 Alternative 1A

Alternative 1A uses an upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.

4.1.2 Alternative 1B

Alternative 1B uses an upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.

4.2 ALTERNATIVE 2

4.2.1 Alternative 2A

Alternative 2A uses an upgraded MBR in BNR configuration to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.



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4.2.2 Alternative 2B

Alternative 2B uses an upgraded MBR in BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.

4.3 ALTERNATIVE 3

4.3.1 Alternative 3A

Alternative 3A is the same as Alternative 1A with an effluent pump station that can discharge effluent to both the Sheep River and Highwood River to improve dilution.

4.3.2 Alternative 3B

Alternative 3B is the same as Alternative 1B with an effluent pump station that can discharge effluent to both the Sheep River and Highwood River to improve dilution.

4.4 ALTERNATIVE 4

4.4.1 Alternative 4A

Alternative 4A is the same as Alternative 1A with an effluent pump station that can discharge effluent to both the Sheep River and Bow River to improve dilution.

4.4.2 Alternative 4B

Alternative 4B is the same as Alternative 1B with an effluent pump station that can discharge effluent to both the Sheep River and Bow River to improve dilution.

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Alternative 1 Details
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5.0 ALTERNATIVE 1 DETAILS

5.1 ALTERNATIVE 1A

5.1.1 Raw sewage pumping

Raw sewage pumps are used to deliver raw sewage to the existing grinder/spiral screens and to create sufficient hydraulic head that will maintain gravity flow through the downstream unit processes. Okotoks WWTP has three (3) influent raw sewage pumps (SP-101, SP-102, and SP-103).

As described on TM#2, the maximum capacity of the existing screw pumps (SP-101, SP-102, and SP-103) is reached at the current Peak Hourly Flow (PHF) condition. For future PHF conditions, Stantec evaluated Archimedes screw pumps, screw impeller, and non-clog (mixed flow) centrifugal pumps.

Archimedes screw pumps have a relatively low capital cost. However, the associated civil and structural work required to retrofit the existing station with new, higher capacity pumps would significantly increase project costs. Archimedes screw pumps are relatively inefficient and the sump must be drained to access the submersible bearings.

The existing wet well can be retrofit with centrifugal solids handling pumps to lift raw wastewater into the existing raw wastewater channel upstream of the grinders. Centrifugal pumps are available in many configurations that make them suitable for use in space-constrained retrofit applications.

For the purpose of this feasibility study, Stantec assumes that the existing wet well is structurally sound and can be reused. Stantec recommends replacing two Archimedes screw pumps (SP-101 and SP-102) with 1,825 m³/h submersible sewage pumps. Combined with the capacity of the remaining screw pump, the submersible pumps will provide sufficient firm capacity to handle the projected PHF of 2,441 m³/h in 2041. The final screw pump can be replaced in 2042 with a third centrifugal pump to handle the projected PHF up to 2065.

5.1.2 Screens

Screening removes large material such as rags, wood, and plastic objects to prevent any plugging or damage to downstream mechanical equipment.

As described in TM#2, the maximum capacity of the existing grinder/spiral screen combo is reached at the current Peak Hourly Flow (PHF) condition of 1,081 m³/h. Assuming that the existing channel has sufficient capacity to handle future PHF conditions up to 3,642 m³/h in 2065, Stantec recommends the following:

- Replace the existing grinder/spiral screen system immediately with a single 6-mm screen/washer compactor unit to fit within the existing channel;
- Convey the washed screenings to a discharge bin for off-site disposal;
- Discharge the wash water back to the primary influent channel; and



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- Construct a bypass channel beside the existing channel to accommodate a manually cleaned bar rack that can be used when the mechanical screen is taken offline for maintenance.

5.1.3 Grit Removal

Grit removal removes dense, abrasive particulates from the influent sewage to minimize the effects of wear and accumulation on downstream equipment.

As described on TM#2, the existing mechanically induced vortex grit removal chamber has a flow capacity of 1,058 m³/h, that has been exceeded at the current PHF. Stantec recommends replacing the internal mechanism in 2016 to increase the capacity to 2,584 m³/h, sufficient to meet projected PHF until 2043. A second vortex grit trap mechanism with a flow capacity of 2,584 m³/h must be installed by 2044 to handle additional flows. The capacity of both mechanisms is 5,168 m³/h (greater than projected 2065 PHF). The installation of the second vortex grit mechanism requires additional structural modifications to the approach and discharge channels as well as the headworks building.

Full redundancy is not required for the grit removal equipment. With two larger capacity replacement units, the WWTP can conduct scheduled maintenance on a single train during low flow conditions.

5.1.4 Primary Treatment

Primary clarification at Okotoks WWTP removes readily settleable solids and floating material from screened sewage by allowing suspended solids to settle down to the bottom of the clarifier and skimming floating materials off the wastewater surface. The sludge blanket in the activated primary clarifier (APC) is maintained at 1 – 3 m depth to promote the fermentation of organics in the blanket to volatile fatty acids (VFAs) used to enhance nutrient removal in the bioreactor.

As detailed in TM#2, the existing APC has sufficient capacity to treat up to 9,880 m³/d at average flow conditions and 22,800 m³/d at peak flow conditions. However, due to the hydraulic limitations of the inlet pipe to the APC, the maximum flow is limited to 15,000 m³/d.

Based on the current treatment capacity and hydraulic limitations of the existing APC, a new 21m diameter APC will be required immediately by 2016. A third 21m diameter APC is required by 2037.

Both APCs can be constructed directly to the east of the existing unit. Stantec recommends modifying the existing inlet channel and extending a new inlet pipe from headworks to maximize the hydraulic and process capacity of the new APCs.

The capacity of the three APCs at Okotoks WWTP will be sufficient to handle the projected PHF in 2065. Full redundancy is not provided for this option. With three APCs, the WWTP can conduct scheduled maintenance on a single train during low flow conditions.

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5.1.5 Secondary Treatment

The Biological Nutrient Removal (BNR) secondary system is based on Modified Johannesburg Process consisting of a single seven-zone aeration tank surrounding a single secondary clarifier for solids separation. The aeration tank consists of a small pre-anoxic zone, followed by an anaerobic zone, two anoxic zones, and three aerobic zones.

As detailed in TM#2, the existing secondary system is almost at capacity at the maximum month BOD₅ loading conditions. It is capable of treating wastewater for an equivalent population of 31,440 which is projected to be reached in 2017.

In this analysis, Stantec identified the clarifier solids loading rate as the main factor limiting the capacity of the secondary system based on typical loading rates from the literature. Site-specific analysis of sludge settling characteristics is necessary to evaluate the actual capacity of the secondary clarifier.

Stantec recommends a staged upgrade to the secondary system to meet projected maximum month loadings. An additional bioreactor-secondary clarifier system with an alum trim (identical to the existing units) should be installed by 2017. A third identical unit is needed by 2040 to meet 2065 flow and treatment requirements.

5.1.6 Tertiary Treatment

Three (3) disc filtration units (2 duty + 1 standby) with a capacity of 512 m³/h each provide tertiary filtration to the secondary effluent prior to disinfection. The firm capacity of the existing filtration system with two units in operation is exceeded under current PHF conditions as detailed in TM#2.

Stantec recommends a staged upgrade to meet projected PHF conditions. An additional disk filter with a capacity of 1,024 m³/h is required in 2016. To accommodate the proposed disk filtration units, a new filtration building with all associated piping and ancillary components is required by 2016 as well. By 2024 an additional disk filter is required, while a final disk filter is needed in 2044 to provide sufficient PHF firm capacity through 2065.

This staging scenario will allow the WWTP to take the largest unit offline for scheduled maintenance at any time during the planning period.

5.1.7 Disinfection

The UV disinfection system at Okotoks WWTP operates with a total of 112 UV lamps located along one (1) channel with 2 banks in series per channel and a provision for a third bank. Each UV bank has a treatment capacity of 512 m³/d.

The firm capacity of the existing UV disinfection system with one bank in operation is exceeded at PHF conditions as detailed in TM#2. Stantec recommends staged upgrades to meet anticipated PHF conditions as follows:



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- 2016: install a complete second channel with two 512 m³/h UV banks, and provide space for a third bank.
- 2024: install a third 512 m³/h UV bank in the first channel.
- 2034: install a third 512 m³/h UV bank in the second channel.
- 2044: install a complete third channel with one 512 m³/h UV bank, and provide space for two additional banks.
- 2054: install a second 512 m³/h UV bank in the third channel.

This staging scenario will allow one UV bank to be taken offline for scheduled maintenance at any time during the planning period.

A Bioassay Validation procedure is needed to determine the most efficient UV dose at various flow rates and water qualities to meet the disinfection objectives.

5.1.8 Fermentation

The existing APC will be capable of providing sufficient VFA production until 2046 as detailed in TM#2. As indicated in Section 5.1.4, Stantec recommends installing a second APC immediately in 2016 and a third one by 2037 to provide primary clarification to influent PHF until 2065. The three APCs will provide sufficient fermentation capacity to support biological phosphorus removal in the bioreactor through 2065. Chemical phosphorus trimming can be used to supplement biological phosphorus removal when required.

5.1.9 WAS Thickening

The existing dissolved air flotation (DAF) unit which is used for WAS thickening is operating more efficiently than the original design expectations. However, with current solids loading rate of 4.2 kg/m²/d at max month conditions, the existing DAF system is nearing its design process capacity of 4.4 kg/m²/d. Exceeding the recommended loading rate would decrease process efficiency to less than 95%. It is possible to double the capacity of the existing DAF system by adding polymer to the process (dependent on bench testing), although this will not provide any redundancy for the DAF system.

To continue operating with high process efficiency, Stantec recommends installing a new DAF immediately (2016). The addition of a second DAF will provide sufficient WAS processing capacity through to 2037. To meet WAS thickening demands beyond 2037 through 2065, Stantec recommends adding polymer to the process. Also, a second DAF will enable the WWTP to take one unit offline for maintenance without jeopardizing WAS thickening capacity.

There is sufficient space within the existing solids handling building to accommodate a new DAF system. Stantec recommends relocating the existing centrifuge and screw conveyor to provide space for the proposed DAF system. DAF supernatant will be sent to APC influent.

5.1.10 Sludge Holding & Blending

The sludge blend tank is used to mix and store primary sludge and thickened waste activated sludge (TWAS) before it is pumped to the sludge dewatering system. Within the sludge blend



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tank, there are two submersible horizontal propeller mixers which thoroughly mix the sludge. Although the existing sludge blend tank was identified in TM#2 as having sufficient capacity until 2035, the existing mixing system within the tank cannot provide adequate mixing when the tank is less than 40% full. As such, Stantec recommends installing a new mixing system in 2016 to maximize the working volume of this tank.

In order to accommodate projected maximum month sludge production through 2065, a new sludge blend tank with a volume of 126 m³ will be required in 2035.

5.1.11 Sludge Dewatering

The existing sludge dewatering system consists of a single centrifuge, with 14.3 m³/h process capacity. If operated 8 hours per day, 7 days a week at full capacity, the existing centrifuge will service the WWTP until 2021.

It is possible to increase the process capacity by extending the operating time to longer than 8 hours/day. However, the extended operating time would not provide the WWTP with any redundant capacity if the centrifuge were to be taken offline for maintenance.

Therefore, Stantec recommends installing a new centrifuge by 2021 to provide the WWTP with additional solids dewatering capacity through to 2047. By extending the operating time of both centrifuges, additional solids dewatering capacity can be gained after 2047 through 2065.

There is sufficient room within the existing solids handling building to install a second centrifuge if the existing pug mills are decommissioned and removed. A second centrifuge will require modifying the existing sludge screw conveyor and installing a second one.

Sludge disposal is discussed in Section 5.1.12.

5.1.12 Sludge Disposal

Currently, the WWTP mixes dewatered sludge with wood chips and trucks the amendment to an offsite compost facility. In order to maintain this operation, a third pug mill mixer is required by 2020 in order to have sufficient capacity to handle maximum month sludge production.

The existing footprint of the solids handling room will not be able to accommodate an additional pug mill mixer plus a second DAF tank and a second centrifuge. For operational and cost reasons, Okotoks has indicated that the WWTP is interested in discontinuing the process of blending dewatered sludge with wood chips before trucking to the compost facility. If acceptable to the compost facility, the process could be simplified by eliminating the wood chip mixing process and only trucking dewatered sludge.

Eliminating woodchip addition will enable the WWTP to decommission the pug mixers, remove them from the solids handling building and replace the existing compost storage bins with sludge bins suitable for hauling dewatered sludge.

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Stantec assumes that sludge can be hauled directly to the compost facility without first being mixed with woodchips.

If the unmixed dewatered sludge is not acceptable to the compost facility, Stantec recommends installing a sludge stabilization process, such as anaerobic "high rate" mesophilic sludge digestion, prior to disposal. In the "high rate" process, the blended sludge is fed intermittently, and the digester tank contents are kept well mixed and heated to maintain a steady temperature of 35 – 37 °C. Digested sludge can then be sent for disposal at a landfill, or potentially land applied.

Stantec recommends installing a single 20m diameter x 6m height digester to service the WWTP until 2032. At this time a second digester of equal size is recommended to service the WWTP through 2065.

The cost of each digester is estimated at approximately \$12.0 Million including 22% contingency and 15% engineering fees

5.1.13 Summary of Upgrade Costs

Given the conceptual nature of this feasibility study, it is important to consider the listed costs in comparative terms between the various options. Stantec referenced several recently completed projects with similar nature and supplier budgetary quotations to determine the Opinion of Probable Cost (OPC) to upgrade Okotoks WWTP. The actual cost will be highly dependent on the timing of the capital upgrades and the ability to package multiple upgrades into single construction contracts. All costs were estimated in 2015 dollars and do not include GST. Piping, channels and required civil work is included in the OPC of the respective unit processes. O&M cost is not included in this estimate.

Table 5.1 and Table 5.2 summarize the OPC for required process upgrades at the WWTP using conventional BNR process to service the Town of Okotoks until year 2040 and from 2040 to 2065, respectively. Effluent discharge location will continue to be within the Sheep River. However, there will be excessive operating cost associated with chemical phosphorus trimming to meet ASWQG.

