2020/21 - 2024/25

Five-Year Business Plan

Approved by the Halifax Water Board

January 30, 2020

STRAIGHT from the SOURCE

Halifax Water

Glossary

AM	Asset Management
AMIT	Asset Management Implementation Team
AMP	Asset Management Plan
AO	Aesthetic Objective
AMI	Advanced Metering Infrastructure
AWWA	American Water Works Association
BLT	Beechville-Lakeside Timberlea
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
BPF	Biosolids Processing Facility
CapEx	Capital Expenditures
CBOD	Carbonaceous Biochemical Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
CCTV	Closed Circuit Television
CEC	Contaminants of Emerging Concern
CIPP	Cured in Place Pipe
CFIA	Canadian Food Inspection Agency
COMFIT	Community Feed-In Tariff
COS	Cost of Service
CMMS	Computerized Maintenance Management System
CRM	Customer Relationship Management
CSO	Combined Sewer Overflow
CSMMW	Canada-Wide Strategy for the Management of Municipal Wastewater Effluent
CUPE	Canadian Union of Public Employees
CWWF	Clean Water and Wastewater Fund
dia.	Diameter
EMAP	Energy Management Action Plan
EMP	Emergency Management Plan
EMS	Environmental Management System
EMSC	Energy Management Steering Committee
EMO	Energy Management Opportunities
EPWWTF	Eastern Passage Wastewater Treatment Facility
ERA	Environmental Risk Assessment
ERM	Enterprise Risk Management
ERP	Enterprise Resource Planning
GHG	Greenhouse Gas
GIS	Geographic Information System
HHSP	Halifax Harbour Solutions Project
HRM	Halifax Regional Municipality
HRWC	Halifax Regional Water Commission
I&I	Inflow & Infiltration
ICI	Industrial, Commercial & Institutional

ICIP	Investing in Canada Infrastructure Program
ICS	Incident Command System
IDF	Intensity-Duration-Frequency
IMP	Infrastructure Master Plan
IRP	Integrated Resource Plan
IRS	Internal Responsibility System
IS	Information Systems
JOHSC	Joint Occupation Health & Safety Committee
LSL	Lead Service Line
m3	Cubic Metre
MAC	Maximum Acceptable Concentration
MGD	Million Gallons per Day
NDWAC	National Drinking Water Advisory Council
NOM	Natural Organic Matter
NSE	Nova Scotia Environment
NSERC	Natural Sciences and Engineering Research Council
NSPI	Nova Scotia Power Inc.
NSUARB	Nova Scotia Utility and Review Board
OHS	Occupational Health & Safety
OpEx	Operating Expenditures
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PRV	Pressure Reducing Valve
PS	Photovoltaic
PV	Pumping Station
PWI	Preventing Workplace Injury
RDC	Regional Development Charge
RDII	Rainfall Derived Inflow & Infiltration
ROW	Right of Way
RWWFP	Regional Wastewater Functional Plan
SCADA	Supervisory Control and Data Acquisition
SSES	Sanitary Sewer Evaluation Survey
SSO	Sanitary Sewer Overflow
TA	Transitional Authorization
TOC	Total Organic Carbon
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
UV	Ultraviolet
WEF	Water Environment Federation
WRWIP	West Region Wastewater Infrastructure Plan
WSER	Wastewater Systems Effluent Regulations
WWMP	Wet Weather Management Plan
WWTF	Wastewater Treatment Facility
WQMP	Water Quality Master Plan

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APPENDICES

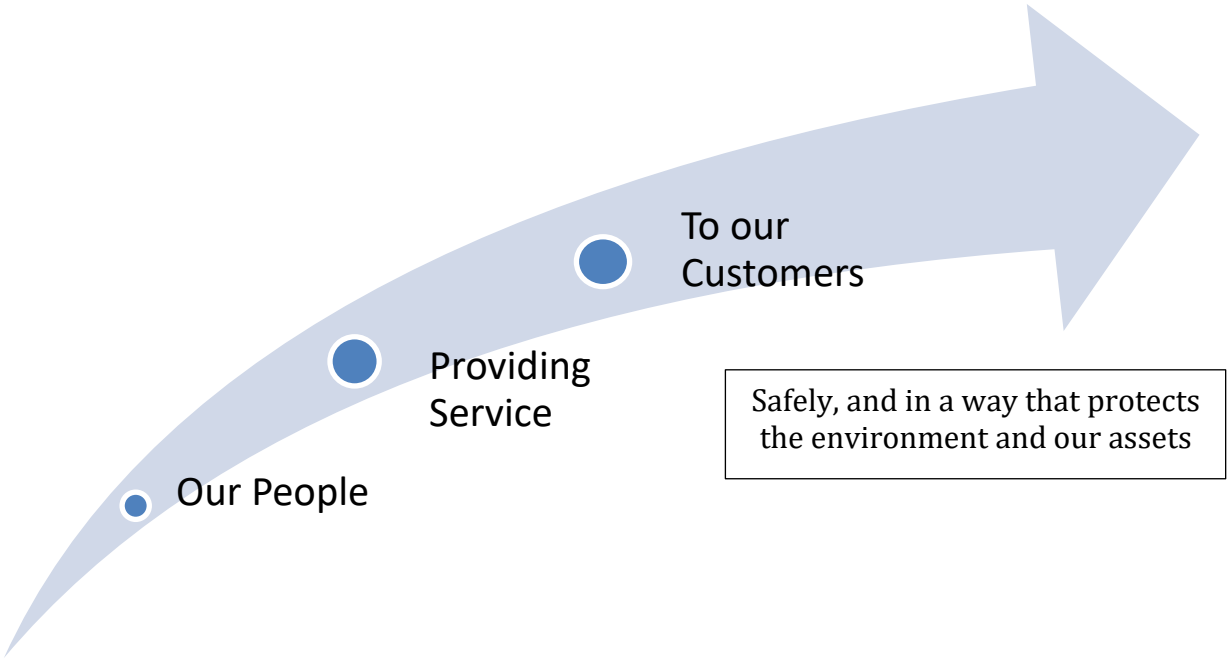
1. EXECUTIVE SUMMARY

January 1, 2020 marks 75 years of service for Halifax Water. Halifax Water has grown from the Halifax Public Service Commission established in 1945 to provide water service to the city of Halifax; to an integrated water, wastewater and stormwater utility serving 105,000 customers and an estimated population of 370,000.

Halifax Water has ambitious plans for continued innovation and improvement that are outlined in this Five-Year Business Plan for the period 2020/21 – 2024/25.

This Five-Year Business Plan and 75th Anniversary presents a great opportunity to reflect on accomplishments but also provides an opportunity to recalibrate business plans for current strategic drivers. As such, staff have compiled a Five-Year Business Plan to capture the most current information. The attached Business Plan will serve as a guidance document for the implementation of programs and strategies over the next five years and position the utility for service delivery in the long-term. This Five-Year Business Plan recognizes the need for further capital investment as contemplated in the updated Integrated Resource Plan (IRP). Halifax Water is taking positive actions towards climate adaptation in ensuring the updated IRP considers climate vulnerabilities to reduce risk to infrastructure and service delivery.

Figure 1: Graphic Representation of Halifax Water Mission



HALIFAX WATER
Five-Year Business Plan
2020/21 to 2024/25

Halifax Water's mission is **to provide world class services for our customers and our environment**; and our vision of how we will accomplish this is threefold.

1. We will provide our customers with high quality water, wastewater and stormwater service.
2. Through the adoption of best practices, we will place the highest value on public health, customer service, fiscal responsibility, workplace safety and security, asset management, regulatory compliance and stewardship of the environment.
3. We will fully engage employees through teamwork, innovation and professional development.

In addition to the mission, vision and values Halifax Water's business plans are guided by decisions of the Halifax Water Board, and regulations, policies and direction from two regulators – the Nova Scotia Utility and Review Board and the Nova Scotia Department of Environment.

Halifax Water develops both long-term and short-term business plans for the approval of the Commission Board. The Five-Year Business Plan is consistent with the updated IRP approved by the Halifax Water Board in November 2019.

The Nova Scotia Utility and Review Board (NSUARB) Accounting and Reporting Handbook requires the submission of multi-year (three year) operating and capital budgets by September 30th of each year. The three years submitted are a subset of the Five-Year budget. To meet the annual three-year reporting requirement, the Five-Year budget must be refreshed mid-cycle. A refresh would also be considered as part of rate applications to ensure the information submitted is current. The last Five-Year Business Plan covered the period 2018/19 to 2022/23; and was based on the 2012 IRP.

The Five-Year Business Plan provides an overview of the framework and strategic drivers that impact the delivery of water, wastewater and stormwater services over the long-term. The framework consists of the 2019 IRP, the Debt Strategy, and Cost of Service Manual. These mature strategies guide development of business plans, capital and operating budgets; revenue requirements and rates.

As indicated in the 2019 IRP, there is a pressing need to replace aging water, wastewater and stormwater infrastructure that will affect operating and capital budgets. The Business Plan presents the capital program and projected operating budgets for the next five years, and includes many major capital projects such as upgrades to the Pockwock and Lake Major water supply plants, upgrades to the Mill Cove Wastewater Treatment facility, and the next phase of the Sullivan's Pond stormwater project. Over the next five years, Halifax Water will be developing and implementing strategies to increase the level of capital expenditures to the level recommended by the IRP to address the strategic drivers of asset renewal, growth, and regulatory compliance. Of the three strategic drivers included in the IRP, asset renewal

will present the greatest challenge recognizing the backlog of investments in relation to the replacement of aging infrastructure.

The updated Five-Year Business Plan is important to support the application to increase water and wastewater rates in 2020. No rate changes for stormwater service are planned at this time; however, the need to adjust stormwater rates will be considered after satellite imagery used to measure billable impervious area is updated in spring 2020.

Halifax Water has ambitious plans for continued innovation and improvement that are outlined in the Five-Year Business Plan. Along with many other technology and customer focused projects, a customer portal combined with recently installed Advanced Meter Infrastructure will help transform Halifax Water into the utility of the future. The document also recognizes the increased importance of enterprise risk management, formal asset management, energy management and wet weather management programs to optimize service delivery and demonstrate value for our customers.

Several challenges and opportunities will garner the attention of the utility over the next five years, namely:

1. **Implementation of the updated IRP and optimizing the processes used to plan, procure, and deliver capital projects:** The current water, wastewater and stormwater rates are insufficient to meet the capital needs for sustainable infrastructure as identified in the IRP. The IRP acknowledges that wastewater and stormwater assets have been grossly underfunded historically. Institutional capacity will have to be optimized over the term of this Business Plan in order to deliver the expected capital projects; and the processes used to plan, procure and deliver capital projects will be reviewed to achieve a target of spending 80 – 90% of the annual capital budget within the year it is approved. This is an aggressive target, given the multi-year nature and complexity of some of Halifax Water's capital projects.

2. **Enhanced Customer Service:** Investment in employee training and technology are key to enhancing customer service. With the completion of installation of advanced meter infrastructure as part of the Customer Connect Project in 2020; Halifax Water is now focused on building and implementing a customer portal. The expectation of customers is increasing rapidly and the adoption of new technologies and business process is paramount to provide the best in customer service. Halifax Water has and will continue to invest in enhancing integration and functionality of existing systems Geographic Information System (GIS), Computerized Maintenance Management Systems (CMMS), the telephony system, and Customer Relationship Management (CRM) to enhance the customer experience through its Customer Care Centre. Greater emphasis will be placed on measuring customer satisfaction, and utility performance relative to customer centric service levels.

3. **Lead Line Replacement Program:** The utility will further enhance its program to replace all lead service lines (LSLs) on the Halifax peninsula and downtown Dartmouth areas by increasing the level of financial assistance, and pushing for more integration of LSL replacements in conjunction with the HRM street renewals. This is based on industry best practice and recent research conducted in partnership with Dalhousie University. As Halifax Water is in the health protection` business, complete LSL renewal will be pursued for public health outcomes.

4. **Wet Weather Management:** The level of service offered by the utility can be increased if innovative business processes and technology are embedded in day to day operations for the ultimate protection of the environment. Managing the effects of wet weather, and reducing inflow and infiltration (I&I) are key to creating capacity within existing infrastructure and avoiding some future capital costs. Over the next five years, it is anticipated Halifax Water will develop new programs and tools to work with customers to address I&I issues on private property. It is estimated that more than 50% of I&I originates from private property.

5. **Employee Satisfaction:** In the next five years many of Halifax Water's workforce will be eligible to retire. To compete, attract and retain top talent, in addition to providing competitive wages and benefits, Halifax Water must strive to create a respectful work environment where employees are fully engaged through teamwork, innovation and professional development. Continued investment in improving internal communications, talent management, training, civility and respect in the workplace, and diversity will help create the kind of work environment where our employees are engaged and provide service safely, and in a way that protects the environment, our assets, and always keeps the customer in mind.

6. **Regulatory Compliance:** 2020/21 will see the implementation of a new system to track regulatory compliance and support regulatory compliance activities. In addition to improved systems and processes to support environmental regulatory compliance, a new payroll system being implemented in 2020/21 will have new functionality that will promote Occupational Health and Safety (OHS) through tracking of training and certifications required by employees.

7. **Environmental Stewardship:** Halifax Water's updated IRP contains projects that will help the utility with climate change adaptation and mitigation. Recent research indicates that climate change is accelerating, as evidenced by projections of sea level rise, more intense storm events, and changing precipitation patterns. Our environmental stewardship will also be enhanced through extension of the Environmental Management System (EMS) (ISO 14001) on a corporate wide basis. The EMS will help minimize the impact our operations have on the environment, and promote compliance with applicable laws, regulations, and other environmentally oriented requirements.

8. **Water and Wastewater Research:** Building on the success of the current drinking water research program with Dalhousie University, Halifax Water is expanding the program to include wastewater to ensure that treatment plants are optimized and upgraded to meet the current federal wastewater regulations at the lowest cost. Wastewater research focused on optimizing treatment processes and contaminants of emerging concerns (CEC) may help Halifax Water reduce what is estimated to be a $425 M cost to upgrade the three HHSP from advanced primary to secondary treatment.

9. **Technological Investment:** Halifax Water's Five-Year IT Strategic Plan calls for continued investment in core operating systems. Throughout the span of the Five-Year Business Plan Halifax Water will implement a new payroll solution (including an employee portal), a customer portal, a new Enterprise Resource Planning system (ERP), and will continue to make investments in foundational security projects that support cyber-security, continuity of service and protection of data.

In order to achieve the strategic objectives presented in this Five-Year business plan, Halifax Water will have to increase rates. Overall annual revenues will need to increase over the five-year period with the primary focus on the capital needs driven by asset renewal. Halifax Water is not alone in its quest for more sustainable funding. Unfortunately, water, wastewater and stormwater assets have been underfunded throughout North America, and other municipalities/utilities have made, or are making plans to increase rates. The projected rate increases associated with this business plan will be viewed in the context of customer affordability, with a goal of maintaining an average annual residential bill for water, wastewater and stormwater service that is less than 2% of median household income. The utility is proposing to continue with the H20 (Help to Others) Program to support low income customers, with funding from unregulated activities; and hopes to increase the funding, awareness, and utilization of this program.

Inherent in the business activities for Halifax Water is an obligation to provide value for customers as stewards of essential services. To that end, the Business Plan highlights very formal programs to deliver efficient and effective service through Enterprise Risk Management, Asset Management, Energy Management, Wet Weather Management, and the Cost Containment Program. The Wet Weather Management program, in particular, presents an opportunity to improve service delivery at a lower cost and has already shown positive results. A structured approach is in place, similar to the process used by the utility for water loss control. Halifax Water is recognized as a world leader in water loss control and the corporate goal is to put wet weather management in the same category.

2. INTRODUCTION

Halifax Water is a "one water" utility, delivering water, wastewater and stormwater service. Halifax Water is just reaching maturity as a one water utility. 2019 was the first year since the transfer of wastewater and stormwater assets from the Halifax Regional Municipality (HRM) in 2007 that all 14 wastewater treatment facilities were in compliance with regulations.

In 2012, the utility completed its first IRP; and an updated IRP in 2019 identifying investments required over a thirty year period under the strategic drivers of asset renewal, regulatory compliance and growth. After the first IRP in 2012 plans were put in place to make progress on all three strategic drivers. Halifax Water has made significant progress on wastewater treatment facility compliance. Since the upgrade of the Aerotech plant was completed in 2019, all wastewater treatment facilities are compliant with the new federal wastewater system effluent regulations or operate under approved transitional authorizations. The utility has also kept pace with growth within the municipality and helped facilitate development while ensuring cost neutrality to the existing rate base by implementing Regional Development Charges (RDCs) consistent with the Public Utilities Act. With respect to asset renewal, there has been steady progress to increase capital investments as contemplated in the IRP, although at a more moderate pace. These capital investments continue to benefit from better information and data collected over the last ten years.

As part of Halifax Water's sustainability framework, key projects will be ready to advance under existing and future federal infrastructure programs, such as the Investing in Canada Infrastructure Program (ICIP, the Building Canada Fund and the Clean Water and Wastewater Fund (CWWF). Support from other levels of government through infrastructure funding is necessary if Halifax Water is to reach the recommended level of capital spend while preserving rate affordability.

In order to close the gap on asset renewal funding however, future rate increases are inevitable. These rate increases must follow the principle of gradualism to balance rate shock and affordability to customers. Accordingly, Halifax Water will attempt to implement its infrastructure investments with a smoothing strategy in mind. In conformance with the Public Utilities Act, all of these investments and associated funding must be based on cost causation principles and occur within the context of intergenerational equity. It is anticipated that additional funding from federal programs will be available to mitigate the impact on Halifax Water's rate base and thus temper otherwise higher rate increases.

3. CURRENT RATE STRUCTURES

Halifax Water has a Cost of Service based rate structure for water, wastewater and stormwater service, as approved by the Nova Scotia Utility and Review Board (NSUARB). Rates are adjusted periodically when the cost of providing the service is out of line with the revenue generated by the existing rates. When an adjustment is required, Halifax Water makes an application to the NSUARB, and a formal public hearing process is held to ensure proposed rates are thoroughly reviewed in an open, objective and transparent manner.

Halifax Water has programs in place to contain costs, monitor rate affordability, and project and smooth future revenue requirements to ensure that customers are not shocked by sudden or dramatic rate increases.

3.1 Water Service

The existing charges for water service have been in place since April 1, 2016 and consist of two components – a base charge, and a charge that varies according to consumption of water. Water base rates vary by meter size and range from $13.00 per month for a 15 mm (5/8") diameter meter to $1,575.00 per month for a 250 mm (10") diameter meter. The consumption charge for water service is $0.976 per m^3. The water-rate structure also provides for a public fire-protection charge to the municipality based on a formula approved by the NSUARB.

3.2 Wastewater Service

The existing charges for wastewater service have been in place since April 1, 2016 and consist of two components – a base charge, and a discharge rate that varies in relation to water consumption. Wastewater base rates vary by meter size and range from $14.00 per month for a 15 mm (5/8") diameter meter to $1,923.00 per month for a 250 mm (10") diameter meter. The wastewater discharge rate is based on metered water consumption, and is $1.753 per m^3.

Halifax Water has a wastewater rebate program that is available to customers who use more than 1,000 m^3 of water in a 12 month period and can demonstrate the volume of wastewater they discharge is less than the volume of water they use. This is covered by Section 22 of Halifax Water's Rules and Regulations. As an example, manufacturing facilities that use a large volume of water that is consumed in their product, or complexes with cooling towers may qualify for this rebate.

3.3 Stormwater Service

Stormwater rates are established based on impervious area. The current rates for stormwater service have been in place since July 1, 2017. There are two stormwater rates – one billed to all customers to recoup the cost of collecting and managing stormwater from private property (Site Related Flow Charge) and one billed to the HRM for collecting and managing stormwater from the street right of way (HRM ROW Charge). HRM, in turn, charges properties within the stormwater serviceable boundary to cover their portion of the HRM ROW Charge, and Halifax Water collects and administers this charge on HRM's behalf.

The Site Related Flow Charge for non-residential customers is $0.135 per m^2 of impervious area. The Site Related Flow Charge for residential customers is based on the same rate per m^2 but residential customers are billed according to a flat rate per tier. There are five tiers and properties are grouped according to the amount of impervious area. The lowest tier is comprised of properties with less than 50 m^2 of impervious area – and they are exempt from the charge, provide they do not have a driveway culvert. The largest properties – those with 810 m^2 or more of impervious area, are charged $81 a year. Most residential properties fall in Tier 2 or 3 and are charged $14 or $28 per year, respectively.

Effective October 1, 2017, Halifax Water is collecting the HRM ROW Charge on behalf of HRM, and the charge is currently set at $40 per year, per property.

Properties that do not receive stormwater service are exempt from both the Site Related Flow Charge and the HRM ROW Charge.

Effective July 1, 2017, a stormwater credit program was implemented for non-residential (Institutional, Commercial, Industrial) customers. Non-residential properties with stormwater Best Management Practices (BMPs), like retention ponds that help manage peak flows, may be eligible for a credit. Non-residential properties include multi-unit dwellings of four or more units.

Halifax Water plans to update satellite imagery, the cost of service model, and rates for stormwater service in 2020/21, with a few to adjusting rates in 2021/22.

3.4 Regional Development Charge

The Halifax Water Regional Development Charge (RDC) is a fee payable at the building permit stage of a new development to fund regional water and wastewater infrastructure expansion requirements related to growth. The RDC was approved in 2014 and provides fairness across the rate base ensuring current customers do not subsidize new growth and development.

When the RDC rates were approved, Halifax Water committed to update the RDC on a 5 year cycle, or mid-cycle if any of the assumptions used in determining the RDC impact the value of the charge by +/- 15%. No mid-cycle adjustment was required. Since approving the RDC, Halifax Water has completed a more detailed Infrastructure Master Plan, for water and wastewater infrastructure, to be used as inputs to the updating of the RDC.

In 2017 and 2019, Halifax Water conducted formal and informal stakeholder consultation on the updated RDC. The proposed updates were presented to the Halifax Water Board in October 2019, and the subsequent application was submitted to the NSUARB in November 2019. There is a Hearing scheduled for March 2020.

The updates included current population forecasts, people per unit, the unit type ratios, design per capita consumption values, standardized costing and benefit to existing frameworks.

Money collected from the RDC funds upgrades and improvements to the regional wastewater and water systems that are required to accommodate growth anticipated within the Municipality's Regional Plan. There is no RDC for stormwater. The infrastructure requirements were identified through the Infrastructure Master Plan which is part of the IRP, discussed in Section 7.1.

4. COST OF SERVICE/RATE DESIGN

Halifax Water has Cost of Service based rates developed using industry best practice. There is a Cost of Service (COS) Manual which clearly guides how rates are calculated for water, wastewater and stormwater service. The COS Manual was based on American Water Works Association (AWWA) and Water Environment Federation (WEF) methodologies for cost of service/rate design.

The COS Manual was developed through a process of engagement with interested parties, including prior rate case interveners and the NSUARB. The COS Manual is a living document which is periodically updated to reflect current data and new information, to support any proposed changes in rates. All changes to the COS Manual must be approved by the NSUARB.

The current rates are in line with the COS Manual, and are a true reflection of the cost of providing service in all respects except for one aspect. Halifax Water has not yet included depreciation as an expense on contributed water and wastewater assets, and most stormwater assets. Halifax Water plans to incorporate this in the future.

The COS Manual for Stormwater will be updated in Year 1 of the Five-Year Business Plan, after impervious area is updated with new satellite imagery. The COS Manual for Water and Wastewater will be updated in Year 2 of the Five-Year Business Plan, based on the first full year of AMI data after all meter conversions are completed.

5. WASTEWATER SYSTEM EFFLUENT REGULATIONS

The Wastewater System Effluent Regulations (WSER) were enacted in June 2012. These regulations, made under the Fisheries Act, implement those aspects of the Canadian Council of the Ministers of the Environment (CCME) Strategy for the Management of Municipal Wastewater Effluent which fall under federal jurisdiction, namely the discharge of deleterious substances to fish habitat. The WSER defines the following as deleterious substances, and sets national standards for their discharge:

- Carbonaceous Biochemical Oxygen Demand (CBOD); 25 mg/L
- Total Suspended Solids (TSS); 25 mg/L
- Total Residual Chlorine (TRC – for facilities using chlorine disinfection); 0.02 mg/L
- Un-ionized Ammonia; 1.25 mg/L as Nitrogen, at $15^0C \pm 1^0C$.

Wastewater treatment facilities (WWTFs) are authorized to discharge these substances at levels below the defined limits, provided that the effluent is not acutely lethal to trout as determined by standard toxicity testing. Facilities not in compliance with the limits were required to apply for a Transitional Authorization (TA) to deposit effluent exceeding those limits. The Authorization is valid for a period of 10, 20 or 30 years, depending on the risk level associated with the effluent, as determined by a defined risk-ranking system in the WSER.

Halifax Water obtained TAs effective January 1, 2015, for the Halifax and Dartmouth WWTFs, which remain in effect until December 31 of 2040. Both Halifax and Dartmouth WWTFs are medium risk, and would normally have 20 years to achieve compliance. However, both of these systems have combined sewer overflows (CSOs) which are higher risk than the WWTFs. The WSER provides that for systems having at least one CSO which is higher risk than the WWTF, the compliance period for high or medium risk WWTFs may be extended from 10 or 20 years respectively, to 30 years (from 2010). CSO discharges must also be reduced beginning in 2041, after the TA has expired. Although there are no further details in the WSER regarding the reduction, such as extent and timing, Environment Canada staff have indicated by email that "*a significant reduction … must be achieved immediately after the TA's expiry date".*

A Compliance Plan was developed as part of the IRP. The Compliance Plan provides Halifax Water with a tool to plan for upgrades to the WWTFs and reduce CSO discharges.

Instances of detected toxicity have been due to chlorine levels (where chlorine is used as a disinfectant), or are of unknown cause, and are under continuing investigation. It is recognized that pH drift during the tests can be a factor, and a pH-stabilized version of the toxicity test is in use for the Mill Cove and Eastern Passage WWTFs. The Lakeside-Timberlea WWTF is the only remaining WWTF using chlorine for disinfection (all others use Ultraviolet

systems), and includes a de-chlorination process prior to discharge to meet the WSER chlorine limit.

The WSER also requires quarterly monitoring reports for each WWTF (depending on Annual Average Daily Volume), documenting the monthly or quarterly total effluent volume, the concentrations of CBOD and TSS and results of toxicity analysis (when required). These reports have all been submitted as required by the WSER, since 2013.

6. DRINKING WATER REGULATIONS

Over the last two years, Health Canada has set a direction of proactively reviewing its guidelines on a regular basis. This is a change from the previous ten to twenty years where the Health Canada Drinking Water agenda could be predicted by the agenda of the US Environmental Protection Agency. As a result, Health Canada has produced draft guidelines for public consultation that were not anticipated by utilities and advocacy groups. This will be cause for some uncertainty in this area until the basis for Health Canada's agenda becomes more widely known.

Manganese: Manganese is a metal which is ubiquitous in most Nova Scotia groundwater and surface water sources. The most common effects of manganese have been black staining on plumbing fixtures and laundry and has, to date, been regulated as an aesthetic objective (AO) in the Guidelines for Canadian Drinking Water Quality. In Nova Scotia, AO parameters serve only as a guidepost to utilities that problems will ensue if the AO value is exceeded. They are not a regulatory compliance issue.

In 2019, Health Canada published a new manganese guideline. The new guideline decreases the AO value from 0.05 to 0.02 ug/L, but more importantly, creates a health related value or maximum acceptable concentration (MAC) of 0.1 ug/L. Health Canada has created the MAC because they believe that manganese can have effects similar to lead in drinking water.

While manganese exists in most of our water sources to some degree, the level is such that it is easily removed. Two of our systems, Bennery Lake and Silver Sands have more challenging manganese issues. Both supplies have appropriate treatment systems to keep manganese below the MAC level continuously. Based on discussion with Nova Scotia Environment regarding their compliance approach, we do not believe manganese will create treatment challenges for Halifax Water. There is no practical effect in lowering the AO value as we currently provide treatment that is aesthetically acceptable to customers the vast majority of the time.

Manganese may prove to be a concern in future as it relates to distribution system water quality. When distribution system events result in discolored water, manganese is often a component of the material causing the color. Halifax Water quality staff is continuing to work on managing distribution system water quality, considering the manganese guideline. The

new guideline may result in some changes in future to how we communicate distribution system water quality to customers.

Lead: In January of 2019, Health Canada issued a new guideline for lead. Health Canada's previous guideline was outdated, not based on the most recent science, and did not serve to protect public health. The new guideline is half of the level of the previous, and uses a more challenging sampling protocol. Based on this, it will be much more challenging to maintain regulatory compliance.

Halifax Water is currently doing everything possible to reduce lead in drinking water. We have customer sampling upon request, and a program to promote LSL replacement with rebates and financing assistance for private lateral replacement. We also have a corrosion control treatment program that is optimized to mitigate lead exposure.

In November 2019, the Halifax Water Board approved proposed enhancements to the LSL rebate program. The program enhancements will be submitted for NSUARB approval in conjunction with the 2020 Rate Application.

While the new guideline may result in the occasional non-compliance with NSE requirements, the solution is to work with customers to replace the LSL. Halifax Water will continue its efforts to inventory LSLs, communicate with customers about lead and work with them to replace LSL's.

Other Guidelines: Health Canada has the following guidelines consultations underway:

- Aluminum
- E.coli
- Natural Organic Matter (NOM)
- Total coliforms
- Chloramines
- Barium

Of the above guidelines, none are expected to be treatment or compliance challenges for Halifax Water. Aluminum and NOM are being proposed as operational guidelines. This means that they will not be automatically included in operating approvals, however, best practice language may inform future iterations of the operating approvals. While both of these may be challenging today, planned upgrades to treatment facilities should address any challenges raised by these proposed guidelines.

Nova Scotia Environment Operating Approvals: Approvals for operating all water systems expired on March 31, 2018. Nova Scotia Environment began issuing new approvals in June of 2019.

Not all approvals have been received, and Halifax Water staff is working through them as they are received to make sure business process are in place to ensure compliance. Previous approvals placed less emphasis on ancillary processes, such as disposal of treatment waste and approval administration. The new approvals appear to be placing greater emphasis on these ancillary areas, bringing them up to the standard of the core drinking water processes. This may result in the requirement to make capital investment in some plant ancillary processes.

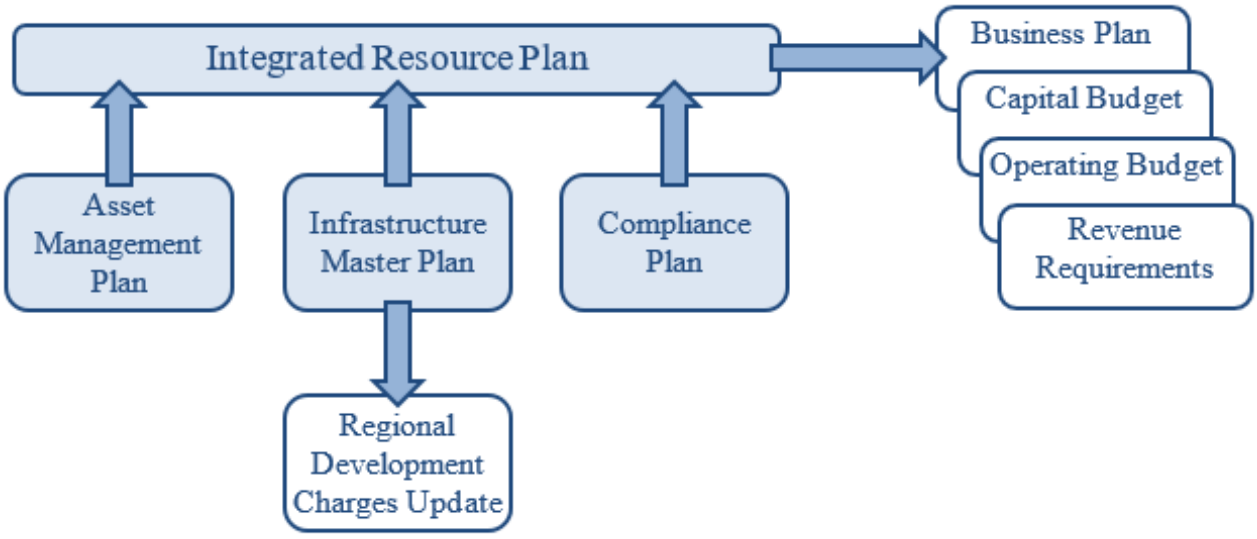
7. FINANCIAL PROGRAMS & PRO FORMA BUDGETS

7.1 Capital Program

7.1.1 2019 Integrated Resource Plan

An updated IRP was completed in 2019. The IRP Update built on the previous studies to address three primary drivers: growth (Infrastructure Master Plan), asset renewal (AMPs), and regulatory compliance (Compliance Plan). This project reviewed existing supply and demand side management activities Halifax Water has done or could do to optimize service delivery, created a six-step program integration approach, and produced a comprehensive 30-year capital investment program.

Figure 2: IRP Strategic Linkages



Several important initiatives aimed at filling data gaps have been completed or initiated since the first IRP in 2012. These included:

- Implementing the Wet Weather Management Program (with inflow and infiltration reduction pilot projects);
- Continuing the implementation of the Asset Management Program (foundational elements from the AM Roadmap);
- Resolving asset attribute information gaps in GIS, and carrying out specific inventory and condition assessment projects;
- Developing Asset Management Plans (AMPs) by asset class;
- Implementing the Corporate Flow Monitoring Program;
- Implementing the Sewer Inspection Program (using closed circuit television (CCTV) inspection methods);
- Completing the Hydraulic Modelling Assessment and Strategy;
- Completing the West Region Wastewater Infrastructure Plan (WRWIP);
- Completing the Infrastructure Master Plan.

The Infrastructure Master Plan project is the latest undertaking towards data and knowledge gap completion. The Infrastructure Master Plan looked at growth requirements for the balance of the wastewater infrastructure planning (east and central regions), included the program developed in the WRWIP, and included a water infrastructure plan for all regions. The project also included a climate change assessment and a policy component to develop a climate change adaptation plan and a systems optimization plan. The project enables Halifax Water to streamline prior long-term planning initiatives to facilitate regular, holistic Infrastructure Master Plan updates on a five-year cycle for water and wastewater infrastructure.