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Alternative 1 Details
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Table 5.1 Alternative 1 A OPC (2015 – 2040)

Item	Cost of Upgrade (\$ Million)
Raw Sewage Pumping	\$0.48
Screen Upgrade	\$0.34
Grit System Upgrade	\$0.19
Activated Primary Clarifier	\$8.26
Bioreactor/Secondary Clarifier #2	\$6.78
Tertiary Filtration Expansion (includes new building)	\$3.38
UV Disinfection Expansion (includes new building)	\$2.06
DAF Upgrade	\$1.03
Sludge Blend Tank	\$0.87
Solids Dewatering (Centrifuge/Conveyance/Solids Storage)	\$0.87
WWTP Upgrade Sub Total	\$24.26
General Conditions (2%)	\$0.50
Construction Contingency (10%)	\$2.49
Design Contingency (10%)	\$2.73
Construction Subtotal	\$29.98
Engineering Fees (15%)	\$4.49
WWTP Upgrade Total	\$34.47

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Alternative 1 Details
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Table 5.2 Alternative 1A OPC (2040 – 2065)

Item	Cost of Upgrade (\$ Million)
Raw Sewage Pumping	\$0.24
Grit System Expansion	\$1.65
Bioreactor/Secondary Clarifier #3	\$6.78
Tertiary Filtration Expansion	\$0.68
UV Disinfection Expansion	\$1.11
New Outfall	\$4.40
WWTP Upgrade Sub Total	\$14.86
General Conditions (2%)	\$0.29
Construction Contingency (10%)	\$1.51
Design Contingency (10%)	\$1.67
Construction Subtotal	\$18.33
Engineering Fees (15%)	\$2.75
WWTP Upgrade Total	\$21.08

The estimated total upgrade cost for Alternative 1A through 2065 is **\$55.55 million**.

5.2 ALTERNATIVE 1B

Alternative 1B represents the implementation of a 30,000 m³/d HRCS at Okotoks WWTP with a conventional BNR process and continued discharge to the Sheep River. The implementation of the HRCS will reduce the capacity upgrade requirements for most treatment processes designed based on peak hour flow conditions which include raw sewage pumps, grit tanks, APCs, tertiary filtration, and UV disinfection systems. Capacity upgrade requirement for other treatment processes, including solids handling, discussed in Alternative 1A will remain unchanged.

5.2.1 Raw sewage pumping

The implementation of a 45,000 m³/d (or 1,250 m³/h) HRCS at Okotoks WWTP will reduce the required number of the submersible sewage pumps from three (3) pumps to two (2) pumps. Stantec recommends replacing two Archimedes screw pumps (SP-101 and SP-102) in 2016 with one 1,825 m³/h submersible sewage pumps. Combined with the capacity of the remaining screw pump, the WWTP will have sufficient firm capacity to handle the projected Dry Weather Flow (DWF) until 2021. To handle projected flows beyond 2021 through 2065, Stantec recommends replacing the third Archimedes screw pump with a second 1,825 m³/h submersible pump in 2021.

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5.2.2 Grit Tanks

The implementation of a 45,000 m³/d HRCS will eliminate the need for an additional grit tanks to handle the projected flows through 2065. Instead, Stantec recommends replacing the internal rotating mechanism of the existing unit in 2016 to provide a process capacity of 2,584 m³/h, sufficient to meet projected flows through 2065.

5.2.3 Primary Treatment

The implementation of a 45,000 m³/d HRCS will reduce the required number of APCs to handle the projected flows through 2065. A second 18m diameter APC will be required in 2019 to handle projected flows through 2065.

Full redundancy will not be provided for this option. With two APCs, the WWTP will be able to conduct scheduled maintenance on a single train during low flow conditions.

5.2.4 Tertiary Treatment

The implementation of a 45,000 m³/d (or 1,250 m³/h) HRCS at Okotoks WWTP will reduce the required number of tertiary filtration units from three (3) to two (2). An additional disk filter with a capacity of 1,024 m³/h is required in 2036. To accommodate the proposed disk filtration units, a new filtration building with all associated piping and ancillary components is required. By 2057 an additional disk filter is required to provide sufficient firm capacity through 2065.

This staging scenario will allow the WWTP to take the largest unit offline for scheduled maintenance at any time during the planning period.

5.2.5 Disinfection

The implementation of a 45,000 m³/d HRCS will reduce the required number of UV disinfection channels to handle the projected flows through 2065 as follows:

- 2016: install a third 512 m³/h UV bank in the first channel.
- 2036: install a complete second channel with one 512 m³/h UV banks, and provide space for two additional banks.
- 2057: install a second 512 m³/h UV bank in the second channel.

This staging scenario will allow one UV bank to be taken offline for scheduled maintenance at any time during the planning period.

A new 1,250 m³/h closed pipe UV disinfection system is required to for HRCS effluent before it is blended with the main WWTP effluent.

A Bioassay Validation procedure is needed to determine the most efficient UV dose at various flow rates and water qualities to meet the disinfection objectives.

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5.2.6 Summary of Upgrade Costs

Table 5.3 and Table 5.4 summarize the OPC for required process upgrades at the WWTP using HRCS and conventional BNR process to service the Town of Okotoks until year 2040 and from 2040 to 2065, respectively. Effluent discharge location will continue to be within the Sheep River. However, there will be excessive operating cost associated with chemical phosphorus trimming to meet ASWQG.

Table 5.3 Alternative 1B OPC (2015 – 2040)

Item	Cost of Upgrade (\$ Million)
HRCS	\$3.13
Raw Sewage Pumping	\$0.48
Screen Upgrade	\$0.34
Grit System Upgrade	\$0.19
Activated Primary Clarifier	\$4.17
Bioreactor/Secondary Clarifier #2	\$6.78
Tertiary Filtration Expansion (includes new building)	\$2.07
UV Disinfection Expansion (includes new building)	\$1.50
Closed Pipe UV Disinfection System	\$0.34
DAF Upgrade	\$1.03
Sludge Blend Tank	\$0.87
Solids Dewatering (Centrifuge/Conveyance/Solids Storage)	\$0.87
WWTP Upgrade Sub Total	\$21.77
General Conditions (2%)	\$0.44
Construction Contingency (10%)	\$2.24
Design Contingency (10%)	\$2.45
Construction Subtotal	\$26.90
Engineering Fees (15%)	\$4.02
WWTP Upgrade Total	\$30.92

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Alternative 1 Details
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Table 5.4 Alternative 1B OPC (2040 – 2065)

Item	Cost of Upgrade (\$ Million)
HRCS	\$0.57
Bioreactor/Secondary Clarifier #3	\$6.78
Tertiary Filtration Expansion	\$0.68
New Outfall	\$4.40
WWTP Upgrade Sub Total	\$12.43
General Conditions (2%)	\$0.25
Construction Contingency (10%)	\$1.27
Design Contingency (10%)	\$1.39
Construction Subtotal	\$15.34
Engineering Fees (15%)	\$2.31
WWTP Upgrade Total	\$17.65

The estimated total upgrade cost for Alternative 1B through 2065 is **\$48.57 million**.

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Alternative 2 Details
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6.0 ALTERNATIVE 2 DETAILS

Alternative 2 represents an upgraded Okotoks WWTP using MBR technology with continued final effluent discharge to the Sheep River. This alternative includes all the recommended upgrades in Alternative 1 minus the third bioreactor system, tertiary filtration system, and associated ancillary equipment.

6.1 DESCRIPTION OF MBR TECHNOLOGY

MBR technology is an advanced activated sludge wastewater treatment process capable of producing superior filtered effluent potentially suitable for indirect water reuse.

Membrane filtration can be implemented at Okotoks WWTP by re-purposing the existing secondary clarifiers. Because of the very fine filtration provided with membranes, bioreactor mixed liquor suspended solids concentrations can be approximately doubled compared to conventional BNR processes using secondary clarifiers. An increase in biomass allows MBR systems to treat more wastewater per unit of bioreactor volume than the current treatment process in Okotoks. The use of MBR treatment will reduce the number of bioreactors required from 3 to 2.

The implementation of MBR at Okotoks will increase the overall power consumption at the WWTP due to aeration and permeate pumping requirements. Estimated power consumption of the MBR system is 0.2 kWh/m³.

Membranes also require ongoing chemical use for cleaning purposes. Typical chemicals used for cleaning include sodium hypochlorite and citric acid.

Though membranes are very effective at removing bacteria from the filtered effluent, UV disinfection is still typically required prior to discharge. It may be possible to obtain a new EPEA approval for MBR treatment without UV disinfection. Membrane manufacturer data combined with information from a number of operating MBR WWTPs in Alberta may be used to justify the elimination of the UV disinfection stage following membrane filtration. If UV disinfection is eliminated, a power saving of 0.02 kWh/m³ can be achieved.

Because the maximum flow rate through membranes is determined by available surface area to meet peak flow conditions, sufficient membranes must be provided or a flow bypass to wet weather treatment must be installed. Generally, membrane treatment is cost-effective when paired with HRCS to reduce the capital investment required for membrane equipment.

Table 6.1 presents the advantages and disadvantages of MBR technology.

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Alternative 2 Details
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Table 6.1 Advantages & disadvantages of MBR technology

Advantages	Disadvantages
Effluent potentially suitable for indirect re-use	Relatively high capital & operating cost
Smaller footprint	More energy intensive
Would eliminate sludge settleability concerns	Fouling & clogging (Costly prevention)
Would eliminate or defer the need to pump treated effluent to other water courses	Ongoing membrane replacement requirements (every 5 – 10 years)
Reduced downstream disinfection requirements	Requires 1- to 3-mm fine screens
Less sludge production	Constrained ability to accommodate peak flows (PHF < 2.0 ADF)
Would eliminate the need for standalone tertiary filtration membrane systems	Cleaning solutions may require special handling, treatment, and disposal
Operate at higher volumetric loading rates resulting in lower hydraulic retention times	FOG in excess of 50 – 100 mg/L may have an adverse impact on the MBR process
Modular design	Manufacturer's guarantee varies in duration
Would reduce the number of required bioreactors to handle the projected loadings from 3 to 2	Increased oxygen requirements in the bioreactors due to the increase in biomass concentration

6.2 ALTERNATIVE 2A

Alternative 2A represents an upgraded Okotoks WWTP using MBR technology without HRCS and with continued final effluent discharge to the Sheep River. This alternative includes all the recommended upgrades in Alternative 1A minus the third bioreactor system, tertiary filtration system, and associated ancillary equipment.

6.2.1 Summary of Upgrade Costs

Table 6.2 and Table 6.3 summarize the OPC for required process upgrades at the WWTP using MBR technology with continued final effluent discharge to the Sheep River to service the Town of Okotoks until year 2040 and from 2040 to 2065, respectively.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 2 Details
April 12, 2016

Table 6.2 Alternative 2A OPC (2015 – 2040)

Item	Cost of Upgrade (\$ Million)
Raw Sewage Pumping	\$0.48
Screen Upgrade	\$0.34
Grit System Upgrade	\$0.19
Activated Primary Clarifier	\$8.26
Upgrade of Bioreactor/Secondary Clarifier #1 to MBR	\$8.04
UV Disinfection Expansion (includes new building)	\$2.06
DAF Upgrade	\$1.03
Sludge Blend Tank	\$0.87
Solids Dewatering (Centrifuge/Conveyance/Solids Storage)	\$0.87
WWTP Upgrade Sub Total	\$22.14
General Conditions (2%)	\$0.45
Construction Contingency (10%)	\$2.27
Design Contingency (10%)	\$2.49
Construction Subtotal	\$27.35
Engineering Fees (15%)	\$4.09
WWTP Upgrade Total	\$31.44

Table 6.3 Alternative 2A OPC (2040 – 2065)

Item	Cost of Upgrade (\$ Million)
Raw Sewage Pumping	\$0.24
Grit System Expansion	\$1.65
New MBR #2	\$11.43
UV Disinfection Expansion	\$1.11
New Outfall	\$4.40
WWTP Upgrade Sub Total	\$18.83
General Conditions (2%)	\$0.37
Construction Contingency (10%)	\$1.92
Design Contingency (10%)	\$2.11
Construction Subtotal	\$23.23
Engineering Fees (15%)	\$3.48
WWTP Upgrade Total	\$26.71

The estimated total upgrade cost for Alternative 2A through 2065 is **\$58.15 million**.



TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 2 Details
April 12, 2016

6.3 ALTERNATIVE 2B

Alternative 2B represents the implementation of a 45,000 m³/d HRCS at Okotoks WWTP with an MBR technology and continued discharge to Sheep River. The implementation of the HRCS will reduce the capacity upgrade requirements for some components as discussed in Section 5.2.1. The HRCS will also eliminate additional MBR trains required to treat peak flow conditions. Capacity upgrade requirement for other treatment processes, including solids handling, discussed in Alternative 2A will remain unchanged.

6.3.1 Summary of Upgrade Costs

Table 6.4 and Table 6.5 summarize the OPC for required process upgrades at the WWTP using HRCS and MBR technology with continued final effluent discharge to the Sheep River to service the Town of Okotoks until year 2040 and from 2040 to 2065, respectively.

Table 6.4 Alternative 2B OPC (2015 – 2040)

Item	Cost of Upgrade (\$ Million)
HRCS	\$3.13
Raw Sewage Pumping	\$0.48
Screen Upgrade	\$0.34
Grit System Upgrade	\$0.19
Activated Primary Clarifier	\$4.17
Upgrade of Bioreactor/Secondary Clarifier #1 to MBR	\$4.68
UV Disinfection Expansion (includes new building)	\$1.50
Closed Pipe UV Disinfection System	\$0.34
DAF Upgrade	\$1.03
Sludge Blend Tank	\$0.87
Solids Dewatering (Centrifuge/Conveyance/Solids Storage)	\$0.87
WWTP Upgrade Sub Total	\$17.60
General Conditions (2%)	\$0.35
Construction Contingency (10%)	\$1.82
Design Contingency (10%)	\$1.99
Construction Subtotal	\$21.76
Engineering Fees (15%)	\$3.25
WWTP Upgrade Total	\$25.01

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 2 Details
April 12, 2016

Table 6.5 Alternative 2B OPC (2040 – 2065)

Item	Cost of Upgrade (\$ Million)
HRCs	\$0.57
New MBR #2	\$8.81
New Outfall	\$4.40
WWTP Upgrade Sub Total	\$13.78
General Conditions (2%)	\$0.28
Construction Contingency (10%)	\$1.41
Design Contingency (10%)	\$1.54
Construction Subtotal	\$17.01
Engineering Fees (15%)	\$2.55
WWTP Upgrade Total	\$19.56

The estimated total upgrade cost for Alternative 2B through 2065 is **\$44.57 million**.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 3 Details
April 12, 2016

7.0 ALTERNATIVE 3 DETAILS

As discussed in Section 2.0, with enhanced chemical treatment, the WWTP should be able to meet current ASWQG limits for TP in the Sheep River. However, any changes in the ASWQG requirements may dictate that the WWTP upgrade to an advanced treatment system (such as MBR) or distribute its effluent to other watersheds to dilute the effect of effluent concentrations.

Discharge options may include discharging a portion of the treated effluent to either Highwood River or Bow River by 2040. For the purpose of this feasibility study, Stantec assumes that treated effluent flows beyond 2039 will be pumped to either Highwood River or Bow River. A regional study of the assimilative capacity of these water courses considering other contributors is highly recommended to assist the Town in its future planning. Depending on the option selected, an upgrade to the existing outfall structure is required to convey the projected flows through 2065.

Alternative 3 represents an upgraded Okotoks WWTP using conventional BNR technology. A portion of the final effluent up to 2040 flows will continue to be discharged to the Sheep River. The remaining flow in excess of 2040 flows will be discharged to Highwood River. This alternative includes all the recommended upgrades in Alternative 1 plus the pump station and pipeline required to pump a portion of the effluent flow to Highwood River.

7.1 SYSTEM DESIGN FLOW

Based on Technical Memorandum #1, maximum day flow from Okotoks WWTP will be reaching 46,619 m³/d and 72,683 m³/d in 2039 and 2065, respectively. Table 7.1 summarizes the projected effluent flow discharged over 25-year and 50-year design horizon. The effluent piping system will be sized to accommodate the additional flow of 26,064 m³/d beyond 2039.

Table 7.1 WWTP Effluent Discharge Flow Summary

Design Horizon	Effluent Flow Projection (m ³ /d)	Effluent Discharge to Sheep River (m ³ /d)	Effluent Discharge to Highwood River (m ³ /d)
25 Year (2039)	46,619	46,619	0
50 Year (2065)	72,683	46,619	26,064

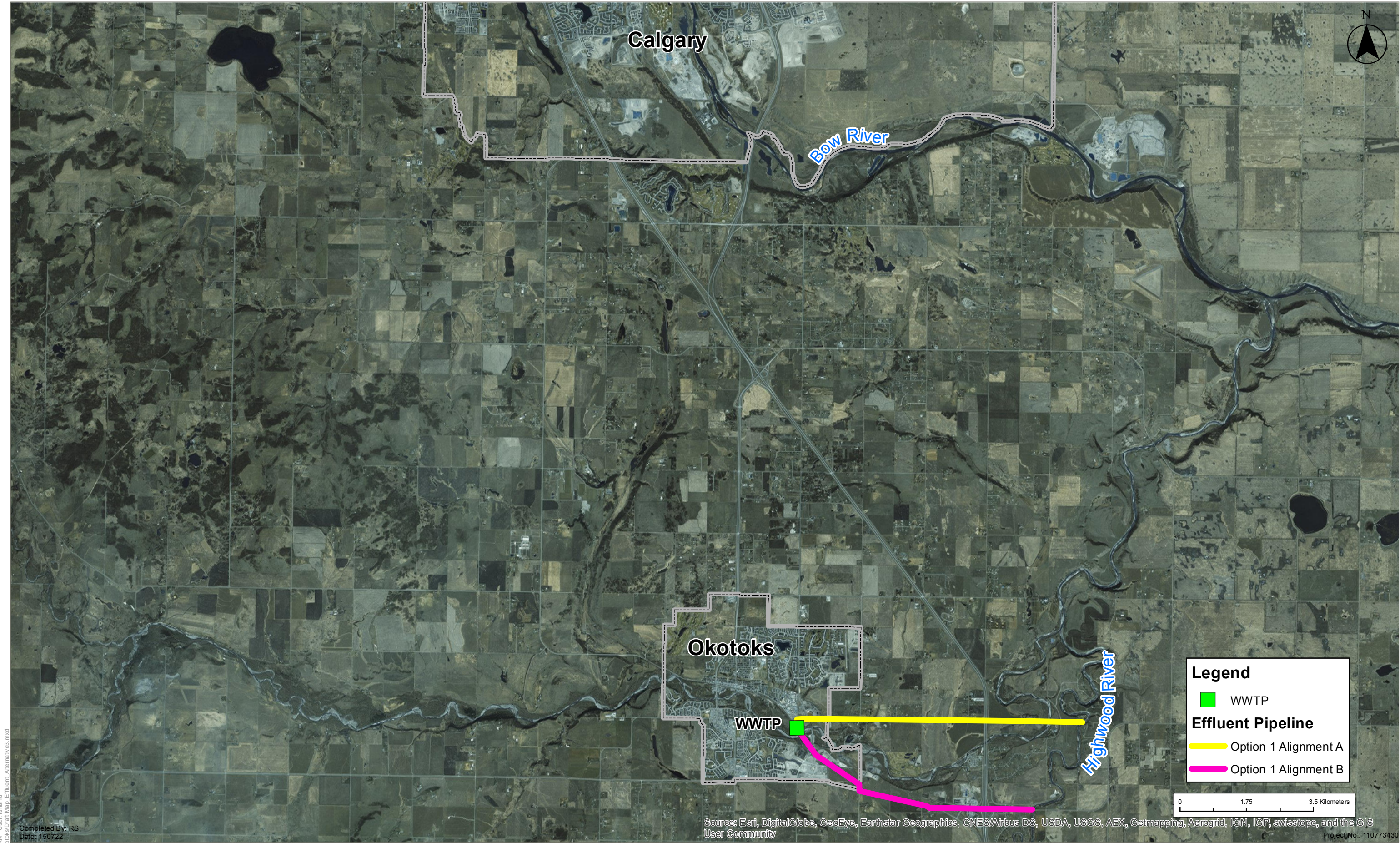
7.2 EFFLUENT PIPELINE ALIGNMENT TO HIGHWOOD RIVER

Stantec assumes two alignment options (A and B) to deliver the effluent from Town's WWTP to Highwood River.

Alignment A: Stantec assumes installing effluent pipeline from WWTP towards the east along N Railway St continuing on 370 Ave E and Township Road 204 to Highwood River, with a total length of approximately 7.7 km.

Alignment B: Stantec assumes installing effluent pipeline from the WWTP to the east along Southbank Road, Hwy 7 and Hwy 547 to Highwood River, with a total length of approximately 7.1 km.





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Date: 150722

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Project No.: 110773430

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 3 Details
April 12, 2016

7.3 SYSTEM HYDRAULIC ANALYSIS

7.3.1 Pipe Materials

Because of their resistance to corrosion, their relative low capital cost, and local prevalence and availability, Stantec considered thermoplastic pipes, such as HDPE, for this feasibility study. During Preliminary Design stage, other materials may be considered.

7.3.2 Pipe Velocity

Pipe velocities vary based on flow rate and pipe diameters within each system. In general, velocities above 1.6 m/s are not recommended due to concerns of high piping frictions and surges. As such, Stantec based the system hydraulic analysis on the pipe velocities less than 1.6 m/s.

7.3.3 Line Pressure

Given the conceptual nature of this study and the lack of a topographic survey to verify the available contour information, Stantec assumed a minimum pressure along the pipe alignment to ensure that the flow could be pumped over the estimated highest point and discharged to the river.

Stantec selected the pipeline materials so that it can accommodate the anticipated system pressures under ultimate operating conditions, and system surges that occur during events such as system starts and stops, power failures, line tapping, and line breaks.

7.3.4 System Sizing

Stantec simulated two pipe alignments A and B to Highwood River. Table 7.2 and Table 7.3 present the analysis results in terms of pipe length, diameter, velocity, total dynamic head (TDH) and estimated power. The selected pump(s) were assumed to be 75% efficient. Detailed results with various pipe size options are provided in Appendix A.

Table 7.2 Analysis Results Alignment A to Highwood River

Alignment Option	Length (m)	Pipe Material	Pipe Diameter	Pipe Velocity (m/s)	TDH (m)	Estimated HP
Alignment A	7,670	HDPE DR 13.5	450 mm	2.58	99	555
		HDPE DR 15.5	500 mm	2.00	50	282
		HDPE DR 17	550 mm	1.60	36	203

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 3 Details
April 12, 2016

Table 7.3 Analysis Results Alignment B to Highwood River

Alignment Option	Length (m)	Pipe Material	Pipe Diameter	Pipe Velocity (m/s)	TDH (m)	Estimated HP
Alignment B	7,154	HDPE DR 13.5	450 mm	2.58	95	535
		HDPE DR 15.5	500 mm	2.00	50	279
		HDPE DR 17	550 mm	1.60	30	166

Table 7.2 and Table 7.3 suggest that the 550 mm HDPE DR 17 pipeline provides lower velocity, lower TDH requirement and less power consumptions. Therefore, Stantec recommends the 550 mm HDPE pipe for alternative 3 as summarized in Table 7.4. Effluent pump(s) should be designed to accommodate effluent flow of 26,064 m³/d with a TDH of 36 m and 30 m for Alignment A and Alignment B, respectively.

Table 7.4 Recommendations for Alternative 3 – Discharge to Highwood River

Alignment Option	Length (m)	Pipe Material	Pipe Diameter	Design Flow (m ³ /d)	Pipe Velocity (m/s)	TDH (m)	Estimated HP
Alignment A	7,670	HDPE DR 17	550 mm	26,064	1.60	36	203
Alignment B	7,154	HDPE DR 17	550 mm	26,064	1.60	30	166

As both Alignment A and B have relatively similar pipe lengths and pumping head requirements, Stantec recommends to conduct further investigations during subsequent design efforts to select the optimum route.

7.4 SUMMARY OF PIPELINE COST

Table 7.5 summarizes the OPC for the new pipeline option required to re-route treated effluent in excess of 2040 flows to Highwood River.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 3 Details
April 12, 2016

Table 7.5 OPC for Pumping WWTP Effluent to Highwood River

Item	Cost of Upgrade (\$ Million)
Effluent Pipeline to Highwood River (includes pumping and civil)	\$14.03
General Conditions (2%)	\$0.28
Construction Contingency (10%)	\$1.43
Design Contingency (10%)	\$1.57
Construction Subtotal	\$17.31
Engineering Fees (15%)	\$2.60
Effluent Pipeline to Highwood River Total	\$19.91

7.5 ALTERNATIVE 3A

Alternative 3A represents an upgraded Okotoks WWTP using conventional BNR system without HRCS. A portion of the final effluent up to 26,064 m³/d will continue to be discharged to the Sheep River. The remaining flow in excess of 26,064 m³/d will be discharged to Highwood River. This alternative includes all the recommended upgrades in Alternative 1A plus the pump station and pipeline required to pump a portion of the effluent flow to Highwood River.

7.5.1 Summary of Upgrade Costs

The combined cost of the WWTP upgrade with conventional BNR process as summarized in Alternative 1A and the proposed effluent pipeline to Highwood River through 2065 in 2015 dollars excluding GST is estimated as **\$75.46 million**.

7.6 ALTERNATIVE 3B

Alternative 3B represents the implementation of a 45,000 m³/d HRCS at Okotoks WWTP with a conventional BNR system. A portion of the final effluent up to 26,064 m³/d will continue to be discharged to the Sheep River. The remaining flow in excess of 26,064 m³/d will be discharged to Highwood River. This alternative includes all the recommended upgrades in Alternative 1B plus the pump station and pipeline required to pump a portion of the effluent to Highwood River.

7.6.1 Summary of Upgrade Costs

The combined cost of the WWTP upgrade with conventional BNR process as summarized in Alternative 1B and the proposed effluent pipeline to Highwood River through 2065 in 2015 dollars excluding GST is estimated as **\$68.48 million**.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 4 Details
April 12, 2016

8.0 ALTERNATIVE 4 DETAILS

Alternative 4 represents an upgraded Okotoks WWTP using conventional BNR technology. A portion of the final effluent up to 2040 flows will continue to be discharged to the Sheep River. The remaining flow in excess of 2040 flows will be discharged to Bow River. This alternative includes all the recommended upgrades in Alternative 1 plus the pump station and pipeline required to pump a portion of the effluent flow to Bow River.

8.1 SYSTEM DESIGN FLOW

Based on Technical Memorandum #1, maximum day flow from Okotoks WWTP will be reaching 46,619 m³/d and 72,683 m³/d in 2039 and 2065, respectively. Table 8.1 summarizes the projected effluent flow discharged over 25-year and 50-year design horizon. The effluent piping system will be sized to accommodate the additional flow of 26,064 m³/d beyond 2039.

Table 8.1 WWTP Effluent Discharge Flow Summary

Design Horizon	Effluent Flow Projection (m ³ /d)	Effluent Discharge to Sheep River (m ³ /d)	Effluent Discharge to Bow River (m ³ /d)
25 Year (2039)	46,619	46,619	0
50 Year (2065)	72,683	46,619	26,064

8.2 EFFLUENT PIPELINE ALIGNMENT TO BOW RIVER

The proposed alignment would start from WWTP and follow 32 St E towards north, then it would proceed west to the Banister Gate where it parallel Hwy 2A the north. The pipeline would then follow Hwy 2 and discharge to Bow River. The total length would be approximately 16 km.