The IRP update was completed in November 2019 and incorporates findings from work completed or planned to support the drivers of regulatory compliance, asset renewal, and growth. The IRP update features a review of demand and supply side management activities Halifax Water has been or could be involved in. Further, it uses a systematic approach to reviewing integration opportunities for outputs of the predecessor plans (Compliance Plan, AMPs, Infrastructure Master Plan).

The resulting IRP Update recalibrates the long-term investment to an estimated $4.1 billion over 30 years with and anticipated review as part of Halifax Water's long-term planning cycle every 5 years. Several key initiatives have been identified to support the next IRP update.

7.1.2 Asset Management Program

The Asset Management division of the Engineering & IS Department provides services related to Infrastructure Planning (master planning, hydraulic system modelling, and flow monitoring), and Asset Management (program initiatives, asset management plan (AMP) development, and capital budget development).

In support of developing formal AMPs, staff have focused efforts on data collection. With some specific projects for condition assessment, staff have been able to provide detailed condition data for the Wastewater Treatment Facilities, Wastewater Pumping Stations, and Stormwater Cross Culvert asset classes. Where condition data has not been available, staff have been gathering data on asset attributes (size, age, and material) to use as a surrogate for condition in developing the AMPs.

A key outcome of the AMPs has been the recommendation for the establishment of Asset Management Implementation Teams (AMITs). AMITs are expected to work towards coordinate and integrated decisions about assets, the services they support, and the expenditures needed to meet agreed levels of service. Three AMITs were established to address Water Transmission Mains, Wastewater Forcemains, and Stormwater Cross Culverts – one for each of the infrastructure system types. Water Chambers and Booster Stations, Water Distribution Mains and Water Reservoirs have been incorporated into a "Water Network AMIT". Adding other asset classes into the Wastewater and Stormwater AMITs is under consideration to determine the most effective aggregation and efficient use of staff resources in Engineering and Operations.

The current sewer inspection program commences year five of the five-year contract in 2020/21. As such, staff will be working on preparing the request for proposal for services associated with the next five-year contract. Staff will review opportunities to pre-qualify service providers that may allow Halifax Water to re-engage mass scale inspection techniques in addition to the conventional closed circuit television (CCTV) inspections. A central focus of the program is collection of the data to enable seamless upload to Halifax Water's GIS and simplicity in sharing the outcomes with all staff.

The Asset Management Team has a well-defined, and well-executed process for capital budget development resulting in the one-year and five-year capital programs. The process leverages inputs from the capital project planning database and the supporting capital project summary reports for each project or line item identified in the capital budget

Following the completion of previous long-term planning initiatives such as the Regional Wastewater Functional Plan (RWWFP), the first IRP, and the West Region Wastewater Infrastructure Plan (WRWIP), Infrastructure Planning staff have completed the Infrastructure Master Plan and the IRP Update.

The Infrastructure Master Plan brought the findings and recommendations of the WRWIP forward, assessed long-term wastewater infrastructure needs for the east and central regions, and water infrastructure needs for all service regions. The project included a "Vulnerability to Climate Change" asset assessment framework task and a rebuild of the wastewater hydraulic model.

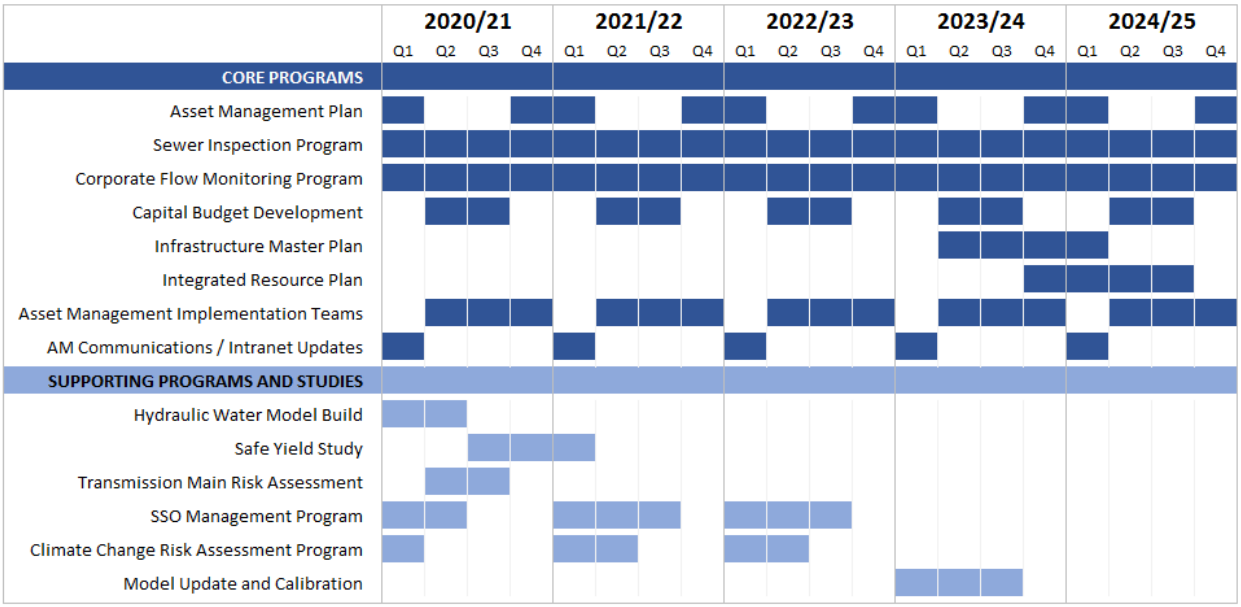
The Infrastructure Planning team manages the corporate flow monitoring program that is entering year five of the five-year contract in 2020/21. The flow monitoring program has been invaluable to Halifax Water in terms of providing accurate, reliable, and defensible data upon which model calibration, system analysis, and system decisions can be made. Similar to the CCTV program, the focus of this program is on purchasing data and its usability and accessibility for other users at Halifax Water.

Infrastructure Planning staff have worked closely on the hydraulic model build for the wastewater system with the consulting team for the Infrastructure Master Plan. Adherence to Halifax Water's Hydraulic Modelling Strategy included building with new modelling software for the wastewater system. For the water system, staff are completing a water model build assessment to confirm the components and requirements for the upcoming model build. The new water model will be able to leverage data collected through the Advance Metering Infrastructure (AMI) project to provide more accurate demand loading.

The Asset Management (AM) team has recently been working on an AM communications assessment aimed at identifying ways the AM team can better highlight the work being done by the team, help other departments connect with the AM programs and personnel, and present key reference documents and processes related to AM and infrastructure planning work. Halifax Water's intranet will be foundational for disseminating information and processes to the organization.

Anticipated projects for the Five-Year Business Plan cycle for the AM and Infrastructure Planning staff are outlined in Figure 3.

Figure 3: Five-Year Business Plan Cycle – AM and Infrastructure Plan



7.1.3 Five-Year Capital Budget – General Overview

As part of the utility's overall mission, the annual capital budget provides funds for the acquisition, replacement, or rehabilitation of capital assets. Capital assets include all equipment; facilities; and linear infrastructures that have an asset value that exceeds $5,000 and a useful life that exceeds one year. The capital budget development funding and subsequent project delivery help ensure that services are provided in a cost-effective and efficient manner with a focus on long-term integrity of systems.

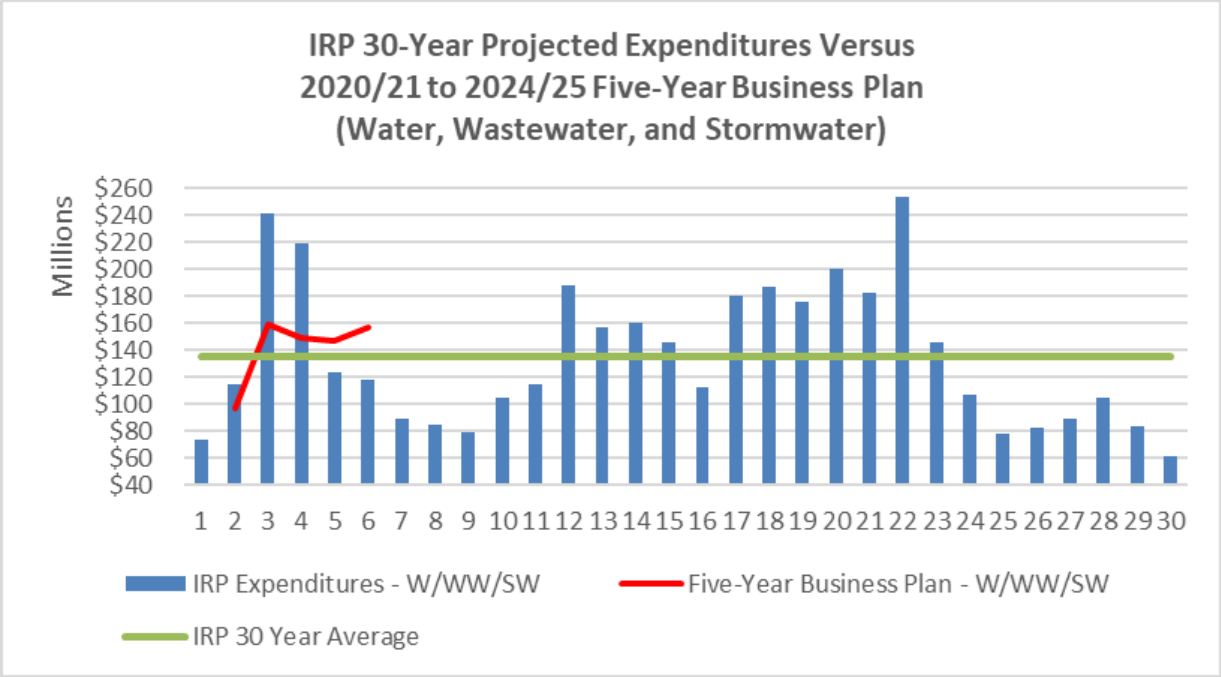
As discussed in Section 7.1, the development of the annual and long-term capital budget has its foundation with the Engineering & IS department's core Asset Management program. This program organizes, evaluates, and prioritizes all infrastructures by individual asset class. The core asset-class priorities are reviewed and coordinated with staff from Engineering & IS and Operations departments to identify the highest-priority projects. These projects are further reviewed with technical staff from the municipality's Transportation and Public Works group to review integration opportunities with the proposed Streets Program. A detailed overview of the major projects within the proposed five-year capital budget is provided in Section 7.1.4.

The proposed five-year capital budget is then reviewed against available sources of funding to consider the impact on depreciation and debt servicing, future operating expenses, and rates.

In addition to the core infrastructure projects within the capital budget, employees from all departments define annual capital-equipment requirements to meet their operational mandates. These include equipment classes such as fleet, large tools, computer equipment, and consumption meters.

The full five-year capital budget is shown in Appendix D. The totals can be seen in Figure 4 below. The year-one (2020/21) budget has a total project value of $48,929,500 for water, $38,448,000 for wastewater, and $9,136,500 for stormwater, with a five-year total project value of $293,775,500 for water, $352,250,500 for wastewater, and $62,425,000 for stormwater. The total planned capital spend over five-year period is projected to be $708,451,000

Figure 4: Five-Year Capital Program Compared to 2019 IRP



The capital budget is funded from a variety of sources. The core funding is from capital-asset depreciation accounts and long-term debt. This core funding is enhanced with regional development charges, external grants, and operating surplus, when available. The base funding amount for capital projects from depreciation increases as the NSUARB approves additions to utility plant-in-service and revenue requirements.

Figure 5: Five-Year Capital Program Funding

	Capital Funding Projection					
	2020-21	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Total**
Water						
External Funding	4,770,000	12,326,050	12,347,950	6,862,000	3,105,200	39,411,200
Depreciation	11,479,000	12,434,000	13,516,000	13,819,000	13,919,000	65,167,000
Debt Funding	23,183,300	46,567,700	39,347,050	28,472,250	33,189,800	170,760,100
Regional Development Charge	150,000	2,828,250	3,264,000	167,250	2,680,500	9,090,000
CCC	9,347,200					9,347,200
Total Water	48,929,500	74,156,000	68,475,000	49,320,500	52,894,500	293,775,500
Wastewater						
External Funding	934,630	820,460	8,278,060	1,003,860	935,360	11,972,370
Depreciation	15,974,000	17,101,000	18,213,000	18,157,000	19,516,000	88,961,000
Debt Funding	17,740,970	32,249,990	19,318,140	35,891,590	27,892,990	133,093,680
Regional Development Charge	3,798,400	22,575,550	14,481,800	32,391,050	44,729,150	117,975,950
CCC		247,500				247,500
Total Wastewater	38,448,000	72,994,500	60,291,000	87,443,500	93,073,500	352,250,500
Stormwater						
External Funding	18,280	255,850				274,130
Depreciation	1,582,000	1,776,000	1,997,000	2,003,000	2,177,000	9,535,000
Debt Funding	7,536,220	9,816,650	18,096,000	8,438,000	8,729,000	52,615,870
Regional Development Charge						-
CCC						-
Total Stormwater	9,136,500	11,848,500	20,093,000	10,441,000	10,906,000	62,425,000
Total	96,514,000	158,999,000	148,859,000	147,205,000	156,874,000	708,451,000

The historical and current level of capital funding is less than the amount recommended by the IRP. The required increase in capital infrastructure investments is defined in detail within the 2019 IRP. The proposed five-year capital budget shows a transition from historical spending levels towards the level recommended within the IRP, as can be seen in Figure 4 above. A transitional period allows for the development of institutional capacity to deliver the increased volume of projects, increased funding, and enhanced Asset Management protocols to identify and prioritize specific projects. The IRP recommended level of spending is not smooth or consistent, therefore increasing capital funding will be balanced with smoothing impacts on rates, and maintaining targets for debt servicing and rate affordability.

7.1.4 Major Projects

Integrated Capital Projects:

Project: Halifax Water Infrastructure Renewal Integrated with Halifax Municipal Street Renewal Program

Asset Class: Water Distribution, Wastewater and Stormwater Collection

Description: This program involves the renewal of water distribution, wastewater collection and stormwater collection infrastructure in an integrated approach with the municipality's annual Street renewal program. Water, wastewater and stormwater pipes and appurtenances are replaced or rehabilitated when approaching or exceeding their useful life cost effectively while the host municipal street is being renewed. The integrated program reduces the total project cost and minimizes the overall disturbance on community neighbourhoods. Halifax Water's planned expenditures on this program are approximately $7 M – $8 M per year.

Project: HRM Cogswell Redevelopment

Asset Class: Water, Wastewater, and Stormwater

Description: The municipality is currently finalizing the design phase of the Cogswell Redevelopment Project. The municipality plans to proceed to the tender phase of the project in late 2019 or early 2020 with approximate three year construction phase. There will be many impacts to the utility's water, wastewater and stormwater infrastructure. All net new infrastructure required to provide service to new buildings would be part of the municipal project cost. However, the relocation of existing infrastructure, required due to road alignment changes would be the responsibility of Halifax Water, based on the municipal Streets By-law. The estimated infrastructure investment for Halifax Water is $15 M.

Water Capital Projects:

Project: Main Street to Caledonia Road Transmission Main

Asset Class: Water – Transmission Main

Description: Halifax Water is working to construct a new 600 mm diameter transmission main from Main Street to Caledonia Road in Dartmouth. This is the first phase of a multiple phase project to improve capacity, resiliency and reliability for the water supply to the general area of Burnside. The overall cost estimate for this project is approximately $6 M.

Project: Chain Control to Peninsula Transmission Main Rehabilitation

Asset Class: Water – Transmission Main

Description: Replacement and rehabilitation of major components of the existing water transmission system from the Chain Lake Control area to the Halifax Peninsula. The project will provide increased capacity, improve reliability and enhance system resilience for water delivery to the peninsula. The multi-year project is estimated to cost approximately $6,500,000.

Project: Bedford South (Hemlock) Reservoir

Asset Class: Water – Structures

Description: The Hemlock Reservoir location and storage volume have been established in previous master planning studies completed for the Bedford South, Bedford West and Birch Cove North development areas. As these areas have developed over the last 20 years, the need for the reservoir is being constructed to meet level of service requirements in the water distribution system. The reservoir will be located at an existing Halifax Water control chamber on Masthead Court and will be 30 meters in diameter and height with a total storage volume of 21.5 million liters. Construction is anticipated to start in spring 2020 with substantial completion in spring 2021. The estimated project cost is approximately $10 M with majority funding for the Halifax Water Capital Cost Contribution program.

Project: Cowie Hill Reservoir Replacement

Asset Class: Water – Structures

Description: The Cowie Hill Reservoir is a 2.4 MG gunite water storage reservoir that was constructed in 1972. The reservoir underwent a significant rehabilitation from 1990 to 1996. The internal and external inspection found numerous locations where the gunite covering had spalled off leaving the underlying steel reinforcing wires exposed and rusting. There are numerous locations on the wall that show evidence of cracks and leakage through the wall of the reservoir. The gunite reservoir inspection program identified the Cowie Reservoir as a priority for rehabilitation, however, subsequent detailed design work determined that the reservoir should be replaced as it has reached the end of its useful life and replacement has a more cost effective than rehabilitation.

The project will involve retaining a consulting engineer to design and prepare a replacement plan. It is anticipated that the design work be undertaken in 2020 and the work will then be tendered and constructed in the summer of 2021.

Project: J.D. Kline Water Supply Plant – Process Upgrades

Asset Class: Water – Treatment Facilities

Description: Source Water Quality at JD Kline WSP has been changing because of the phenomenon known as lake recovery from acidification. Over the past few years, pH of the lake has been coming up. This means that the lake is more susceptible to sustain biological activity. This in turn has shown its effects in the last few years in terms of appearance of geosmin in the source water as well as most recent event in summer of 2018 where algal diatoms clogged filters to the point that it rendered the plant with not enough production to meet the distribution demand. Additionally, the amount of organics in the lake have been increasing (TOC was 1.7 mg/L in 1977 and is at 3.8 mg/l in 2019). It is to a point where it is difficult to operate the plant in its current configuration as a direct filtration plant. In order to deal with the water quality impacts from lake recovery, a clarification step needs to be added to the treatment train. Halifax Water is in the process of procuring services of a consulting team to provide expert advice and help in terms of next steps, treatment process selection, procurement and execution of projects. Some of the projects that are going to form part of these upgrades are a review and potential upgrade of existing pre-treatment setup, new or retrofit existing flocculation basins and addition of a new clarifier treatment. Other important projects that will need to happen concurrently are optimization of the existing backwash system as well as improvements to the lagoons to handle additional solids loading. All these projects are scheduled to be completed over the next five to seven years.

The J.D. Kline Water Supply Plant was commissioned in 1977 to service the City of Halifax, Town of Bedford, and parts of Halifax County. Due to the age of the facility, process equipment is nearing the end of its useful life. As well, certain treatment technologies from 30 years ago no longer meet current standards.

Project: Lake Major Water Supply Plant – Process Upgrades

Asset Class: Water – Treatment Facilities

Description: Lake Major WSP was commissioned in 1999. In the last few years, there have been changes to the source water in terms of pH and organics which are in line with similar trends experienced by Pockwock Lake from lake recovery. In addition to that, there has been a substantial increase in organics load from the mass blowdown of trees in the watershed during Hurricane Juan in 2003. All that has added up to significant increases in process chemicals and challenging conditions for optimal water treatment. Additionally, the clarifier technology employed in the plant is more suited towards highly turbid waters. Contrary to that, Lake Major has very low source water turbidity which leads to improper clarification performance. Moreover, the serviceable life of the clarifier and the filtration system is 20 years. Hence, both clarification and filtration system need to be rehabilitated with newer technology much suited for the current source water. The raw water pump station was built in 1960s and was an inheritance from the old Lake Lamont system. It has also come to the end of its serviceable life. Considering all these factors, Halifax Water has currently engaged a consulting team to help with the upgrade strategy for Lake Major WSP.

Some of the projects that are going to form part of these upgrades are new raw water pump station, clarifier replacement, filter rehabilitation, residual handling upgrades and optimization of the pre-treatment process with incorporation of pre-oxidation. All these projects are scheduled to be undertaken over the next five to eight years.

Wastewater Capital Projects:

Project: Trenchless Sewer Rehabilitation Program

Asset Class: Wastewater – Collection System

Description: The Trenchless rehabilitation program is a continuation of the successful program that Halifax Water has been implementing for the past several years. The program mythology provides full structural renewal of existing sewers reaching the end of their useful life via installation of a structural liner. The process requires no cutting of the street infrastructure and is a cost effective alternative to open cut renewal. The program is estimated at approximately $2 M per year over the five plan.

Project: Inflow/Infiltration Reduction Program

Asset Class: Wastewater – Collection Systems

Description: Inflow and Infiltration reduction is an aggregated program with a goal to reduce the amount of storm water that enters the wastewater system. The systemic evaluation of sewer sheds identifies a series of methods that are most effective within a given sewer shed including private side and public side investments. The program is proposed as a critical component of the Infrastructure Master Plan approach to reduce wastewater flows to facilitate additional regional growth. The five year plan has multiple I/I reduction programs throughout the service area.

Project: New Timberlea Pump Station and Forcemain System

Asset Class: Wastewater – Structures and Forcemains

Description: The Beechville-Lakeside-Timberlea (BLT) WWTF was commissioned in 1982, with a capacity of one million gallons per day (MGD) and the original intent was to increase the facility's capacity as required to provide service to the ultimate flow generated from the lands within the prescribed boundary. The BLT WWTF Environmental Risk Assessment and the BLT Area Wastewater Servicing Options – Concept Development Studies were completed in 2011 and 2012 respectively. Based on the results of these studies and the Regional Wastewater Functional Plan, it was determined that the phased diversion of wastewater from the BLT sewershed toward the Halifax system was the preferred approach for addressing the wastewater capacity issue in this sewershed.

In 2015 the first phase of this diversion was completed when the Lakeside PS Diversion project was undertaken. In 2017 the West Region Wastewater Infrastructure Plan was completed and it reconfirmed that the best approach was full diversion of the BLT sewershed to Halifax and that to complete this diversion a new Timberlea PS and related forcemain system is required for an estimated cost of $21 M. The project will result in the decommissioning of the BLT WWTF.

Project: Bedford to Halifax Trunk Sewer Upgrade

Asset Class: Wastewater – Trunk Sewers

Description: There is existing constraint within the trunk sewer which conveys wastewater along the Bedford Highway from Kearney Lake Road to the Duffus Street Pump Station. A section of this trunk sewer is a 1050mm dia. pipe and is located near Fairview Cove. The upstream sewer is a 2100mm x 1650mm pipe and the downstream sewer is an 1800mm dia. pipe. During major wet weather events, the Kempt Road CSO is activated resulting in discharge to the Fairview Cove Basin. There is observed flooding upstream along the Bedford Highway during mid-size events (< 1 in 2 year events) and the highway has been closed in the past due to flooding as a result of this constraint.

The concept is to twin the 1050mm dia. pipe with a new 1200mm sewer using micro tunneling and access shafts. The total length of the new tunnel will be approximately 900 metres and is estimated to cost $20 M. It is anticipated that the design is in progress and construction will be completed by 2021.

Project: Autoport Pump Station Replacement

Asset Class: Wastewater – Structures

Description: The Autoport Pump Station was constructed in the mid 70's and requires replacement due to a number of concerns which include: the equipment has reached the end of its useful life; the pump station is located within the public right-of-way such that specific measures are required in order for staff to safely access the facility; the upstream wastewater collection system was reconfigured as a result of the Eastern Passage Wastewater Treatment Facility (EPWWTF) project resulting in an increased hydraulic demand on the pump station; and capacity is exceeded in some wet weather events which results in the deployment of vacuum trucks.

In order for this project to proceed there will be the need to purchase land. Assuming that the land can be secured in 2020 then the new pump station would be constructed in 2021 for an estimated cost of $3,000,000.

Project: Pump Station Upgrade Program

Asset Class: Wastewater – Structures

Description: Halifax Water owns and operates 167 wastewater pumping stations as a critical backbone to our wastewater collection system. The maintenance and capital renewal of this asset class is critical to service provision and environmental compliance. The Pumping Station Upgrade Program is a systemic approach to condition assessment and timely renewal of pumping stations as the facility or components reach the end of useful life. The program invests in the range of $4M to $5M per year on priority pumping station upgrades.

Project: Mill Cove WWTF Upgrade

Asset Class: Wastewater – Facilities

Description: The key requirements of the Mill Cove WWTF upgrades is to meet the following objectives:

1. Projected future wastewater flows and loads;
2. Current and future regulatory requirements with respect to treatment effluent quality (Nutrient Removal);
3. Future regulatory requirements with respect to management of wet weather storm flows; and Interaction between the wastewater treatment and sludge treatment processes.

This WWTP design includes information gathered from the Integrated Master Plan taking into consideration findings outlined in the ERA to ensure the design concept is the most cost effective and reliable to achieve regulatory requirements and with flexibility for the future requirements.

Following approval of the Conceptual Design Strategy the project will progress into the following: Preliminary Engineering Design, Pre-Selection of unit process equipment, Detailed Engineering Design, Tender Phase and Construction Phases.

Based on the concept design, the estimated total project cost is approximately $75 M, with $50 M earmarked for within the next five years.

Stormwater Capital Projects:

Project: Sullivan's Pond Storm Sewer System Replacement (Phase 2)

Asset Class: Stormwater – Pipes

Description: The Sullivan's Pond storm sewer system is the outlet for Sullivan's Pond/Lake Banook watershed which is approximately 1500 hectares in size. The system was constructed in the early 1970s and is at the end of its service life. The system is designed for

the major flood event (runoff resulting from a 1 in 100 yr. rainfall event). In 2017/18 the first phase and upper section of the system was constructed between Sullivan's Pond and Irish Town Road. This project involves the lower downstream section from Irish Town Road all of the way to Halifax Harbour. Construction of the second phase will be challenging considering the congested urbanized environment in which the system is located. Construction of this second phase is expected to proceed in 2022, at a cost in the order of $11 M.

Project: Ellenvale Run Retaining Wall Replacement Program

Asset Class: Stormwater – Structures

Description: The Ellenvale Run is a highly urbanized watercourse that runs from Lake Lemont to Morris Lake in Dartmouth. The approximately 3.5 km long watercourse has been rerouted and encroached upon as a result of adjacent development. This has resulted in the stream being contained within culverts and channels made of retaining walls. The majority of the retaining walls are at the end of their service life and need to be replaced. The system is designed for the major flood event (runoff resulting from a 1 in 100 yr. rainfall event). This program involves the systematic replacement of the retaining walls over the period of 2018 – 2024. The estimated cost of the program is $10 M.

Project: Cross Culvert Replacement Program

Asset Class: Stormwater – Culverts/Ditches

Description: Halifax Water owns and maintains approximately 1700 cross road culverts. This infrastructure is a distinct asset class in addition to driveway culverts. They convey stormwater under roads and are less than three metres in diameter. Approximately five percent of the inventory of cross road culverts are in critical condition and another seven percent in poor condition. This program involves the systematic replacement of cross road culverts at the end of their service life. The estimated annual cost of this program is $2 M.

Project: Halifax Water Sewer Separation Program

Asset Class: Wastewater and Stormwater Collection

Description: This program involves the separation of existing combined sewers in key areas of the Halifax peninsula to divert storm flows from the wastewater system as a key component to providing increased wastewater capacity for proposed growth within the Halifax WWTF sewershed. The sewer separation program will generally involve the installation of a new storm sewer on local streets for the collection of surface drainage and select building connections. In the near term, the program will be focused on the Young Street, Kempt Road and Spring Garden Road areas. This program is primarily funded from the Regional Development Charge program. Halifax Water's planned expenditures on this program are approximately $6 M per year.

Corporate Projects:

Project: Information Technology Strategic Plan Implementation

Asset Class: Water, Wastewater and Stormwater

Description: Halifax Water completed an IT Strategic Plan in 2017. The Plan (updated annually) provides a five-year program and investment roadmap consisting of a series of defined initiatives, each supporting a key strategic theme and each contributing to the continuous improvement of one or more facets of the IT environment: organization, applications and infrastructure. Halifax Water's planned expenditures on this program are approximately $8 M per year. See Section 10.4 for a detailed summary.

7.2 Five-Year Operating Budgets

Budgets have been developed to cover the period from 2020/21 to 2025/26, as shown in Appendix E. The operating budgets reveal that rate increases will be required to maintain current levels of service, deliver projects already in progress or approved, meet changing environmental requirements, and generate more funding to meet infrastructure investment demands.

Halifax Water has a goal to keep rates for combined services below 2% of median household income. The cost of annual combined services for an average household is currently estimated as 1.08% of current estimated median household income.

Halifax Water has a customer assistance program - Help to Others (H2O). The H2O program provides dedicated funding for low income households to offset water bills, administered through the Salvation Army, similar to other heating fuel or electricity bill assistance programs. Funds for the program are derived from unregulated activities of the utility.

Some of the primary operating budget drivers and assumptions are:

Revenues

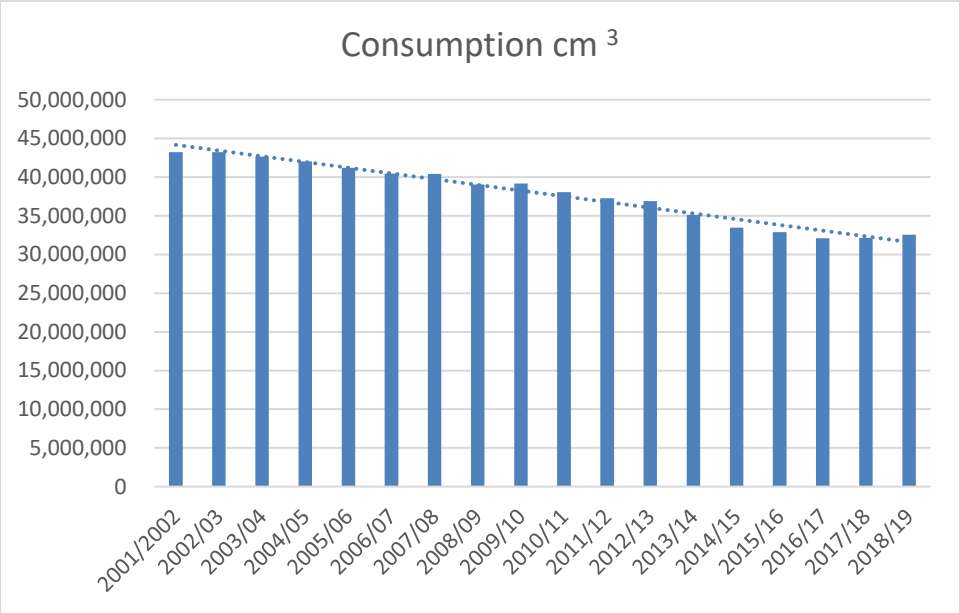
After a long-term trend of declining water consumption, Halifax Water has had back to back increases in consumption of 0.1% and 1.4% in 2017/18 and 2018/19 respectively due to customer growth and conversion to new meters increasing accuracy. Consumption is projected to remain relatively flat as growth in customers will offset decreasing consumption due to conservation and increases in water efficiency.

Halifax Water had experienced net metered consumption decreases of 1.64% per year on average, over seventeen years, as indicated in Figure 6. The total decrease since 2001/02 is a 25% reduction, which was managed predominantly through changing rate structures to

align fixed and variables costs, diversifying rate structures (stormwater with a different billing determinant), increasing rates, increasing unregulated revenue and controlling costs.

For short-term planning purposes, in relation to setting rates, Halifax Water previously used a rolling historic 4 year average (net reduction) – which is currently 0.7%. Declining consumption affects both water and wastewater revenue as the discharge fee billed to most customers is based upon water consumption. Consumption is impacted by timing of development, form of development and new customer growth. It is not certain if future development will be sufficient to offset the trend of declining consumption, so by budgeting based on flat consumption Halifax Water is assuming some risk.

Figure 6: Metered Consumption History



Average	-1.64%
Rolling 4 Year Average decrease	-0.68%
Median	-1.75%
Total Decrease since 2001/02	-24.7%

- The amount of impervious area and number of properties receiving stormwater services is projected to increase gradually over the course of the next five years.
- 638 (0.8%) new customer connections are projected each year based on the actual customer growth in recent years.
- Revenues from unregulated business activities are increasingly important to mitigate future revenue requirements from rates. These are described in more detail in Section 7.4. Unregulated revenues are used to fund unregulated expenses and generate additional unregulated revenues for the benefit of the rate base.

Expenses

Halifax Water's Five-Year Operating Budget is completed on a modified accrual basis and excludes pension expense accrual to provide better information for decision making and align with the NSUARB Accounting and Reporting Handbook for Water Utilities, which is used in determining the revenue requirements for rate making purposes. Reporting on an accrual basis under the International Financial Reporting Standards (IFRS) would require the inclusion of accrued amounts such as a liability for future employee pension benefits. If accrued pension expenses were included, the projected deficit would be greater than currently shown in Figure 7 below. There is sufficient accumulated operating surplus to offset the budgeted operating loss in 2019/20, however, rate adjustments will be required in 2020/21.

The largest components of Halifax Water's consolidated operating budgets are salaries & benefits, electricity, furnace oil and natural gas, debt financing, depreciation, dividend and chemical costs.

Salaries and Benefits: In 2020/21, the increase for salaries/wages ranges between 2.00% and 2.75%, which includes an allowance of 0.5% for the impact of step increases for employees within salary bands or reclassification of positions. For subsequent years, the annual increases for salaries and benefits is budgeted at 3.5%. Any planned new hires are reflected within the budgets.

Electricity: 6.0% in year 1, 2% each year thereafter. The impact of these increases is expected to be partially offset by the formal Energy Management Program.

Natural Gas: 10% in year 1, 2% each year thereafter.

Furnace Oil: 3% in year 1, 2% each year thereafter.

Debt Financing: New debt payments are budgeted to support the five-year capital plan. Over the course of the next five years, debt payments are projected to increase significantly. The amount and timing of the increases will be determined by timing of the completion of the projects and the financing rates and options available. Halifax Water's capital financing strategy is designed to maintain a debt service ratio of 35% or less; and to use a mixture of infrastructure funding, development related charges (reserves), depreciation; and debt. The cost of borrowing is based on the weighted average cost of capital of 3.22%.

Depreciation: As Halifax Water's assets and future capital budgets increase so do depreciation expenses. Depreciation is an integral funding source to support rehabilitation of the existing infrastructure as well as new infrastructure and upgrades to meet future requirements. The depreciation expenses shown in the Five-Year Business Plan are net of depreciation on contributed assets for contributed water and wastewater assets. In the next

rate application, Halifax Water will be requesting permission to phase in depreciation on contributed water and wastewater assets.