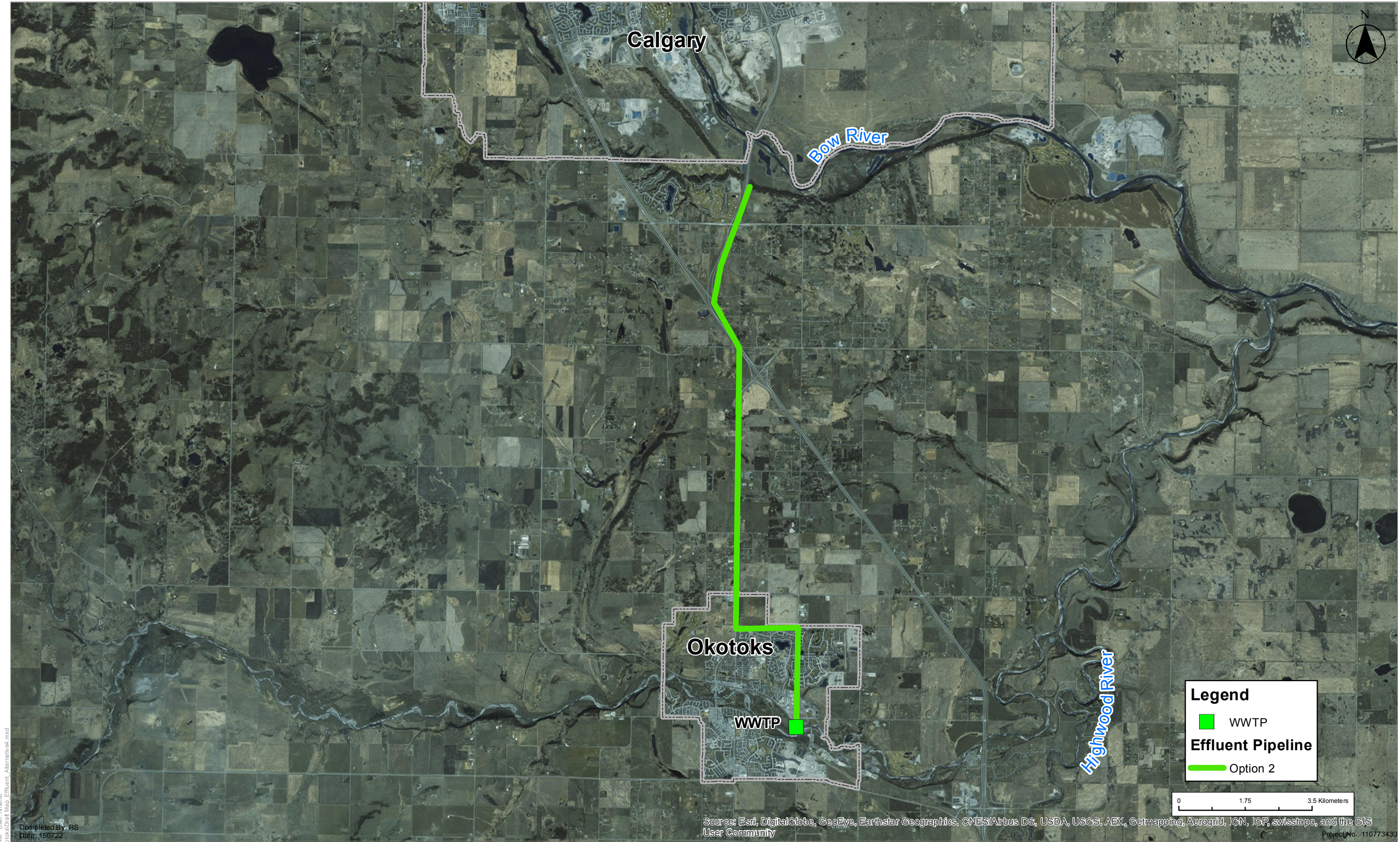
8.3 SYSTEM HYDRAULIC ANALYSIS

8.3.1 Pipe Materials

Because of their resistance to corrosion, their relative low capital cost, and local prevalence and availability, Stantec considered thermoplastic pipes, such as HDPE, for this feasibility study. During Preliminary Design stage, other materials may be considered.

8.3.2 Pipe Velocity

Pipe velocities vary based on flow rate and pipe diameters within each system. In general, velocities above 1.6 m/s are not recommended due to concerns of high piping friction and surges. As such, Stantec based the system hydraulic analysis on the pipe velocities less than 1.6 m/s.



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Project No.: 110773430

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 4 Details
April 12, 2016

8.3.3 Line Pressure

Given the conceptual nature of this study and the lack of a topographic survey to verify the available contour information, Stantec assumed a minimum pressure along the pipe alignment to ensure that the flow could be pumped over the estimated highest point and discharged to the river.

Stantec selected the pipeline materials so that it can accommodate the anticipated system pressures under ultimate operating conditions, and system surges that occur during events such as system starts and stops, power failures, line tapping, and line breaks.

8.3.4 System Sizing

Pipeline alignment to Bow River crosses a couple of high hills enroute from WWTP to Bow River. The beginning of the proposed pipeline (at Okotoks WWTP) is at 1,045 m above sea level. The estimated highest point along the alignment is situated at approximately 1,146 m above sea level. Therefore, Stantec selected high pressure rating pipe material to accommodate the associated system pressure.

As part of system hydraulic analysis, Stantec evaluated and compared various pipe sizes for this discharge option to Bow River. Table 8.2 provides the results of the hydraulic analysis with respect to pipe diameter, velocity, TDH and estimated power requirements. The selected pump(s) were assumed to be 75% efficient.

Table 8.2 Analysis Results for Alternative 4 – Discharge to Bow River

Pipe Diameter	Length (m)	Pipe Material	Pipe Velocity (m/s)	TDH (m)	Estimated HP
750 mm	16,112	HDPE DR 11	1.32	132	744
800 mm		HDPE DR 11	0.89	119	668
850 mm		HDPE DR 11	0.79	117	656

There are no significant differences between these three pipe size options with respect to the pipe material, velocity, TDH and power requirement. Considering pipeline capital cost, Stantec recommends the 750 mm DR 11 HDPE pipe for this alternative. Effluent pump(s) should be designed to accommodate effluent flow of 26,064 m³/d with a TDH of 132 m.

8.4 SUMMARY OF PIPELINE COST

Table 8.3 summarizes the OPC for the new pipeline option required to re-route treated effluent in excess of 2040 flows to Bow River.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Alternative 4 Details
April 12, 2016

Table 8.3 OPC for Pumping WWTP Effluent to Bow River

Item	Cost of Upgrade (\$ Million)
Effluent Pipeline to Bow River (includes pumping and civil)	\$27.04
General Conditions (2%)	\$0.54
Construction Contingency (10%)	\$2.76
Design Contingency (10%)	\$3.03
Construction Subtotal	\$33.37
Engineering Fees (15%)	\$5.01
Effluent Pipeline to Bow River Total	\$38.38

8.5 ALTERNATIVE 4A

Alternative 4A represents an upgraded Okotoks WWTP using conventional BNR system without HRCS. A portion of the final effluent up to 26,064 m³/d will continue to be discharged to the Sheep River. The remaining flow in excess of 26,064 m³/d will be discharged to Bow River. This alternative includes all the recommended upgrades in Alternative 1A plus the pump station and pipeline required to pump a portion of the effluent flow to Bow River.

8.5.1 Summary of Upgrade Costs

The combined cost of the WWTP upgrade with conventional BNR process as summarized in Alternative 1A and the proposed effluent pipeline to Bow River through 2065 in 2015 dollars excluding GST is estimated as **\$93.93 million**.

8.6 ALTERNATIVE 4B

Alternative 4B represents the implementation of a 45,000 m³/d HRCS at Okotoks WWTP with a conventional BNR system. A portion of the final effluent up to 26,064 m³/d will continue to be discharged to the Sheep River. The remaining flow in excess of 26,064 m³/d will be discharged to Bow River. This alternative includes all the recommended upgrades in Alternative 1B plus the pump station and pipeline required to pump a portion of the effluent flow to Bow River.

8.6.1 Summary of Upgrade Costs

The combined cost of the WWTP upgrade with conventional BNR process as summarized in Alternative 1A and the proposed effluent pipeline to Bow River through 2065 in 2015 dollars excluding GST is estimated as **\$86.95 million**.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Operations, Maintenance, & Replacement Cost
April 12, 2016

9.0 OPERATIONS, MAINTENANCE, & REPLACEMENT COST

The costs involved in operating Okotoks WWTP include O&M expenses as well as investment cost to replace worn out equipment. The O&M cost portion include personnel; operational cost (utilities, chemicals, lab supplies, office supplies, sludge disposal fees, etc.); and maintenance costs.

For the purpose of this feasibility study, Stantec prepared a planning-level Operations, Maintenance, and Replacement (OMR) cost estimate to assist the town of Okotoks in their evaluation of the different alternatives discussed in this TM. Stantec estimated the OMR cost using 2015 dollars based on suppliers' estimates, literature review, and O&M costs estimates from other WWTPs similar in size and nature. The OMR cost estimates do not include GST.

Stantec assumes there are no differences in the number of operators required to operate any of the upgrade alternatives. Therefore the OMR estimate does not include operator costs.

The OMR cost estimate does not include costs associated with common expenses to all alternatives such as insurance; and O&M costs of common unit processes such as influent pumps, headworks, primary clarification, fermentation, odor control, and onsite solids handling. Due to the uncertainty associated with the operation of the HRCS, the associated OMR cost was not included in this analysis. However, the benefits of using the HRCS were considered in estimating the OMR cost for downstream unit processes.

The main unit processes included in the OMR cost estimate are BNR system, MBR, tertiary filtration, UV disinfection, and effluent pumping. The O&M cost for BNR system includes the costs associated with blowers, mixers, recycle pumps, chemical phosphorus removal, and chemical sludge disposal. The O&M cost for MBR system includes the costs associated with blowers, mixers, compressors, recycle pumps, permeate pumps, backpulse pumps, Clean-in-Place (CIP) pumps, and CIP chemicals. The O&M cost for tertiary filtration includes the costs associated with motor drives, backwash pumps, and chemicals. The O&M cost for UV disinfection system includes the costs associated with power requirements only. The replacements frequency and cost for the evaluated systems were based on manufacturer recommendation.

Figure 9.1 illustrates the OMR cost estimates for the proposed alternatives. The figure indicates that while alternative 2B (MBR with HRCS) has the lowest O&M cost, alternative 2A (MBR without HRCS) has the highest O&M cost which indicates that the implementation of HRCS would provide significant cost savings to the operations of the WWTP. The few spikes in the OMR cost curve for alternative 2A and alternative 2B represents membranes replacement costs. The OMR cost estimates for other alternatives is between alternative 2B and alternative 2A.

Given the conceptual nature of this feasibility study, it is important to consider the estimated costs in comparative terms between the various alternatives. Furthermore, the cost estimates presented here should be used with caution as they may vary greatly depending on influent wastewater characteristics, equipment configuration, energy and transportation costs, advances in technology, third-party tipping fees, and a variety of other conditions.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Operations, Maintenance, & Replacement Cost
April 12, 2016

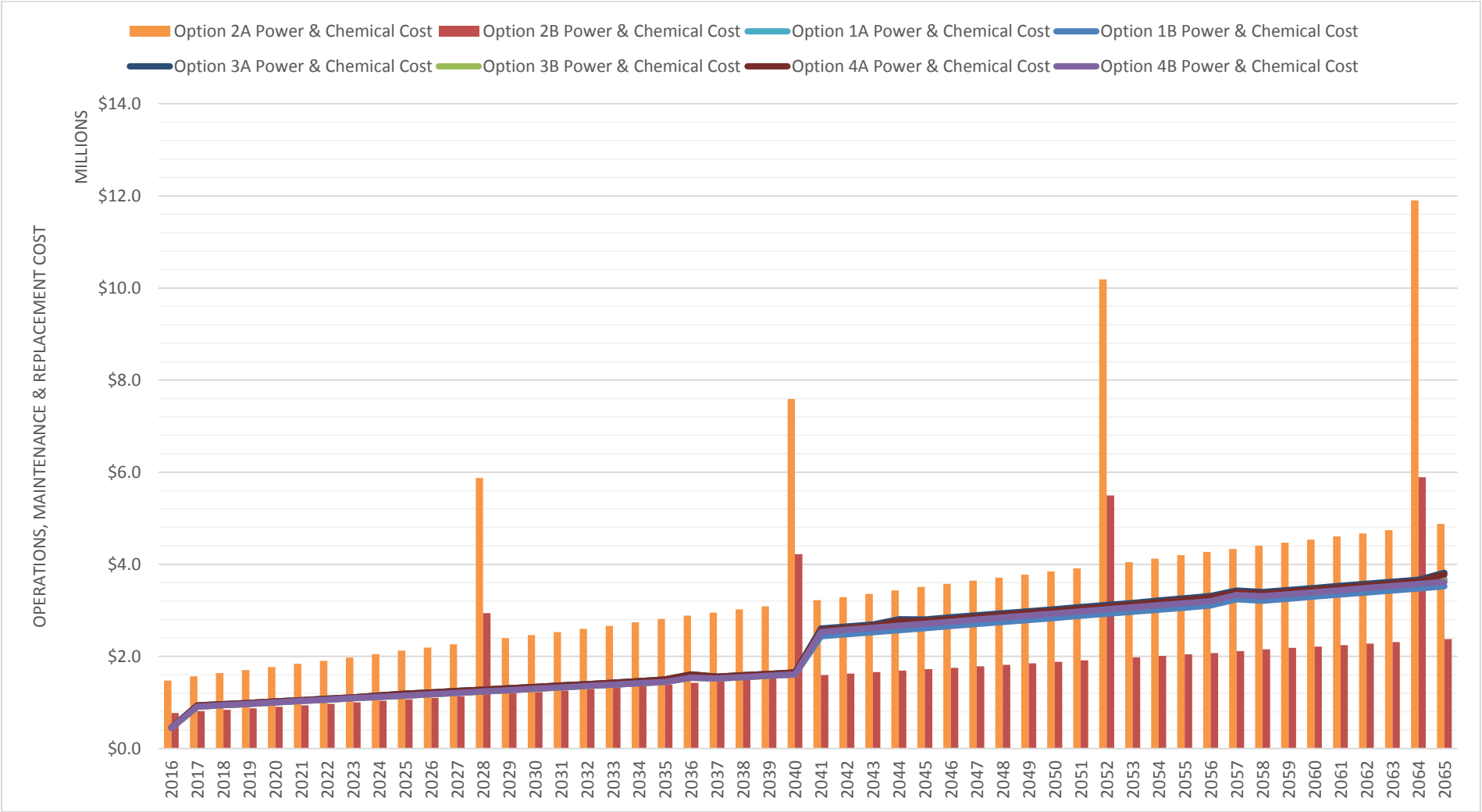


Figure 9.1 Operations, Maintenance, & Replacement Cost of the Proposed Alternatives



TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Cash Flow and Net Present Value Analysis
April 12, 2016

10.0 CASH FLOW AND NET PRESENT VALUE ANALYSIS

Table 10.1 through Table 10.8 present the cash flow of the OPC for the proposed upgrades over the next 50 years. While the OPC is presented during the year in which the upgrade is assumed to be online, The Town should provide sufficient time well in advance to allow for planning, design, engineering, and construction.

Table 10.9 presents the Net Present Value (NPV) of the proposed upgrades which includes the total of OPC and OMR costs for each alternative with and without HRCS using a discount rate of 4% over the next 50 years. The NPV is color coded from dark green (lowest NPV) to dark orange (highest NPV).