Dividend to Halifax Regional Municipality: The current five-year water dividend agreement expires in March 2020 and a new agreement will be negotiated in advance of the 2020/21 fiscal year. HRM staff have expressed interest in expanding the scope of the dividend to include wastewater and stormwater, however this will require approval from the NSUARB and would be considered as part of a rate application. Based on the current agreement, the dividend would grow from $5.1 M in 2019/20 to $7.9 M by 2024/25.

Chemical Costs: Chemicals are tendered annually in January for optimal pricing. Chemical cost increases of 5% are anticipated for year 1, with a 5% increase for years 2, 3, 4 and 5. Long range chemical prices are difficult to predict due to the volatility of the market which is closely linked with energy prices and fluctuations in supply and demand.

Energy and electricity cost assumptions are described within Section 12.10 of the Business Plan.

On a consolidated basis, the projected five-year operating budgets are shown in Figure 7. Over the next five years, operating expenses are projected to increase from $118 M in 2020/21 to $136 M in 2025/26, or 15%, while operating revenues are projected to decrease by $2 M or 1.41%. Non-operating revenues are projected to remain stable. Non-operating expenses will more than double from $37 M to $61 M driven by increasing debt servicing costs as Halifax Water issues debt previously approved to fund prior years' capital budgets and ramps up capital spending to meet the IRP recommendations.

Figure 7: Pro-Forma Income Summary 2018/19 to 2020/21

Operating Budget Summary (in thousands)

	Actual 2018/19	Approved Budget 2019/20	**Proposed Budget 2020/21**	Budget/Budget Variance (Unfavourable)
Operating Revenue	$138,413	$138,727	$138,618	($109)
Operating Expenses	$105,731	$115,088	$118,110	($3,022)
Operating Surplus	$32,682	$23,639	$20,508	($3,131)
Financial Revenue	$1,898	$1,369	$619	($750)
Financial Expenses	$33,190	$33,374	$37,076	($3,701)
Net Surplus (Deficit)	$1,390	($8,366)	($15,949)	($7,583)

Based on figures presented in Figure 7, revenue increases are required over the next five years. Halifax Water will not be able to deliver the existing level of service plus meet the requirements for growth, asset renewal and compliance identified in the IRP without revenue increases. Halifax Water has a rate smoothing strategy that promotes gradual rate increases to avoid rate shock and maintain affordability.

Appearing in Figure 8 is a continuity schedule of the accumulated surplus (deficit) for Halifax Water on a cash basis. As of March 31, 2019, Halifax Water had an accumulated operating surplus of $40.0 M. Results have been reviewed by budget managers in conjunction with plans for the remainder of the 2019/20 fiscal year and Halifax Water is forecasting a net deficit on a cash basis of $3.2 M. This coupled with a budgeted deficit for 2020/21, in the amount of $15.9 M, results in an ending surplus as at March 31, 2021 of $20.9 M. There is sufficient accumulated operating surplus to offset operating deficits in 2019/20 and 2020/21, however, the budgeted deficit for 2021/22 is $26.2 M resulting in an accumulated deficit of $5.3 M. Rate adjustments will be required in the fiscal years thereafter; and Halifax Water needs to begin the process to adjust rates.

Figure 8: Continuity Schedule - Accumulated Surplus (Deficit) on a Cash Basis

Continuity Schedule - Accumulated Surplus (Deficit) on a NSUARB Handbook Basis - which Excludes Pension Accrual

	Total	Water	Wastewater	Stormwater
2018/19 Fiscal Year				
Balance, beginning of year	$38,625,906	$14,669,623	$15,487,608	$8,468,674
Operating surplus (deficit) for the year	$1,390,433	$2,760,942	($570,243)	($800,266)
Balance, end of year	$40,016,339	$17,430,565	$14,917,365	$7,668,408
2019/20 Fiscal Year				
Balance, beginning of year	$40,016,339	$17,430,565	$14,917,365	$7,668,408
Projected operating (deficit) for the year	($3,188,925)	$2,374,560	($3,936,644)	($1,626,841)
Projected balance, end of year	**$36,827,414**	**$19,805,125**	**$10,980,721**	**$6,041,568**
2020/21 Fiscal Year				
Balance, beginning of year	$36,827,414	$19,805,125	$10,980,721	$6,041,568
Budgeted operating (deficit) for the year	($15,948,714)	($4,274,512)	($7,842,633)	($3,831,569)
Projected balance, end of year	**$20,878,700**	**$15,530,613**	**$3,138,088**	**$2,209,999**
2021/22 Fiscal Year				
Balance, beginning of year	$20,878,700	$15,530,613	$3,138,088	$2,209,999
Budgeted operating (deficit) for the year	($26,155,637)	($9,179,931)	($11,980,107)	($4,995,599)
Projected balance, end of year	**($5,276,937)**	**$6,350,682**	**($8,842,019)**	**($2,785,600)**

Projections for 2020/21 and beyond are based on expected normal weather patterns. Should weather patterns deviate from the norm, operating results could be impacted accordingly as significant rain events, prolonged periods of deep cold, or droughts, impact operating revenues and expenses.

As new and more current information becomes available, five-year projections will change. The five-year plan is sensitive to changes in consumption, weather, interest rates, availability of external infrastructure funding, level of development activity and operating results

7.3 Debt Strategy

Halifax Water has an efficient capital financing structure which has been reviewed and accepted by the NSUARB and was developed based on the policies of other utilities, its longer-term capital needs, and consideration of fairness to present and future ratepayers. Utilization of debt is a key component of the capital financing structure. Debt impacts the operating budget and, therefore, the future rate requirements in several ways:

1. Increased debt payments need to be accommodated through rates.
2. Increased depreciation related to growth in the capital program needs to be accommodated through rates.
3. Operating costs of new capital assets need to be accommodated through rates.
4. Capital requirements not funded by debt will increase the requirement of capital from operating funding through rates.

Different financing alternatives were considered taking into account rate stability and affordability, Halifax Water long term financial sustainability, and intergenerational equity.

The debt strategy approved for Halifax Water concludes that appropriate financial ratios for Halifax Water to utilize are:

1. Target Maximum Debt Service Ratio of 35%
2. Target Debt/Equity Ratio of 40%/60%

In essence, the two targets serve as a framework for Halifax Water's utilization of debt. Long-term debt is projected to increase from $208 M at March 31, 2019[1], to $436 M by March 31, 2025. It is estimated that additional debt servicing will increase from $30.9 M in 2020/21 to $54 M in 2024/25, and the debt service ratio will increase from 22.0% to 39.0 % during this five-year period.

The amount of timing of issuance of debt is dependent on the timing of capital projects and also on availability of infrastructure funding from other levels of government. Any changes in capital plans or availability of other funding sources will impact the requirement for new debt.

[1] March 31, 2019Audited Financial Statements

7.4 Alternative Revenue

Revenues from unregulated business activities are increasingly important to mitigate future revenue requirements from rates. Unregulated revenues help to pay for some expenses which would otherwise be funded by rate-regulated activities, and are also used to fund unregulated expenses. Halifax Water has had success generating alternative revenues aside from user fees on both the regulated and unregulated side of the business. On the regulated side, Halifax Water has entered into agreements for the sale of land deemed to be no longer used or useful for utility purposes. With NSUARB approval, revenue from land sales can be used as a source of funds for capital projects related to the delivery of water services in recognition that the land was originally purchased with water-rate base funds. As much of the surplus land has been sold, this is not a significant source of funds in the future.

Notwithstanding limitations for generating revenue from the regulated side of the business, there has and will continue to be opportunities from the unregulated side. Currently, Halifax Water generates revenue from third-party contracts for water and wastewater treatment operations, septage tipping fees, and treatment of airline effluent.

Halifax Water also generates revenue for the lease of land for telecommunications facilities throughout the municipality in recognition that reservoir and watershed sites are located on higher elevations that afford more direct line of site for telemetry. In conjunction with these leases, Halifax Water installs telecommunications equipment on these facilities for its own needs for the ultimate benefit of the water, wastewater, and stormwater rate base. As Halifax Water continues to expand the Supervisory Control and Data Acquisition (SCADA) system in accordance with its master plan, further opportunities for leases and hosting of Halifax Water equipment will be realized.

Halifax Water has expertise in water-loss control, the utility offers a wide range of related services to generate revenue. These range from leak-detection services, for Halifax Water customers and other municipalities, to consulting services under contract to municipalities and First Nation communities. There is potential to expand these services to generate additional revenue and, at the same time, provide professional development opportunities for staff.

Halifax Water also recognizes that its assets can be leveraged to bring in revenue from energy generation. This includes projects to generate electricity from wind turbines and control chambers where water pressure is reduced. These opportunities have been developed for interface with the Nova Scotia Department of Energy's Community Feed-In Tariff (COMFIT) program, which provides preferential rates to feed electricity into Nova Scotia Power Incorporated (NSPI) distribution grid. Halifax Water has completed the installation of a hydrokinetic turbine in the Orchard control chamber in Bedford, in October 2014, and the projected net revenues are in the current business plan. These projects are structured to ensure they are compliant with the Public Utilities Act with the recognition that regulated activities cannot subsidize the unregulated side of the business.

In partnership with HRM, Halifax Water has also studied the potential for a green thermal utility whereby energy can be extracted from the heat in sewage and delivered through a local distribution system in the vicinity of treatment facilities. The planned redevelopment of the Cogswell interchange in Halifax will provide an opportunity to advance this concept since the Halifax WWTF is adjacent to the Cogswell interchange. This project is currently being pursued as a regulated activity subject to the approval of the NSUARB.

In an effort to be open and transparent to stakeholders, including the NSUARB, Halifax Water discloses revenue and expenses associated with unregulated business separately within the financial statements and budgets. Net gains from these activities ultimately go to the benefit of the rate base as they are closed out to accumulated operating surplus/(deficit) each fiscal year.

Rates for some the main sources of unregulated revenue – septage tipping fees and treatment of airline effluent were increased in 2018. Halifax Water periodically reviews and adjusts these rates.

Unregulated revenues are budgeted to be $ 1.1 M in 2020/21 and will remain consistent for the next 5 years.

8. CUSTOMER SERVICE ENHANCEMENTS

The most recent Customer Service (Quality of Service) Survey indicates satisfaction with Halifax Water's overall service delivery remains high at 96%, consistent with the last two years.

For the first time, questions were included related to stormwater service. Of the 750 surveyed, 44% were aware they receive stormwater service and 83% of those receiving stormwater service were very or generally satisfied.

Other key highlights:

- The ratings for staff promptness have improved
- Most customers believe their water is safe and the quality is high
- Confidence in the safety of water in the Halifax Harbour remains low at 44%
- Residents continue to lack awareness of the source of their municipal tap water
- Awareness of the LSL subsidy is low
- Awareness of the emergency assistance program (H2O Fund) is low
- Over 50% of customers would be interested in rounding up their bill to the nearest dollar with the rounded portion given as a charitable donation to help low income customers in need (this is an initiative being explored to grow the H2O Fund)

Strategic objectives that will help address some of areas of potential improvement are implementation of the customer portal, enhancements in the customer care centre that will reduce call wait times, and enhanced customer communications particularly around stormwater service. Many initiatives are underway that ultimately will help us continue to enhance service to customers to keep them satisfied.

In early 2020, the phone system used to answer customer calls is being improved, to enable their calls to be answered more quickly and their issues resolved more easily.

2020/21 will see the implementation of a Customer Portal that will increase and improve the options for customers to engage with Halifax Water and get easier access to information on their account at their convenience. The Customer Connect (AMI) Project has surpassed the 90% installation mark and the information on customer water usage is being successfully received. The ability of our customers to access their water usage data will be a significant component of the Customer Portal. Customers will also be able to request many services online, the Halifax Water website will be easier for customers to use and navigate, and there will be increased functionality for customers to receive information about their account, water consumption, property characteristics used to bill for stormwater, and receive and pay bills electronically.

Within the Five-Year Business Plan, there are significant technology initiatives that will enhance integration of key corporate systems such as CMMS, GIS, and the ERP with the Customer Care Centre. The utility is well positioned to implement a corporate customer service strategy and utilize information received through AMI and the computerized maintenance management system (CMMS) to track resolution of customer requests. Halifax Water is continuing to improve and enhance service standards to respond to customer issues and the mechanisms to monitor and report to ensure all departments are meeting service standards.

The Dispute Resolution Process continues to provide an opportunity for customers to have an outside review of their complaint, but adds additional costs to revenue requirements. Statistics from the last two years are shown in table 3 below:

Figure 9: DRO Statistics

Year	Cost Paid to DRO	# Complaints	Dismissed/ Withdrawn	Successful
2017/18	$225,850	39	35 dismissed 2 withdrawn	2
2018/19	$137,730	43	41	2

It is hoped that increasing the focus on customer communication, and early resolution will help reduce complaints going to the Dispute Resolution Officer, as the majority of the complaints are without merit and result in unnecessary costs that are passed on to rate payers.

9. ENERGY EFFICIENCY AND GHG REDUCTION

9.1 Energy Management Program

Through its Energy Management Program, Halifax Water is committed to creating and ensuring an ongoing focus on sustainability and energy efficiency throughout all operating areas. This program defines the goals, objectives, accountabilities, and structure for activities related to sustainability and responsible energy use. The focus of this Program is being updated to include more emphasis on GHG emission reduction, and developing specific targets and actions for Halifax Water that will support HalifACT 2050. HalifACT 2050 is a long-term climate change plan to reduce emissions and help communities adapt.

In support of this program, Halifax Water's Energy Management Policy defines longer-term goals and commits Halifax Water to the principles of responsible energy management. This includes reducing dependence on fossil fuels through energy conservation and best practices; identifying and implementing cost-effective energy-reduction initiatives; developing alternative and renewable forms of energy from utility assets; and reducing pollution by increasing the usage of energy supplied from sources that are less greenhouse gas intensive.

Halifax Water has an Energy Management Steering Committee (EMSC) that guides creation and implementation the corporate Energy Management Action Plan (EMAP).

Energy Management Action Plan

The EMAP includes details of energy-management activities that will be developed and undertaken by Halifax Water each year. Key activities contained in the action plan include:

- Delegation of the responsibility for achieving energy goals;
- Assignment of team members as required to meet goals;
- Development of an employee-awareness strategy to facilitate energy savings at work and home;
- Establishment of an energy accounting system that allows for collection, monitoring, and reporting of all data on energy-consuming assets, energy consumption, energy costs, energy savings, and key performance indicators;
- Preparation of energy audits on all facilities on a priority basis;

- Implementation of identified energy projects based on sound financial principles;
- Benchmarking of Halifax Water's facilities and establishment of annual energy-reduction targets;
- Identification of funding requirements and external funding sources for the EMAP;
- Refinement of contract and purchasing policies to incorporate energy-efficient practices; and
- Development of renewable energy generation projects.

Greenhouse Gas (GHG) Emissions

Following on its recent endorsement of the Pan-Canadian Framework on Clean Growth and Climate Change, the government of Nova Scotia implemented a carbon "Cap & Trade" program in 2018 to comply with the federal government's carbon pricing regulations. This program applies only to very large industrial GHG emitters (> 100,000 tonnes CO_2e per year), electric utilities, petroleum product suppliers and natural gas distributors. Halifax Water's GHG emissions at source are currently very low, and do not meet the industrial threshold as implemented. As such, Halifax Water will continue to monitor the provincial Cap & Trade program, and will continue to work to reduce energy usage, GHG emissions, and track energy savings achieved through various energy efficiency projects and annual initiatives.

Halifax Water's efforts to reduce energy use and GHG emissions began in 2010. Since that time, over 57,000 MWh_e of cumulative energy savings, over 37,000 tonnes CO_{2e} of cumulative GHG emission reductions, and over $5,700,000 in cumulative operational cost savings have been realized from either the numerous and specific energy efficiency projects, or annual energy savings initiatives such as our annual UV shutdown program, or the annual winter season Odour Control System by-pass program in the HHSPs. Halifax Water will continue to focus on annual targets for energy savings and GHG reductions, and will work with external funding organizations such as Efficiency Nova Scotia to advance and implement more projects in the future.

In January 2019, HRM declared a climate emergency. Halifax Water staff have been engaged in HalifACT 2050. The Intergovernmental Panel on Climate Change (IPCC) released a special report on global warming that indicates the global community has only 10 years to table actions to course-correct if there is any hope of keeping global warming at 1.5°C. Halifax Water will update the Energy Management Policy and EMAP to reflect aggressive targets in support of broader community objectives.

9.2 Renewable-Energy Generation

Halifax Water has identified renewable energy as an important way of offsetting energy costs and increasing revenue that will help the utility to significantly reduce energy use and greenhouse gas emissions in the region.

To date, two key project areas have been identified: renewable energy and energy recovery from both water and wastewater systems.

9.2.1 Solar Energy

Under Nova Scotia's Solar Energy for Community Buildings Pilot Program, Halifax Water was awarded a 75 kW solar photovoltaic (Solar PV) project in 2018. This project is scheduled to be installed at our Halifax Wastewater Treatment Facility in early 2020. This project will see 264 solar panels installed on the roof of the Halifax WWTF, and will generate approx. 108,000 kWh/yr of clean, renewable energy. Additional Solar PV projects are being considered for other Halifax Water facilities in the future.

9.2.2 Energy Recovery Turbines

Halifax Water installed an in-line hydrokinetic turbine in its Orchard Pressure Reducing Valve (PRV) Chamber in 2014. Since that time, the system has performed flawlessly, generating in excess of 1,100 MWh of clean renewable energy to date, and over $150,000 in operating revenue. The system produces enough energy annually to power in excess of 25 average Nova Scotian households. Additional in-line turbine projects are being considered for other Halifax Water facilities in the future.

9.2.3 Wind Energy

In 2014, Halifax Water worked with the Chebucto Community Wind Fields to install a 10 MW wind farm, on lands near Halifax Water's J.D. Kline Water Supply Plant, as part of the provincial Community Feed-In Tariff (COMFIT) program. Since that time, the system has performed as expected, generating in excess of 150,000 MWh of clean renewable energy, and delivering almost $600,000 in operational royalties to Halifax Water.

9.3 Energy/Nutrient Recovery

Energy recovery from process or waste streams is recognized as one of the biggest renewable energy opportunities available to society. Recoverable energy is everywhere – in solid municipal/residential waste streams, industrial by-products, and water and wastewater streams. Halifax Water has significant recoverable energy resources available in

both its water and wastewater streams. Specifically, as noted in the previous section, inline turbines can be used in place of pressure reducing valves (PRVs) to recover energy from water distribution systems. In the wastewater system, energy can be recovered from the waste sludge produced by wastewater treatment facilities, along with thermal energy from the effluent streams.

Reducing the cost of wastewater collection and treatment has been an important issue and has been on the radar of most utilities for some time. Over the years, the field of wastewater treatment has seen a gradual progression with a focus changing from sewage treatment to water reclamation to resource recovery. Following industry best practices, many utilities currently view the wastewater components of water, biosolids, nutrients, and energy as valuable resources. Nutrients, such as phosphorus, can be recovered in various forms for use in agricultural fertilizers. Energy can be extracted from organics to offset energy demands of the facility, or sold to the local community. Halifax Water has been progressing several initiatives over the years on all four forms of resources available from wastewater. These efforts will continue in the future.

9.3.1 Biosolids Strategy

Halifax Water currently supplies approximately 30,000 tonnes per year of partially de-watered sewage sludge, or biosolids, to its Aerotech Biosolids Processing Facility (ABPF). Currently, the biosolids are turned into a soil amendment and fertilizer for beneficial reuse for agricultural purposes such as topsoil manufacturing, sod growing, horticultural use, and land reclamation.

Energy recovery from biosolids is one of the most developed opportunities for wastewater treatment plants. This is commonly achieved through anaerobic digestion of wastewater sludge. Halifax Water's Mill Cove WWTF and Lakeside Timberlea WWTF are equipped with anaerobic digesters, and the methane gas generated within those digesters is utilized for digester operation and space heating within the plants. All of Halifax Water's WWTFs currently produce biosolids that are subsequently treated in the ABPFs alkaline stabilization process and utilized as soil amendment for beneficial reuse. Halifax Water expects to continue this practice given the success of the current beneficial reuse program. There are several emerging technologies in the industry that show promise for alternative uses of biosolids for energy production. Halifax Water staff have reviewed these technologies as part of the recently completed biosolids management planning process, along with the risks associated with the complex issue of biosolids management.

Halifax Water will be issuing an RFP in 2020 seeking innovative solutions to utilize biosolids and maximize resource recovery.

9.3.2 Wastewater Effluent Heat Recovery

The volume of wastewater effluent flowing out of wastewater treatment facilities is immense. The capacity of water to store energy in the form of heat is also immense, as noted in Figure 10 below. This combination presents a real and readily available resource for an efficient, cost-effective heat sync that can be used, at a minimum, to provide or remove energy to and from wastewater treatment facilities, or to the local community at large.

Figure 10: Wastewater Effluent Heat-Recovery Potential

Facility	Annual Flow (m^3/yr.)	Available Power Capacity[(1)] (MW)
Halifax WWTF	36,825,000	59.7
Dartmouth WWTF	22,100,000	35.3
Herring Cove WWTF	4,630,000	7.4
Totals	**63,555,000**	**102.4**

Notes: *Total available power based on an average effluent temperature of 12°C.*
Based on 2013/14 usage and cost data.

Halifax Water has completed studies at the three Harbour Solutions plants to determine and understand the technical and financial challenges associated with these types of energy-recovery systems, and then implement the projects that make sense from an energy efficiency and financial perspective.

Cogswell District Energy System

The HalifACT 2050 program initiated by the municipality identifies the Cogswell District Energy System as a significant climate change mitigation opportunity. A study was completed in 2016 to determine the feasibility and preliminary business case for an Ambient Temperature District Energy System [ATDES] within the Cogswell Redevelopment Area of downtown Halifax. The feasibility of the DES is predicated on the assumption that connection to the DES will be mandatory within the redevelopment area. To that end, HRM has completed amendments to its Charter through the Legislature to facilitate this authorization. Work on the Cogswell ATDES continues with stakeholder consultation, and the completion of preliminary and detailed design work in parallel with the Municipality's effort to advance the Cogswell Redevelopment project. Halifax Water strategic objectives related to DES in 2020/21 include enactment of a mandatory connection by-law by the municipality, confirming that the service will be regulated by the NSUARB, finalizing the business case, and securing necessary Halifax Water Board and NSUARB approvals to proceed.

10. CONTINUOUS IMPROVEMENT

10.1 Organizational Cultural Change

Halifax Water has approximately 475 employees, 3/4 of which are unionized under CUPE Locals 227 and 1431. Changing culture within a large organization takes time, but is often accelerated by new technology or societal events. Halifax Water is going through an accelerated period of change during the next five years, prompted by new technology, new business processes, new policies and turnover in key positions as a result of demographics and retirement. One advantage Halifax Water has as employer implementing change, is that turnover is low relative to other public sector organizations, and employee satisfaction is generally high.

Halifax Water conducts an employee survey every year. The survey is a very important tool to help identify opportunities and challenges from the perspective of employees. The 2019 employee survey results indicated a "B+" rating, and improvement over the 2018 B rating. Halifax Water's target is an A, and it is hoped that target will be achieved during the period covered by this Five-Year Business Plan.

As part of the overall approach to talent management, Halifax Water has a succession plan for key positions, and has an approach to total compensation that supports attraction and retention of employees. Many initiatives are underway, or planned that will help maintain a positive culture within the organization and build resilience to respond to new challenges. The primary areas of focus in the next five years will be:

- Ensuring all employees are aware of Halifax Water's strategic objectives
- Helping employees understand how they can meet personal career or performance targets and providing access to training and development opportunities
- Communicating and recognizing achievements to help employees feel a sense of accomplishment from their work
- Demonstrating that senior leadership is approachable, and promoting more two-way communication and feedback at all levels
- Promoting a workplace that is psychologically safe and healthy, respectful and civil for all employees, and reflective of the diverse community served by Halifax Water
- Developing employees to be ready to take on new responsibilities in the organization, and building resilience to adapt to change.

10.2 Cost Containment

Halifax Water reports semi-annually to the HRWC Board, and annually to the NSUARB on the results of cost containment initiatives. The next cost containment report will be filed with the NSUARB in June 2020. Some of these initiatives are on-going, and some are one time in nature. The containment initiatives from 2013/14 to 2019/20 reflect cost savings of $6.3 M. The inclusion of initiatives and amounts from prior years reflects an intentional focus on sustainable results over the long-term.

Halifax Water continues to promote and develop a cost containment culture. As salaries and benefits are the largest element in the operating budget, the most significant opportunity identified is to improve workforce planning and the staffing process. The redesign of the Halifax Water Pension Plan has resulted in the Plan being fully funded as of January 1, 2019. The result is an elimination of the special payment, saving Halifax Water over $800 thousand annually. Another area of opportunity is focusing on productivity through enhanced business processes and technology, performance management, and improving time and attendance tracking.

10.3 Advanced Metering Infrastructure (AMI)

With the approval of the Customer Connect (AMI) Project by the NSUARB in the fall of 2016 and the launch in December 2016, Halifax Water has installed over 90% of the new meters, 80,000 meters. We have begun to collect customer water usage information without the need to visit a customer and have been using the water usage information to bill customers.

In addition to removing the need to visit a customer to read the meter, the Customer Connect Project will improve the level of service Halifax Water can offer its customers. These include:

- The ability to offer monthly billing to residential and small commercial customers; making it easier for customers to manage cash flow and automated payments.
- The ability to provide an accurate reading of water usage for customers moving into or out of a residence.
- The capability to alert customers to higher than normal consumption including plumbing leaks; almost as they happen. This will reduce billing disputes and high bills.

The ability, through the Customer Portal, to manage their water consumption, in near real time, and see the effect of any conservation measures they take. To realize the full benefits of the AMI, we continue to strive for installation of meters to all Halifax Water customers, however, some customers have not been accepting of the radio frequency technology. We continue to work with these customers but we do expect that a small number of meters will need to be read in the traditional manner and a manual read fee may apply in the future.

The new technology will enable significant reductions in the cost of reading meters, billing and collecting from customers and the number of disputes related to high bills.

10.4 IT Five-Year Strategic Plan

Halifax Water continues to update its IT Strategic Plan. The business focus is on using progressive technologies to improve organizational efficiency, effectiveness and customer service.

The Strategic Business Drivers shaping the information technology environment have not changed:

- Provide world class services to our customers and our environment
- Retain leadership position as an integrated water, wastewater and stormwater utility
- Retain position as a top utility in all Lines of Business focused on Public and Employee Safety, Water Quality, Sustainable Infrastructure and Asset Renewal, Regulatory Compliance and Growth, and Environmental Stewardship.
- Follow an IRP Framework

Six Strategic Themes characterize the plan:

- **Customer Experience:** Providing customers with the ability to access most services using online services.
- **Information Integration with Location:** Having all necessary data linked together and tracked through a geographic lens.
- **Analytics Driven Decision Making:** Being able to model customer usage, financial, environmental, and infrastructure data across the Water, Wastewater and Stormwater systems and having the capability to tie data together into business intelligence.
- **Managed Knowledge and Workflow:** Capturing and storing key content in a logical and easy to access place for those who need it.
- **Enable Employees Anywhere:** Providing functionality for employees to access, capture and update the information they need to effectively do their job and support others, wherever they may be working.
- **Secure IT Foundation:** Effectively managing the IT function and providing infrastructure that is resilient, cost effective, well supported, and recoverable within clearly defined requirements.

The IT Strategy Five-Year Roadmap 2020/21 is a high-level snapshot of the sequence of programs to deliver on the approved technology vision and recommended architecture. The plan has an estimated total cost of $28,000,000. The projects contained within the Five-Year Business plan can be seen in the detailed Capital Budget under Corporate Projects in Appendix D.

10.5 Water Quality Master Plan

Halifax Water began developing its first Water Quality Master Plan (WQMP) in 2005 to assess its water quality program and to keep in front of the rapidly changing drinking water regulations. The initial WQMP established a road map towards more effective water quality management and staff determined at the time that a water quality research program was the most effective way to achieve the plan goals.

In 2006, Halifax Water executed a research agreement with Dr. Graham Gagnon of Dalhousie to execute the WQMP research. Subsequently, Dr. Gagnon applied to the Natural Sciences and Engineering Research Council (NSERC) for an Industrial Research Chair (IRC). Under the research chair, NSERC matches all funds provided to Dr. Gagnon by research chair partners, effectively doubling Halifax Water's investment.

In April 2017, Dr. Gagnon was awarded a third, five-year research chair term and the chair has grown to include other partners including Cape Breton Regional Municipality, the City of Moncton, CBCL Limited consulting engineers, and several water analysis technology companies, further multiplying the value of Halifax Water's investment.

Since its beginning in 2007, the IRC has created many benefits. Through our collective efforts, Dr. Gagnon and Halifax Water have emerged as leaders in North America on drinking water quality. Dr. Gagnon has trained many graduate students who have found employment, in some cases, at Halifax Water, and also in prominent roles in the drinking water sector.

Direct benefits of this Chair to Halifax Water include:

- Documentation for NSE that there was no public health benefit to install filter-to-waste at the JD Kline water supply plant, thus avoiding a $5 M capital cost and ongoing organizational risk. Halifax Water did improve public health as part of this process by adopting new filter washing practices at minimal cost.

- Halifax Water chose not to adopt chloramines as a secondary disinfectant, which was a preferred strategy for disinfection byproduct removal when research showed that chloramines would have adverse effects for lead levels in drinking water.

- Identifying the need to increase corrosion control levels, reducing lead levels in drinking water by 35%.

- Adoption of biofiltration at the JD Kline plant, saving $40,000 per year in chlorine costs and reducing disinfection by-product levels by 40%. Longer term plans are in place to convert Lake Major to biofiltration.

- Determination that partial replacement of LSLs was not protective of public health and possibly harmful. Halifax Water was one of the first utilities to take this stand in 2012, a position that is now commonly held in the water industry.

- Identified the phenomenon of lake recovery. This is a process where lakes are experiencing increasing pH as a result of the reduction of sulfur oxide emissions into the atmosphere. This process has negative consequences for water treatment and early discovery has led to a head start on planning treatment upgrades.

Halifax Water published its third WQMP in September 2017 and it was subsequently approved by the Halifax Water Board. The WQMP guides Halifax Water's water quality work and also guides the research chair. There are four themes in the current WQMP as follows:

1. **Understanding Lake Recovery:** As indicated above, lake recovery is a process whereby improved air quality and the reduction on acid rain is allowing lakes to recover to their previous state. Unfortunately, this process has resulted in increasing levels of total organic carbon (TOC) which is a critical treatment parameter and increasing levels of biotic activity in the lakes. The increasing levels of biotic activity are an explanation for the geosmin episodes experienced since 2012. Increasing levels of biotic activity are also a potential precursor to other taste and odour causing compounds as well as potentially harmful algal toxins such as microcystsin-LR. As well, the increasing levels of TOC are challenging the ability of the water supply plants to operate efficiently and may eventually reach levels beyond what the plants were designed to deal with. Plant improvements will be required in the medium term and understanding how far the process of lake recovery will go is necessary to design the plant processes of the future.

2. **Adapting to Lake Recovery:** As indicated above, lake recovery is already impacting the treatment plants. While treated water quality still meets Halifax Water goals, the plants are more difficult and more expensive to operate. Short and medium term strategies and operating approaches are necessary to continue to produce high quality drinking water. This includes planning for a new intake for Lake Major to get access to more treatable and more consistent water quality as well as maximizing the utilization of biofiltration.

3. **Maintaining Distribution System Water Quality:** Maintaining water quality between the water treatment plant and the customer's tap is an important part of the multiple barrier approach to providing safe drinking water. Continuing our research into lead occurrence and corrosion control chemistry will remain a focal point. This theme will also explore maintaining water quality during emergencies such as water

main breaks and continuing to optimize disinfection in the distribution system to maintain chlorine residuals while reducing disinfection by-products.

4. **Water Quality Data Mining:** Ten years of research and source water protection work has resulted in an immense resource of water quality data. New resources recruited as part of the LSL Program include a data analyst whose long-term responsibility will be to work with water quality data sets to gain new insights into water quality issues and employ data analytics techniques for processes like distribution system water quality modelling.

***for*Water Network**

In 2015, Halifax Water was asked to participate in an application by researchers at the University of Waterloo and the University of Alberta in an application to NSERC for a $5 M network grant. The purpose of the network is to bring forest ecology researchers from across Canada to share ideas on how to manage forests to protect drinking water quality.

The network grant was awarded in 2016 and unites 7 research platforms across Canada, including Dalhousie University. Halifax Water staff participate in the network in addition to hosting research on our watersheds. Research in Halifax is focusing on how climate change impacts the transfer of naturally occurring carbon from the forest to water, where the carbon levels impact the treatment process.

It is expected that this program will have a major influence on watershed management in coming years.

10.6 Lead Service Lines

One significant new program that has grown out of water quality master planning has been the adoption of a formal LSL replacement program. Halifax Water has approximately 2,500 LSLs remaining in the public right of way and up to 3,500 remaining on private property. In 2017, Halifax Water initiated a program intended to remove all LSLs by 2050, consistent with the recommendation made to the USEPA by the National Drinking Water Advisory Council (NDWAC). In 2019, the Halifax Water Board approved an enhanced program that will see all LSLs replaced by 2039 or earlier, subject to NSUARB approval.

Halifax Water is one of a few utilities in Canada to adopt a NDWAC based approach to LSL replacement. This approach is consistent with industry association policy, is consistent with the safeguarding of public health, and positions Halifax Water well from increased public attention to the lead issues arising from the new Health Canada guideline.

The program has the following five pillars:

1. **Replace all LSLs by 2039:** Both those owned by the utility and those owned by customers. Program enhancements approved by the Halifax Water Board in 2019, if approved by the NSUARB, will remove remaining barriers to private LSL replacement.

2. **Inventory:** Getting an accurate inventory of where LSLs are, both public and private is key to working with customers and executing an effective program. Resources and new business process will be dedicated to building an accurate inventory of LSLs. This portion of the program has been very successful to date. Several record sources have been consolidated and confidence is improving in existing records. Halifax Water is working toward an industry best practice of an online inventory tool for customer access.

3. **Customer communication:** The NDWAC recommendations require direct communication with customers who have a LSL, a minimum of once every three years until the LSL is removed. Further, to encourage customers to replace LSL's, it will be necessary to provide more information on our web site and interactive tools to see what type of service they have. It will also be necessary to provide them more frequent and better information on the replacement process, how to access funding programs, how to hire a contractor and the health risks associated with LSL's.