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Cash Flow and Net Present Value Analysis
April 12, 2016

Table 10.1 Alternative 1A Cash Flow (in \$ Million)

Year	EP	Sewage Pumps	Screens	Grit Removal	APC	BNR	TF	UV	Outfall	DAF	Sludge Blend Tank	Centrifuge	Alternative 1A Total
2016	29,874	\$0.68	\$0.49	\$0.26	\$5.87	\$0	\$3.94	\$2.92	\$0	\$1.47	\$0.08	\$0	\$15.71
2017	31,146	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$0	\$0	\$0	\$9.63
2021	36,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$1.24
2024	40,046	\$0	\$0	\$0	\$0	\$0	\$0.87	\$0	\$0	\$0	\$0	\$0	\$0.87
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$1.16
2037	56,576	\$0	\$0	\$0	\$5.87	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.87
2041	61,662	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$6.24	\$0	\$0	\$0	\$15.87
2042	62,933	\$0.33	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0.33
2044	65,476	\$0	\$0	\$2.35	\$0	\$0	\$0.97	\$1.56	\$0	\$0	\$0	\$0	\$4.88
Area Total		\$1.01	\$0.49	\$2.61	\$11.73	\$19.26	\$5.78	\$4.48	\$6.24	\$1.47	\$1.24	\$1.24	\$55.55

Table 10.2 Alternative 1B Cash Flow (in \$ Million)

Year	EP	HRCS	Sewage Pumps	Screens	Grit Removal	APC	BNR	TF	UV	UV WW	Outfall	DAF	Sludge Blend Tank	Centrifuge	Alternative 1B Total
2016	29,874	\$4.44	\$0.38	\$0.49	\$0.26	\$0	\$0	\$0	\$0	\$0.49	\$0	\$1.47	\$0.08	\$0	\$7.61
2017	31,146	\$0	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$9.63
2019	33,689	\$0	\$0	\$0	\$0	\$5.92	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.92
2021	36,232	\$0	\$0.30	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$1.54
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$1.16
2036	55,304	\$0	\$0	\$0	\$0	\$0	\$0	\$2.93	\$2.13	\$0	\$0	\$0	\$0	\$0	\$5.06
2041	61,662	\$0.81	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$6.24	\$0	\$0	\$0	\$16.68
2057	82,006	\$0	\$0	\$0	\$0	\$0	\$0	\$0.97	\$0	\$0	\$0	\$0	\$0	\$0	\$0.97
Area Total		\$5.25	\$0.68	\$0.49	\$0.26	\$5.92	\$19.26	\$3.90	\$2.13	\$0.49	\$6.24	\$1.47	\$1.24	\$1.24	\$48.57

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Cash Flow and Net Present Value Analysis
April 12, 2016

Table 10.3 Alternative 2A Cash Flow (in \$ Million)

Year	EP	Sewage Pumps	Screens	Grit Removal	APC	MBR	UV	Outfall	DAF	Sludge Blend Tank	Centrifuge	Alternative 2A Total
2016	29,874	\$0.68	\$0.49	\$0.26	\$5.87	\$11.41	\$2.92	\$0	\$1.47	\$0.08	\$0	\$23.18
2021	36,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$1.24
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$1.16
2037	56,576	\$0	\$0	\$0	\$5.87	\$0	\$0	\$0	\$0	\$0	\$0	\$5.87
2041	61,662	\$0	\$0	\$0	\$0	\$16.23	\$0	\$6.24	\$0	\$0	\$0	\$22.47
2042	62,933	\$0.33	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0.33
2044	65,476	\$0	\$0	\$2.35	\$0	\$0	\$1.56	\$0	\$0	\$0	\$0	\$3.91
Area Total		\$1.01	\$0.49	\$2.61	\$11.73	\$27.64	\$4.48	\$6.24	\$1.47	\$1.24	\$1.24	\$58.15

Table 10.4 Alternative 2B Cash Flow (in \$ Million)

Year	EP	HRCS	Sewage Pumps	Screens	Grit Removal	APC	MBR	UV	UV_WW	Outfall	DAF	Sludge Blend Tank	Centrifuge	Alternative 2B Total
2016	29,874	\$4.44	\$0.38	\$0.49	\$0.26	\$0	\$6.65	\$0	\$0.49	\$0	\$1.47	\$0.08	\$0	\$14.26
2019	33,689	\$0	\$0	\$0	\$0	\$5.92	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.92
2021	36,232	\$0	\$0.30	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$1.54
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$1.16
2036	55,304	\$0	\$0	\$0	\$0	\$0	\$0	\$2.13	\$0	\$0	\$0	\$0	\$0	\$2.13
2041	61,662	\$0.81	\$0	\$0	\$0	\$0	\$12.51	\$0	\$0	\$6.24	\$0	\$0	\$0	\$19.56
Area Total		\$5.25	\$0.68	\$0.49	\$0.26	\$5.92	\$19.16	\$2.13	\$0.49	\$6.24	\$1.47	\$1.24	\$1.24	\$44.57

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Cash Flow and Net Present Value Analysis
April 12, 2016

Table 10.5 Alternative 3A Cash Flow (in \$ Million)

Year	EP	Sewage Pumps	Screens	Grit Removal	APC	BNR	TF	UV	Outfall	DAF	Sludge Blend Tank	Centrifuge	Pipeline to Highwood River	Alternative 3A Total
2016	29,874	\$0.68	\$0.49	\$0.26	\$5.87	\$0	\$3.94	\$2.92	\$0	\$1.47	\$0.08	\$0	\$0	\$15.71
2017	31,146	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$9.63
2021	36,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$0	\$1.24
2024	40,046	\$0	\$0	\$0	\$0	\$0	\$0.87	\$0	\$0	\$0	\$0	\$0	\$0	\$0.87
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$0	\$1.16
2037	56,576	\$0	\$0	\$0	\$5.87	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.87
2041	61,662	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$6.24	\$0	\$0	\$0	\$19.91	\$35.78
2042	62,933	\$0.33	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0.33
2044	65,476	\$0	\$0	\$2.35	\$0	\$0	\$0.97	\$1.56	\$0	\$0	\$0	\$0	\$0	\$4.88
Area Total		\$1.01	\$0.49	\$2.61	\$11.73	\$19.26	\$5.78	\$4.48	\$6.24	\$1.47	\$1.24	\$1.24	\$19.91	\$75.46

Table 10.6 Alternative 3B Cash Flow (in \$ Million)

Year	EP	HRCS	Sewage Pumps	Screens	Grit Removal	APC	BNR	TF	UV	UV_WW	Outfall	DAF	Sludge Blend Tank	Centrifuge	Pipeline to Highwood River	Alternative 3B Total
2016	29,874	\$4.44	\$0.38	\$0.49	\$0.26	\$0	\$0	\$0	\$0	\$0.49	\$0	\$1.47	\$0.08	\$0	\$0	\$7.61
2017	31,146	\$0	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$9.63
2019	33,689	\$0	\$0	\$0	\$0	\$5.92	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.92
2021	36,232	\$0	\$0.30	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$0	\$1.54
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$0	\$1.16
2036	55,304	\$0	\$0	\$0	\$0	\$0	\$0	\$2.93	\$2.13	\$0	\$0	\$0	\$0	\$0	\$0	\$5.06
2041	61,662	\$0.81	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$6.24	\$0	\$0	\$0	\$19.91	\$36.59
2057	82,006	\$0	\$0	\$0	\$0	\$0	\$0	\$0.97	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0.97
Area Total		\$5.25	\$0.68	\$0.49	\$0.26	\$5.92	\$19.26	\$3.90	\$2.13	\$0.49	\$6.24	\$1.47	\$1.24	\$1.24	\$19.91	\$68.48

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Cash Flow and Net Present Value Analysis
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Table 10.7 Alternative 4A Cash Flow (in \$ Million)

Year	EP	Sewage Pumps	Screens	Grit Removal	APC	BNR	TF	UV	Outfall	DAF	Sludge Blend Tank	Centrifuge	Pipeline to Bow River	Alternative 4A Total
2016	29,874	\$0.68	\$0.49	\$0.26	\$5.87	\$0	\$3.94	\$2.92	\$0	\$1.47	\$0.08	\$0	\$0	\$15.71
2017	31,146	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$9.63
2021	36,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$0	\$1.24
2024	40,046	\$0	\$0	\$0	\$0	\$0	\$0.87	\$0	\$0	\$0	\$0	\$0	\$0	\$0.87
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$0	\$1.16
2037	56,576	\$0	\$0	\$0	\$5.87	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.87
2041	61,662	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$6.24	\$0	\$0	\$0	\$38.38	\$54.25
2042	62,933	\$0.33	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0.33
2044	65,476	\$0	\$0	\$2.35	\$0	\$0	\$0.97	\$1.56	\$0	\$0	\$0	\$0	\$0	\$4.88
Area Total		\$1.01	\$0.49	\$2.61	\$11.73	\$19.26	\$5.78	\$4.48	\$6.24	\$1.47	\$1.24	\$1.24	\$38.38	\$93.93

Table 10.8 Alternative 4B Cash Flow (in \$ Million)

Year	EP	HRCS	Sewage Pumps	Screens	Grit Removal	APC	BNR	TF	UV	UV	Outfall	DAF	Sludge Blend Tank	Centrifuge	Pipeline to Bow River	Alternative 4B Total
2016	29,874	\$4.44	\$0.38	\$0.49	\$0.26	\$0	\$0	\$0	\$0	\$0.49	\$0	\$1.47	\$0.08	\$0	\$0	\$7.61
2017	31,146	\$0	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$9.63
2019	33,689	\$0	\$0	\$0	\$0	\$5.92	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$5.92
2021	36,232	\$0	\$0.30	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.24	\$0	\$1.54
2035	54,033	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1.16	\$0	\$0	\$1.16
2036	55,304	\$0	\$0	\$0	\$0	\$0	\$0	\$2.93	\$2.13	\$0	\$0	\$0	\$0	\$0	\$0	\$5.06
2041	61,662	\$0.81	\$0	\$0	\$0	\$0	\$9.63	\$0	\$0	\$0	\$6.24	\$0	\$0	\$0	\$38.38	\$55.06
2057	82,006	\$0	\$0	\$0	\$0	\$0	\$0	\$0.97	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0.97
Area Total		\$5.25	\$0.68	\$0.49	\$0.26	\$5.92	\$19.26	\$3.90	\$2.13	\$0.49	\$6.24	\$1.47	\$1.24	\$1.24	\$38.38	\$86.95



Cash Flow and Net Present Value Analysis
April 12, 2016

Table 10.9 Net Present Worth Value (NPV) for OPC and OMR (in \$ Million)

Year	Alt 1A	Alt 2A	Alt 3A	Alt 4A	Alt 1B	Alt 2B	Alt 3B	Alt 4B
2016	\$16.16	\$24.65	\$16.16	\$16.16	\$8.05	\$15.03	\$8.05	\$8.05
2017	\$10.16	\$1.51	\$10.16	\$10.16	\$10.13	\$0.78	\$10.13	\$10.13
2018	\$0.89	\$1.51	\$0.89	\$0.89	\$0.87	\$0.78	\$0.87	\$0.87
2019	\$0.88	\$1.51	\$0.88	\$0.88	\$6.12	\$6.04	\$6.12	\$6.12
2020	\$0.87	\$1.51	\$0.87	\$0.87	\$0.85	\$0.77	\$0.85	\$0.85
2021	\$1.88	\$2.53	\$1.88	\$1.88	\$2.11	\$2.04	\$2.11	\$2.11
2022	\$0.85	\$1.51	\$0.85	\$0.85	\$0.84	\$0.77	\$0.84	\$0.84
2023	\$0.84	\$1.50	\$0.84	\$0.84	\$0.83	\$0.76	\$0.83	\$0.83
2024	\$1.48	\$1.50	\$1.48	\$1.48	\$0.82	\$0.76	\$0.82	\$0.82
2025	\$0.84	\$1.49	\$0.84	\$0.84	\$0.81	\$0.75	\$0.81	\$0.81
2026	\$0.82	\$1.48	\$0.82	\$0.82	\$0.80	\$0.74	\$0.80	\$0.80
2027	\$0.81	\$1.47	\$0.81	\$0.81	\$0.79	\$0.74	\$0.79	\$0.79
2028	\$0.80	\$3.67	\$0.80	\$0.80	\$0.77	\$1.84	\$0.77	\$0.77
2029	\$0.79	\$1.44	\$0.79	\$0.79	\$0.76	\$0.72	\$0.76	\$0.76
2030	\$0.77	\$1.42	\$0.77	\$0.77	\$0.75	\$0.71	\$0.75	\$0.75
2031	\$0.76	\$1.40	\$0.76	\$0.76	\$0.74	\$0.70	\$0.74	\$0.74
2032	\$0.75	\$1.39	\$0.75	\$0.75	\$0.72	\$0.69	\$0.72	\$0.72
2033	\$0.73	\$1.37	\$0.73	\$0.73	\$0.71	\$0.68	\$0.71	\$0.71
2034	\$0.72	\$1.35	\$0.72	\$0.72	\$0.70	\$0.67	\$0.70	\$0.70
2035	\$1.26	\$1.89	\$1.26	\$1.26	\$1.24	\$1.21	\$1.24	\$1.24
2036	\$0.73	\$1.32	\$0.73	\$0.73	\$3.01	\$1.62	\$3.01	\$3.01
2037	\$3.26	\$3.87	\$3.26	\$3.26	\$0.67	\$0.64	\$0.67	\$0.67
2038	\$0.67	\$1.27	\$0.67	\$0.67	\$0.65	\$0.63	\$0.65	\$0.65
2039	\$0.66	\$1.25	\$0.66	\$0.66	\$0.64	\$0.62	\$0.64	\$0.64
2040	\$0.64	\$2.96	\$0.64	\$0.64	\$0.63	\$1.65	\$0.63	\$0.63
2041	\$6.88	\$9.64	\$14.40	\$21.31	\$7.17	\$7.94	\$14.69	\$21.60
2042	\$1.03	\$1.31	\$1.08	\$1.06	\$0.89	\$0.59	\$0.94	\$0.93
2043	\$0.89	\$1.16	\$0.93	\$0.92	\$0.88	\$0.58	\$0.92	\$0.91
2044	\$2.52	\$2.45	\$2.56	\$2.55	\$0.86	\$0.56	\$0.90	\$0.89
2045	\$0.86	\$1.12	\$0.90	\$0.89	\$0.84	\$0.55	\$0.88	\$0.87
2046	\$0.84	\$1.10	\$0.88	\$0.87	\$0.82	\$0.54	\$0.86	\$0.85
2047	\$0.82	\$1.08	\$0.86	\$0.85	\$0.80	\$0.53	\$0.84	\$0.83
2048	\$0.80	\$1.06	\$0.84	\$0.83	\$0.78	\$0.52	\$0.82	\$0.81
2049	\$0.78	\$1.04	\$0.82	\$0.81	\$0.77	\$0.51	\$0.80	\$0.79
2050	\$0.76	\$1.01	\$0.80	\$0.79	\$0.75	\$0.50	\$0.78	\$0.77
2051	\$0.74	\$0.99	\$0.78	\$0.77	\$0.73	\$0.49	\$0.76	\$0.75
2052	\$0.73	\$2.48	\$0.76	\$0.75	\$0.71	\$1.34	\$0.74	\$0.74
2053	\$0.71	\$0.95	\$0.74	\$0.73	\$0.70	\$0.46	\$0.73	\$0.72
2054	\$0.69	\$0.93	\$0.72	\$0.72	\$0.68	\$0.45	\$0.71	\$0.70
2055	\$0.68	\$0.91	\$0.71	\$0.70	\$0.66	\$0.44	\$0.69	\$0.68
2056	\$0.66	\$0.89	\$0.69	\$0.68	\$0.65	\$0.43	\$0.67	\$0.67
2057	\$0.66	\$0.87	\$0.69	\$0.68	\$0.84	\$0.42	\$0.87	\$0.86
2058	\$0.63	\$0.85	\$0.65	\$0.65	\$0.62	\$0.41	\$0.64	\$0.64
2059	\$0.61	\$0.83	\$0.64	\$0.63	\$0.60	\$0.40	\$0.63	\$0.62
2060	\$0.60	\$0.81	\$0.62	\$0.61	\$0.59	\$0.39	\$0.61	\$0.60
2061	\$0.58	\$0.79	\$0.60	\$0.60	\$0.57	\$0.38	\$0.59	\$0.59
2062	\$0.57	\$0.77	\$0.59	\$0.58	\$0.56	\$0.38	\$0.58	\$0.57
2063	\$0.55	\$0.75	\$0.57	\$0.57	\$0.54	\$0.37	\$0.56	\$0.56
2064	\$0.54	\$1.81	\$0.56	\$0.55	\$0.53	\$0.90	\$0.55	\$0.54
2065	\$0.54	\$0.71	\$0.56	\$0.55	\$0.52	\$0.35	\$0.53	\$0.53
NPV	\$74.70	\$103.07	\$82.96	\$89.68	\$69.06	\$62.75	\$77.33	\$84.05

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Site Layout
April 12, 2016

11.0 SITE LAYOUT

Figure 10.1 through Figure 11.4 illustrate the layout of the proposed upgrades for Okotoks WWTP for alternatives 1A, 1B, 2A, and 2B, respectively. Alternatives 3A and 4A include the recommended upgrades in Alternative 1A plus the pump station and effluent pipeline. Alternatives 3B and 4B include the recommended upgrades in Alternative 1B plus the pump station and effluent pipeline. The layout of the effluent pipeline is shown in Figure 7.1 and Figure 8.1. The presented site layout takes into consideration footprint limitations and building restrictions provided by the Town.



Proposed Future Upgrades for Alternative 1A
Town of Okotoks





Proposed Future Upgrades for Alternative 2A
Town of Okotoks



TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Conclusion
April 12, 2016

12.0 CONCLUSION

The OPC developed for this evaluation considered the capital cost for the different alternatives discussed in this TM with or without implementing HRCS. The OMR cost estimate excluded the costs associated with common expenses to all alternatives such as personnel; insurance; as well as O&M costs of common unit processes such as influent pumps, headworks, primary clarification, fermentation, odor control and onsite solids handling. Due to the uncertainty associated with the frequency of operating the HRCS, the associated OMR cost was not included in this analysis. The main unit processes included in the OMR cost estimate are BNR system, MBR, tertiary filtration, UV disinfection, and effluent pumping.

Table 12.1 summarizes the NPV cost of the different alternatives in order from the lowest NPV to the highest NPV. The table suggests that alternative 2B (MBR + HRCS) has the lowest NPV amongst all alternatives.

Table 12.1 A summary of NPV of the Proposed Upgrades through 2065 (in \$ Million)

Year	Alt 2B	Alt 1B	Alt 1A	Alt 3B	Alt 3A	Alt 4B	Alt 4A	Alt 2A
NPV	\$62.75	\$69.06	\$74.70	\$77.33	\$82.96	\$84.05	\$89.68	\$103.07

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Appendix A
April 12, 2016

13.0 RECOMMENDATIONS

Based on the analysis presented in this TM, Stantec recommends the following:

- The Town should consider alternative 2B (MBR + HRCS) as the preferred alternative in their future upgrades planning;
- The Town should immediately initiate a desktop analysis of the frequency, severity, and duration of historical wet weather events which would assist in sizing the proposed HRCS;
- The Town should immediately pursue Alberta Environments & parks (AEP) approval of the proposed HRCS. Discussions with AEP indicated that the review period for any EPEA permit application could take up to one year which will push the completion date of any proposed upgrade; and
- If HRCS is not approved, the Town should consider alternative 1A instead.

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Appendix A
April 12, 2016

14.0 REFERENCES

Carter, K., & Ryan, M. C. (2010). *Sheep River Water Quality Monitoring (Up- and Downstream of the Town of Okotoks) Summer 2009*. Calgary: University of Calgary.
Stantec Consulting Ltd. (2009). *Okotoks Wastewater Treatment Plant Downstream Users Study*.

APPENDIX

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Appendix A
April 12, 2016

Appendix A

Effluent Pipe Line from Okotoks to Highwood River - Opt #1 Alignment A															
Locations	Elevation (m)	Design Flow (L/s)	Design Flow (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	Nom. Dia (mm)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size - 450 mm HDPE															
WWTP	1045			DR 13.5	160	130	2708	450	386	104.9	2.58	141	99	1143.5	555
J-40	1060													1038.6	
Highwood River	1019	302	26064											1031.7	
Sub-total		302	26064				7670			111.81			99		
Pipe Size - 500 mm HDPE															
WWTP	1045			DR 15.5	138	130	2708	500	439	21.1	2.0	71	50	1095.0	282
J-40	1030													1073.9	
Highwood River	1019	302	26064											1035.3	
Sub-total		302	26064				7670			59.74			50		
Pipe Size - 550 mm HDPE															
WWTP	1045			DR 17	125	130	2708	550	490	12.3	1.6	51	36	1081.0	203
J-40	1060													1068.7	
Highwood River	1019	302	26064											1046.0	
Sub-total		302	26064				7670			34.98			36		
Pipe Size - 600 mm HDPE															
WWTP	1045			DR 17	125	130	2708	600	534	8.1	1.35	45	32	1076.5	177
J-40	1060													1068.4	
Highwood River	1019	302	26064											1053.5	
Sub-total		302	26064				7670			23.01			32		
Effluent Pipe Line from Okotoks to Highwood River - Opt #1 Alignment B															

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Appendix A
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Locations	Elevation (m)	Design Flow (L/s)	Design Flow (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	Nom. Dia (mm)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size - 450 mm HDPE															
WWTP	1045			DR 13.5	160	130	4986	450	386	95.8	2.58	13	95	1140.0	535
J-16	1035													1044.2	
Highwood River	1020	302	26064											1035.7	
Sub-total		302	26064				7154			104.30			95		
Pipe Size - 500 mm HDPE															
WWTP	1045			DR 15.5	138	130	4986	500	439	51.2	2.00	12	50	1094.5	279
J-16	1035													1043.3	
Highwood River	1020	302	26064											1038.8	
Sub-total		302	26064				7154			55.73			50		
Pipe Size - 550 mm HDPE															
WWTP	1045			DR 17	125	130	4986	550	490	30.0	1.6	14	30	1074.5	166
J-16	1035													1044.5	
Highwood River	1020	302	26064											1041.9	
Sub-total		302	26064				7154			32.63			30		
Pipe Size - 600 mm HDPE															
WWTP	1045			DR 17	125	130	4986	600	534	19.7	1.35	17	22	1066.5	121
J-16	1043													1046.8	
Highwood River	1020	302	26064											1045.0	
Sub-total		302	26064				7154			21.46			22		

Effluent Pipe Line from Okotoks to Bow River - Opt #2

TECHNICAL MEMORANDUM #4 TOWN OF OKOTOKS WASTEWATER TREATMENT PLANT – WWTP UPGRADE OPTIONS

Appendix A
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Locations	Elevation (m)	Design Flow (L/s)	Design Flow (m3/d)	Pipe Material	Pressure Rating(psi)	C Value	Length (m)	Nom. Dia (mm)	I.D (mm)	Headloss (m)	Velocity (m/s)	Residual Pressure (psi)	TDH (m)	HGL (m)	Estimated HP
Pipe Size - 750 mm HDPE															
WWTP	1045			DR 11	200	130	7877	750	540	22.4	1.32	12	132	1177.0	744
J-52	1146													1154.6	
Bow River	1035	302	26064											1131.1	
Sub-total		302	26064				16112			45.86			132		
Pipe Size - 800 mm HDPE															
WWTP	1045			DR 11	200	130	7877	800	657	8.6	0.89	12	119	1163.5	668
J-52	1146													1154.9	
Bow River	1035	302	26064											1145.9	
Sub-total		302	26064				16112			17.59			119		
Pipe Size - 850 mm HDPE															
WWTP	1045			DR 11	200	130	7877	850	698	6.4	0.79	12	117	1161.5	656
J-52	1146													1155.1	
Bow River	1035	302	26064											1148.4	
Sub-total		302	26064				16112			13.09			117		
Pipe Size - 900 mm HDPE															
WWTP	1045			DR 11	200	130	7877	900	739	4.8	0.7	12	115	1159.5	645
J-52	1146													1154.7	
Bow River	1035	302	26064											1149.6	
Sub-total		302	26064				16112			9.91			115		
Pipe Size - 1050 mm HDPE															
WWTP	1045			DR 13.5	160	130	7877	1050	901	1.8	0.69	12	112	1157.0	631
J-52	1146													1155.2	
Bow River	1035	302	26064											1153.2	
Sub-total		302	26064				16112			3.78			112		

APPENDIX E – TM 5

Technical Memorandum #5
Criteria and Evaluation
Methodology

Okotoks Regional Wastewater
Study



Prepared for:
Town of Okotoks


Prepared by:
Stantec Consulting Ltd.

April 12, 2016

Revision Record							
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Sign-off Sheet

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TECHNICAL MEMORANDUM #5
CRITERIA AND EVALUATION METHODOLOGY

April 12, 2016

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TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Introduction
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Executive Summary

In this Technical Memorandum, Stantec conducted a pairwise comparison of multiple Wastewater Treatment Plant (WWTP) upgrade alternatives as presented in TM #3 and TM #4.

Pairwise comparison is the method of ranking multiple proposed alternatives by assigning scores to each alternative based on the list of criteria generated by the Stantec's understanding of the Town's objective and priorities. Each described criterion is weighted through criteria pairwise weighting analysis. Based on the criteria weight and assigned score, each presented alternative acquires a normalized score which is used to rank the proposed alternatives.

The list of criteria developed for this analysis are summarize in Table ES.1.

Table ES.1 - Evaluation Criteria

Item	Criteria	Description
1	Implementation	Date service could be available to meet Okotoks' needs
2	Cost Certainty	Confidence of cost estimate
3	NPV	The Net Present Worth of the total capital cost over the evaluation period
4	Short Term Capital Cost	Capital cost in the first five years
5	Medium Term Capital Cost	Capital cost between year 5 and 25
6	O&M Cost	Total value of operations and maintenance cost for selected alternative
7	Staging Flexibility	Ability to stage expenditure
8	Resiliency	Effect on operation following an extreme flow event
9	Permitting Requirements	Number of approvals and difficulty in obtaining them
10	Effluent Quality	Meet effluent discharge criteria and minimum impact on downstream receiving water quality

Table ES.2 ranks the WWTP upgrade alternatives evaluated in TM#3 and TM#4.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Introduction
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Table ES.2- Upgrade Alternatives

Rank	Upgrade alternative	Description	Normalized Score
1	Alternative 2B	Upgraded MBR in BNR configuration to treat up to 2 x average annual flow plus High Rate Clarification System (HRCS) to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	73.6%
2	Alternative 1B	Upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	51.4%
3	Alternative 1A	Upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	38.9%
4	Alternative 3B	Same as Alternative 1B, but discharging to both the Sheep River and Highwood River.	37.5%
5	Alternative 2A	Upgrade membrane bioreactor (MBR) in a BNR configuration and discharge to Sheep River.	36.1%
6	Alternative 4B	Same as Alternative 1B, but discharging to both the Sheep River and Bow River.	31.9%
7	Alternative 3A	Same as Alternative 1A, but discharging to both the Sheep River and Highwood River.	20.8%
8	Alternative 4A	Same as Alternative 1A, but discharging to both the Sheep River and Bow River.	15.3%
N/A	Alternative 5	Shutdown Okotoks' WWTP and discharge to Pine Creek WWTP.	N/A
N/A	Alternative 6	Run the Okotoks' WWTP to its maximum capacity and discharge the additional flow to Pine Creek WWTP.	N/A

The ranks of the upgrade alternatives summarized in Table ES.2 indicates that all treatment alternatives with HRCS have higher normalized scores compared to the ones without HRCS. This suggests that the implementation of HRCS would be highly beneficial to the Town.

The implementation of MBR technology with HRCS, and continued discharge to the Sheep River has achieved the highest normalized score of 73.6%, followed closely by a conventional upgrade with HRCS, and continued discharge to the Sheep River.

Alternatives with partial discharge of treated effluent to either Highwood River or Bow River showed lower normalized scores with Alternative 4A as the lowest. This is mainly due to the extra capital and O&M costs associated with new pump stations and forcemains.

TECHNICAL MEMORANDUM #5

CRITERIA AND EVALUATION METHODOLOGY

Introduction
April 12, 2016

1.0 INTRODUCTION

1.1 BACKGROUND

The Town of Okotoks (The Town) is currently experiencing rapid economic and population growth that is increasing the demand for wastewater collection and treatment services. The Town is investigating water supply and wastewater treatment upgrade options to meet projected populations for the 25-year (2040) and 50-year (2065) design horizons of 59,119 and 92,172, respectively.

Stantec Consulting Ltd. (Stantec) is comparing the cost, capacity, and upgrade requirements of treating wastewater locally at Okotoks' Wastewater Treatment Plant (WWTP) or connecting to the City of Calgary through a regional wastewater pipeline. Water supply options are being investigated by others.