4. **Continuation of customer sampling programs:** Sampling properly for lead detection is expensive and intrusive for the customer. It is important that Halifax Water continue to offer free lead sampling for at risk homeowners in order to engage them in the issue and provide public health information. Through our partnership with Dalhousie University we have been able to provide very cost effective lead sampling.

5. **Corrosion control:** Providing corrosion control treatment at the treatment plant is an important part of a comprehensive lead strategy. Effective corrosion control reduces lead levels where service lines exist and will continue to protect customers from lead found in solder and brass fixtures well after LSLs are removed.

Halifax Water launched its new lead program on April 1, 2017. In August 2017, the NSUARB approved a program to enable Halifax Water to provide a 25% rebate for customers replacing a LSL and to replace LSLs that are disturbed during emergency repairs, at the utilities expense. This makes Halifax Water one of the first utilities in North America to take this step. To further reduce barriers to replacement, Halifax Water has applied to the NSUARB to allow Halifax Water to offer customers a financing program for the balance of the replacement cost. This financing program was approved in 2018.

In the first two years of the program, 197 public LSL's and 212 private LSL's were replaced. Unfortunately, in 2019 we saw a reduction in uptake in the program. Based on discussions with other utilities across North America, this appears to be a common phenomenon, as motivated customers participate in the program in the early years leaving less motivated customers in later years.

Accordingly, Halifax Water will be exploring further regulatory and incentive options to promote LSL replacement and anticipates an application to the NSUARB in 2020.

10.7 Compliance Plan

The Regulatory Compliance division of Regulatory Services has established a tracking system to monitor trends of non-compliance and associated sources for all of the wastewater treatment facilities (WWTF). A working group has been established between Asset Management, Operations and Design Services staff to track and plan for the upgrades to maintain compliance with Provincial and Federal regulations. As of 208/19, all treatment facilities are in compliance with WSER or have approval for operational variances consistent with the CCME Municipal Wastewater Effluent Strategy.

Building on the framework of the basic Compliance Plan from 2012, the plan was updated in 2019 utilizing information Halifax Water has available to create a path forward to maintain or achieve compliance for our wastewater, water and stormwater infrastructure systems over the next 30 years. The Compliance Plan highlights the current state of compliance at our wastewater treatment facilities and water supply plants as well as future compliance requirements. It also includes overall guidance on our wastewater collection system, sanitary and combined sewer overflows and our water distribution system including water reservoirs.

The key objectives of the Compliance Plan included:

- Review of previous work completed that relates to compliance, including the 2012 IRP, 2019 Infrastructure Master Plan and 5-year Capital Program;
- Understanding current and future compliance requirements as they relate to wastewater, water and stormwater infrastructure;
- Understanding previous compliance trends and exploring potential compliance requirements taken from regional and global examples;
- Reviewing, documenting and analyzing the current performance of infrastructure against compliance requirements;
- Generation of infrastructure needs and costs to meet current and future compliance requirements;

- Incorporating the three drivers behind infrastructure planning (growth, asset management and compliance) through incorporating the impact of future growth trends and outlining projects that contain compliance components and asset renewal / growth components;
- Developing an action plan that outlines current, medium and long-term projects; and
- Identification of action plan risks and potential mitigation methods.

Halifax Water has been consistently working toward achieving the provincial level of wastewater treatment as stipulated by Nova Scotia Environment (NSE) permits and Federal Wastewater System Effluent Regulations (WSER). Historically, NSE has set compliance standards for each wastewater treatment facility (WWTF) issuing Approval for Operation which sets the effluent limits, and the Canada-wide Strategy for the Management of Municipal Wastewater Effluent (CSMMW) provided national standards for combined sewer overflows (CSO) and sanitary sewer overflows (SSO). Then in June 2012, the WSER was enacted which set national standards for WWTF effluent discharge and CSO and SSO standards.

Since the introduction of the federal WSER standards, NSE has been reviewing and renewing Halifax Water's operating permits with steady increases in compliance and reporting requirements.

The Compliance Plan is a key input to the Infrastructure Resource Plan (IRP). The IRP provides holistic guidance to understand the current level of compliance and actions required for maintaining compliance. Several initiatives have recently been completed and others underway shall continue. Current compliance initiatives are as follows:

- Compliance Monitoring and Reporting through the Regulatory Services Department;
- Engaging Dalhousie University in compliance research;
- Adopting the Environmental Management System (EMS);
- Environmental Risk Assessments (ERA); and
- WSER Transitional Authorization.

Halifax Water has entered into a 3-year research agreement with Dalhousie University to conduct specific research and optimization of Halifax Water facilities to stay "ahead of the curve" to meet its compliance requirements. The research program is eligible for funding under NSERC's Collaborative Research and Development Grant, an application to NSERC was made in spring 2019; the approval is pending. The NSERC is in the midst of redesigning its funding programs, Halifax Water and Dalhousie University intend to make a future application for a long-term funding when the new programs are in place. The current 3-year plan has a primary objective to improve effluent quality from chemically enhanced primary systems through bench, pilot and full scale testing and optimization of coagulation/

flocculation processes; the other elements being the application of innovative UV technologies and assessment of contaminants of emerging concern.

Post Walkerton, Nova Scotia was a leading province in modernizing its drinking water regulatory framework. Between 2005 and 2010, Halifax Water went through the provincial process to make sure all water supply plants were compliant at that time. This process resulted in minor upgrades to most facilities and major upgrades to two of the small systems. Nova Scotia Environment maintains a process of doing a systems assessment of all water plants, compare to design standards every ten years with the next round of system assessment reports due to be completed in 2023.

With the discovery of the lake recovery phenomenon, Halifax Water's focus now is to keep water supply plants compliant in the face of changing source water. It is almost certain that significant upgrades will be required to the Pockwock and Lake Major plants to equip them to deal with a source water that is significantly different than when the plants were designed.

10.8 Environmental Management System Expansion

An Environmental Management System (EMS) is a system of procedures, records and processes to manage environmental issues and assist with regulatory compliance. It also makes day to day operations more sustainable and engages employees in these operational activities. The EMS program can be audited against ISO 14001 standards, and if found to comply, receives a Certification through ISO. The ISO standard changed from a 2004 version to a 2015 version, with greater focus placed on organizational leadership and identification of risks and the associated influences, both internal and external to an organization.

Staff have successfully obtained certification for the existing facilities, Pockwock, Lake Major and Bennery Water Treatment Facilities and the Herring Cove and Dartmouth Wastewater Treatment Facility under the new Standard. Halifax Water is currently preparing for internal audits for Eastern Passage, Halifax and Mill Cove WWTFs. It is anticipated they will be certified in 2020.

A request for proposal closed in November and a Consultant will be in place by January 2020 to develop the framework for a corporate wide EMS program. It is anticipated the implementation of a corporate EMS will be completed by 2022. Expansion of the EMS program presents a significant opportunity to reduce Halifax Water's environmental footprint.

10.9 Wet Weather Management

Halifax Water maintains approximately 1,000 km of wastewater mains, 300 km of combined sewer mains, 14 wastewater treatment facilities, and 166 wastewater pumping stations. Like many municipalities and utilities across North America, Halifax Water's wastewater collection system is subject to dramatic flow increases in response to precipitation events due to age, historical construction practices, maintenance, number of connections as well as other factors. These Inflow & Infiltration (I&I) flows can lead to wastewater releases, sewer backups/basement flooding, increased operation and maintenance costs, treatment process upsets, and treatment facility effluent quality & capacity issues.

Recognizing the impacts of wet weather generated flows on the system, Halifax Water developed a wet weather management program (WWMP). The WWMP is a strategic program to address the negative impacts of wet weather on the wastewater collection system and treatment facilities. The WWMP monitors flows within priority sewersheds before and after wet weather flow reduction activities, while separating the combined sewer systems when practical to do so. The program is long-term in nature and follows a phased implementation approach to meet objectives.

The negative impacts of wet weather can generally be managed by the following:

1. Peak flow reduction - Reduce the quantity of wet weather generated flows that are collected, pumped and treated by the wastewater collection and treatment systems.
2. Peak flow attenuation - Store wet weather generated flows during wet weather periods and release & treat the flows when the system has capacity.
3. System capacity increase

The WWMP intends to systematically identify opportunities to employ the most cost effective wet weather management strategy. Where possible, all three methods are considered based on a cost benefit analysis and the sewershed specific driver for flow reduction, with regulatory compliance being the highest priority. By reducing wet weather flows, the wastewater system will see a reduction in untreated discharges to the environment, effluent noncompliance at WWTFs, operational and maintenance costs, and an increase in available system capacity.

I&I is grouped into two sources, public infrastructure (mains, manholes, laterals up to the property line, etc.) and private infrastructure (laterals from property line up to and including connections within buildings). The program employs a variety of strategies to reduce wet weather impacts such as pipe condition assessments, cured in place pipe (CIPP) rehabilitation, sewer separation, flow monitoring, illegal connection investigations, public communications, and modeling. To effectively address all the issues that contribute to the impacts of wet weather, multiple business units within Halifax Water are engaged to work together to achieve the goals of the WWMP. Figure 11 indicates the working relationships and activities between the contributing business units.

Figure 11: Contributing Business Activities of the Wet Weather Management Program

A phased approach is being followed to implement the program. While the phasing is prescriptive; it is important to revisit the objectives of the program periodically and adjust where necessary.

- **Phase I:** The initial phase of the WWMP involved initiation and development of the program. It was quickly realized that strategies would have to be implemented within each priority sewershed based on individual system characteristics. The program's initial organizational structure was comprised of a wet weather steering committee and a wet weather action committee. Key contributors continue to be engaged in the program with monthly meetings between the steering committee and implementation team.

- **Phase II:** Phase II of the program required identifying priority sewersheds that demonstrated a need for wet weather management. In the absence of measured flow data, pump station run time data was used to develop a sewershed prioritization matrix. Since that time, significantly more flow monitoring data is available and has almost negated the need for pump station run time data.

- **Phase III:** Pilot sewersheds were identified from the prioritization matrix from Phase II. These pilots were selected so that specific wet weather management strategies could be assessed. Each pilot sewershed was evaluated using pre and post rehabilitation flow data and a cost benefit analysis was conducted with respect to actual wet weather flow reductions. Post rehabilitation flows continue to be monitored in the pilot sewersheds to confirm wet weather flow reductions are achieved long-term.

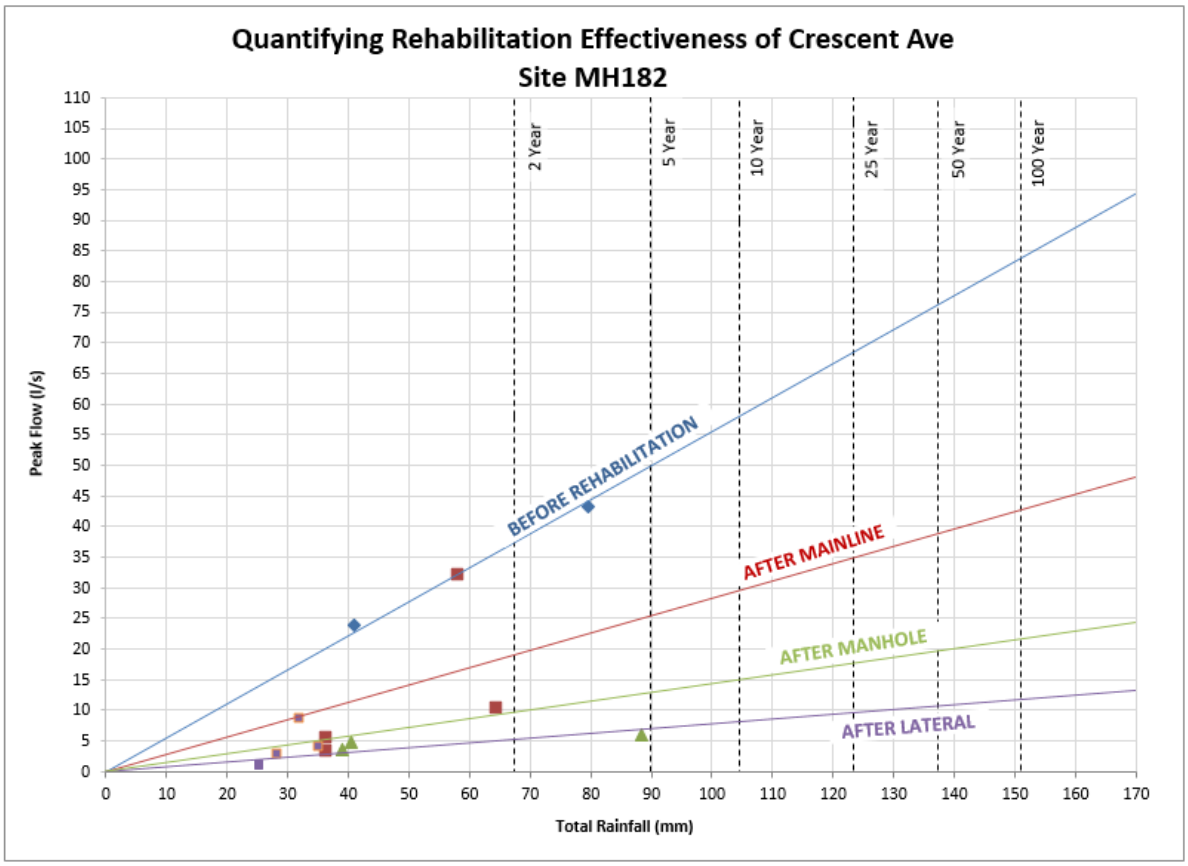
- **Phase IV:** With the information collected from pilot and other wet weather reduction projects, future project recommendations are being identified and implemented in other sewersheds. This approach allows Halifax Water to identify the most cost-effective strategies to manage wet weather flows using system-specific historical data. Since the initiation of the program, 205 sewersheds have been identified with varying degrees of impacts from wet weather.

Recognizing the importance of flow monitoring and infrastructure condition assessments, Halifax Water enhanced the service delivery of the flow monitoring and CCTV programs. Both programs have performance-based contracts to ensure accurate and dependable data delivery to the industry standard.

The near term (2020/2021) goals for Halifax Water's Wet Weather Management Program include:

1. **Rehabilitation Pilot Projects:** Halifax Water's WWMP has completed 5 pilot projects: Stuart Harris Pump Station Sewershed, Cow Bay Rd., Leiblin Park, North Preston, and Crescent Ave. These pilot areas were chosen to enable Halifax Water to assess the effectiveness of the various wet weather management strategies and collect rehabilitation cost information. Wet weather management strategies for these sewersheds included mainline, manhole, and lateral CIPP, new stormwater mains, and system spot repairs. 2020/21 will see continued flow monitoring and data analysis on pre and post activity for each pilot. As an example, Figure 12 below illustrates the reduction in rainfall derived inflow and infiltration (RDII) peak flow for the Crescent Ave pilot project. This pilot underwent a three-phase rehabilitation including mainline, manhole, and lateral renewal activities.

Figure 12: Crescent Ave. Pilot Project RDII Peak Flow Reduction by Rehabilitation Phase



2. **Refinement of Cost Benefit Analysis:** Phase IV of the WWMP involved applying a cost benefit analysis of the various strategies to manage wet weather flows. As expected, the pilot sewersheds are demonstrating a significant reduction in RDII as the various wet weather management strategies are implemented. The financial cost of the RDII reduction was normalized so that the information can be applied to other sewersheds and compared to more traditional approaches to wet weather management such as capacity increase and storage. Additional data from various sewersheds is continually analyzed as it becomes available. In addition to flow data, cost information is available for application to larger scale rehabilitation projects.

   The cost and reductions in RDII have been compiled since the inception of the formalized WWMP. The program is structured to evaluate all wet weather management activities using the same methodology to ensure consistent application across identified areas. This enables Halifax Water to employ the most cost effective strategy to future areas. It has become evident that the RDII reduction cost has significant dependence on the sewershed characteristics; however, it provides essential guidance for the future projects. The Program continues to augment this information and its application to future projects.

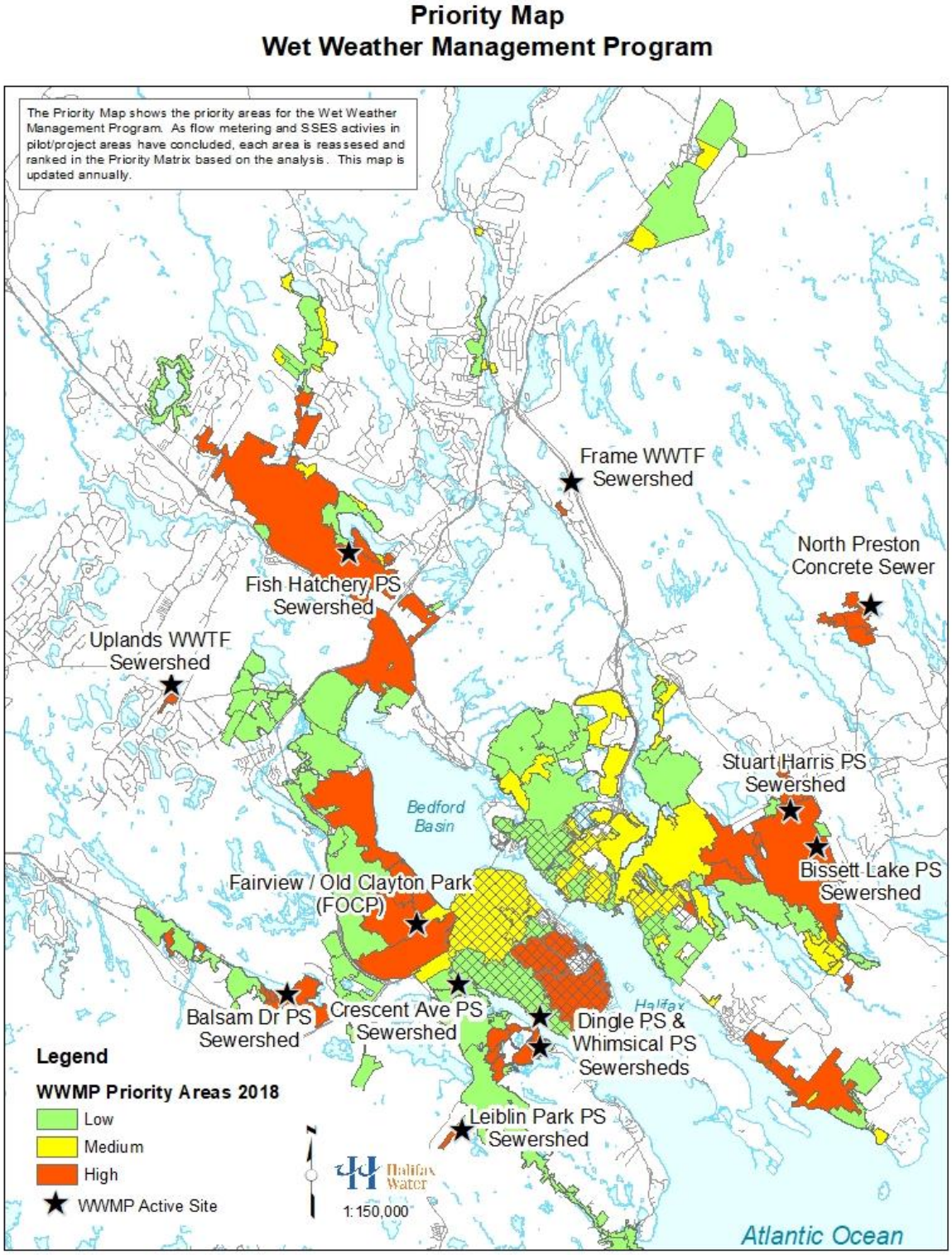
3. **Fairview / Old Clayton Park / Bridgeview:** The analysis of flow monitoring data undertaken as part of the West Region Wastewater Infrastructure Plan identified the potential for significant reductions in RDII in the Fairview, Old Clayton Park and Bridgeview areas. With the goal of reducing peak flows by approximately 200 L/s, a phased I&I reduction program was initiated in 2017. In 2018/19, approximately 11 km of CIPP lining was completed as part of Phase I and 2019/20 Phase 2 will see approximately 15 km completed. 2019/20 included smoke testing with the goal of identifying both public and private inflow sources. Flow monitoring and data analysis will continue to quantify RDII reductions for the project area and assess the effectiveness of the asset renewal during all phases of the project.

4. **Program Expansion: Central and East Region Infrastructure Master Plan:** Work on the Infrastructure Master Plan for the East and Central regions has been completed in 2019. Wet weather flow management is a part of the overall wastewater strategy for the Infrastructure Master Plan (IMP). The WWMP will continue to work with the IMP project team in strategy selection for management of wet weather flows. In 2020/21, the WWMP will continue with SSES (Sanitary Sewer Evaluation Survey) activities in the Fish Hatchery Park Pump Station and Eastern Passage sewersheds with the goal of identifying the sub-sewersheds where implementation of wet weather projects are considered feasible.

5. **Decision Matrix Implementation:** Building on the past experience with WWMP projects; an enhanced prioritization methodology is being developed with the addition of a decision matrix to assist in identifying areas that can benefit from wet weather management in a cost effective manner. The decision matrix provides a process flow framework to prioritize candidate sewersheds for future rehabilitation projects.

Figure 13 below shows current sewershed priority ranking based on a previous methodology. Beginning in 2020/21, the WWMP is updating the sewershed prioritization methodology by incorporating recommended criteria to refine priority areas going forward.

Figure 13: Priority Map Wet Weather Management Program



The planned WWMP activities for the next five years are listed in Figure 14 (WWMP Preliminary 5 Year Plan) below. Note that activities planned in years 1-2 are unlikely to change and the activities in years 3-5 are subject to change as the program evolves.

Figure 14: WWMP Preliminary 5 Year Plan

2020/2021

Refresh Prioritization Matrix
SSES Activity (CCTV, Smoke Testing & Flow Monitoring)
Fish Hatchery PS Sewershed (FMZ07 & FMZ10)
Hornes Rd Sewershed - Private-side Pilot Project (FMZ37)
Eastern Passage Sewersheds (FMZ37)
Loon Lake Sewersheds (FMZ24)
Rehabilitation: Capital Projects
Fairview/Old Clayton Park/Bridgeview - Phase III

2021/2022

Refresh Prioritization Matrix
SSES Activity (CCTV, Smoke Testing & Flow Monitoring)
Fish Hatchery PS Sewershed (FMZ07 & FMZ10)
Hornes Rd Sewershed - Private-side Pilot Project (FMZ37)
Eastern Passage Sewersheds (FMZ37)
Loon Lake Sewersheds (FMZ24)
Rehabilitation: Capital Projects
Fish Hatchery PS Sewershed (FMZ10) - Phase I
Eastern Passage Sewersheds (FMZ37) - Phase I

2022/2023

Refresh Prioritization Matrix
SSES Activity (CCTV, Smoke Testing & Flow Monitoring
Fish Hatchery PS Sewershed (FMZ07 & FMZ10)
Hornes Rd Sewershed - Private-side Pilot Project (FMZ37)
Loon Lake Sewersheds (FMZ24)
Bissett PS Sewersheds
Rehabilitation: Capital Projects
Fish Hatchery PS Sewershed (FMZ10) - Phase II
Eastern Passage Sewersheds (FMZ37) - Phase II

2023/2024

Refresh Prioritization Matrix	
SSES Activity (CCTV, Smoke Testing & Flow Monitoring)	
	Hornes Rd Sewershed - Private-side Pilot Project (FMZ37)
	Eastern Passage Sewersheds (FMZ37)
	Loon Lake Sewersheds (FMZ24)
	Bissett PS Sewersheds
Rehabilitation: Capital Projects	
	Fish Hatchery PS Sewershed (FMZ07) - Phase III
	Fish Hatchery PS Sewershed (FMZ10) - Phase I
	Loon Lake Sewersheds (FMZ24) - Phase I

2024/2025

Refresh Prioritization Matrix	
SSES Activity (CCTV, Smoke Testing & Flow Monitoring)	
	Hornes Rd Sewershed - Private-side Pilot Project (FMZ37)
	Bissett PS Sewersheds
Rehabilitation: Capital Projects	
	Fish Hatchery PS Sewershed (FMZ10) - Phase II
	Loon Lake Sewersheds (FMZ24) - Phase II

**Subject to change due to data review supporting refresh of prioritization matrix*

10.10 National Water and Wastewater Benchmarking Initiative (NWWBI)

The Nova Scotia Utility and Review Board approved Halifax Water participation in the Canadian National Water and Wastewater Benchmarking Initiative (NWWBI) as a recommendation from a previous rate review process. The Canadian NWWBI was started in 1998 and has since grown to include about 45 of Canada's most progressive municipal and regional water, wastewater, and stormwater utilities from coast to coast.

The success of the initiative comes from how data is collected to ensure quality. To guarantee that data is collected on a like-for-like basis between utilities, significant effort is placed on the definition of each performance measure and the data items that are collected. Halifax Water has participated in the initiative since 2014 and has been refining the data collection process in that time.

Initial data collection efforts in the first three years of participation were challenging and NWWBI consultants cautioned Halifax Water that initial years would require extra effort around data collection. The effort was front loaded and entering the fifth year of data collection, Halifax Water has a more streamlined approach to data collection.

There have been several enhancements to the NWWBI program in recent years. In 2018, a new web-based data collection portal was launched. The objective of the new system is to help simplify the data collection process and ultimately reduce the workload burden of data collection. Additionally, the data collection deadline date has changed aligning better with our business processes particularly with financial year end.

Halifax Water has participated in the NWWBI survey for the past five years. Internal data collection procedures have matured quickly and will continue to streamline as Cityworks is implemented across the service areas.

The results of the annual surveys reveal industry trends and identify individual diversions from normal. Halifax Water reviews the trends and diversions to identify areas of improvement within the business. Generally Halifax Water is not an outlier in any particular business area for which data is collected and compared. Over the next few years, the NWWBI program will continue to be monitored to determine the strategic benefits to our organization of information received.

10.11 Talent Management

Halifax Water uses the term talent management to describe strategic workforce management activities to ensure the right people are in the right place, at the right time, and at the right price to execute the business of the utility.

Figure 15: Talent Management Cycle

Talent Management encompasses a variety of Human Resource strategies to ensure Employees continue to feel valued and are ready for more challenging careers as they become available. Employee engagement is a vital piece for a successful talent management program and continues to be a focus for Halifax Water. Another focus will be to create a culture of feedback which is necessary in developing employees at all levels of the organization. Halifax Water recognizes that a workplace which is psychologically safe and healthy is another key component in managing talent and, therefore, will be embarking on many initiatives to create a workplace that is psychologically healthy and safe for all.

10.12 Performance Measurement

Halifax Water's overall performance is assessed against the Corporate Balanced Scorecard (CBS). Halifax Water has been utilizing a corporate balanced scorecard (CBS) to measure utility performance since 2001. Each year the Halifax Water Board sets organizational indicators and reviews performance results. Adjusting the CBS targets to ensure they are relevant and challenging, keeps the utility focused on continuous improvement

There are eight Critical Success Factors (CSFs) derived from Halifax Water's vision statement (shown in Appendix A) and under each of the CSFs, there are organizational indicators to track performance and allow for the establishment of targets. The following lists the current CSFs and corresponding results for the organizational indicators under each category.

1. High Quality Drinking Water

- Adherence with Water Quality Master Plan - Percentage of sites achieving targets
- Bacteriological tests - Percentage free from Total Coliform
- Customer satisfaction about water quality - Percentage from customer survey

2. Service Excellence

- Customer satisfaction with service - Percentage from customer survey
- Water service outages - Number of connection hours/1000 customers
- Wastewater service outages – Number of connection hours/1000 customers
- Average speed of answer – Percentage of calls answered within 20 seconds

3. Responsible Financial Management

- Operating expense/revenue ratio percentage
- Annual cost per customer connection – Water
- Annual cost per customer connection – Wastewater

4. Effective Asset Management

- Water leakage control – target leakage allowance of 160 litres/service connection/ day
- I&I reduction - Number of inspections on private property for discharge of stormwater into the wastewater system
- Peak flow reduction from wet weather management capital projects
- Hours of unplanned outages in GIS and Cityworks
- Capital budget expenditures - Percentage of budget spend by end of fiscal year

5. Workplace Safety and Security

- Average score on internal safety audits
- NS Labour and Advanced Education compliance - # of Incidents with written compliance orders
- Lost time accidents -Number of accidents resulting in lost time per 100 employees
- Safe driving - Number of traffic Accidents per 1,000,000 km driven
- Training - Number of employees trained or re-certified before due date

6. Regulatory Compliance

- Percentage of public health and environmental regulatory infractions resulting in an environmental warning report, summary offense ticket, ministerial order, or prosecution
- Percentage of WWTFs complying with NSE approval permits

7. Environmental Stewardship

- Number of ICI properties inspected by Pollution Prevention each year
- Energy management kwh/m^3 reduction associated with capital projects
- Bio-solids residual handling - % of sludge meeting bio-solids concentration targets

8. Motivated and Satisfied Employees

- Percentage of grievances resulting in arbitration
- Percentage of jobs filled with internal candidates
- Employee satisfaction survey result
- Average number of days absenteeism

11. SAFETY & SECURITY

11.1 Occupational Health & Safety Programs

Halifax Water's Occupational Health and Safety Program is based on the Internal Responsibility System (IRS), which is the foundation of the Nova Scotia Occupational Health and Safety Act. The IRS is an internal system that provides for direct responsibility for health and safety for all staff in an organization.

The Safety and Security Division of Regulatory Services has principal duties and responsibilities as part of the IRS as follows:

- Assisting in formulating and supervising the execution of the utility's Occupational Health and Safety Program, and assist management to fulfill, to the greatest degree possible, its responsibilities for safety.
- Coordinating and/or providing safety training to staff in an effort to prevent incidents, minimize losses, increase productivity and efficiency, and ensure compliance with safety legislation and policies.
- Conducting safety audits in the workplace to identify safety hazards and recommend control measures.

- Assisting in the development and maintenance of a system of incident investigation, reporting, and follow-up.
- Providing program education for job safety.
- Acting as a resource to the Joint Occupational Health and Safety Committee (JOHSC).
- Liaising with federal, provincial, and local safety organizations by taking part in the activities and services of these groups.

Halifax Water has established and maintains an Occupational Health and Safety Program in consultation with the Joint Occupational Health and Safety Committees (JOHSC). Halifax Water's JOHSC's continue to mature and grow in knowledge and ability and will continue to be a large part of creating a positive workplace safety culture.

Halifax Water is a signatory of the Nova Scotia Health and Safety Leadership Charter which represents a commitment from industry leaders across Nova Scotia to the continuous growth of a positive workplace safety culture. Mental health and psychological health and safety are increasingly being recognized as an important component of occupational health and safety. In 2020/21 Regulatory Services and Human Resources will be working together to further psychological health and safety initiatives and all Halifax Water employees will receive psychological health and safety training.

In 2020, to assist with the management of the safety program, it is proposed to review the applicability of the ***ISO 45001*** International Standard that specifies requirements for an occupational health and safety (OH&S) management system, with guidance for its use, to enable an organization to proactively improve its OH&S performance in preventing injury and ill-health. Implementing ISO 45001 would be a multi-year initiative within the period covered by the Five-Year Business Plan.

11.2 Corporate Security Program

Halifax Water's Security Program is based on enterprise asset protection and is designed to protect three types of assets: people, property, and information. It also considers intangible assets such as the organization's reputation, relationships, and creditworthiness. The program has been developed to take an all-hazards approach, be it from natural, intentional, or accidental hazards, when reviewing risks to the organization.

Halifax Water uses the three basic elements of a physical security system to protect its assets.

> ***Protection:*** The protection element is the physical barrier that delays the determined adversary and the opportunist in accomplishing their goals. Halifax Water uses barriers such as building fabric, fences, doors, door hardware, and containers to protect its assets.

Detection: The detection element indicates and may also verify an actual or attempted overt or covert penetration. Halifax Water uses intrusion alarms, access control systems, CCTV, and patrols to protect its assets.

Response: This element is the reaction to an attempted or actual penetration. Halifax Water works closely with local and national police and security agencies to ensure a rapid response to events.

Halifax Water will be updating its Security Plan and will be providing training to all employees based on their roles and responsibilities.

Emergency Management Planning

Safe and reliable drinking water, sanitation and environmental protection are vital to the sustainability of communities within HRM. In recognition of this, Halifax Water maintains an Emergency Management Plan (EMP), as required by the provincial Emergency Management Act.

The purpose of the EMP is to establish an organizational structure and procedures for response to water and wastewater/stormwater incidents. It assigns roles and responsibilities for the activation and implementation of the plan during an emergency, using the Incident Command System (ICS). The preparation and exercising of an EMP can save lives, reduce risk to public health, enhance system security, minimize property damage, and lessen liability.

With the challenges posed by climate change, such as more frequent, intense storms, heat waves, drought, extreme flooding and sea levels it is important that Halifax Water continues to exercise the actions contained within the Emergency Response Plan, both internally and with external partners.

Halifax Water continues to liaise with the municipality with respect to flooding events and will encourage the municipality to complete an updated response plan to extreme flooding events. Halifax Water will assist in the development of the plan, providing information on critical infrastructure, known drainage restrictions and flood prone areas.

The Municipality has developed a GIS based Situational Awareness to assist in tracking and monitoring impacts to the systems/infrastructure during an emergency. Halifax Water is exploring the development of its own tool and potentially integration with the Municipality's in the coming years.

12. BUSINESS RISKS & MITIGATION STRATEGIES

12.1 Enterprise Risk Management

In 2019 Halifax Water completed an Enterprise Risk Management (ERM) Framework, and the Halifax Water Board approved an ERM Policy, and a risk appetite and tolerance matrix. There are seven broad risk categories outlined in the policy, which align very closely to the Corporate Balanced Scorecard critical success factors. The risk categories and critical success factors may both change over time. In future, there will be consideration of the alignment. The more closely the risk categories and critical success factors align the less opportunity there will be for confusion or goal misalignment.

The ERM Policy will be rolled out in 2020, and Halifax Water will begin risk based reporting to the Halifax Water Board. It will take 2 – 3 years to fully embed ERM at Halifax Water; and an additional resource is required to coordinate enterprise risk management, and well as internal audit functions. Compliance with policies and standard operating procedures (SOPs) is important to help manage risk. Halifax Water will add capacity to conduct internal audits with a focus on promoting policy and SOP compliance.