The feasibility analyses are provided in the following Technical Memorandums (TMs):

1. TM#1 Design Basis Definition (Completed)
2. TM# 2 WWTP Capacity Assessment (Completed)
3. TM# 3 Sanitary Forcemain Options (Completed)
4. TM# 4 WWTP Upgrade Options (FINAL pending)
5. TM# 5 Evaluation Criteria, Criteria Weighting, and Ranking of the Upgrade Alternatives (This TM)
6. Final Feasibility Report (Pending)

1.2 WORK SCOPE

Stantec evaluated and presented multiple WWTP upgrade alternatives in TM #3 and TM #4. In TM #3, Stantec completed a cost evaluation for a potential sanitary forcemain connection from the current Okotoks WWTP to the City of Calgary's Pine Creek WWTP for both full wastewater flow and partial wastewater flow conditions. TM #4 presented alternatives to upgrade the WWTP for both capacity and quality, and included alternatives to pump all or a portion of the treated effluent to either the Highwood River or the Bow River to improve dilution. Both TM #3 and TM #4 examined 25-year and 50-year growth scenarios to develop total cost estimates for the upgrade alternatives.

This memorandum compares and ranks the upgrade alternatives using a pairwise comparison method. TM #5 is divided into the two parts. Part one describes the comparison methodology, defines the criteria and the objective ratings used to score each upgrade alternative, and develops preliminary weights for the criterion. Part two uses the developed criteria and their weights to rank and compare the proposed upgrade alternatives.

TECHNICAL MEMORANDUM #5

CRITERIA AND EVALUATION METHODOLOGY

Introduction
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This initial process prioritizes the proposed upgrade alternatives based on Stantec's understanding of the objectives and priorities of the Town and other stakeholders. The information presented in this report is based on Stantec's initial interpretation of Okotoks' needs. A review meeting will follow this TM to discuss and modify the selected criteria and their weights to reflect internal and external stakeholder priorities. The Town may wish to engage other potential stakeholders including EPCOR and Alberta Environment and Parks (AEP) to ensure results from the decision-making process are representative of stakeholders' objectives.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Proposed Upgrade alternatives
April 12, 2016

2.0 PROPOSED UPGRADE ALTERNATIVES

2.1 EVALUATION OF UPGRADE ALTERNATIVES

The objective of this analysis is to prioritize the WWTP upgrade alternatives identified in TM#3 and TM #4. The upgrade alternatives evaluated are summarized in Table 2.1.

Table 2.1 - Upgrade alternatives

Upgrade alternative	Description
Alternative 1A	Upgraded conventional Biological Nutrient Removal (BNR) system to treat Peak Hour Flow (PHF) at the design horizon. The WWTP discharges all effluent to Sheep River.
Alternative 1B	Upgraded conventional BNR system to treat up to 2 x average annual flow plus High Rate Clarification System (HRCS) to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
Alternative 2A	Upgraded Membrane Bioreactor (MBR) in BNR configuration to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
Alternative 2B	Upgraded MBR in BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.
Alternative 3A	Same as Alternative 1A, but discharging to both the Sheep River and Highwood River.
Alternative 3B	Same as Alternative 1B, but discharging to both the Sheep River and Highwood River.
Alternative 4A	Same as Alternative 1A, but discharging to both the Sheep River and Bow River.
Alternative 4B	Same as Alternative 1B, but discharging to both the Sheep River and Bow River.
Alternative 5	Shutdown Okotoks' WWTP and discharge to Pine Creek WWTP.
Alternative 6	Run the Okotoks' WWTP to its maximum capacity and discharge the additional flow to Pine Creek WWTP.

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CRITERIA AND EVALUATION METHODOLOGY

Part One - Evaluation Criteria and Criteria Weighting
April 12, 2016

3.0 PART ONE - EVALUATION CRITERIA AND CRITERIA WEIGHTING

3.1 EVALUATION METHOD – PAIRWISE COMPARISON METHOD OVERVIEW

Stantec used a pairwise comparison method to evaluate the alternative upgrade alternatives identified in TM#3 and TM#4. The pairwise comparison method is applied to convert qualitative information into quantitative results for multi-criteria systems and to generate preferential rankings when numerical data is not available or is not sufficient to create a satisfactory priority list.

The pairwise evaluation method uses the following steps:

1. Criteria selection;
2. Development of criteria rating descriptions;
3. Assignment of rating scores for each criteria;
4. Determination of criteria weights; and
5. Criteria Ranking.

3.2 CRITERIA SELECTION

For pairwise comparisons, the selection of evaluation criteria is critical to the end result. A single criterion must have substantial importance and should be restricted to a limited subset to prevent dilution of weights for very important features. Stantec will review the selected criteria during the workshop to ensure that relevant parameters are captured, while relatively unimportant features are removed from the analysis.

Table 3.1 summarizes the selected criteria for this analysis.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Part One - Evaluation Criteria and Criteria Weighting
April 12, 2016

Table 3.1 - Evaluation Criteria

Item	Criteria	Description
1	Implementation	Date service could be available to meet Okotoks' needs
2	Cost Certainty	Confidence of cost estimate
3	NPV	The Net Present Worth of the total capital cost over the evaluation period
4	Short Term Capital Cost	Capital cost in the first five years
5	Medium Term Capital Cost	Capital cost between year 5 and 25
6	O&M Cost	Total value of operations and maintenance cost for selected alternative
7	Staging Flexibility	Ability to stage expenditure
8	Resiliency	Effect on operation following an extreme flow event
9	Permitting Requirements	Number of approvals and difficulty in obtaining them
10	Effluent Quality	Meet effluent discharge criteria and minimum impact on downstream receiving water quality

Stantec assumes that all proposed alternatives will treat wastewater to the minimum standards required for discharge to the relevant watercourse. Therefore, treated effluent quality was not selected as a criterion.

3.3 CRITERIA RATING DESCRIPTIONS

Table 3.2 defines the ratings for each selected criterion as poor, fair, and good. Assigning a rank expresses the relative importance of the selected criteria. For example, ratings for NPV are based on the range of costs estimated in TM #3 and TM #4. All of the alternatives will fall within the range of criteria ratings.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Part One - Evaluation Criteria and Criteria Weighting
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Table 3.2 - Criteria Rating Description

Criterion	Criteria Rating Description		
	Poor	Fair	Good
Implementation	Pass / Fail Note: If the upgrade alternative does not pass this criterion, it will be disqualified from the pairwise comparison.		
Cost Certainty	Many unknowns, low cost certainty	Moderate unknowns in project, moderate certainty	Few unknown elements in project, high cost certainty
NPV	>\$75M	\$75M to \$85M	<\$85M
Short Term Capital Cost	>\$25M	\$21M - \$25M	<=\$21M
Medium Term Capital Cost	>\$8M	\$5M - \$8M	<\$5M
O&M Cost	Highest Cost	Moderate Cost	Lowest Cost
Staging Flexibility	Lowest spread of capital cost	Moderate spread of capital cost	Most even spread of capital cost
Resiliency	Biomass washout and delayed resumption of normal operation	System returns to normal operation quickly	No effect on operation
Permitting Requirements	Complex or uncertain EPEA approval process	Standard EPEA approval process	No EPEA approval required by Okotoks
Effluent Quality	Pass / Fail Note: Upgrade alternative 5 and 6 were not evaluated against this criteria as further studies are required to assess the performance of the Pine Creek WWTP.		

3.4 CRITERIA RATING SCORES

Stantec assigned a whole integer score for the criteria ratings to indicate the relative degree of preference; higher scores indicating improved benefit. The rating scores used in the analysis are listed in Table 3.3.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Part One - Evaluation Criteria and Criteria Weighting
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Table 3.3 - Criteria Rating Scores

Criteria Rating	Score Assigned
Good	2
Fair	1
Poor	0

Though more than three ratings and different scores for each rating for each criterion could be developed, the tool is primarily used for comparative analysis. Stantec's experience is that extra focus on delineating scores does not typically provide a higher degree of confidence in the initial results.

3.5 CRITERIA WEIGHTING

The pairwise weighting process compares two criteria at a time to select the criterion of higher importance. The number of times that a criterion is selected is divided by the total number of comparisons conducted. The process generates a numerical weight specific to each criteria.

Stantec assigned each of the criteria a shorthand designation (A-L). Stantec then compared all criteria pairs, selected the criterion which has the highest assumed importance for Okotoks, and entered the shorthand for the selected criterion at the intersection of the comparison criteria in the pairwise scoring table.

Based on Stantec's initial assumptions about Okotoks' preferences in selecting the WWTP upgrade alternative, the relative importance of each criterion was assessed through the pairwise comparison matrix, in Table A.1 Appendix A.

The total number of times that a particular criterion was selected (i.e. appeared in the white and blue comparison cells) was entered into the criteria counts column. The total number of possible pairings for eight criteria (without ties) is 36. Stantec determined the relative weight of each criterion using the following formula:

$$\text{Criterion Weight} = W = n_x / N * 100\%$$

Where:

n_x = the number counts for each criterion observed in Table A.1.

N = total number of possible criterion pairings

Based on this pairwise evaluation technique for the number of criteria, the minimum and maximum weight that a criterion can receive are 2.8% and 22.2%, respectively.

Stantec used the proposed criteria and weighting outlined in previous sections to weight the different criteria as illustrated in Table 3.4. The weighting is based on Stantec's interpretation of Okotoks' needs and must be reviewed and adjusted by key decision making stakeholders to reflect their objectives and priorities. Comments received by Stantec regarding criteria and their relative importance will be incorporated into the final report.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Part One - Evaluation Criteria and Criteria Weighting
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Table 3.4 - Criteria Ranking

Item	Criteria	Weight
1	Implementation	Pass / Fail
2	Cost Certainty	11.1%
3	NPV	8.3%
4	Short Term Capital Cost	16.7%
5	Medium Term Capital Cost	5.6%
6	O&M Cost	13.9%
7	Staging Flexibility	8.3%
8	Resiliency	19.4%
9	Permitting Requirements	16.7%
10	Effluent Quality	Pass / Fail

The top three criteria with the highest weight are Resiliency, Short Term Capital Cost, and Permitting.

The lowest importance criterion is medium term capital cost.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Part Two – Ranking The Upgrade alternatives
April 12, 2016

4.0 PART TWO – RANKING THE UPGRADE ALTERNATIVES

4.1 RANKING OF UPGRADE ALTERNATIVES

Each of the WWTP update alternative as stated in Table 2.1 is evaluated for each evaluation criteria in Table 3.1, and assigned a score as described in Section 0. The detailed scoring results for each evaluated alternative are provided in Appendix A.

Stantec compiled these results from each upgrade alternative evaluation into the upgrade alternatives summary matrix, Table C.1 provided in Appendix C. Subject to each criteria weight and scores assigned, Stantec computed a normalized score and determined a rank for each alternative relative to its score.

Table 4.1 summarizes the preliminary rankings of the proposed alternatives and the associated normalized score.

Table 4.1 - Preliminary Ranking of the Proposed Upgrade alternatives

Rank	Upgrade alternative	Description	Normalized Score
1	Alternative 2B	Upgraded MBR in BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	73.6%
2	Alternative 1B	Upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	51.4%
3	Alternative 1A	Upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.	38.9%
4	Alternative 3B	Same as Alternative 1B, but discharging to both the Sheep River and Highwood River.	37.5%
5	Alternative 2A	Upgrade membrane bioreactor (MBR) in a BNR configuration and discharge to Sheep River.	36.1%
6	Alternative 4B	Same as Alternative 1B, but discharging to both the Sheep River and Bow River.	31.9%
7	Alternative 3A	Same as Alternative 1A, but discharging to both the Sheep River and Highwood River.	20.8%
8	Alternative 4A	Same as Alternative 1A, but discharging to both the Sheep River and Bow River.	15.3%
N/A	Alternative 5	Shutdown Okotoks' WWTP and discharge to Pine Creek WWTP.	N/A
N/A	Alternative 6	Run the Okotoks' WWTP to its maximum capacity and discharge the additional flow to Pine Creek WWTP.	N/A

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

Part Two – Ranking The Upgrade alternatives
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4.2 PRELIMINARY RANKING ANALYSIS

The preliminary scoring based on Stantec's analysis summarized in Table 4.1 indicates that all treatment alternatives with HRCS have higher normalized scores compared to the ones without HRCS. This suggests that the implementation of HRCS would be highly beneficial to the Town. However, the main challenge to proceed with HRCS is permitting requirements. Even though several facilities in the Edmonton area operate as HRCSs, the Province of Alberta does not have specific regulations related to HRCSs and their implementation. This means that each facility must be examined in detail through discussions with Alberta Environment and Parks (AEP). During consultative meetings with the City of Calgary, AEP has indicated a reluctance to give preliminary approval for HRCS treatment in southern Alberta without reviewing a complete, formal application package. No formal application for approval for HRCS has been attempted in southern Alberta. Because of uncertainty surrounding approvals for HRCS, Stantec assigned a "Poor" rating on permitting to all upgrade alternatives with HRCS.

The top three upgrade alternatives maintain effluent discharge to the Sheep River. Alternatives with partial discharge of treated effluent to either Highwood River or Bow River showed lower normalized scores with Alternative 4A as the lowest. This is mainly due to the extra capital and O&M costs associated with new pump stations and forcemains.

The implementation of MBR technology with HRCS, and continued discharge to the Sheep River has achieved the highest normalized score of 73.6%, followed by a conventional upgrade with HRCS, and continued discharge to the Sheep River.

Alternatives 5 and 6 with full or partial discharges of sewage to the City of Calgary's Pine Creek WWTP were disqualified, as they could not be implemented in time to meet the Town of Okotoks' growth needs. This was confirmed by the City of Calgary during a meeting held on August 26, 2015 that the transfer of sewage from Okotoks to the Pine Creek WWTP is not possible until either the Pine Creek WWTP or Fish Creek WWTPs is expanded for more capacity. Both of the Pine Creek and Fish Creek WWTPs are operating above their firm capacity and currently cannot accept any unplanned-for sewage flows, such as from Okotoks.

The City of Calgary is currently studying options to upgrade the capacity of the Fish Creek WWTP and/or the Pine Creek WWTP. The capacity upgrade of either WWTP is not planned to be in service before 2025 which does not meet the Town's objectives. For this reason, upgrade alternatives 5 and 6 did not pass the implementation pass/fail test and are eliminated from further consideration.