12.2 Nova Scotia Environment (NSE) Regulatory Compliance

Wastewater:

Since the last Five-Year Business Plan was completed, a number of upgrades, optimizations, system enhancements and one decommissioning has occurred to achieve compliance with the WSER for all WWTFs.

Halifax Water meets and communicates regularly with NSE staff, with the objective of achieving consensus on priorities. Regulatory compliance plans have been updated.

Funding of capital improvements for a number of the wastewater treatment facilities has already been approved, or are in process in the Five-Year Capital Budget, namely:

- Decommissioning of the Timberlea WWTF, with diversion to Halifax
- Upgrades to the Mill Cove WWTF for increased capacity
- On-going studies for the management of Sanitary Sewer Overflows (SSOs) and Combined Sewer overflows (CSOs)

Halifax Water continues to take advantage of the seasonal disinfection program, allowing for enhanced and easier maintenance of the ultraviolet disinfection systems at Eastern Passage, Dartmouth, Halifax and Herring Cove WWTF.

Water:

The Approvals for the water treatment facilities expired in 2018, with interim approvals issued by NSE. Renewal applications have been submitted to NSE and updated permits have been provided or are being finalized this year.

The Bennery Lake withdrawal permit requires options for the continued supply of water to the Airport and Aerotech areas be established. A master plan will be completed in 2020 to review alternatives to the continued use of Bennery Lake. The water withdrawal permit for the Pockwock system expires in 2021 staff are currently preparing the supporting documents required to obtain the renewal of the permit.

Upgrades are planned for JD Kline (Pockwock) and Lake Major water treatment facilities to improve ease operability, asset renewal and continued compliance. These projects will be completed over two phases at each facility.

With the extension of water services to the Fall River area, Halifax Water completed an extension of the watermain to the Miller Lake Water system. This will allow for the decommissioning of the Miller Lake system in 2019 and the customers will be included in the Pockwock water system.

System Assessments:

Halifax Water is committed to supplying safe and clean water, and effective wastewater collection and treatment. In support of these goals, Halifax Water undertakes assessments of all water and wastewater systems, in conformance with NSE regulations.

It is a regulatory requirement that Water System Assessments be completed every ten years with the latest reports for all water systems submitted to NSE in 2013, except for Bomont, which was prepared in 2015. Assessments of municipal drinking water systems are conducted to evaluate the capability of the system to consistently and reliably deliver an adequate quantity of safe drinking water; to verify compliance with regulatory requirements; and provide preliminary costs and timelines to address any identified deficiencies and/or concerns. Corrective Action Plans are in place where required by NSE, as follow-up to the Water System Assessments.

Wastewater System Assessments (similar to water system assessments) are currently not a regulatory requirement. However, Halifax Water regularly reports to NSE on the performance of some components of the wastewater system for conformance with regulatory requirements. Additionally, Halifax Water conducts wet weather flow studies on parts of the wastewater system. These studies are similar to system assessments, but are not as comprehensive.

12.3 Climate Change

Climate change is a documented global phenomenon. Climate data indicates a global warming progression since the beginning of the industrial era. The Intergovernmental Panel on Climate Change forecasts continued warming with global increases of between 2 and 4 degrees Celsius or more by the end of this century. Changes will be gradual, progressive, and will impact communities and natural systems well before the end of the century. Climate change may have a number of effects on the water cycle and natural water systems, with resulting impacts on water, wastewater and stormwater operations and infrastructure.

12.3.1 Overview

Climate change effects may include:

- greater weather variability (more extreme wet-weather events and more dry-weather periods),
- greater intensity of precipitation during extreme events,
- greater risk of hurricanes in the Maritimes,
- increased stormwater runoff,
- increased risk of flooding and sea level rise of up to 1 metre by 2100,
- decreased water supplies during dry weather, and
- ecological changes from nuisance or disease-causing organisms.

Consequently, the impact to utilities may include:

- increased stormwater flows during extreme events,
- increased risk of erosion,
- increased flows during snow melt events,
- increased flows within combined systems during extreme events (increased risk of inflow/infiltration and overflows for wastewater systems),
- increased water demand and storage requirements during dry summer weather,
- increased uncertainty regarding water supply,
- reservoir replenishment and groundwater recharge due to uncertainty of local annual precipitation patterns,
- increased risk of power failures during extreme weather events, and
- infrastructure impacts due to sea-level rise.

These effects and impacts of climate change will require that water/wastewater /stormwater utilities be proactive in planning for contingencies and emergencies.

12.3.2 Mitigation Strategies

Climate change mitigation involves actions that reduce the rate of climate change. Halifax Water's mission statement, "To provide world-class services for our customers and our environment" declares our commitment to good environment stewardship. As good stewards of the environment, it is not enough to simply adapt to the effects of climate change but to pro-actively participate in limiting or preventing greenhouse gas emissions.

Halifax Water is working and delivering on numerous projects that will contribute to the mitigation of climate change:

- Increasing energy efficiency through the Energy Management Program (Section 9)
- Renewable-Energy Generation
- Solar Energy
- Wind Energy
- Wastewater Effluent Heat Recovery
- In-line hydro power turbine

Halifax Water is also an active participant in HRMs "HalifACT 2050: Acting on Climate Together" initiative. HalifACT 2050 is a collaborative project to bring together the municipal government, industry, academia, and community groups to develop a plan to reduce emissions, and adapt to climate change.

12.3.3 Adaptation Strategies

Vulnerability to Climate Change Assessment Framework

The Infrastructure Master Plan, referenced in Section 7, included development of a Vulnerability to Climate Change Assessment Framework.

The Vulnerability to Climate Change Risk Assessment Framework was developed based on a review of best practices and the existing body of knowledge.

The Vulnerability to Climate Change Assessment Framework was developed such that it can be applied consistently across assets groups to complete vulnerability assessments of existing infrastructure. In addition to assessing the vulnerability of Halifax Water's infrastructure, the framework includes the development of action plans and implementation of climate adaptation measures.

Stage 1, Assessment Stage, of the Vulnerability to Climate Change Assessment Framework follows an existing framework: The Public Infrastructure Engineering Vulnerability Committee (PIEVC). This developed in Canada framework was chosen as it provides a step by step guide to evaluating municipal assets vulnerability and responses to the impacts of changing climate and aligns with the ISO 31000 Risk Assessment standards.

Beginning in the next capital year, Halifax Water plans to conduct a PIEVC assessment for each asset class already delimited by the Asset Management Plans (Section 7.1.2). The Asset Management Plans are a report card on the state of the infrastructure in each asset class. Their goal is to provide information to decision makers supporting reinvestment decisions for those assets. The Climate Change Vulnerability and Risk appendix to the asset management plan will provide additional information to decision makers on the climate change risks to existing infrastructure in each class.

The Vulnerability to Climate Change Assessment will also create a formalized body of knowledge to be used when designing new or upgrades to infrastructure in that asset class. This body of knowledge of climate change factors specific to our region will be used to supplement national design standards resulting in better designs that adapt to climate change in the Halifax context.

Updated Design Standards

The Infrastructure Master Plan included recommended some immediate changes to Design and Construction Specifications to begin adapting new infrastructure to climate change. Specifically, this includes:

- a modified Intensity-Duration-Frequency (IDF) curve for calculating rainfall for design, and
- guidelines on sea level rise including storm surge and wave run-up.

These updated design standards were used in the development of the Infrastructure Master Plan and will also be included in Halifax Water's Design and Construction Specification when it is next published in 2020.

Investing in Canada Infrastructure Program

The Government of Canada has created the "Investing in Canada Infrastructure Program" (ICIP) to fund investments in infrastructure. The funding plan identifies five priority investment streams: Public Transit, Green Infrastructure, Social Infrastructure, Rural and Northern Communities, and Trade and Transportation Infrastructure.

The Green Infrastructure stream includes three sub-streams: climate change mitigation; adaptation, resilience, disaster mitigation; and, environmental quality. To qualify for funding, proposed projects must meet at least one of the following outcomes:

- Climate Change Mitigation
- Adaptation, Resilience and Disaster Mitigation
- Environmental Quality

Several of Halifax Water's planning projects are likely to meet the requirements for the Green Infrastructure stream.

In conjunction with the Investing in Canada Infrastructure Program, the Government of Canada has created the "Climate Lens" assessment requirement. The Climate Lens requirement consists of two components: The Green House Gas (GHG) Mitigation Assessment, and the Climate Change Resilience Assessment. Proponents could be asked to undertake one or both types of assessment, depending on the program, funding stream, and the estimated total eligible cost of the project". Projects must have completed the relevant Climate Lens assessments complete with an attestation signed by a certified or qualified party when applying for ICIP funding.

Halifax Water is undertaking a project to identify projects that may qualify for funding through the Investing in Canada Infrastructure Program and complete the required Climate Lens assessments. This will result in a selection of projects that are ready for application when the next round funding is released.

12.4 WSER Regulations

On February 14, 2009, the Canadian Council of Ministers of the Environment (CCME) adopted a national strategy for the management of municipal wastewater. The strategy advocates a risk-based approach to management of wastewater effluent whereby requirements are based on environmental and health-risk assessments that are to be carried out for all treatment facilities. However, the strategy also includes a prescriptive approach with a requirement for a uniform minimum standard for all effluent equivalent to secondary treatment. Halifax Water's inland treatment facilities that discharge to fresh water already provide secondary or better treatment, as does the Mill Cove facility in Bedford and the Eastern Passage facility. However, the three Halifax Harbour Solutions Project (HHSP) facilities are advanced-primary. Upgrading to secondary level is required for the HHSP facilities under the WSER, with estimated capital costs in the order of $286 M. As outlined in Section 5 of this Business Plan (Wastewater System Effluent Regulations), the upgrade deadlines could be up to 30 years for Halifax and Dartmouth WWTFs under Transitional Authorizations sought under the WSER, due to high-risk CSOs. The Herring Cove WWTF currently is able to meet the WSER discharge limits since it is well under capacity, although

it was designed as an advanced-primary facility. As growth in the Herring Cove sewershed brings the facility closer to its rated capacity, effluent quality may come closer to exceeding WSER limits. In this case, advance planning for an upgrade will be required so that the facility remains compliant.

A more immediate operational/regulatory issue with Halifax Water's wastewater system is wet weather flow and resultant overflows into the environment as detailed in Section 5. Many of the sewers in the municipality are combined, built many decades ago with many greater than 100 years in age. Combined sewers have not been permitted since the early sixties, but even the older, separate sanitary sewers experience significant I&I problems.

Of the approximately 166 wastewater pumping stations owned by Halifax Water, approximately 35 stations experience overflows during wet weather or high rain events. Many of these overflows go to inland receiving waters and, as such, represent higher environmental and health risks than marine discharge of primary treated effluent. As an initial step, a program is underway to provide sensors to detect overflow conditions and estimate volumes for the sanitary sewer overflows. Eighteen such installations are complete. Halifax Water staff are utilizing a combination of flow monitoring and estimating of overflows to provide the additional flow volumes.

Much of the capital and operating budgets have been allocated to mitigate these wet weather flow problems based on a priority-ranking process. It is preferred that resources be allocated based on risk and assessed priority, rather than on the basis of a national standard (the CCME/WSER) that does not consider local conditions. Identification of funding mechanisms and cost-sharing arrangements with senior levels of government will be critical now that the WSER regulations are in force.

12.5 Pension Plan

Halifax Water has a defined benefit pension plan (Halifax Water Employees' Pension Plan) which was redesigned effective January 1, 2016 to make the plan more affordable and sustainable for current and future Halifax Water employees. Pension plan re-design was achieved through collective bargaining. In 2018, the employer and the employee contributions on pensionable earnings totaled $6.2 M. The contribution rates were 10.34% for the employees and 9.85% for the employer. From 2019 - 2021, the contribution rates will be 10.34% for both the employees and the employer.

The financial position of the plan, based on the most recent audited financial statements, is shown in Figure16 below. As at December 31, 2018 there were $126 M in assets, and $124 M in pension obligations, for a surplus of $2 M. Assets of the Plan are invested as part of the Halifax Regional Municipality Master Trust, and represent 6.2% of the Master Trust's assets. The next actuarial valuation is required by January 1, 2022.

Figure 16: Pension Plan Statement of Financial Position as of December 31, 2018

Statement of financial position December 31				
			Change	
	2018	2017	$	%
Net assets available for benefits (note 4)	$126,458,630	$119,731,882	$6,726,748	5.6%
Pension obligations (note 5)	$124,371,400	$121,473,083	$2,898,317	2.4%
Surplus (Deficiency)	$2,087,230	($1,741,201)	$3,828,431	219.9%

Halifax Water also has almost 100 employees that joined the utility as part of the 2007 Wastewater/Stormwater transfer, that are members of the HRM Pension Plan.

12.6 Development Pressures and Obligations

As growth is a strategic driver of the Infrastructure Master Plan, Halifax Water continues to work closely with the development community to facilitate infrastructure necessary for a rapidly growing municipality. The Municipality completed the last Regional Plan update in 2014 with a current focus on the completion of the Centre Plan. In that regard, Halifax Water project managed the Local Wastewater Collection System Assessment for HRM in support of the potential growth within the city centre and is currently coordinating with the Municipality on the implementation of the required projects.

Staff recently updated the Bedford West and Geizer Hill Capital Cost Contribution plan to reflect the modifications respective servicing scenarios and population projections. Applications are currently before the Nova Scotia Utility and Review Board (NSUARB).

The land owners of the Port Wallace Master Plan area are currently seeking secondary planning approvals and Halifax Water have been providing technical support in the evaluation of whether the Port Wallace area will include a possible new capital cost contribution charge and the required implementation of the servicing strategies.

Halifax Water is currently engaged with the Municipality to support their replacement of the permitting software, HANSEN and move to a digital platform for development approvals.

12.7 Biosolids

The WWTF upgrades at Aerotech, Eastern Passage and installation of dewatering equipment at Mill Cove WWTF has strengthened Halifax Water's capacity to dewater sludge from its facilities. Additionally, Halifax Water has been successfully worked with Nova Scotia Environment for elimination of the permitting requirements to dewater sludge at various facilities. These initiatives have provided required flexibility thereby reducing the risk of a dewatering facility malfunction and as a result the overall plant operational risks have reduced.

The Biosolids Processing Facility (BPF) is operated by Walker Environment Group with overall responsibility for operating the facility to produce a soil amendment in conformance with Canadian Food Inspection Agency (CFIA) regulations and marketing the product for beneficial reuse. The current asset management plan developed in cooperation with the contractor addresses the parts replacement/upgrade needs of the facility. The BPF is also approaching its design capacity. With population growth and the improvement in performance of treatment plants, the WWTFs are producing an increased quantity of sludge. The contract agreements with Walker Environmental expires at the end of March 2021. Staff are currently reviewing the overall operation, while simultaneously working on the capacity upgrade requirements and a new operating contract. The future BPF could utilize completely different technology with a different operating contractor. In light of the recent industry trends with focus on resource recovery from Biosolids, Halifax Water is exploring all aspects of resource recovery when considering alternatives for biosolids processing. Since this will potentially be a long-term contract, there is a medium level risk with potential changes, considering the complexities associated with the management of biosolids.

12.8 Halifax Harbour Solutions Project (HHSP) Facilities

Climate change is considered to be one of the main challenges to urban wastewater systems in future decades as these Wastewater systems are vulnerable to extreme precipitation events; earlier snowmelt runoff, increased flooding and storm-induced wastewater system failures often lead to environment pollution and put public health at risk. The HHSP, specifically Halifax and Dartmouth operate as combined treatment systems and are most vulnerable to climate changes. When issuing new or updated operational permits Nova Scotia Environment requires that facilities comply with the New Atlantic Canada Design Guidelines. Once the guidelines are finalized the effect of the new guidelines will be taken into consideration for future IRP and Compliance Plan updates along with Halifax Water's infrastructure asset vulnerability to climate change assessments.

Currently the Halifax and Dartmouth WWTFs are operating under WSER transitional authorization that expires on December 31, 2040. At such time the facility will be required to achieve the WSER Baseline Minimal Effluent Quality Standards that are currently more stringent that than existing regulations. The Herring Cove WWTF is required to comply with

the WSER as of June 2015 although existing NSE permits are less stringent the facility can maintain compliance due existing flows and loadings less than the facilities design capacity. To help reduce and eliminate non-compliance with existing Approvals to Operate Halifax Water has developed a Compliance Plan as a part of the IRP to address its long-term compliance needs.

To further strengthen the Compliance Plan, in June 2019 Dalhousie University and Halifax Water have signed a Memorandum of Understanding that will direct research initiatives to the advancement of wastewater effluent quality for the protection of public and environmental health. The initial phase of the partnership will focus on improving wastewater effluent quality from the enhanced primary treatment Harbour Solutions Wastewater Treatment Facilities located in Halifax, Dartmouth and Herring Cove to align with the Federal Wastewater Systems Effluent Regulations. This will be accomplished through bench-, pilot-, and full-scale optimization of coagulation/flocculation processes, tracer studies, computational fluid dynamic work to understand the tank hydraulics, application of innovative UV disinfection technology, and assessment of contaminants of emerging concern. The initial phase of the project will span three years to address research needs surrounding the increasing complexity of Canada's wastewater and address the current operational challenges. The program will provide training of highly qualified personnel to address regulatory challenges, outline cost effective methods to meet the Federal effluent regulations, provide advancements in wastewater treatment beneficial to Halifax Water and the industry, as well as align with the research efforts at Dalhousie University for Clean Technology, Energy Efficiency, Environment Protection, Clean Water and Sanitation Sustainable Development Goals.

Additionally, Halifax Water has recommended and is on the process of implementing strategies to address compliance deficiencies are outlined below.

Halifax Water is undertaking the following activities to address ongoing cause of the non-compliances related to disinfection:

- All Trojan UV 3000+ system ultraviolet disinfection lamps and sleeves were replaced during the 2018/19 winter season. Additionally, Halifax Water will be changing the lamps and sleeves on a set time frame rather than relying on UV transmittance.
- Investigating potential modifications to the UV channels by replacing the hydraulic leveling system with motorized weir gates with electrical actuators to ensure lamps remain submerged and reduce scaling on the sleeves.
- Removal of the existing UV baffles and increase UV dose and exposure time by reducing channel velocities by adding additional UV modules and controls within buildout footprint of the existing channels.
- Address the need for improved screenings capture to reduce material being caught up on the screens and allowing of the lamp sleeves to be automatically cleaned efficiently.

Halifax Water acknowledges that the challenges associated with the combined system and is currently planning process improvement to maintain optimal and realistic removal efficiencies with the existing infrastructure. The following activities are being implemented to ensure existing permit compliance related to cBOD and TSS:

- Review of coagulation and flocculation process, i.e.: conducting additional jar testing to arrive at optimum dose across the various design flow regimes and investigate alternative coagulants.
- Further review of data and influent pump/s optimization to enhance hydraulics through the plant.
- Conduct computation fluid dynamics modeling to help improve hydraulic balancing both through passive modifications (baffles, weirs etc.) and active modifications (flow dosing compensation).
- Replacing the chemical feed pumps with pumps that have a wider ranges of flow to meet both high chemical demand periods and low chemical demand periods.
- Relocating the chemical application points to more evenly distribute chemicals to both Densadeg trains, and to both coagulation and flocculation tanks in each train, during times of dry weather flow.
- Investigate setting up two separate chemical feed systems: one to handle low flow conditions and one to handle high flow conditions if a single pump does not meet turndown requirements.
- Implement flow monitoring to each treatment train and reactors to ensure adequate process chemicals are injected to achieve optimal coagulation and flocculation.
- Assessment of exiting tube settlers for optimal surface area to allow for floc to settle and assess alternative clarifications enhancements that allow for easier maintenance and eliminate blockage.
- The Harbour Solutions facilities are were not designed to treat soluble BOD as that requires secondary level of treatment. During periods of unusually low flows, the influent soluble BOD increases which results in CBOD concentrations over the permit values. Additionally, the coagulation/flocculation process is negatively impacted by the wide range of flows typical of a combined sewer system. Ultimately this will have to be addresses as we move to comply with the deadline of the transitional authorization:
- Assess through ongoing research the implications of enhanced removal on secondary treatment requirements such as low alkalinity and effects on nitrification, sludge residual handing requirements, changes in influent wastewater characteristics, aeration system implications and installation issues.

Short-term initiatives relevant to the Harbour Solutions WWTF for the 2020-21 to 2024-25 Business Plan include:

- Preliminary Screening Improvements
- Coagulating Dosing System Upgrades;
- Hydraulic Balancing Improvements;
- Disinfection Upgrades,
- Odour Control Asset Renewal; and
- Solids Dewatering Upgrades.

12.9 Small to Medium Wastewater Treatment Facilities

Halifax Water has seven community based WWTFs in the communities of Springfield Lake, Frame Subdivision, Middle Musquodoboit, Uplands Park, North Preston, Fall River and Wellington. Besides these facilities, there are other medium sized facilities located in the Aerotech Business Park and at Beechville-Lakeside-Timberlea. The compliance with NSE permits has improved at all of these facilities either by virtue of upgrades, asset renewal and process optimization. Aerotech and Frame WWTF are equipped with leading edge Membrane Bioreactor technology while other facilities have seen improvement via peak flow reductions through Wet Weather Management program. These efforts will continue in the future. As regional development encroaches on these systems, there are opportunities to connect them to the larger core systems as identified in the IMP and IRP. The risk of non-compliance with the NSE permits have lowered when compared with previous business plan.

12.10 Energy Costs

Through its Energy Management Program, Halifax Water has committed to an ongoing focus on sustainability and energy efficiency throughout the utility, including water and wastewater operations. This program serves to define the goals, objectives, accountabilities, and structure for activities related to responsible energy use.

The Water and Wastewater/Stormwater departments operating budgets are significantly impacted by energy costs that are expected to increase over the life of this business plan and beyond. Figure 17 provides projected energy cost impacts over the next five years:

Figure 17: Projected Energy Cost Increases and Budget Impacts

Year	Electricity	Heating Fuel Oil	Natural Gas	Water Budget Impact	Wastewater Budget Impact	Total Budget Impact
2019/20	3.0%	5.0%	10.0%	$76,000	$168,000	$244,000
2020/21	6.0%	3.0%	10.0%	$141,000	$301,000	$442,000
2021/22	2.0%	2.0%	2.0%	$7,000	$22,000	$29,000
2022/23	2.0%	2.0%	2.0%	$34,000	$78,000	$112,000
2023/24	2.0%	2.0%	2.0%	$28,000	$66,000	$94,000
2024/25	2.0%	2.0%	2.0%	$28,000	$68,000	$97,000

Notes:
(1) Projected electricity rate increases based on NSPI 2020 – 2022 Fuel Stability Plan and NSUARB rate application dated June 27, 2019, and on historical trends.
(2) Projected HFO rate increases based on historical trends from 2012 to present day.
(3) Projected Natural Gas rate increases based on historical trends from 2012 to present day.

The Energy Management Action Plan identifies energy reduction targets for Water and Wastewater Operations over a five-year planning period. Targets will be reviewed each year and adjusted for future years based on the previous year's performance, operating and capital budget allocations, and anticipated energy price increases.

Water and Wastewater Operation's energy-reduction targets over the next five years are outlined in Figure 18:

Figure 18: Energy Reduction Targets

Year	Water Operations Projected Savings		Wastewater Operations Projected Savings	
	Energy Reduction Target	Energy Savings (kWh_e)	Energy Reduction Target	Energy Savings (kWh_e)
2019/20	3.0%	576,000	3.0%	1,209,000
2020/21	2.0%	372,000	2.0%	782,000
2021/22	2.0%	365,000	2.0%	766,000
2022/23	2.0%	357,000	2.0%	751,000
2023/24	2.0%	350,000	2.0%	736,000
2024/25	2.0%	343,000	2.0%	721,000

As a result of Halifax Water's Energy Management Action Plan, presented with the last general rate application, Halifax Water was able to reduce revenue requirements associated with energy by 2%. Presently the Five-Year Business Plan operating budgets do not incorporate the energy reduction targets outlined in Figure 18. As future electricity rates become known with greater certainty and the energy savings of various initiatives are measured, budgets will be adjusted on an annual basis. The projected savings shown above are also contingent on the availability of human and capital resources as approved in the annual operating and capital budgets. As capital budgets are approved or amended, actual energy savings may need to be adjusted on an annual basis.

To date, a number of potential energy-management opportunities (EMOs) have been identified through low to mid-level energy audits in a number of facilities.

For Water Operations and Corporate facilities, EMOs include HVAC system upgrades, retro-commissioning of PRV- station HVAC systems, lighting retrofits; reactive power correction, variable frequency drive upgrades, pumping system performance upgrades, and new construction design review for energy efficiency.

For Wastewater Operations, EMOs include effluent stream heat recovery, energy recovery from biosolids, retro-commissioning of WWTF and pumping station HVAC systems, UV disinfection system upgrades, UV system channel isolation, variable frequency drive upgrades, and new construction design review for energy efficiency.

A number of these EMOs have been successfully implemented, and some have been partially funded through Efficiency Nova Scotia's various programs.

As new or existing facility construction projects occur, those projects are also evaluated for energy efficiency improvements. Recently completed projects include the new Aerotech Wastewater Treatment Facility, the Eastern Passage WWTF upgrade, the Bedford West Trunk Sewer and Pumping Station Upgrade, the Lakeside/Bayer's Lake PS Upgrade, the Bedford pump station upgrade, and the Herring Cove sanitary pump station. Energy efficiency is now an integral part of the overall project evaluation and design process ensuring improvements are incorporated prior to the construction phase of a given project.

A number of Halifax Water's standard design specifications have also been reviewed to ensure energy efficiency is taken into account in any future new construction activities (e.g., wastewater pumping stations, booster stations, treatment plants).

12.11 Chemical Costs

Water treatment chemicals represent 30% of the cost of running our large water treatment facilities, totally approximately $3 M per year.

Chemicals for water treatment are a secondary markets for many chemical manufactures. For example, chlorine and caustic soda markets are driven by the demand for PVC plastic in the construction and home building industries. Phosphates for corrosion control, and fluoride are secondary markets to the agriculture industry. As a result, demand created by these primary industries can put cost pressure on chemicals consumed by water utilities.

In the last couple of years, after about five years of stable market prices, we have experienced two consecutive years of double digit increases for coagulants due to market consolidation. Caustic Soda Caustic soda has also seen greater and inflation rate increases the last two years

As we begin to look at upgrading treatment process due to lake recovery, this presents an opportunity to select processes which are viable with a wide range of treatment chemical options, thereby opening broader markets for the purchase of treatment chemicals. We will also look for opportunities to use bulk delivered commodity chemicals rather than proprietary or packaged chemicals.

Wastewater and Stormwater Services uses chemicals for wastewater treatment, sludge processing, and odour control. The chemicals represent 13% of the cost of running our WWTFs, at approximately $2,750,000 per year.

All of the WWTFs use UV systems for disinfection with the exception of one community plant in Timberlea which uses chlorine based products. The cost fluctuation risk is mitigated by the very small quantities that is required. Halifax Water has seen stable prices for wastewater treatment chemicals over the last 5 years. Alum and polymers are the largest share of the cost and quantity. The recent contract for polymers is a 3 year term and the price per kilogram is 6% lower than the 2017-18 pricing. As mentioned above, alum is a commodity product. Halifax Water has experienced stable pricing over the years, and it is expected to remain stable over the 5 year period.

Wastewater Collection Services use Bioxide for odour control in the collection system. This proprietary product is proven in the industry to be most effective. Currently, this product is used in Dartmouth at an approximate cost of $150,000 per year. The utility will continue to explore other opportunities or make system enhancements in order to reduce this cost. However, it is expected that the chemical price will remain stable in the near future.

12.12 Lake Recovery

Lake recovery will ultimately require modifications or upgrades to the Pockwock and Lake Major plants. It is also possible that the Bennery lake plant will require upgrades, however that plant has completed a multi-year optimization program that should equip it well enough to deal with water quality challenges for the next several years.

A three pronged approach has been implemented to deal with lake recovery as follows:

Immediate: Operational improvements have been made at all three treatment plants to make them more robust and better equipped to deal with treatment challenges. This includes upgrading and adding instrumentation to provide better information for operators, upgrading chemical delivery systems, and instituting a filter surveillance program so that operators have the best available information about filter performance.

Short-term: Several short-term plant improvements are planned, or have been completed, which will improve plant performance. This includes upgrading filter media and underdrains and installing air scour at Pockwock, and continuing through a ten year upgrade program at

Lake Major which will make the plant more flexible and provide better quality water. Lake Major projects include replacing clarifier plates and tubes, and planning for construction of a new intake and pumping station.

Medium-term: Preparation for plant upgrades have begun on a number of fronts. Recently, design team have been procured to plan out the process upgrade projects. As mentioned above, understanding the impact of lake recovery and studying the impact on the plants makes up two of three research themes through the NSERC Industrial Research Chair with Dalhousie University. Halifax Water was also successful in an application to the Tailored Collaboration Program through the Water Research Foundation which will provide guidance on designing a new plant process while water quality is changing. This project will be completed in early 2020 and the outcome will inform the plant upgrade design teams. All of these activities will position the utility to begin a plant upgrade process for Pockwock and Lake Major in the next 2-4 years, while achieving interim process in the short-term.

12.13 External Funding

The federal and provincial governments have a current bilateral agreement for infrastructure funding under the ***Investing in Canada Infrastructure Program*** (ICIP). The five-year business plan was developed with assumptions with respect to external funding from provincial or federal government partners under the ICIP. The Five-Year Business Plan assumes $51,657,700 in external funding broken down as follows:

- Water - $39,411,200
- Wastewater - $11,972,370
- Stormwater - $274,130

It is anticipated that the federal and provincial governments will announce another round of infrastructure funding in 2020 for implementation beginning in 2021/22.

12.14 Flood Plain Delineation

The Municipality has completed a municipal wide flood risk assessment study for the identified high risk areas across the Municipality. The outcome of the completed study was two detailed studies for the Sackville Rivers and Shubenacadie watersheds. The Sackville study focuses on creating a mitigation plan along the system based on the completed studies. As for the Shubenacadie watershed, the plan is to have a consultant create updated flood mapping for the watershed from Lock 2 to Lock 5. Halifax Water operational and engineering staff will be providing much needed input relating to system knowledge as these and other projects progress.

This information will assist HRM in the planning exercises relating to the placement for new development projects. As well, it will allow for risk assessments and emergency planning to occur relating to existing critical infrastructure and transportation routes.

Halifax Water cost shared this exercise with the Municipality in relation to the National Disaster Mitigation plan to prioritize known drainage issues and flood prone areas. Halifax Water continues to engage with the Municipality on projects where a joint benefit can be achieved with the implementation of mitigation strategies and programs.

12.15 Financial Risks

Some of the most significant risks facing Halifax Water relate to infrastructure, therefore there are financial risks also - insufficient revenues to meet the projected operating requirements, and insufficient capital funding to meet the IRP recommended level of spend.

Halifax Water has experienced net metered consumption decreases of 24.7% over the past seventeen years. On average, the annual reduction is 1.64% which has been managed through changing rate structures, diversifying revenues (stormwater with a different billing determinant), controlling costs, and increasing rates.

13. RECOMMENDATIONS FOR RATE APPLICATIONS

Halifax Water maintains a long range financial model that projects future impacts on revenue requirements, but not rates. It is not possible to accurately project rates, as updated demand analyses and rate studies would have to be conducted for each service prior to an application.

The projected five-year financial model indicates that water and wastewater rate increases will be required after the 2019/20 fiscal year. Halifax Water is planning to submit an application to increase rates for water and wastewater service in February 2020, for rate increases over a two year test period.

A rate application to adjust stormwater rates is also planned for late 2020, with rates to take effect April 1, 2021.

Appendix A

Mission, Vision & Values

&

Corporate Balanced Scorecard

STRAIGHT from the SOURCE

Our Mission:

"To provide world class services
for our customers and our environment"

Our Vision:

- *We will provide our customers with high quality water, wastewater, and stormwater services.*
- *Through adoption of best practices, we will place the highest value on public health, customer service, fiscal responsibility, workplace safety and security, asset management, regulatory compliance, and stewardship of the environment.*
- *We will fully engage employees through teamwork, innovation, and professional development.*

Our Values:

Halifax Water promotes a culture where:

- *All Interactions are respectful, courteous, and civil*
- *We respect confidentiality of people and transparency of process*
- *We have an inclusive environment*
- *We lead by example*
- *We are positive and collaborative*
- *We treat employees and customers equitably*
- *We have a safe, accessible work environment*
- *We are accountable for our actions & behaviours*

Corporate Balanced Scorecard		
Organizational Indicators	**2018/19 Result**	**2019/20 Target**
High Quality Drinking Water		
1. Adherence with 5 objectives of Water Quality Master Plan for all water systems - Percentage of sites achieving targets	64/100	80 - 100/100
2. Bacteriological tests - Percentage free from Total Coliform	99.97%	99.3%
3. Customer satisfaction about water quality - Percentage from customer survey	89%	85%
Service Excellence		
4. Customer satisfaction with service - Percentage from customer survey	96%	90%
5. Water service outages - Number of connection hours/1000 customers	203	200
6. Wastewater service outages – Number of connection hours/1000 customers	2.06	8
7. Average speed of answer – Percentage of calls answered within 20 seconds * Revised in 2019/20. Was previously average call wait time.	N/A	60 – 65%
Responsible Financial Management		
8. Operating expense/revenue ratio percentage	0.764	0.815
9. Annual cost per customer connection – Water	$477	$517
10. Annual cost per customer connection – Wastewater	$684	$708
Effective Asset Management		
11. Water leakage control – target leakage allowance of 160 litres/service connection/day	172	160-170
12. I&I reduction - Number of inspections on private property for discharge of stormwater into the wastewater system	932	900
13. Peak flow reduction from wet weather management capital projects * New in 2019/20	N/A	34-38 l/sec
14. Hours of unplanned outages in GIS and Cityworks	70.85%	95-97%
15. Capital budget expenditures - Percentage of budget spend by end of fiscal year	68.4%	80-90% approved
Workplace Safety and Security		
16. Average score on internal safety audits *New in 2019/20	N/A	85-95%
17. NS Labour and Advanced Education compliance - # of Incidents with written compliance orders	1	0-2
18. Lost time accidents -Number of accidents resulting in lost time per 100 employees	2.5	2.0-3.0

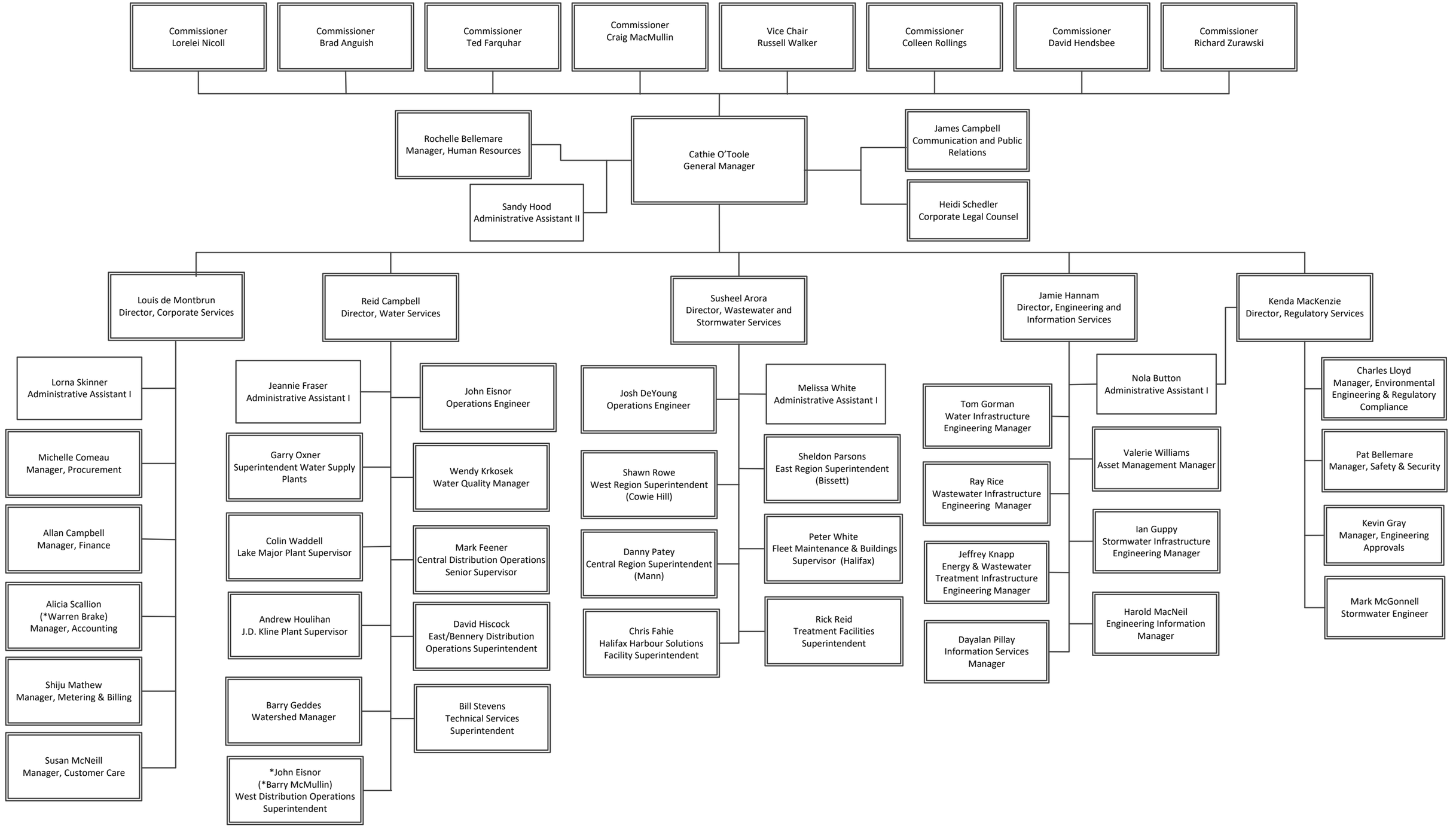
19. Safe driving - Number of traffic Accidents per 1,000,000 km driven	4.3	4
20. Training - Number of employees trained or re-certified before due date	81%	80-90%
21. Percentage of completed safety talks	81%	80-90%
Regulatory Compliance		
22. Percentage of public health and environmental regulatory infractions resulting in an environmental warning report, summary offense ticket, ministerial order, or prosecution	3	0-2
23. Percentage of WWTFs complying with NSE approval permits	94.9%	95-100%
Environmental Stewardship		
24. Number of ICI properties inspected by Pollution Prevention each year	528	500
25. Energy management kwh/m^3 reduction associated with capital projects	4.7%	3%
26. Bio-solids residual handling - % of sludge meeting bio-solids concentration targets	99.5%	92-97%
Motivated and Satisfied Employees		
27. Percentage of grievances resulting in arbitration	0	0
28. Percentage of jobs filled with internal candidates	63%	80%
29. Employee satisfaction survey result	B	A-
30. Average number of days absenteeism	7.8	<7

Appendix B

Organizational Structure

STRAIGHT from the SOURCE

HALIFAX WATER ORGANIZATIONAL STRUCTURE

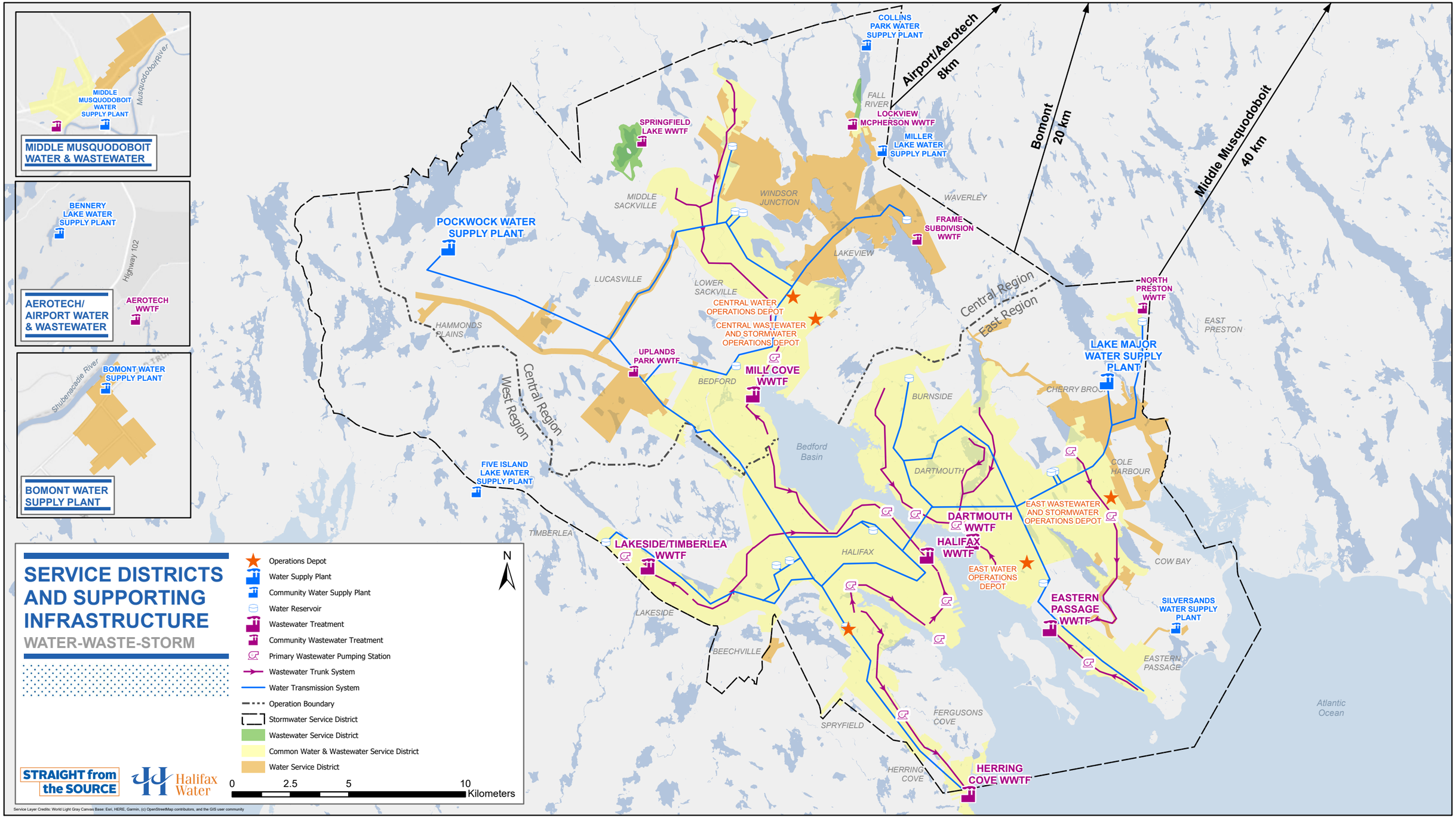


January 2020

Appendix C

Water, Wastewater & Stormwater Service Districts and Supporting Infrastructure

STRAIGHT from the SOURCE


MIDDLE MUSQUODOBOIT WATER & WASTEWATER
MIDDLE MUSQUODOBOIT WATER SUPPLY PLANT
Musquodoboit River
AEROTECH/ AIRPORT WATER & WASTEWATER
BENNERY LAKE WATER SUPPLY PLANT
Highway 102
AEROTECH WWTF
BOMONT WATER SUPPLY PLANT
Shubenacadie River
BOMONT WATER SUPPLY PLANT
COLLINS PARK WATER SUPPLY PLANT
Airport/Aerotech 8km
Bomont 20 km
Middle Musquodoboit 40 km
FALL RIVER
LOCKVIEW MCPHERSON WWTF
MILLER LAKE WATER SUPPLY PLANT
SPRINGFIELD LAKE WWTF
MIDDLE SACKVILLE
WINDSOR JUNCTION
WAVERLEY
FRAME SUBDIVISION WWTF
POCKWOCK WATER SUPPLY PLANT
LAKEVIEW
LUCASVILLE
LOWER SACKVILLE
CENTRAL WATER OPERATIONS DEPOT
CENTRAL WASTEWATER AND STORMWATER OPERATIONS DEPOT
HAMMONDS PLAINS
UPLANDS PARK WWTF
BEDFORD
MILL COVE WWTF
Central Region
East Region
NORTH PRESTON WWTF
EAST PRESTON
LAKE MAJOR WATER SUPPLY PLANT
BURNSIDE
CHERRY BROOK
West Region
Central Region
Bedford Basin
DARTMOUTH
COLE HARBOUR
FIVE ISLAND LAKE WATER SUPPLY PLANT
DARTMOUTH WWTF
EAST WASTEWATER AND STORMWATER OPERATIONS DEPOT
TIMBERLEA
LAKESIDE/TIMBERLEA WWTF
HALIFAX
HALIFAX WWTF
EAST WATER OPERATIONS DEPOT
COW BAY
EASTERN PASSAGE WWTF
SILVERSANDS WATER SUPPLY PLANT
LAKESIDE
BEECHVILLE
EASTERN PASSAGE
Atlantic Ocean
FERGUSONS COVE
SPRYFIELD
HERRING COVE
HERRING COVE WWTF
SERVICE DISTRICTS AND SUPPORTING INFRASTRUCTURE
WATER-WASTE-STORM
Operations Depot
Water Supply Plant
Community Water Supply Plant
Water Reservoir
Wastewater Treatment
Community Wastewater Treatment
Primary Wastewater Pumping Station
Wastewater Trunk System
Water Transmission System
Operation Boundary
Stormwater Service District
Wastewater Service District
Common Water & Wastewater Service District
Water Service District
N
0
2.5
5
10
Kilometers
STRAIGHT from the SOURCE
Halifax Water
Service Layer Credits: World Light Gray Canvas Base: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Appendix D

Projected Capital Budgets for

2020/21 to 2024/25

STRAIGHT from the SOURCE

2020 - 21 to 2024 - 25 Capital Expenditure Program	TOTALS					
	All $ in 000's					
	Y1	Y2	Y3	Y4	Y5	Y1 to Y5
	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025	Totals
Water / Wastewater / Stormwater Budget Summary						
Water - Land	$100	$100	$100	$100	$100	$500
Water - Transmission	$10,453	$6,738	$7,894	$8,122	$11,036	$44,243
Water - Distribution	$5,277	$6,595	$6,495	$6,320	$6,495	$31,182
Water - Structures	$10,980	$9,520	$11,197	$5,360	$7,400	$44,457
Water - Treatment Facilities	$15,129	$38,418	$30,438	$25,496	$23,846	$133,327
Water - Energy	$200	$200	$200	$200	$200	$1,000
Water - Security	$50	$50	$50	$50	$50	$250
Water - Equipment	$103	$50	$50	$50	$50	$303
Water - Corporate Projects	$6,638	$12,485	$12,051	$3,623	$3,718	$38,515
Sub Total - Water	$48,930	$74,156	$68,475	$49,321	$52,895	$293,777
Wastewater - Trunk Sewers	$500	$14,025	$2,000	$2,000	$2,000	$20,525
Wastewater - Collection System	$14,473	$24,407	$22,165	$31,582	$26,560	$119,187
Wastewater - Forcemains	$825	$1,000	$1,000	$1,000	$16,100	$19,925
Wastewater - Structures	$8,415	$9,343	$8,144	$5,900	$11,677	$43,479
Wastewater - Treatment Facilities	$5,525	$9,841	$13,286	$39,771	$29,804	$98,227
Wastewater - Energy	$75	$600	$600	$600	$600	$2,475
Wastewater - Security	$200	$200	$200	$200	$0	$800
Wastewater - Equipment	$255	$145	$145	$145	$145	$835
Wastewater - Corporate Projects	$8,180	$13,434	$12,751	$6,246	$6,188	$46,799
Sub Total - Wastewater	$38,448	$72,995	$60,291	$87,444	$93,074	$352,252
Stormwater - Pipes	$2,380	$3,992	$14,469	$5,474	$6,101	$32,416
Stormwater - Culverts/Ditches	$3,107	$2,930	$2,125	$2,950	$2,445	$13,557
Stormwater - Structures	$1,900	$2,100	$500	$1,000	$1,000	$6,500
Stormwater - Security	$0	$0	$0	$0	$0	$0
Stormwater - Equipment	$0	$0	$0	$0	$0	$0
Stormwater - Corporate Projects	$1,750	$2,827	$2,999	$1,017	$1,360	$9,953
Sub Total - Stormwater	$9,137	$11,849	$20,093	$10,441	$10,906	$62,426
TOTALS - Water/Wastewater/Stormwater	$96,514	$158,999	$148,859	$147,205	$156,874	$708,451

Five Year Capital Budget - Water

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
Water - Land									
3.033	Watershed Land Acquisition	HRM	$100	$100	$100	$100	$100	$500	$0
Water - Land -- T O T A L S			**$100**	**$100**	**$100**	**$100**	**$100**	**$500**	**$0**
Water - Transmission									
3.042	Critical Valve Replacement Program	HRM	$300	$300	$300	$300	$300	$1,500	$0
3.503	Chain Control Valve Upgrade Program	West	$45					$45	$0
3.581	Transmission Main Monitoring System Pilot	HRM	$200					$200	$0
3.550	Burnside Connextor - Transmission Main Corridor - Rock Trench	East/Central			$815			$815	$0
3.549	Chain Control Transmission - Existing Peninsula Low Upsize	West	$100	$2,013			$1,728	$3,841	$0
3.552	Chain Control Transmission - Existing Peninsula Intermediate Upsize	West	$100	$1,358			$1,192	$2,650	$0
3.553	Peninsula Intermediate Looping - Quinpool Rd to Young St	West					$431	$431	$3,888
3.562	Geizer 158 to Lakeside High Looping	West					$225	$225	$2,000
3.564	Herring Cove Rd Looping - McIntosH Street	West	$228					$228	$0
3.568	Tacoma PRV Chamber	East	$420					$420	$0
3.291	Port Wallace Transmission Main - Caledonia Section	East	$6,000					$6,000	$0
3.571	Highway 118 Crossing - Shubie Park to Dartmouth Crossing	East			$300	$5,763		$6,063	$0
3.554	North End Feeder Replacement	West	$200	$200	$1,731	$1,731	$6,919	$10,781	$16,595
3.572	New Primary Feed to Sackville High	Central						$0	$4,953
3.574	Cobequid Looping	Central				$223	$223	$446	$1,784
3.551	Wellington Connector - Transmission Main Corridor - Rock Trench	Bennery			$505			$505	$0
3.399	Cogswell Interchange - Water Transmission Main Realignments	West	$2,850	$2,850	$2,850			$8,550	$0
3.504	Burnside Expansion Phase 13 - Watermain Oversizing Cost Share	East			$1,220			$1,220	$0
3.045	Bedford West CCC - Various Phases	Central	$5	$2	$28	$5	$18	$58	$0
3.260	Morris (Russell) Lake Estates CCC	East		$15				$15	$0
3.261	Lakeside Timberlea CCC	West	$5			$100		$105	$0
3.343	Northgate Oversizing	Central			$145			$145	$0
Water - Transmission -- T O T A L S			**$10,453**	**$6,738**	**$7,894**	**$8,122**	**$11,036**	**$44,243**	**$29,220**
Water - Distribution									
3.022	Water Distribution - Main Renewal Program	HRM	$3,525	$5,000	$5,175	$5,000	$5,175	$23,875	$0
3.067	Valves Renewals	HRM	$125	$125	$125	$125	$125	$625	$0
3.068	Hydrants Renewals	HRM	$75	$75	$75	$75	$75	$375	$0
3.069	Service Lines Renewals	HRM	$100	$100	$100	$100	$100	$500	$0
3.390	Lead Service Line Replacement Program	HRM	$1,000	$1,000	$1,000	$1,000	$1,000	$5,000	$0
3.294	Automated Flushing Program	HRM	$20	$20	$20	$20	$20	$100	$0
3.334	Coburg Road Bridge Watermain Replacement	West	$300					$300	$0
3.501	South Street CN Bridge Watermain Installation	West	$25	$275				$300	$0
3.296	Water Sampling Station Relocation Program	HRM	$10					$10	$0
3.513	Meadowbrook PRV Chamber - Replace PRV Valves	Central	$35					$35	$0

Five Year Capital Budget - Water

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
3.569	Fall River Rechlorination Station	Central	$25					$25	$0
3.573	Spring Garden Road - Water Design Services	West	$37					$37	$0
Water - Distribution -- T O T A L S			**$5,277**	**$6,595**	**$6,495**	**$6,320**	**$6,495**	**$31,182**	**$0**
Water - Structures									
3.262	Chambers, Pumping Stations and Distribution Monitoring Asset Renewal Program	HRM	$0	$350	$350	$350	$350	$1,400	$0
3.512	Eaglewood Pumping Station - New Pump Control Panel	Central	$35					$35	$0
3.514	Steel Reservoir Climbing Systems - Safety Upgrades	HRM	$225	$225				$450	$0
3.116	Bedford South (Hemlock) Reservoir CCC	West	$10,160					$10,160	$0
3.309	Cowie Hill Reservoir Replacement	West	$200	$8,040				$8,240	$0
3.288	Akerley Reservoir Rehabilitation	East		$300	$5,100			$5,400	$0
3.515	Meadowbrook Reservoir Overflow Pipe Replacement	Central	$70					$70	$0
3.517	Mount Edward Control Chamber - Extension of Power Supply	East	$20					$20	$0
3.508	Beaver Bank Reservoir Rehabilitation	Central			$720			$720	$0
3.509	Aerotech Reservoir Rehabilitation	Aerotech			$200	$2,160		$2,360	$0
	Aerotech Storage	Aerotech		$400	$4,352			$4,752	$0
3.511	Stokil Reservoir Rehabilitation	Central					$300	$300	$5,330
3.510	Mount Edward 2 Steel Reservoir Rehabilitation	East				$300	$5,100	$5,400	$0
3.453	Geizer 123 Reservoir Rehabilition	West			$150	$2,400		$2,550	$0
3.454	Robie Street Reservoir Rehabilitation	West				$150	$1,650	$1,800	$0
3.523	Lake Major Dam - Site Improvements	East	$240					$240	$0
3.528	Beaver Bank Booster Station - Pump Upgrades	Central	$30	$180				$210	$0
3.561	Prince Albert PRV Chamber Replacement	East		$25	$325			$350	$0
Water - Structures -- T O T A L S			**$10,980**	**$9,520**	**$11,197**	**$5,360**	**$7,400**	**$44,457**	**$5,330**
Water - Treatment Facilities									
	JD Kline Water Supply Plant:								
3.264	JD Kline WSP Upgrade Program	W/C				$300		$300	$0
3.541	JD Kline WSP - Process Upgrades - Phase 1 - New Clarifier and Pre-Treatment	W/C	$1,475	$16,220	$12,535	$3,690		$33,920	$0
3.542	JD Kline WSP - Process Upgrades - Phase 1 - Backwash Optimization	W/C	$1,700	$1,700				$3,400	$0
3.543	JD Kline WSP - Process Upgrades - Phase 1 - Building Improvements	W/C	$110	$1,440	$1,000			$2,550	$0
3.544	JD Kline WSP - Process Upgrades - Phase 1 - Raw Water Pumping Station	W/C			$670	$5,975	$6,900	$13,545	$1,725
3.545	JD Kline WSP - Process Upgrades - Phase 1 - Lagoon Upgrades	W/C				$740	$3,900	$4,640	$3,840
3.546	JD Kline WSP - Process Upgrades - Phase 1 - Pilot Plant Replacement	W/C					$150	$150	$1,550
3.141	JD Kline WSP - Pumping Station - Raw Water Valve Actuators Replacement	W/C	$100	$100	$100			$300	$0
3.428	JD Kline WSP - Caustic Tank Liner Replacements	W/C	$25					$25	$0
3.465	JD Kline WSP - Low Lift Pump Replacements	W/C	$1,120	$1,000				$2,120	$0
3.351	JD Kline WSP - Replace Westinghouse Electrical Panels	W/C	$8	$8	$8	$8	$8	$40	$0
3.530	JD Kline WSP - Alum Tank Liner Replacement	W/C	$45					$45	$0
3.531	JD Kline WSP - New Ultrasonic Level Transmitter	W/C	$10					$10	$0

Five Year Capital Budget - Water

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
3.472	JD Kline WSP - Replace Floc Tank Valve Actuators	W/C	$35					$35	$0
3.374	JD Kline WSP - Replace Filter Isolation Gates Program	W/C	$300	$300	$300	$300	$300	$1,500	$0
3.463	JD Kline WSP - New Fluoride Supply Line	W/C		$15				$15	$0
3.431	JD Kline WSP - Fluoride Tank Liner Replacement	W/C		$19				$19	$0
3.475	JD Kline WSP - Low Lift Station Intake Structure Concrete Rehabilitation	W/C			$160			$160	$0
	Lake Major Water Supply Plant:								
3.532	Lake Major WSP - Phase 1 - Temporary Side Stream	East	$3,320	$2,990	$1,330			$7,640	$0
3.533	Lake Major WSP - Phase 1 - New Clarifiers and Pre-Treatment	East	$1,770	$9,290	$7,520	$1,770		$20,350	$0
3.534	Lake Major WSP - Phase 1 - Filtration System Replacement	East	$370			$4,055	$4,055	$8,480	$0
3.535	Lake Major WSP - Phase 1 - Raw Water Pump Station	East	$265	$665	$4,380	$5,710	$4,250	$15,270	$0
3.536	Lake Major WSP - Phase 1 - Building Additions	East	$184	$2,396	$1,660			$4,240	$0
3.537	Lake Major WSP - Phase 1 - New Pilot Plant	East			$150	$1,550		$1,700	$0
3.538	Lake Major WSP - Phase 1 - Residuals Management	East				$738	$3,908	$4,646	$3,834
3.162	Lake Major WSP - Butterfly valve replacement program	East	$350	$350				$700	$0
3.507	Lake Major WSP - New Boat Launch	East	$42					$42	$0
3.321	Lake Major WSP - Replace Fluoride Tank and Piping	East	$250					$250	$0
3.557	Lake Major WSP - Sludge Drying Beds Improvements	East	$500	$500				$1,000	$0
3.526	Lake Major WSP - Roof Replacement	East	$400					$400	$1,000
3.506	Lake Major WSP - Driveway Pavement Renewal	East		$0				$0	$390
3.560	Lake Major WSP - Emergency Pumps - Sitework Preparations	East	$320					$320	$0
3.524	Lake Major WSP - Fuel Storage for Generator at Low Lift Station	East	$135					$135	$0
	Bennery Lake Water Supply Plant:								
3.267	Bennery Lake WSP - Upgrade Program	Bennery	$0	$225	$225	$0	$225	$675	$0
3.477	Aerotech Booster Station Capital Upgrades	Aerotech	$200	$800				$1,000	$0
3.488	Bennery Lake WSP - Surge Anticipator Valves Replacement	Bennery	$100					$100	$0
3.486	Bennery Lake WSP - Access Road Upgrade	Bennery	$1,500					$1,500	$0
3.489	Bennery Lake WSP - Manganese Removal Strategy	Bennery			$100	$435		$535	$0
	Non - Urban Core Water Supply Plant:								
3.266	Non-Urban Core WSP Upgrade program	HRM		$150	$150	$150	$150	$600	$0
3.582	Bomont Equipment Upgrade	HRM	$150					$150	$0
3.518	Pump Replacement Program - Small Systems	HRM	$45					$45	$0
3.455	Reservoir Mixing and Residuals Management Upgrade Program	HRM	$300	$250	$150	$75		$775	$0
Water - Treatment Facilities -- T O T A L S			**$15,129**	**$38,418**	**$30,438**	**$25,496**	**$23,846**	**$133,327**	**$12,339**
Water - Energy									
3.221	Energy Management Capital Program (Water)	HRM	$100	$100	$100	$100	$100	$500	$0
3.107	Chamber HVAC Retro-Commissioning Program	HRM	$100	$100	$100	$100	$100	$500	$0
Water - Energy -- T O T A L S			**$200**	**$200**	**$200**	**$200**	**$200**	**$1,000**	**$0**

Five Year Capital Budget - Water

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
Water - Security									
4.009	Security Upgrade Program	HRM	$50	$50	$50	$50	$50	$250	$0
Water - Security -- T O T A L S			**$50**	**$50**	**$50**	**$50**	**$50**	**$250**	**$0**
Water - Equipment									
3.101	Miscellaneous Equipment Replacement	HRM	$50	$50	$50	$50	$50	$250	$0
3.502	Leak Detection Equipment	HRM	$8					$8	$0
3.516	Purchase Hydraulic Saws	HRM	$45					$45	$0
Water - Equipment -- T O T A L S			**$103**	**$50**	**$50**	**$50**	**$50**	**$303**	**$0**
TOTALS - Water			**$42,292**	**$61,671**	**$56,424**	**$45,698**	**$49,177**	**$255,262**	**$46,889**

Five Year Capital Budget - Wastewater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
Wastewater - Trunk Sewers									
2.526	Wastewater Trunk Sewer Asset Renewal Program	HRM			$2,000	$2,000	$2,000	$6,000	$0
2.822	Odour Level of Service and Optimization Review	West	$100					$100	$0
2.467	Kearney Lake Road Wastewater Sewer Upgrades	West						$0	$4,100
2.584	Fairview Cove Trunk Sewer	West	$400	$14,025				$14,425	$0
Wastewater - Trunk Sewers -- T O T A L S			**$500**	**$14,025**	**$2,000**	**$2,000**	**$2,000**	**$20,525**	**$4,100**
Wastewater - Collection System									
2.052	Integrated Wastewater Projects - Program	HRM	$2,000	$1,700	$1,800	$1,700	$1,840	$9,040	$0
2.168	Wastewater System - Trenchless Rehabilitation Program	HRM	$3,000	$2,000	$2,000	$2,000	$2,000	$11,000	$0
2.504	Collection System Asset Renewal Program	HRM			$0	$500	$500	$1,000	$0
2.830	Eastern Passage RDII Reduction Program FMZ24	East				$862	$707	$1,569	$0
2.831	Eastern Passage RDII Reduction Program FMZ37	East		$1,364	$1,116			$2,480	$0
2.832	Mill Cove RDII Reduction Program FMZ07 & FMZ40	Central		$3,271	$2,500	$1,241		$7,012	$0
2.833	Mill Cove RDII Reduction Program FMZ10	Central				$157	$1,414	$1,571	$0
2.834	Ellenvale area RDII Reduction Program	East			$370	$1,667	$1,667	$3,704	$0
2.835	LoWSCA: Canal Street Separation	East			$184	$829	$829	$1,842	$0
2.836	Wyse Road Separation Phase 1	East	$386	$1,737	$1,737			$3,860	$0
2.837	Wyse Road Separation Phase 2	East			$280	$1,261	$1,261	$2,802	$0
2.838	Albro Lakes Watershed Separation	East	$811	$3,650	$3,650			$8,111	$0
2.839	Eastern Passage Gravity Pressure Sewer	East		$300	$2,037	$5,843	$5,843	$14,023	$11,686
2.840	Eastern Passage Gravity Pressure Sewer - Install new pump out stations	East				$168	$168	$336	$1,340
2.841	Local network upgrades on Beaver Bank Road - Design (and North of Glendale Drive)	Central	$176	$138	$939	$939		$2,192	$0
2.842	Local network upgrades on Beaver Bank Road. At Galloway Drive	Central	$0		$100	$670	$670	$1,440	$0
2.843	Local network upgrades on Beaver Bank Road. By Windgate Drive	Central	$0		$111	$750	$750	$1,611	$0
2.844	Atlantic Street Upgrade	East		$50		$383	$383	$816	$3,015
2.845	Pleasant Street Upgrade	East				$77	$690	$767	$0
2.852	Maynard Lake and Clement Street Wetland Separation	East			$642	$4,540	$1,155	$6,337	$453
2.692	Cogswell Redevelopment - Sewer Relocation	West	$1,000	$1,000	$1,000			$3,000	$0
2.557	Punch Bowl PS Eliminiation	West	$100	$2,320				$2,420	$0
2.746	Sewer Relocation at South Street CN Bridge	West	$450					$450	$0
2.437	Hines Road Rider Sewer Extension	East	$80	$400				$480	$0
2.356	Auburn Avenue PS Elimination	West		$60	$645			$705	$0
2.357	Manhole Renewals WW	HRM	$25	$25	$28	$28	$28	$134	$0
2.358	Lateral Replacements WW (non-tree roots)	HRM	$1,720	$1,750	$1,785	$1,820	$1,856	$8,931	$0
2.563	Lateral Replacements WW (tree roots)	HRM	$541	$552	$567	$582	$594	$2,836	$0
2.223	Wet Weather Management Program	HRM	$350	$350	$350	$350	$350	$1,750	$0
2.074	Bedford West Collection System CCC	West	$39		$24			$63	$0

Five Year Capital Budget - Wastewater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
	- WRWIP PROJECTS							$0	$0
2.672	Young Street - Sewer Separation	West	$100	$1,430				$1,530	$0
2.674	South Park Street - Sewer Separation	West	$3,270					$3,270	$0
2.679	College Street - Sewer Separation	West	$100	$2,310				$2,410	$0
2.675	Bayers Road Phase 1 - Sewer Separation	West			$100	$1,375		$1,475	$0
2.743	Spring Garden Road Phase 1 - Sewer Separation	West			$100	$1,880		$1,980	$0
1.233	Spring Garden Road Phase 2 - Sewer Separation	West				$100	$1,570	$1,670	$0
2.742	Windsor - Almon - Sewer Separation	West				$100	$2,285	$2,385	$0
2.744	Young Street Pocket - Sewer Separation - Side Streets	West			$100	$1,760		$1,860	$0
2.526	Prince Albert Road Sewer Separation - Side Streets	East	$325					$325	$0
Wastewater - Collection System -- T O T A L S			**$14,473**	**$24,407**	**$22,165**	**$31,582**	**$26,560**	**$119,187**	**$16,494**
Wastewater - Forcemains									
2.080	Forcemain Replacement Program	HRM		$400	$1,000	$1,000	$1,000	$3,400	$0
2.823	Akerley Blvd Forcemain Replacement	East	$65	$600				$665	$0
2.819	Pumping Station Oil Tank Replacements	HRM	$60					$60	$0
2.820	Morris Lake Forcemain Investigation and Rehabilitation	East	$500					$500	$0
2.608	New Timberlea Pump Station Forcemain System	West	$200				$15,100	$15,300	$0
Wastewater - Forcemains -- T O T A L S			**$825**	**$1,000**	**$1,000**	**$1,000**	**$16,100**	**$19,925**	**$0**
Wastewater - Structures									
2.420	Emergency Pumping Station Pump Replacements	HRM	$250	$250	$250	$250	$250	$1,250	$0
2.442	Wastewater Pumping Station Component Replacement Program - West Region	West	$200	$200	$200	$200	$200	$1,000	$0
2.443	Wastewater Pumping Station Component Replacement Program - East Region	East	$200	$200	$200	$200	$200	$1,000	$0
2.444	Wastewater Pumping Station Component Replacement Program - Central Region	Central	$250	$250	$250	$250	$250	$1,250	$0
2.476	Wastewater Pumping Station Asset Renewal Program	HRM			$0	$4,000	$4,000	$8,000	$0
2.818	Jamieson Pumping Station - Automatic Bar Screen	East	$60	$840				$900	$0
2.853	Fairfield Holding Tank - Concept Design	West	$150					$150	$0
2.824	Bruce Street Pumping Station Relocation	East	$150	$1,380				$1,530	$0
2.827	Wastewater Pumping Station Generator Plug/Switch Installations	HRM	$125					$125	$0
2.825	First Lake Pumping Station Upgrades	Central	$70	$640				$710	$0
2.654	PS Control Panel / Electrical Replacement	HRM	$725					$725	$0
2.829	Armcrest Pumping Station - Piping and Valve Upgrades	Central	$71					$71	$0
2.005	Autoport Pleasant Street PS Replacement	East	$3,000					$3,000	$0
2.660	Bissett PS Component Upgrade	East	$50	$1,200				$1,250	$0
2.655	Roach's Pond PS Component Upgrade	West	$550					$550	$0
2.088	Russell Lake PS Upgrade	East	$0	$2,475				$2,475	$0
2.093	Windmill Road PS Replacement	East	$1,355					$1,355	$0
2.665	CSO Upgrade Program	HRM	$300	$300	$1,000	$1,000	$1,000	$3,600	$0