Moreover, the Town would have to pay City of Calgary their share of the capital costs for upgrades at the Fish Creek WWTP and/or the Pine Creek WWTP either as a lump sum upfront payment or via installments included in the service rate charges. The Town will also be responsible for the cost of the construction, operation, and maintenance of the pump station and the sewer pipeline. Construction of a lift station and forcemain, and paying for upgrades to the City of Calgary's WWTPs is the highest cost option for treatment.

An upgrade of the Town's existing WWTP is likely able to be phased and constructed to meet growth requirements, unlike options that rely on a forcemain connection to the City of Calgary.

TECHNICAL MEMORANDUM #5 CRITERIA AND EVALUATION METHODOLOGY

CONCLUSION
April 12, 2016

5.0 CONCLUSION

Stantec conducted a pairwise criteria comparison method to evaluate each WWTP upgrade alternative presented to the Town of Okotoks in TM #3 and TM #4. The information presented in this draft technical memo represents initial ranking results of the upgrade alternatives based on Stantec's interpretation and selection of criteria.

Stantec's preliminary analysis found alternative 2B (MBR in BNR configuration plus HRCS and continued discharge to Sheep River) to be the highest rated upgrade alternative for the design horizon.

The ranking developed for different alternatives will be reviewed and adjusted at the workshop review meeting with the Town and other stakeholders to confirm the weightings and scoring results.

APPENDIX A CRITERIA PAIRWISE WEIGHTING ANALYSIS

Table A.1 - Pairwise Comparison Matrix

Criteria		Implementation	Cost Certainty	NPV	Short term capital cost	Medium term capital cost	O&M Cost	Staging flexibility	Resiliency	Permitting requirements	Counts	Weight
		A	B	C	D	E	F	G	H	I		
Implementation	A											
Cost Certainty	B		B	B	D	E	F	B	H	B	4	11.1%
NPV	C			C	D	C	F	G	H	C	3	8.3%
Short term capital cost	D				D	D	D	D	H	I	6	16.7%
Medium term capital cost	E					E	F	G	H	I	2	5.6%
O&M Cost	F						F	F	H	I	5	13.9%
Staging flexibility	G							G	H	I	3	8.3%
Resiliency	H								H	I	7	19.4%
Permitting requirements	I									I	6	16.7%
Effluent Quality	A											
Total											36	100.0%

APPENDIX B DETAILED EVALUATION OF INDIVIDUAL UPGRADE ALTERNATIVE

Table B.1 - Upgrade alternative 1A

Evaluation Alternative		1A				
Alternative Description		Upgraded conventional BNR system to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online at the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Few unknown elements in project, high cost certainty	Good	2	Least probability of cost uncertainty in predetermined plant upgrade design, specifically if there is no change in existing discharge location.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	<\$75 M	Good	2	Lowest project cost compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	>\$25M	Poor	0	High upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	>\$8M	Poor	0	High midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Moderate Cost	Fair	1	Moderate O&M cost due to the upgrade of the equipment and structures, and addition of new discharge location.
7	Staging flexibility	Ability to stage expenditure	Moderate spread of cost	Fair	1	Moderate variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	Biomass washout and delayed resumption of normal operation	Poor	0	Excessive washout and poor recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Standard EPEA approval process	Fair	1	Standard permitting process to upgrade the WWTP.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to the Sheep River with minimum impact on receiving water.

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Table B.2 - Upgrade alternative 1B

Evaluation Alternative		1B				
Alternative Description		Upgraded conventional BNR system to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online at the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Few unknown elements in project, high cost certainty	Good	2	Least probability of cost uncertainty in predetermined plant upgrade design, specifically if there is no change in existing discharge location.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	<\$75 M	Good	2	Lowest project cost compared to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	~\$23M	Fair	1	Moderate upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	\$5M-\$8M	Fair	1	Moderate midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Moderate Cost	Fair	1	Moderate O&M cost due to the upgrade of the equipment and structures, and addition of new discharge location.
7	Staging flexibility	Ability to stage expenditure	Moderate spread of cost	Fair	1	Moderate variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	System returns to normal operation quickly	Fair	1	Adequate washout and fast recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Complex or uncertain EPEA approval process	Poor	0	Uncertain permitting process to upgrade the WWTP due to HRCS addition.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to the Sheep River with minimum impact on receiving water.

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Table B.3 - Upgrade alternative 2A

Evaluation Alternative		2A				
Alternative Description		Upgraded MBR in a BNR configuration to treat PHF at the design horizon. The WWTP discharges all effluent to Sheep River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online at the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Few unknown elements in project, high cost certainty	Good	2	Least probability of cost uncertainty in predetermined plant upgrade design, specifically if there is no change in existing discharge location.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	>\$85M	Poor	0	highest project cost bracket compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	~\$23M	Fair	1	Moderate upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	>\$8M	Poor	0	High midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Highest Cost	Poor	0	Poor O&M cost due to the MBR technology without HRCS.
7	Staging flexibility	Ability to stage expenditure	Most even spread of cost	Good	2	Lower variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	Biomass washout and delayed resumption of normal operation	Poor	0	Excessive washout and poor recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Standard EPEA approval process	Fair	1	Standard permitting process to upgrade the WWTP.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to the Sheep River with minimum impact on receiving water.

Table B.4 - Upgrade alternative 2B

Evaluation Alternative		2B				
Alternative Description		Upgraded MBR in a BNR configuration to treat up to 2 x average annual flow plus HRCS to treat all remaining flow up to PHF at the design horizon. The WWTP discharges all effluent to Sheep River.				
ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online at the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Few unknown elements in project, high cost certainty	Good	2	Least probability of cost uncertainty in predetermined plant upgrade design, specifically if there is no change in existing discharge location.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	<\$75 M	Good	2	Lowest project cost compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	<\$21M	Good	2	Lowest upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	<\$5M	Good	2	Lowest midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Lowest Cost	Good	2	lower O&M cost due to the implementation of MBR technology with HRCS.
7	Staging flexibility	Ability to stage expenditure	Most even spread of cost	Good	2	Lower variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	System returns to normal operation quickly	Fair	1	Adequate washout and fast recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Complex or uncertain EPEA approval process	Poor	0	Uncertain permitting process to upgrade the WWTP due to HRCS addition.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to the Sheep River with minimum impact on receiving water.

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Table B.5 - Upgrade alternative 3A

Evaluation Alternative		3A				
Alternative Description		Same as Alternative 1A, but discharging to both the Sheep River and Highwood River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online on the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Moderate unknowns in project, moderate certainty	Fair	1	Moderate probability of cost certainty as a new discharge location is added in addition to the existing one.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	\$75M to \$85M	Fair	1	Moderate project cost compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	>\$25M	Poor	0	High upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	>\$8M	Poor	0	High midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Moderate Cost	Fair	1	Moderate O&M cost due to the upgrade of the equipment and structures, and addition of new discharge location.
7	Staging flexibility	Ability to stage expenditure	Lowest spread of cost	Poor	0	High variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	Biomass washout and delayed resumption of normal operation	Poor	0	Excessive washout and poor recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Standard EPEA approval process	Fair	1	Standard permitting process to upgrade the WWTP.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to both the Sheep and Highwood River with minimum impact on receiving water.

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Table B.6 - Upgrade alternative 3B

Evaluation Alternative		3B				
Alternative Description		Same as Alternative 1B, but discharging to both the Sheep River and Highwood River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online on the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Moderate unknowns in project, moderate certainty	Fair	1	Moderate probability of cost certainty as a new discharge location is added in addition to the existing one.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	\$75M to \$85M	Fair	1	Moderate project cost compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	~\$23M	Fair	1	Moderate upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	\$5M-\$8M	Fair	1	Moderate midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Moderate Cost	Fair	1	Moderate O&M cost due to the upgrade of the equipment and structures, and addition of new discharge location.
7	Staging flexibility	Ability to stage expenditure	Lowest spread of cost	Poor	0	High variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	System returns to normal operation quickly	Fair	1	Adequate washout and fast recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Complex or uncertain EPEA approval process	Poor	0	Uncertain permitting process to upgrade the WWTP due to HRCS addition.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to both the Sheep and Highwood River with minimum impact on receiving water.

Table B.7 - Upgrade alternative 4A

Evaluation Alternative		4A				
Alternative Description		Same as Alternative 1A, but discharging to both the Sheep River and Bow River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online on the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Many unknowns, low cost certainty	Poor	0	Lowest probability of cost certainty as a new discharge location is added in addition to the existing one.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	>\$85M	Poor	0	Highest project cost bracket compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	>\$25M	Poor	0	High upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	>\$8M	Poor	0	High midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Moderate Cost	Fair	1	Moderate O&M cost due to the upgrade of the equipment and structures, and addition of new discharge location.
7	Staging flexibility	Ability to stage expenditure	Lowest spread of cost	Poor	0	High variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	Biomass washout and delayed resumption of normal operation	Poor	0	Excessive washout and poor recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Standard EPEA approval process	Fair	1	Standard permitting process to upgrade the WWTP.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to both the Sheep and Bow River with minimum impact on receiving water.

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Table B.8 - Upgrade alternative 4B

Evaluation Alternative		4B				
Alternative Description		Same as Alternative 1B, but discharging to both the Sheep River and Bow River.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service to be online on the given time frame	Pass	-	The additional treatment capacity can be available as required if the upgrade work commences within a reasonable time frame.
2	Cost Certainty	Confidence of cost estimate	Many unknowns, low cost certainty	Poor	0	Lowest probability of cost certainty as a new discharge location is added in addition to the existing one.
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	\$75M to \$85M	Fair	1	Moderate project cost compare to other proposed alternatives.
4	Short term capital cost	Capital cost in the first five years	~\$23M	Fair	1	Moderate upfront cost due to the capacity upgrade of treatment processes compare to other upgrade alternatives.
5	Medium term capital cost	Capital cost between year 5 and 25	\$5M-\$8M	Fair	1	Moderate midterm cash flow due to the addition of the process equipment during this term.
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	Moderate Cost	Fair	1	Moderate O&M cost due to the upgrade of the equipment and structures, and addition of new discharge location.
7	Staging flexibility	Ability to stage expenditure	Lowest spread of cost	Poor	0	High variance in annual cash flow compared to other upgrade alternatives annual cash flow during the service life of the project.
8	Resiliency	Effect on operation following an extreme flow event	System returns to normal operation quickly	Fair	1	Adequate washout and fast recovery of biomass during the peak flow.
9	Permitting requirements	Number of approvals and difficulty in obtaining them	Complex or uncertain EPEA approval process	Poor	0	Uncertain permitting process to upgrade the WWTP due to HRCS addition.
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	Meets the effluent discharge criteria	Pass	-	Meets the requirements to discharge the effluent to both the Sheep and Bow River with minimum impact on receiving water.

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Table B.9 - Upgrade alternative 5

Evaluation Alternative		5				
Alternative Description		Shutdown Okotoks' WWTP and discharge the sewage to City of Calgary Pine Creek WWTP.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service won't be online on the date service required	Fail	-	Tie into the City of Calgary Pine Creek WWTP won't be available until next 10-15 years
2	Cost Certainty	Confidence of cost estimate	N/A	N/A		
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	N/A	N/A		
4	Short term capital cost	Capital cost in the first five years	N/A	N/A		
5	Medium term capital cost	Capital cost between year 5 and 25	N/A	N/A		
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	N/A	N/A		
7	Staging flexibility	Ability to stage expenditure	N/A	N/A		
8	Resiliency	Effect on operation following an extreme flow event	N/A	N/A		
9	Permitting requirements	Number of approvals and difficulty in obtaining them	N/A	N/A		
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	N/A	N/A		

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Table B.10 - Upgrade alternative 6

Evaluation Alternative		6				
Alternative Description		Run the Okotoks' WWTP to its maximum capacity and discharge the additional flow to City of Calgary Pine Creek WWTP.				

ID	Criteria	Explanation	Condition	Rating	Score	Discussion
1	Implementation	Date service could be available to meet Okotoks' needs	Service won't be online on the date service required	Fail	-	Tie into the City of Calgary Pine Creek WWTP won't be available until next 10-15 years
2	Cost Certainty	Confidence of cost estimate	N/A	N/A		
3	NPV	The Net Present Worth of the total capital cost over the evaluation period	N/A	N/A		
4	Short term capital cost	Capital cost in the first five years	N/A	N/A		
5	Medium term capital cost	Capital cost between year 5 and 25	N/A	N/A		
6	O&M Cost	Total value of operations and maintenance cost for selected alternative	N/A	N/A		
7	Staging flexibility	Ability to stage expenditure	N/A	N/A		
8	Resiliency	Effect on operation following an extreme flow event	N/A	N/A		
9	Permitting requirements	Number of approvals and difficulty in obtaining them	N/A	N/A		
10	Effluent Quality (Environmental)	Meet effluent discharge criteria and minimum impact on downstream receiving water quality	N/A	N/A		

APPENDIX C UPGRADE ALTERNATIVES SUMMARY MATRIX

Table C.1 - Upgrade alternatives Summary Matrix

ID	Criteria	Criteria Weight	Alternative Criteria Rating and Scores									
			1A	1B	2A	2B	3A	3B	4A	4B	5	6
1	Implementation	Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail
2	Cost Certainty	11.1%	Good	Good	Good	Good	Fair	Fair	Poor	Poor	N/A	N/A
3	NPV	8.3%	Good	Good	Poor	Good	Fair	Fair	Poor	Fair	N/A	N/A
4	Short term capital cost	16.7%	Poor	Fair	Fair	Good	Poor	Fair	Poor	Fair	N/A	N/A
5	Medium term capital cost	5.6%	Poor	Fair	Poor	Good	Poor	Fair	Poor	Fair	N/A	N/A
6	O&M Cost	13.9%	Fair	Fair	Poor	Good	Fair	Fair	Fair	Fair	N/A	N/A
7	Staging flexibility	8.3%	Fair	Fair	Good	Good	Poor	Poor	Poor	Poor	N/A	N/A
8	Resiliency	19.4%	Poor	Fair	Poor	Fair	Poor	Fair	Poor	Fair	N/A	N/A
9	Permitting requirements	16.7%	Fair	Poor	Fair	Poor	Fair	Poor	Fair	Poor	N/A	N/A
10	Effluent Quality (Environmental)	Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	N/A	N/A
Raw Score			0.778	1.028	0.722	1.472	0.500	0.750	0.306	0.639	0.000	0.000
Max Score			2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	0.000	0.000
Normalized Score			38.9%	51.4%	36.1%	73.6%	25.0%	37.5%	15.3%	31.9%	N/A	N/A
Rank			3	2	5	1	7	4	8	6	N/A	N/A