Five Year Capital Budget - Wastewater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
2.459	William's Lake PS Rehabilition	West	$100		$2,710			$2,810	$0
2.740	Duffus PS CSO - Modification	West	$100		$2,240			$2,340	$0
2.846	Upgrade Quigley Corner Pumping Station	East	$287	$1,294	$1,294			$2,875	$0
2.847	Optimize Quigley Corner Pumping Station	East	$22	$314				$336	$0
2.609	New Timberlea Pumping Station	West	$400				$5,560	$5,960	$0
2.617	WRWIP_YoungeStreet: Upgrade Young Pumping Station Capacity - Pumps_YNG_PS	West					$217	$217	$1,952
Wastewater Structures -- T O T A L S			**$8,415**	**$9,343**	**$8,144**	**$5,900**	**$11,677**	**$43,479**	**$1,952**
Wastewater - Treatment Facility									
2.056	Plant Optimization Program	HRM	$125	$125	$125	$125	$125	$625	$0
2.522	Emergency Wastewater Treatment Facility equipment replacements	HRM	$400	$400	$400	$400	$400	$2,000	$0
2.668	Wastewater Research Program Pilot Plant	HRM	$300					$300	$0
2.564	Carbon Media Replacement	HRM		$50			$50	$100	$0
2.849	HHSP - OCS H2S Analysers	HRM	$60					$60	$0
2.720	Harbour WWTFs - Outfall Inspection Program	HRM					$30	$30	$0
2.701	HHSP - OCS Wet Scrubber Chlorine Analyzers	HRM	$60					$60	$0
	Halifax Wastewater Treatment Facility:								
2.506	Halifax WWTF - Asset Renewal Program	West			$750	$750	$750	$2,250	$0
2.532	Halifax WWTF - Duct Work Replacement	West	$50	$50	$50	$50	$50	$250	$0
2.765	Halifax WWTF - Raw Water Pump Refurbishment	West	$50	$50	$50	$50	$50	$250	$0
2.767	Halifax WWTF - Fixed Gas Meters - Replacement	West	$150					$150	$0
2.768	Halifax WWTF - New Coagulant Dosing System	West	$100					$100	$0
2.769	Halifax WWTF - New Polymer Dosing System	West	$40					$40	$0
2.770	Halifax WWTF - Sludge Pumps - New Mechanical Seals	West	$60					$60	$0
2.706	Halifax WWTF - Desadeg Hydraulic Optimization	West	$100					$100	$0
2.762	Halifax WWTF - Fine Screens - Replace with Perforated Plate Screens	West		$1,900				$1,900	$0
2.772	Halifax WWTF - Grit System - Parts Replacements and New Screws	West	$50	$150				$200	$0
2.773	Halifax WWTF - Industrial Water System - Replacement	West	$50	$0				$50	$0
2.774	Halifax WWTF - UV Disinfection System - New Modules and PLC Upgrade	West			$900			$900	$0
2.775	Halifax WWTF - UV Disinfection System - New Automatic Level Controls	West			$500			$500	$0
2.776	Halifax WWTF - Sludge Dewatering - Fournier Press Upgrades	West	$50	$1,000				$1,050	$0
2.777	Halifax WWTF - Densadegs - Sludge Scraper Rebuilds (x2)	West		$100				$100	$0
2.778	Halifax WWTF - Densadegs - Mixer Gearbox Rebuilds	West		$70	$70	$70		$210	$0
2.779	Halifax WWTF - Densadegs - Lamella Tube Settler Upgrades	West		$800				$800	$0
	Dartmouth Wastewater Treatment Facility:								
2.507	Dartmouth WWTF - Asset Renewal Program	East	$0	$500	$500	$500	$500	$2,000	$0
2.502	Dartmouth WWTF - Duct Work Replacement	East	$50	$50	$50	$50	$50	$250	$0
2.781	Dartmouth WWTF - Fine Screens - New Perforated Plate Screens	East	$1,800					$1,800	$0

Five Year Capital Budget - Wastewater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
2.783	Dartmouth WWTF - New Coagulant Dosing System	East	$100					$100	$0
2.784	Dartmouth WWTF - New Polymer Dosing System	East	$40					$40	$0
2.707	Dartmouth WWTF - Densadegs - CFD Analysis and Flow Diversion Vanes	East	$110					$110	$0
2.785	Dartmouth WWTF - Heat Exchangers - Refurbishment	East	$40					$40	$0
2.787	Dartmouth WWTF - Sludge Pumps - New Mechanical Seals	East	$60					$60	$0
2.788	Dartmouth WWTF - UV Disinfection System - New Modules and PLC Upgrade	East		$775				$775	$0
2.789	Dartmouth WWTF - UV Disinfection System - New Automatic Level Controls	East		$500				$500	$0
2.790	Dartmouth WWTF - Fournier Press - Sludge Dewatering Upgrade	East				$800		$800	$0
2.791	Dartmouth WWTF - Desadegs - Lamella Tube Settler Replacements	East	$300	$300				$600	$0
2.850	Dartmouth WWTF - Ballasted Flocculation Pilot	East	$75					$75	$0
2.855	Dartmouth WWTF - Industrial Water System Replacement	East	$50					$50	$0
2.851	Dartmouth WWTF - New Coarse Screen	East					$400	$400	$0
	Herring Cove Wastewater Treatment Facility:								
2.508	Herring Cove WWTF - Asset Renewal Program	West	$0	$250	$250	$250	$250	$1,000	$0
2.639	Herring Cove WWTF - Duct Work Replacement Program	West	$50	$50	$50	$50	$50	$250	$0
2.794	Herring Cove WWTF - Spare Sludge Tank Mixer	West	$25					$25	$0
2.795	Herring Cove WWTF - Sludge Pumps - New Mechanical Seals	West	$40					$40	$0
2.796	Herring Cove WWTF - New Coagulant Dosing System	West	$30					$30	$0
2.797	Herring Cove WWTF - Heat Exchangers - Refurbishment	West	$40					$40	$0
2.798	Herring Cove WWTF - Waste Oil System - New Waste Oil Tank	West	$15					$15	$0
2.799	Herring Cove WWTF - Electrical System - Spare Transfer Switch	West	$40					$40	$0
2.856	Herring Cove WWTF - Industrial Water System Replacement	West	$50					$50	$0
2.800	Herring Cove WWTF - Densadegs - Lamella Tube Settler Replacement	West		$400				$400	$0
2.801	Herring Cove WWTF - Fine Screens - New Perforated Plate Screens	West			$1,500			$1,500	$0
2.802	Herring Cove WWTF - UV Disinfection System - New Automatic Level Controls	West				$400		$400	$0
2.803	Herring Cove WWTF - Ballasted Flocculation Upgrades	West				$3,500		$3,500	$0
	Mill Cove Wastewater Treatment Facility:								
2.505	Mill Cove WWTF - Asset Renewal Program	Central		$350	$350			$700	$0
2.804	Mill Cove WWTF - OCS Carbon Replacements	Central	$0	$40	$40			$80	$0
2.640	Mill Cove WWTF - Process Upgrades - Preliminary + Detailed Design	Central		$901	$901			$1,802	$0
2.817	Mill Cove WWTF - Plant Upgrade - Design and Contract Admin	Central			$5,850	$5,850		$11,700	$0
2.805	Mill Cove WWTF - Plant Upgrade - Construction and Commissioning	Central				$25,499	$25,499	$50,998	$25,500
	Eastern Passage Wastewater Treatment Facility:								
2.666	Eastern Passage WWTF - Asset Renewal Program	East	$0	$150	$150	$150	$150	$600	$0
2.468	Eastern Passage WWTF - Process Upgrade Program	East	$0	$0	$0	$0	$0	$0	$0
2.646	Eastern Passage WWTF - Secondary Launder Covers	East	$150					$150	$0
2.806	Eastern Passage WWTF - Carbon Replacement	East	$0	$120				$120	$0

Five Year Capital Budget - Wastewater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
2.807	Eastern Passage WWTF - UV Disinfection System - Spare Parts	East		$40				$40	$0
2.808	Eastern Passage WWTF - New Yard Tractor	East				$12		$12	$0
	Aerotech Wastewater Treatment Facility:								
2.667	Aerotech WWTF - Asset Renewal Program	Aerotech		$150	$200	$250	$250	$850	$0
2.809	Aerotech WWTF - Road Rehabilition	Aerotech	$25					$25	$0
2.810	Aerotech WWTF - Bioreactors - Short Circuiting Modifications	Aerotech	$200					$200	$0
2.811	Aerotech WWTF - Lab - HVAC Modifications	Aerotech	$75					$75	$0
2.812	Aerotech WWTF - Centrifuge - Rebuild	Aerotech	$50		$50		$50	$150	$0
2.814	Aerotech WWTF - Lagoon Dredging	Aerotech					$600	$600	$0
	Timberlea Wastewater Treatment Facility:								
2.509	Asset Renewal Program	West		$50	$50			$100	$0
2.647	Decommissioning	West				$500		$500	$0
2.816	Timberlea WWTF - Grit System - Chain and Bucket Replacement	West	$50					$50	$0
	Community Wastewater Treatment Facility:								
2.050	Community WWTFs - Asset Renewal Program	HRM	$0	$250	$250	$250	$250	$1,000	$0
2.761	Springfield Lake - Driveway Refurbishment	HRM	$15					$15	$0
	Biosolids Processing Facility:								
2.126	Biosolids Processing Facility - Asset Renewal Program	HRM				$250	$250	$500	$0
2.857	Biosolids Processing Facility - Building Upgrades	HRM	$250					$250	$0
2.732	Biosolids Processing Facility - Conveyor CS1 Liners	HRM	$30					$30	$0
2.733	Biosolids Processing Facility - Biofilter Media	HRM	$50		$50		$50	$150	$0
2.815	Biosolids Processing Facility - Dryer Upgrades	HRM	$70					$70	$0
2.734	Biosolids Processing Facility - Serpentix Conveyor Refurbishment	HRM		$30				$30	$0
2.735	Biosolids Processing Facility - Live Bottom Bin Rebuild	HRM		$150				$150	$0
2.513	Biosolids Processing Facility - Silo Painting	HRM		$90				$90	$0
2.736	Biosolids Processing Facility - CS1 Conveyor Replacement	HRM			$200			$200	$0
2.737	Biosolids Processing Facility - Scissor Lift Replacement	HRM				$15		$15	$0
Wastewater - Treatment Facility -- T O T A L S			**$5,525**	**$9,841**	**$13,286**	**$39,771**	**$29,804**	**$98,227**	**$25,500**
Wastewater - Energy									
2.362	Energy Management Capital Program (Wastewater)	HRM		$500	$500	$500	$500	$2,000	$0
2.491	Pump Station HVAC Retro-Commissioning Program	HRM		$100	$100	$100	$100	$400	$0
2.650	HHSP - BAS + HVAC Recommissioning	HRM	$50					$50	$0
2.651	Wastewater Pump Stations - NSPI Meter Relocations	HRM	$25					$25	$0
Wastewater - Energy -- T O T A L S			**$75**	**$600**	**$600**	**$600**	**$600**	**$2,475**	**$0**
Wastewater - Security									
4.008	Security Upgrade Program	HRM	$200	$200	$200	$200		$800	$0
Wastewater - Security -- T O T A L S			**$200**	**$200**	**$200**	**$200**	**$0**	**$800**	

Five Year Capital Budget - Wastewater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
Wastewater - Equipment									
2.161	I&I Reduction (SIR) Program Flow Meters and Related Equipment	HRM	$25	$25	$25	$25	$25	$125	$0
2.451	Miscellaneous Equipment Replacement	HRM	$120	$120	$120	$120	$120	$600	$0
2.821	Duffus Street PS Flow Meter Replacement	West	$110					$110	$0
Wastewater - Equipment -- T O T A L S			**$255**	**$145**	**$145**	**$145**	**$145**	**$835**	**$0**
TOTALS - Wastewater			**$30,268**	**$59,561**	**$47,540**	**$81,198**	**$86,886**	**$305,453**	**$48,046**

Five Year Capital Budget - Stormwater

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
Stormwater - Pipes									
1.108	Stormwater Pipe Asset Renewal Program	HRM				$4,000	$4,700	$8,700	$0
1.140	Stormwater Main Sewer Lining - Program	HRM		$100	$100	$100	$100	$400	$0
1.038	Integrated Stormwater Projects - Program	HRM	$1,000	$1,000	$1,000	$1,000	$1,000	$5,000	$0
1.102	Manhole Renewals SW	HRM	$15	$16	$16	$17	$17	$81	$0
1.103	Catchbasin Renewals SW	HRM	$60	$63	$65	$68	$70	$326	$0
1.135	Lateral Replacements SW	HRM	$12	$13	$13	$14	$14	$66	$0
1.204	National Disaster Mitigation Program	HRM		$50	$100	$200	$200	$550	$0
1.134	Stormwater Quality Compliance Needs Assessment from IRP	HRM			$75	$75		$150	$0
1.145	Sullivan's Pond Storm Sewer System Replacement - Phase 2 Irishtown Rd to Harbour	East	$25	$350	$11,000			$11,375	$0
1.034	Raymond Street, Phase 2 - Storm Sewer Rehabilitation	East	$100	$1,000	$750			$1,850	$0
1.188	Cogswell Redevelopment - SW Sewer Relocation	West	$955	$1,350	$1,350			$3,655	$0
1.201	Stormwater Pipe Condition Inspections (CSP)	HRM	$50	$50	$0	$0	$0	$100	$0
1.223	Rocky Lake and Bedford Highway Intersection Storm Sewer Upgrade	West	$75					$75	$0
1.224	Thistle Street Storm Drainage System Upgrade - Preliminary Engineering	East	$50					$50	$0
1.227	Stormwater System Upgrade near Civic #1681 Waverley Road	East	$38					$38	$0
Stormwater - Pipes -- T O T A L S			**$2,380**	**$3,992**	**$14,469**	**$5,474**	**$6,101**	**$32,416**	**$0**
Stormwater - Culverts/Ditches									
1.104	Driveway Culvert Replacement Program	HRM	$1,200	$930	$925	$950	$945	$4,950	$0
1.109	Cross Culvert Renewal Program	HRM	$0	$2,000	$1,200	$2,000	$1,500	$6,700	$0
	Street Specific Culvert Replacement:								
1.205	Kipawa Crescent	Central	$400					$400	$0
1.125	Coronet Avenue Driveway Culvert Replacement Project	West	$925					$925	$0
1.147	Cole Harbour Road (near #1560) - Culvert Replacement	East	$350					$350	$0
1.183	St Margarets Bay Rd, near Civic 2797 - Culvert Replacement	West	$80					$80	$0
1.228	Blue Forest Lane, near civic 42	Central	$38					$38	$0
1.229	Devils Hill Rd at Boulderbrook Lane	West	$38					$38	$0
1.231	Ketch Harbour Rd, near civic 31	West	$38					$38	$0
1.232	Waverley Rd, near civic 832	East	$38					$38	$0
Stormwater - Culverts/Ditches -- T O T A L S			**$3,107**	**$2,930**	**$2,125**	**$2,950**	**$2,445**	**$13,557**	**$0**
Stormwater - Structures									
1.133	Ellenvale Run Retaining Wall System - Replacement	East			$500	$1,000	$1,000	$2,500	$0
1.225	Ellenvale Run Retaining Wall - Phase 2	East	$1,900					$1,900	$0
1.226	Ellenvale Run Retaining Wall - Phase 3 (Wanda Lane)	East		$2,100				$2,100	$0
Stormwater - Structures -- T O T A L S			**$1,900**	**$2,100**	**$500**	**$1,000**	**$1,000**	**$6,500**	**$0**
TOTALS - Stormwater			**$7,387**	**$9,022**	**$17,094**	**$9,424**	**$9,546**	**$52,473**	**$0**

Five Year Capital Budget - Corporate Projects

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
Corporate - Information Technology									
4.031	IT Strategic Projects	HRM				$3,770	$4,150	$7,920	$0
4.097	Analytics Decision Support System	HRM	$335	$350	$150			$835	$0
4.102	Approval Forms Framework	HRM		$280	$250			$530	$0
4.111	Asset Condition	HRM	$125	$190	$190			$505	$0
4.151	Capital Planning	HRM	$100	$500	$1,000	$100		$1,700	$0
4.105	Cityworks Upgrade	HRM		$200		$200		$400	$0
4.083	Computerized Maintenance Management System (CMMS) Enhancements	HRM	$1,000	$500	$1,000	$100		$2,600	$0
4.011	Desktop Computer Replacement Program	HRM	$350	$350	$350	$350	$350	$1,750	$0
4.146	Disaster Recovery	HRM	$630					$630	$0
4.147	Document Management SharePoint Rollout	HRM	$300					$300	$0
4.149	Electronic Content Management Linkage	HRM			$200			$200	$0
4.126	Full Enterprise Data Warehouse	HRM	$200	$300	$300			$800	$0
4.153	General Analytic Tool	HRM		$400				$400	$0
4.131	HR Training and Benefits	HRM		$320				$320	$0
4.012	Network Upgrades	HRM	$280	$280	$280	$280	$280	$1,400	$0
4.101	Mobile Devices and Applications	HRM		$600				$600	$0
4.095	New CRM with Integration	HRM		$200	$1,000			$1,200	$0
4.121	New Payroll System	HRM	$230					$230	$0
4.048	SAP Rate Structure Support	HRM	$220		$220		$220	$660	$0
4.150	Enterprise Resource Planning Solution	HRM	$2,630	$1,580	$200	$200		$4,610	$0
4.130	Team Collaboration	HRM			$230			$230	$0
4.107	Customer Portal	HRM	$50	$50				$100	$0
4.152	Security Projects	HRM	$300	$100				$400	$0
Corporate - Information Technology -- T O T A L S			**$6,750**	**$6,200**	**$5,370**	**$5,000**	**$5,000**	**$28,320**	**$0**
Corporate - GIS									
4.040	GIS Data Program	HRM	$100	$250	$100	$250	$100	$800	$0
4.115	GIS Data Build - Services (ICI)	HRM	$150	$150	$0	$0	$0	$300	$0
4.010	Sewer Service Entry	HRM	$250	$150	$0	$0	$0	$400	$0
4.116	GIS Data Project	HRM	$150	$0	$100	$0	$200	$450	$0
4.038	GIS Hardware/Software Program	HRM	$50	$50	$50	$50	$50	$250	$0
4.039	GIS Application Support Program	HRM	$150	$150	$150	$150	$150	$750	$0
4.059	Utility Network modeling/Data Modeling	HRM	$50	$250	$250	$50	$50	$650	$0
4.118	Engineering Drawing Database	HRM	$100	$50		$100	$50	$300	$0
4.155	Stormwater Biling Imagery Acquisition and Analysis	HRM	$350		$350		$350	$1,050	$0
Corporate - GIS -- T O T A L S			**$1,350**	**$1,050**	**$1,000**	**$600**	**$950**	**$4,950**	**$0**
Corporate - Asset Management									
4.020	Asset Management Program Development	HRM		$100	$100	$100	$100	$400	$0

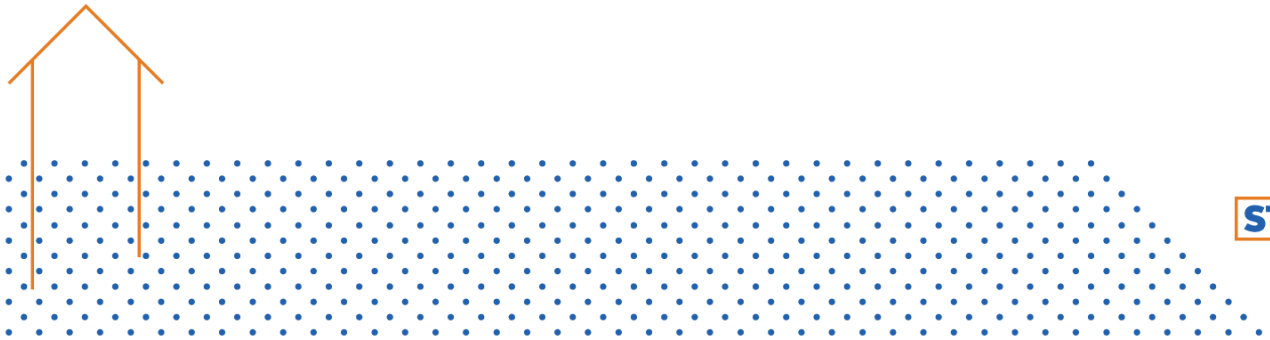
Five Year Capital Budget - Corporate Projects

Project ID	Project Name	Region	All $ in 000's						
			Y1	Y2	Y3	Y4	Y5	Total Y1 to Y5	Future Years
			2020-2021	2021-2022	2022-2023	2023-2024	2024-2025		
2.523	Wastewater Sewer Condition Assessment	HRM	$215	$220	$225	$230	$235	$1,125	$0
1.156	Storm Sewer Condition Assessment	HRM	$95	$100	$105	$110	$115	$525	$0
2.043	Corporate Flow Monitoring Program	HRM	$1,870	$2,000	$2,000	$2,000	$2,000	$9,870	$0
4.113	Vulnerability to Climate Change Risk Assessment - Asset Class Pilot	HRM	$250	$275	$250			$775	$0
2.562	Outfall Assessment Project	HRM	$20					$20	$0
4.140	SSO Management Program	HRM	$100					$100	$0
4.141	System Constraints Analysis HRM (Was East Additional Flow Monitoring)	HRM	$252					$252	$0
4.143	Safe Yield Study	HRM	$200					$200	$0
4.144	New Hydraulic Water Model (InfoWater)	HRM	$200					$200	$0
4.145	Transmission Main Risk Assessment and Prioritization Framework	HRM	$50					$50	$0
Corporate - Asset Management -- T O T A L S			**$3,252**	**$2,695**	**$2,680**	**$2,440**	**$2,450**	**$13,517**	**$0**
Corporate - Facility									3
2.176	East/Central Regional Operational Facility	East	$2,000	$16,000	$16,000			$34,000	$0
4.077	Building Capital Improvements	West	$185	$100	$100	$100	$100	$585	$0
3.221	Energy Managerment Capital Program	HRM	$100	$100	$100	$100	$100	$500	$0
Corporate - Facility -- T O T A L S			**$2,285**	**$16,200**	**$16,200**	**$200**	**$200**	**$35,085**	**$0**
Corporate - SCADA & Other Equipment									
4.093	GPS Units - Replacement	HRM	$70					$70	$0
4.004	SCADA Control System Enhancements	HRM	$100	$100	$100	$100	$100	$500	$0
4.136	ICS Cyber Security Enhancements	HRM	$100					$100	$0
4.137	Halifax Harbour Solutions Radio Upgrade	HRM	$60					$60	$0
4.138	Wastewater Community Plants SCADA System Relocation	HRM	$45					$45	$0
4.139	PI System Enhancements	HRM	$100					$100	$0
4.154	Customer Meters - New and Replacement	HRM	$500	$415	$500	$575	$545	$2,535	$0
Corporate - SCADA & Other Equipment -- T O T A L S			**$975**	**$515**	**$600**	**$675**	**$645**	**$3,410**	**$0**
Corporate - Fleet									
4.006	Fleet Upgrade Program - Stormwater	HRM	$269	$354	$297	$327	$315	$1,562	$0
4.006	Fleet Upgrade Program - Wastewater	HRM	$1,076	$1,416	$1,188	$1,308	$1,260	$6,248	$0
4.007	Fleet Upgrade Program - Water	HRM	$610	$315	$466	$335	$445	$2,171	$0
Corporate - Fleet -- T O T A L S			**$1,955**	**$2,085**	**$1,951**	**$1,970**	**$2,020**	**$9,981**	**$0**
TOTALS - Corporate Projects			**$16,567**	**$28,745**	**$27,801**	**$10,885**	**$11,265**	**$95,263**	**$3**

Appendix E

Projected Operating Budgets for

2020/21 to 2024/25



STRAIGHT from the SOURCE

HALIFAX WATER
CONSOLIDATED SUMMARY OF ESTIMATED REVENUE & EXPENSES
PROPOSED 5 YEAR BUSINESS PLAN
APRIL 1, 2020 to MARCH 31, 2025
(in thousands)

DESCRIPTION	ACTUAL APR 1/18 MAR 31/19	APPROVED BUDGET * APR 1/19 MAR 31/20	BUSINESS PLAN APR 1/20 MAR 31/21	APR 1/21 MAR 31/22	APR 1/22 MAR 31/23	APR 1/23 MAR 31/24	APR 1/24 MAR 31/25
OPERATING REVENUE	$138,413	$138,727	**$138,618**	**$138,123**	**$137,632**	**$137,145**	**$136,663**
OPERATING EXPENSES	$105,731	$115,088	**$118,110**	**$123,631**	**$128,761**	**$131,998**	**$135,962**
OPERATING SURPLUS BEFORE FINANCIAL REVENUE AND EXPENSES	$32,682	$23,639	**$20,508**	**$14,492**	**$8,871**	**$5,148**	**$700**
FINANCIAL REVENUE							
INVESTMENT INCOME	$1,156	$816	**$86**	**$86**	**$86**	**$86**	**$86**
MISCELLANEOUS	$742	$553	**$532**	**$535**	**$537**	**$539**	**$541**
	$1,898	$1,369	**$619**	**$621**	**$623**	**$625**	**$628**
FINANCIAL EXPENSES							
LONG TERM DEBT INTEREST	$7,430	$8,181	**$8,823**	**$10,124**	**$12,654**	**$15,254**	**$17,417**
LONG TERM DEBT PRINCIPAL	$20,516	$19,822	**$21,880**	**$24,203**	**$28,150**	**$32,131**	**$36,180**
AMORTIZATION DEBT DISCOUNT	$199	$202	**$228**	**$271**	**$328**	**$401**	**$439**
DIVIDEND/GRANT IN LIEU OF TAXES	$4,999	$5,147	**$6,113**	**$6,638**	**$6,705**	**$6,772**	**$6,840**
MISCELLANEOUS	$45	$22	**$32**	**$32**	**$31**	**$31**	**$31**
	$33,190	$33,374	**$37,076**	**$41,268**	**$47,868**	**$54,588**	**$60,906**
OPERATING SURPLUS (DEFICIT) AVAILABLE FOR CAPITAL EXPENDITURES	$1,390	($8,366)	**($15,949)**	**($26,156)**	**($38,374)**	**($48,815)**	**($59,578)**

** 2019/20 Operating Budget was approved by the Halifax Water Board on January 31, 2019.*
*** 2020/21 Operating Budget was approved by the Halifax Water Board on January 30, 2020.*

HALIFAX WATER
ESTIMATED REVENUE AND EXPENSES - WATER OPERATIONS
PROPOSED 5 YEAR BUSINESS PLAN
APRIL 1, 2020 to MARCH 31, 2025
(in thousands)

DESCRIPTION	ACTUAL APR 1/18 MAR 31/19	APPROVED BUDGET * APR 1/19 MAR 31/20	BUSINESS PLAN APR 1/20 MAR 31/21	APR 1/21 MAR 31/22	APR 1/22 MAR 31/23	APR 1/23 MAR 31/24	APR 1/24 MAR 31/25
OPERATING REVENUE							
METERED SALES	$48,040	$47,744	**$48,069**	**$47,904**	**$47,738**	**$47,574**	**$47,409**
FIRE PROTECTION	$7,074	$7,074	**$7,074**	**$7,074**	**$7,074**	**$7,074**	**$7,074**
PRIVATE FIRE PROTECTION SERVICES	$869	$873	**$884**	**$893**	**$903**	**$912**	**$922**
BULK WATER STATIONS	$227	$292	**$303**	**$303**	**$303**	**$303**	**$303**
CUSTOMER LATE PAY./COLLECTION FEES	$244	$223	**$238**	**$238**	**$238**	**$238**	**$238**
MISCELLANEOUS	$98	$179	**$177**	**$177**	**$177**	**$177**	**$177**
	$56,552	$56,387	**$56,746**	**$56,590**	**$56,434**	**$56,279**	**$56,125**
OPERATING EXPENSES							
WATER SUPPLY & TREATMENT (including Small Systems)	$9,747	$10,808	**$10,562**	**$10,910**	**$11,272**	**$11,647**	**$11,982**
TRANSMISSION & DISTRIBUTION	$10,014	$11,127	**$11,282**	**$12,283**	**$12,633**	**$12,994**	**$13,248**
OTTER LAKE CONTRACT	$20	$26	**$28**	**$29**	**$30**	**$31**	**$32**
TECHNICAL SERVICES (SCADA)	$889	$1,037	**$1,029**	**$1,060**	**$1,093**	**$1,127**	**$1,157**
ENGINEERING & INFORMATION SERVICES	$3,749	$3,901	**$4,162**	**$4,280**	**$4,402**	**$4,527**	**$4,618**
REGULATORY SERVICES	$679	$1,142	**$1,195**	**$1,233**	**$1,273**	**$1,313**	**$1,350**
CUSTOMER SERVICE	$2,524	$2,918	**$2,758**	**$2,839**	**$2,923**	**$3,009**	**$3,076**
ADMINISTRATION & PENSION	$3,986	$4,355	**$4,112**	**$4,230**	**$4,351**	**$4,477**	**$4,571**
DEPRECIATION	$9,046	$9,955	**$10,993**	**$11,971**	**$13,082**	**$13,488**	**$13,555**
	$40,655	$45,270	**$46,121**	**$48,837**	**$51,059**	**$52,614**	**$53,589**
OPERATING SURPLUS BEFORE FINANCIAL REVENUE AND EXPENSES	$15,898	$11,117	**$10,625**	**$7,754**	**$5,376**	**$3,665**	**$2,536**
FINANCIAL REVENUE							
INVESTMENT INCOME	$521	$367	**$39**	**$39**	**$39**	**$39**	**$39**
MISCELLANEOUS	$559	$431	**$394**	**$395**	**$397**	**$399**	**$401**
	$1,080	$798	**$432**	**$434**	**$436**	**$438**	**$440**
FINANCIAL EXPENSES							
LONG TERM DEBT INTEREST	$1,924	$2,238	**$3,127**	**$3,983**	**$5,484**	**$6,996**	**$8,027**
LONG TERM DEBT PRINCIPAL	$7,181	$5,165	**$6,465**	**$7,564**	**$9,548**	**$11,450**	**$13,138**
AMORTIZATION DEBT DISCOUNT	$85	$67	**$84**	**$108**	**$136**	**$173**	**$173**
DIVIDEND/GRANT IN LIEU OF TAXES	$4,999	$5,147	**$5,654**	**$5,710**	**$5,767**	**$5,825**	**$5,883**
MISCELLANEOUS	$24	$12	**$2**	**$2**	**$1**	**$1**	**$1**
	$14,214	$12,630	**$15,332**	**$17,368**	**$20,936**	**$24,445**	**$27,223**
OPERATING DEFICIT AVAILABLE FOR CAPITAL EXPENDITURES	$2,764	($715)	**($4,275)**	**($9,180)**	**($15,124)**	**($20,343)**	**($24,247)**

** 2019/20 Operating Budget was approved by the Halifax Water Board on January 31, 2019.*
*** 2020/21 Operating Budget was approved by the Halifax Water Board on January 30, 2020.*

HALIFAX WATER
ESTIMATED REVENUE AND EXPENSES - WASTEWATER OPERATIONS
PROPOSED 5 YEAR BUSINESS PLAN
APRIL 1, 2020 to MARCH 31, 2025
(in thousands)

DESCRIPTION	ACTUAL APR 1/18 MAR 31/19	APPROVED BUDGET * APR 1/19 MAR 31/20	BUSINESS PLAN APR 1/20 MAR 31/21	APR 1/21 MAR 31/22	APR 1/22 MAR 31/23	APR 1/23 MAR 31/24	APR 1/24 MAR 31/25
OPERATING REVENUE							
METERED SALES	$69,901	$70,031	**$70,365**	**$69,994**	**$69,625**	**$69,258**	**$68,893**
WASTEWATER OVERSTRENGTH AGREEMENTS	$75	$50	**$30**	**$30**	**$30**	**$30**	**$30**
LEACHATE	$330	$394	**$387**	**$395**	**$403**	**$411**	**$419**
CONTRACT REVENUE	$87	$86	**$86**	**$86**	**$86**	**$86**	**$86**
SEPTAGE TIPPING FEES	$764	$760	**$505**	**$530**	**$556**	**$584**	**$613**
DEWATERING FACILITY/ SLUDGE LAGOON	$210	$210	**$0**	**$0**	**$0**	**$0**	**$0**
AIRLINE EFFLUENT	$143	$160	**$105**	**$105**	**$105**	**$105**	**$105**
CUSTOMER LATE PAY./COLLECTION FEES	$186	$164	**$176**	**$176**	**$176**	**$176**	**$176**
MISCELLANEOUS	$185	$139	**$136**	**$136**	**$136**	**$136**	**$136**
	$71,881	$71,993	**$71,790**	**$71,451**	**$71,116**	**$70,785**	**$70,457**
OPERATING EXPENSES							
WASTEWATER COLLECTION	$11,676	$10,972	**$11,847**	**$12,167**	**$12,496**	**$12,835**	**$13,184**
WASTEWATER TREATMENT PLANTS (including Small Systems)	$19,459	$20,463	**$20,571**	**$21,156**	**$21,761**	**$22,385**	**$23,030**
DEWATERING FACILITY/ SLUDGE MGM'T	$226	$636	**$404**	**$421**	**$438**	**$455**	**$473**
BIOSOLIDS TREATMENT	$27	$101	**$101**	**$103**	**$105**	**$107**	**$109**
LEACHATE CONTRACT	$286	$325	**$337**	**$346**	**$355**	**$365**	**$375**
TECHNICAL SERVICES (SCADA)	$1,450	$1,784	**$1,652**	**$1,703**	**$1,755**	**$1,809**	**$1,858**
ENGINEERING & INFORMATION SERVICES	$3,783	$3,556	**$3,769**	**$3,876**	**$3,986**	**$4,099**	**$4,181**
REGULATORY SERVICES	$886	$1,434	**$1,537**	**$1,585**	**$1,636**	**$1,688**	**$1,735**
CUSTOMER SERVICE	$2,057	$2,536	**$2,352**	**$2,421**	**$2,492**	**$2,566**	**$2,623**
ADMINISTRATION & PENSION	$3,242	$3,606	**$3,405**	**$3,502**	**$3,603**	**$3,706**	**$3,784**
DEPRECIATION	$12,986	$13,921	**$15,072**	**$16,113**	**$17,195**	**$17,187**	**$18,429**
	$56,079	$59,334	**$61,045**	**$63,393**	**$65,821**	**$67,203**	**$69,780**
OPERATING SURPLUS BEFORE FINANCIAL REVENUE AND EXPENSES	$15,801	$12,659	**$10,745**	**$8,059**	**$5,295**	**$3,582**	**$677**
FINANCIAL REVENUE							
INVESTMENT INCOME	$520	$367	**$39**	**$39**	**$39**	**$39**	**$39**
MISCELLANEOUS	$183	$122	**$139**	**$139**	**$140**	**$140**	**$141**
	$703	$489	**$178**	**$178**	**$179**	**$179**	**$179**
FINANCIAL EXPENSES							
LONG TERM DEBT INTEREST	$4,939	$5,133	**$4,772**	**$4,970**	**$5,707**	**$6,202**	**$7,028**
LONG TERM DEBT PRINCIPAL	$12,015	$12,965	**$13,442**	**$14,277**	**$15,768**	**$16,984**	**$18,810**
AMORTIZATION DEBT DISCOUNT	$103	$113	**$124**	**$136**	**$158**	**$181**	**$207**
DIVIDEND/GRANT IN LIEU OF TAXES	$0	$0	**$398**	**$804**	**$812**	**$820**	**$828**
MISCELLANEOUS	$21	$10	**$30**	**$30**	**$30**	**$30**	**$30**
	$17,077	$18,220	**$18,766**	**$20,217**	**$22,474**	**$24,216**	**$26,903**
OPERATING DEFICIT AVAILABLE FOR CAPITAL EXPENDITURES	($573)	($5,072)	**($7,843)**	**($11,980)**	**($17,001)**	**($20,455)**	**($26,047)**

** 2019/20 Operating Budget was approved by the Halifax Water Board on January 31, 2019.*
*** 2020/21 Operating Budget was approved by the Halifax Water Board on January 30, 2020.*

HALIFAX WATER
ESTIMATED REVENUE AND EXPENSES - STORMWATER OPERATIONS
PROPOSED 5 YEAR BUSINESS PLAN
APRIL 1, 2020 to MARCH 31, 2025
(in thousands)

DESCRIPTION	ACTUAL APR 1/18 MAR 31/19	APPROVED BUDGET * APR 1/19 MAR 31/20	BUSINESS PLAN APR 1/20 MAR 31/21	APR 1/21 MAR 31/22	APR 1/22 MAR 31/23	APR 1/23 MAR 31/24	APR 1/24 MAR 31/25
OPERATING REVENUE							
STORMWATER SITE RELATED SERVICE	$5,906	$6,351	**$6,047**	**$6,047**	**$6,047**	**$6,047**	**$6,047**
STORMWATER RIGHT-OF-WAY SERVICE	$3,835	$3,835	**$3,835**	**$3,835**	**$3,835**	**$3,835**	**$3,835**
CUSTOMER LATE PAY./COLLECTION FEES	$118	$66	**$106**	**$106**	**$106**	**$106**	**$106**
MISCELLANEOUS	$120	$95	**$92**	**$92**	**$92**	**$92**	**$92**
	$9,980	$10,347	**$10,081**	**$10,081**	**$10,081**	**$10,081**	**$10,081**
OPERATING EXPENSES							
STORMWATER COLLECTION	$4,901	$5,750	**$5,779**	**$5,935**	**$6,095**	**$6,260**	**$6,429**
TECHNICAL SERVICES (SCADA)	$49	$39	**$42**	**$44**	**$45**	**$46**	**$48**
ENGINEERING & INFORMATION SERVICES	$624	$1,122	**$1,273**	**$1,309**	**$1,346**	**$1,384**	**$1,412**
REGULATORY SERVICES	$1,587	$1,505	**$1,627**	**$1,679**	**$1,733**	**$1,788**	**$1,838**
CUSTOMER SERVICE	$335	$273	**$304**	**$312**	**$322**	**$331**	**$339**
ADMINISTRATION & PENSION	$527	$586	**$554**	**$570**	**$586**	**$603**	**$615**
DEPRECIATION	$974	$1,208	**$1,365**	**$1,554**	**$1,755**	**$1,768**	**$1,913**
	$8,997	$10,484	**$10,943**	**$11,402**	**$11,881**	**$12,181**	**$12,594**
OPERATING SURPLUS BEFORE FINANCIAL REVENUE AND EXPENSES	$983	($137)	**($862)**	**($1,321)**	**($1,800)**	**($2,100)**	**($2,513)**
FINANCIAL REVENUE							
INVESTMENT INCOME	$116	$82	**$9**	**$9**	**$9**	**$9**	**$9**
MISCELLANEOUS	$0	$0	**$0**	**$0**	**$0**	**$0**	**$0**
	$116	$82	**$9**	**$9**	**$9**	**$9**	**$9**
FINANCIAL EXPENSES							
LONG TERM DEBT INTEREST	$567	$810	**$924**	**$1,170**	**$1,463**	**$2,057**	**$2,362**
LONG TERM DEBT PRINCIPAL	$1,320	$1,692	**$1,973**	**$2,362**	**$2,834**	**$3,697**	**$4,232**
AMORTIZATION DEBT DISCOUNT	$11	$22	**$20**	**$27**	**$34**	**$46**	**$58**
DIVIDEND/GRANT IN LIEU OF TAXES	$0	$0	**$62**	**$125**	**$126**	**$127**	**$128**
MISCELLANEOUS	$0	$0	**$0**	**$0**	**$0**	**$0**	**$0**
	$1,899	$2,524	**$2,978**	**$3,683**	**$4,457**	**$5,927**	**$6,780**
OPERATING DEFICIT AVAILABLE FOR CAPITAL EXPENDITURES	($800)	($2,579)	**($3,832)**	**($4,996)**	**($6,249)**	**($8,018)**	**($9,284)**

** 2019/20 Operating Budget was approved by the Halifax Water Board on January 31, 2019.*
*** 2020/21 Operating Budget was approved by the Halifax Water Board on January 30, 2020.*

Appendix F

Water Quality Master Plan

Version 3.0

STRAIGHT from the SOURCE

Water Quality Master Plan

V3.0

September 2016

Reid Campbell and Wendy Krkosek

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1 Introduction

Halifax Water has consistently produced drinking water that has safeguarded public health and achieved regulatory compliance, despite the challenges that occur as regulations become more stringent, infrastructure ages and once current technologies are eclipsed by more modern designs to meet the new regulatory environment. One important tool Halifax Water uses is water quality strategic planning which is formally executed through a Water Quality Master Plan (WQMP). Water quality master planning describes the process whereby a water utility assesses the public's expectations for water quality and the direction of water quality regulations and trends, sets corresponding water quality goals and then plans for necessary capital or operational improvements.

In 2006, Halifax Water completed its first formal WQMP. This plan was designed to set goals for water quality that exceed regulatory requirements and to set a path for Halifax Water to achieve those goals while treating water at an optimal cost. In 2011, the WQMP Version 2.0 was created and focused mainly on upgrades and investigations concerning the JD Kline Water Treatment Plant; Halifax Water's most mature treatment facility.

WQMP Version 3.0 has a shift in focus away from one plant in particular and focuses more on source water quality and its impact on treatment processes and distribution system water quality as a whole. There are two main drivers for this change in focus. Firstly, recent research indicates that lakes in Nova Scotia may be experiencing a recovery from acid rain, as sulphur emissions have drastically decreased over the past few years. Recovery results in higher pH, increased productivity, and increased total organic carbon. Both the Lake Major and J.D. Kline plants have been dealing with recent changing source water quality which has been challenging the treatment process at both plants, resulting in higher chemical usage and increased stress on treatment processes. WQMP V3.0 will focus efforts on identification of lake recovery processes, what this means for future source water quality, and also how to provide effective and robust treatment with existing infrastructure in the short term, while developing a plan for capital upgrades to address changing source water quality and aging infrastructure in the long term. Secondly, with the recent events in Flint Michigan around lead exposure in homes, outcomes of research with Dalhousie University, and a shift in the industry approach (via American Water Works Association policy) towards managing lead in the distribution system, WQMP V3.0 will focus on developing a plan for removal of both public and private lead service lines by 2050, while concurrently optimizing corrosion control treatment. It is likely that a Canadian regulatory requirement will be adopted in the coming years in this direction and Halifax Water wants to ensure they are at the forefront of this change in industry approach. Lead is a shared responsibility between the utility and the homeowner, and as such, the focus will be a shift away from sampling and towards public engagement and policy as new ways of engaging the public in uptake of replacement programs will need to be identified and pursued.

Implementation of the WQMP is a combined effort between Halifax Water staff and a research partnership with Dr. Graham Gagnon at Dalhousie University, and ultimately consulting engineers and contractors who design and construct identified necessary changes. The NSERC/Halifax Water Industrial Research Chair in Water Quality and Treatment is an integral part of conducting the research that leads to internal policy and operational changes, treatment optimization opportunities, and ensures that

Halifax Water is at the forefront of water quality research and active in the development of best practice for water utilities.

2 Research Accomplishments

Numerous research accomplishments since inception of the IRC program have led to both public health benefits and cost savings for Halifax Water. The following table provides an overview of some of the major discoveries and their associated impacts to Halifax Water of water quality research with the Dalhousie Research Chair. Many of these discoveries form the basis of the direction of WQMP V3.0.

Discovery	Impact to Halifax Water
A) Identification of Lake Recovery. Discovered through assessment of plant data over a 20-year period that both Pockwock and Lake Major are experiencing increased pH, color and TOC due to decreases in sulphur deposition.	• Increased dosing of coagulant at both Lake Major and J.D. Kline but J.D. Kline is pushing the limits of a direct filtration plant • Decreased filter run times • Potential explanation for algal occurrence and geosmin
B) Development of NOM Monitoring Tools. Developed a new method for oxygen demand in water industry: peCOD. Developed a new model for Fluorescence excitation-emission matrix (FEEM) analysis.	• peCOD is a new tool for assessing NOM that has ideal applications for oxidation processes, and shows promise for detecting subtle changes in organic profiles over traditional TOC/DOC techniques. • FEEM models will lead to online tools for improved treatment operation
C) Coagulant Mixing. Demonstrated that coagulation mixing energy can be reduced by 4-5 times without compromising NOM removal	• Outside of pumping, mixing represents the highest energy costs to water plants • Applied new particle analysis technology to demonstrate discovery
D) Biological Removal of NOM in Direct Filtration. Successfully demonstrated that biofiltration can be applied in a direct filtration plant without pre-oxidation	• Biofiltration reduced THM concentrations by 40% for Halifax Water • Bio filtration was reliable under broad temperature range (4-25°C) • Reduced chlorine costs by $30,000 per year
E) Monitoring Biological Filtration. Demonstrated that biomass measurements of ATP evolve operationally and within filter cycles	• Applied ATP as an emerging monitoring technology for biofiltration • Developed protocols to demonstrate appropriate ATP range and application to be used as performance monitoring tools moving forward
F) Partial Lead Service Lines. Demonstrated that PLSLs are an inappropriate solution for Halifax Water	• Research based on 5-years of water sample analysis by Dalhousie students • Led to policy change at Halifax Water in 2012, partials are no longer conducted unless part of an existing disruption. • Neither PVC or copper provide decreased lead concentrations post PLSLs
G) Lead Exposure. Demonstrated that current	• Halifax Water now uses a 4L profile sampling to

Health Canada guideline for sampling does not give true indication of lead exposure	monitor lead concentrations rather than a first draw sample.
H) Impact of Iron on Lead. Developed a fundamental understanding of the relationship between iron particles and lead	• Established that cast iron water mains interact with lead materials • Developed new analytical method for quantifying colloidal lead in water and a new procedure to evaluate iron mineral and lead interaction • Allows Halifax Water to target specific areas of the distribution for future LSL replacement programs
I) Role of Phosphate in Distribution System. Demonstrated that phosphate has a significant role in stabilizing iron particles and controlling lead release	• Halifax Water increased phosphate dose to reduce lead in water and continues to study the impact of this increase in customers' homes
J) Lead Release in Large Buildings Showed how localized lead release can be in large buildings and demonstrated long-term risks of fountains to children with researchers from École Polytechnique	• Halifax Water has developed sampling protocols for large buildings • Halifax Water was part of a national survey of lead management in Canada
K) Avoided Unintended Consequences of Disinfectant Changeover. Demonstrated that conversion from free chlorine to chloramines would lead to increased lead exposure	• Halifax Water was able to avoid negative consequences of lead exposure by avoiding a planned disinfectant changeover
L) Filter-to-Waste. Demonstrated that there was no public health benefit to implementing filter-to-waste at J.D. Kline.	• NSE accepted evaluation, which saved Halifax Water from a $5 Million capital investment. Led to changes in NSE Treatment Standard • Implemented zero cost filter resting procedures in place of filter-to-waste

In addition to these major discoveries, the IRC has published a total of 45 peer reviewed publications since 2006 that are directly related to Halifax Water operations or research questions. Of these publications, 5 have been in the Journal of the American Water Works Association, which is the most widely read journal by utilities in North America. The two figures below show the publications by year and also by topic area. Research through the IRC has generated 111 conference posters or presentations provided by IRC staff and students since 2006. Dr. Gagnon has trained 20 PhDs, 50 MASc students, 6 Post Doctoral students and numerous undergrad students. Four of these graduate students are now employed with Halifax Water, several more are working as consultants for key local firms, and a few are employed in government, at both the provincial and federal levels. Bi-annual symposia are held twice per year where research findings and current issues are transferred to Halifax Water Engineering and Water Services staff. Furthermore, treatment plant operators are trained by Dalhousie twice per year on specific relevant operational issues. This knoweldge transfer between the Chair and Halifax Water staff ensures the utility is at the forefront of water research discovery and engages and elevates staff to be able to address complex operational issues with a solid knowledge base.

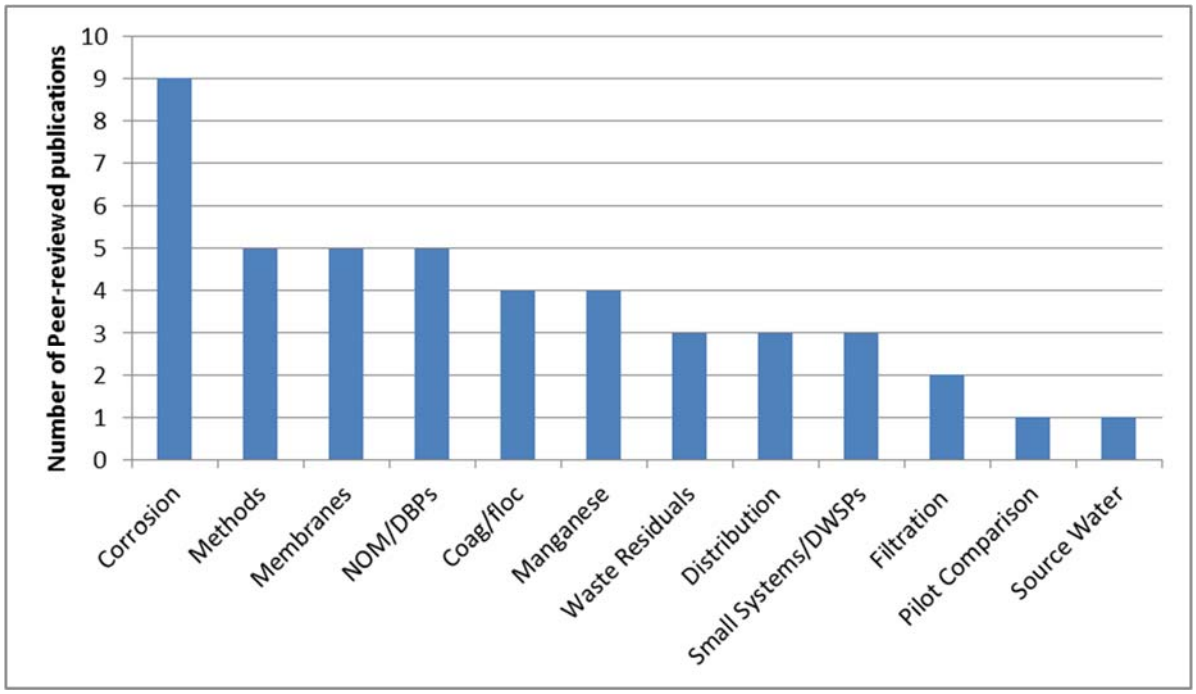

Figure 1 – Number of peer-reviewed publications by the IRC since 2006, by topic area.

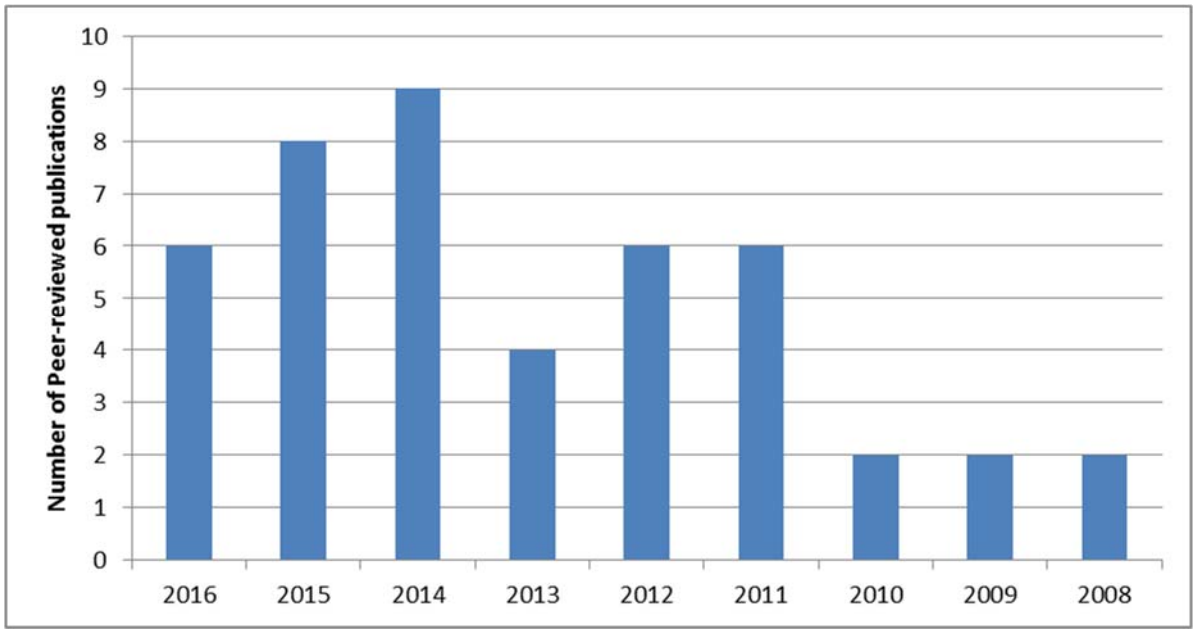

Figure 2 – Number of peer-reviewed publications by the IRC by year since 2006.

3 WQMP Direction

The overall water quality goals identified in the original WQMP remain on the priority list of Halifax Water. There are also other water quality objectives that the utility has identified as being significant to improving or strengthening water quality management and performance within the utility. Efforts will also be placed on shifting the focus of Halifax Water's strategic planning partially away from long term WQ goals and more towards what can be done to support treatment plant operations and improve water quality from a day to day perspective.

Over the course of the last five years, several water quality challenges have emerged that will challenge Halifax Water's ability to meet its water quality goals on an ongoing basis. There challenges are listed as follows:

- Changing Source Water Quality. Due to lake recovery from reductions in acid rain, and the effects of climate change, Halifax Water's primary water sources are undergoing a quality change that will challenge the capabilities of our treatment plants.
- Water Treatment. The effects of aging plants, and source water quality changes are requiring Halifax Water to look at the effectiveness of our treatment processes. There is a need to determine if the current processes are suitable for long term efforts and also to come up with short term solution to provide effective robust treatment capability while long term solutions are explored.
- Lead. Research has revealed that removing lead service lines from the system, combined with optimal corrosion control is the best way to protect customers from exposure to lead.
- Data. Halifax Water has accumulated an immense resource of water quality data. The appropriate tools and business processes need to be brought to bear to ensure that water quality is well managed and that the investments in water quality and treatment are sound.

The research and operations plan (Appendix A) is organized according to four themes aligning with these identified challenges.

3.1 Source Water: Lake Recovery and Changing Source Water Quality

Source Water quality is changing as a result of the effects of lake recovery from acid rain and possibly climate change. This is being realized through increased difficulty in operating both the JD Kline and Lake Major water supply plants. It manifests itself in increased chemical costs at Lake Major and in high head loss and shorter filter runs at JD Kline. JD Kline is now operating near the margins of its design capability. The major emphasis of this theme will include:

- Identification of Changing Source Water Quality. Existing water and air quality data will be mined and analyzed to better understand how the phenomenon affects water quality from both a biological and physical/chemical point of view. Paleolimnological work will be continued to better understand the effects of industrialization on water quality and what the natural or post recovery water quality might be.
- Lake Recovery Monitoring. The water quality response to lake recovery will be evaluated and characterized. This will include evaluation of the effects of lake recovery on algal activity and the

occurrence of taste and odour causing compounds. Existing programs to sample and monitor lakes will be evaluated to ensure that the appropriate monitoring is being undertaken. Also a program to monitor algae throughout the growing season will be developed to understand its occurrence and plan an appropriate response.

- Asssessment of Intake Structure Locations. The Lake Major Water Supply Plant optimization study identified diurnally changing source water quality as a limitation on plant performance. A new intake that draws a more consistent water quality is predicted to improve plant performance. Evaluating intake location and design at other facilities, including JD Kline, is also seen as a way to mitigate impacts of changing source water quality broadly and issues like geosmin occurrence more specifically.

3.2 Treatment

Treatment processes are being challenged due to the lake recovery phenomenon. It is necessary to develop both long term strategies and short term mitigation approaches to dealing with the effects of changing source water. Additionally, the recently completed Lake Major Water Supply Plant Optimization Study identified over one hundred plant improvements to address process deficiencies and component obsolescence. Further investigation is required to ensure that plant improvements consider other treatment factors and the changing source water. This theme will also include provision for shorter term research that is intended to assist plant operations staff with specific short term treatment challenges that may arise. Major components, listed by plant, include:

- JD. Kline Water Supply Plant. Previous research has identified deficiencies in pre-treatment and flocculation processes. Work will be conducted to further evaluate improvement opportunities and identify physical improvement projects and treatment strategies. Flocculation will be evaluated to consider whether the proposed investment in mechanical flocculation is worthwhile, or whether improved flocculation can be realized with changes to existing hydraulic flocculator operation. Filter performance will be evaluated through a formalized filter surveillance program. Further research will be conducted on passive biofiltration to see if it can be enhanced through changes to pre-oxidation strategies or nutrient addition and through a greater understanding of biofiltration processes. Further work will be conducted on coagulant optimization to improve filter headloss performance and to ensure that the plant can source coagulants that perform optimally and consistently. Further work will be conducted to optimize backwash and air scour cycles and monitoring the effects of new media, underdrains and air scour capability on treatment performance .
- Lake Major Water Supply Plant. A ten year capital program was developed as an output of the Lake Major Optimization Study. Research will be aimed at supporting and enhancing the ten year capital improvement plan and will include research to support determination of a new intake location, premix optimization, coagulant selection, clarification process optimization, possible consideration of biofiltration, manganese optimization, and all aspects of filter operation and filter performance. This theme will also support improvements in the process waste system.

- Bennery Lake Water Supply Plant. This plant is nearing the end of an optimization cycle. Remaining significant improvements include installation of plate settlers, the establishment of filter surveillance, and continued optimization of manganese optimization.

3.3 Distribution System Water Quality

Historically, within Halifax Water and the water industry as a whole, distribution system water quality has received less attention than treatment process operations and performance. Recently, there has been an increased focus on possible risk factors to public health associated with distribution systems, a good example of this is the recent attention being focused on the health risks associated with lead pipe in the distribution system and the lack of understanding of the appropriate methods to replace such materials without presenting additional health risks to people directly affected by replacement efforts. In light of the increasingly stringent regulations surrounding distribution water quality, and to remain loyal to the multi-barrier approach to water quality management, Halifax Water will direct efforts towards actively monitoring and assessing both distribution system water quality and physical integrity, and understanding the interrelationships between the two. Establishing a baseline of distribution water quality, hydraulic and integrity information will allow the utility to integrate water quality and hydraulic goals into the operation of the distribution system and focus attention on identifying and mitigating areas that are a high risk for contamination or sensitive to significant water quality fluctuations. The results of the monitoring program will be used to improve distribution system practices and implement another layer of protection to public health. The main components of this theme include:

- Lead. Based on operational experience and previous research, Halifax Water has determined that the removal of lead service lines and optimized corrosion control treatment are required to protect customers from exposure to lead. This will be realized through operationally adopting the 2015 recommendations of the National Drinking Water Advisory Council (NDWAC). The program will support this transformational initiative while continuing to grow the understanding of the occurrence of lead in our local systems in order to continue to optimize corrosion control practices.
- Distribution System Water Quality and Integrity Monitoring. Programs to monitor the integrity of distribution system water quality will be continued. This will include incorporation of the Partnership for Safe Water distribution program. Success of a recent fluoride tracer study in the Lake Major system conducted to understand water age will be translated to other systems. This will provide staff with an understanding of hydraulics and impacts on water quality throughout the distribution system. Programs to monitor biological water quality will be evaluated and operational strategies to optimize disinfection residuals will be identified and implemented. Development of water quality integrity protocols through distribution systems events will also be developed to ensure continuous safe water delivery.
- Disinfection Efficiency and Minimizing Disinfection By Product Formation. Significant work has been done in monitoring and minimizing DBP formation. However, there is further opportunity for improvement in this area, including work on chlorine age in water storage facilities and optimal chlorine dosing.

3.4 Data Management

Better tools and processes are required to use and integrate the large quantity of water quality data that exists. Enhanced data management tools will allow for better monitoring, day to day operational decisions and sound investment in process improvements. Data management tools and business processes will be explored and integrated.

4 Water Quality Goals

Water Quality Goals are based on the outcomes of previous terms of the WQMP combined with what has been achieved by other "best in class" utilities that have adopted similar programs. These goals are intended to ensure that Halifax Water not only meets current regulatory requirements, but will be well positioned to meet predicted regulatory changes and maintain water quality that well exceeds the current regulatory requirements. Though many of these goals remain the same, there are some additional goals being added to this version of the WQMP to reflect overall direction and focus of the WQMP and to set a standard for the associated research tasks. Many of these goals are a product of the utility's commitment to adapting a more proactive approach to water quality management, monitoring and optimization.

Halifax Water has developed both global and specific water quality goals. The global goals are very general and are intended to describe the overall objectives of the specific water quality goals. The specific goals clearly define measurable objectives associated with priority water quality targets identified by Halifax Water.

4.1 Overall Objectives:

4.1.1 Compliance

- Full compliance with Guidelines for Canadian Drinking Water Quality.
- Full permit compliance

4.1.2 Source Water Quality

- Proactively protect our source water quality.
- Monitor source water quality to provide early warning of potential problems.

4.1.3 Water Quality and Treatment

- Adapt a pro-active approach to water quality monitoring and operations.
- Develop indicators of pending non-compliance events.
- Provide required training to improve operator knowledge of operational, treatment and water quality objectives.
- Actively optimize treatment processes through monitoring and assessing the relationships between treatment operations and finished water quality.
- Develop facility specific water quality and operational goals.

4.1.4 Distribution System Water Quality

- Integrate water quality goals into the operation of the distribution system.
- Actively monitor and understand water quality and physical integrity in the distribution system.

- Identify distribution system contamination vulnerabilities and clearly identify communication plans, responsibilities and accountabilities.

4.1.5 Customer Expectations

- Maintain customer perception of water quality that exceeds corporate strategic objectives.
- Incorporate our understanding of customer perspectives when developing overall water quality goals.

4.2 Specific Goals:

4.2.1 Particle/Precursor Removal Goals

These goals describe HW's efforts to optimize the basic treatment process to improve particle removal, which is the fundamental pathogen barrier, while at the same time also optimizing for TOC removal.

- 2 to 3 log removal of giardia by filtration
- 3/4/4 log removal for giardia/viruses/cryptosporidium
- Individual filter turbidity values <0.1NTU: 95%, 0.3 NTU: 100%

DBP Goals: *These goals describe how HW will improve disinfection which is one of the primary barriers to protect public health, while at the same time also lowering disinfection by-products such as THM's and HAA's.*

- THM's < 80 ug/L (LRAA)
- HAA's < 60 ug/L (LRAA)

4.2.2 Distribution Water Quality Goals

These goals recognize that water quality is managed not only at the treatment plant but also to the customers tap. They also recognize that the distribution system and water quality can positively or negatively affect each other.

- Minimum distribution chlorine residual of 0.2 mg/L at all locations
- Develop and achieve distribution system HPC targets
- Maintain 90th percentile residential lead levels below 15-µg/L
- Removal of 100 public lead service lines per year
- Removal of all public and private lead service lines by 2050

4.2.3 Waste Treatment Goals

These goals recognize that plant waste processing is a significant operating cost and that waste management costs can be impacted by process changes. While secondary to public health issues, plant process improvements must also consider the impact on waste treatment.

- Optimize residual disposal costs
- Achieve wastewater permit requirements

5 Overall Strategy to Achieve Goals

Based on the research findings to date and an overview of industry best practices, Halifax Water has identified a number of tasks to be carried out to achieve the goals outlined above and to address facility specific and system wide operational and treatment challenges that have been identified since the initial WQMP was completed. Some tasks will serve to achieve multiple goals and others are focused on very specific research tasks pertaining to the optimization of a specific treatment process. These tasks take the form of several different types of activities such as the following:

- Pilot scale research studies.
- Consultant studies.
- Data collection and surveillance techniques.
- Development/evaluation of long-term monitoring programs.
- Best practice adoption.
- Operational changes.
- Training programs.

Some tasks will be completed by means of a well-defined research project over a relatively short period of time and others, specifically treatment and distribution monitoring and optimization programs, will require a significantly larger time commitment. Such programs encompass multiple planning, development and implementation stages which may include identifying and setting achievable and realistic goals, the development and implementation of monitoring programs, baseline performance assessments, operator training programs, and the development of optimization plans, to name a few.

All of the tasks have been organized into the WQMP research and operations plan (Appendix A). Justification and description of the themes in this plan were provided in section 3. As tasks are completed, process changes, some resulting in capital projects, will be identified. These modifications will be scheduled as resources and financing allow.

6 Research Plan and Execution

The overall program will be governed by a steering committee consisting of staff from Halifax Water and Dalhousie University. The steering committee will periodically review research projects and progress. The steering committee will meet quarterly to review research proposals for upcoming research and the results of previous and ongoing research. At this time, Dalhousie will present detailed research results in a seminar format to the steering committee and Halifax Water staff that are directly impacted by the particular research tasks. Technical reports will be submitted as requested for specific research tasks. Bi-annual symposia will be held to update a broader group of Halifax Water Operations and Water Services staff on relevant research.

Depending on the specific research and expertise requirements, individual research tasks will be executed either internally by Halifax Water staff or externally by the Dalhousie University research team or external consultants, as required. An outline of parties responsible for each task is provided in Appendix B.

6.1 Halifax Water Research Team

Tasks that involve the optimization of day-to-day process operations or monitoring programs will be completed internally using in-house staff and resources. The Water Quality Manager has been assigned a leadership role in the provision of high quality drinking water; specifically related to treatment, water quality and distribution operations optimization, monitoring and research. This person will play a lead role in conducting water quality research, solving water quality, treatment and distribution problems, pro-actively monitoring and improving treatment and distribution operations and methodologies, and developing, implementing and monitoring water quality plans.

The Water Quality Manager has the role of advocate for the development and implementation of water quality strategic plans and research programs. However, implementation of these programs will require cooperation and commitment of several other stakeholders within the utility structure including the general management, plant managers and operations superintendents, distribution superintendents, and all directly impacted operations staff.

As Halifax Water undertakes the transformational lead service line replacement program, a new lead team will be developed at Halifax Water to ensure that adequate resources are put towards the program to achieve goals. The team will report to the Water Quality Manager, and will consist of a Lead Program coordinator, a Data Analyst and a Water Quality Inspector specific to lead. These three staff will work with staff in a variety of other departments, including Operations, GIS, Customer Service, metering, and Water Services to implement new initiatives.

Water Quality Master Plan

V3.0

Appendix A – Research and Operating Plan

September 2016

Wendy Krkosek, Ph.D., P.Eng.
Water Quality Manager

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Theme 1: Source Water: Lake Recovery and Variable Source Water Quality

As a result of successful air emissions control, a number of studies have shown evidence of lake recovery from acidification, mainly in parts of Europe and the UK. The impact of recovery is healthier ecosystems as measured by changes in natural organic matter, pH and changes in biological activity and species.

In the fall of 2016, through both an analysis of basic historical data, and noticeable operational changes at both J.D. Kline and Lake Major, it became apparent that there has been a change in source water quality resulting in higher colour, TOC and pH. At J.D. Kline, the source water quality is approaching the upper limits of design for a direct filtration plant, including a TOC of 3.5 mg/L and colour of 20 TCU. At Lake Major, colour has gone from 20 to 45 TCU since commissioning of the plant, and as a result, the alum dose to remove the increased organics has gone from 15 to 50 mg/L over this time frame. These observed changes challenge earlier thinking of scientists studying the recovery from acidification in Atlantic Canada but are consistent with the observations of drinking water operators in the UK and Scandinavia. The Atlantic Canadian studies were published in 2007 and 2011, and many of the changes described have occurred within the past five years, so it is possible that water quality has recently hit a threshold that has allowed for recovery.

Very recent changes to sulphur emissions from marine fuels and continuing conversion of coal plants to natural gas in the Northeastern United States will continue to result in lower sulphur deposition, thus it can be expected that source waters will continue to change, which is expected to produce more challenges for Halifax Water treatment plants.

A large component of the research activities associated with this Water Quality Master Plan involve issues related to lake recovery, including:

- Identifying changes to source water quality,
- Developing appropriate monitoring strategies for changing source water quality,
- Developing operational tools to assist with plant operations in the short term, and
- Developing long term capital plans for robust design or retrofit of existing treatment plants to deal with a moving target of source water quality.

Task 1.1 Identification of Changing Source Water Quality

The major objective of this task is to develop an understanding of possible lake recovery and changing source water quality in Halifax Water's source waters after years of acidification caused by sulphur deposition, and to understand how this phenomenon impacts water chemistry from a drinking water quality standpoint. This research activity will:

- Mine currently available source water and air quality data to understand changing water quality both biologically and chemical/physical including changes to organic matter, pH, sulphate, nutrients, and biological species and richness.
- Expand and update currently available paleolimnological sediment analyses to include key source waters to estimate pre-industrial lake chemistry, and response of lakes to changes in land management practices.

- Determine which source waters and tributaries are susceptible to experiencing algal blooms in the future, and where these blooms may occur.

Task 1.2 Lake Recovery Monitoring

The overall research objective of this task is to identify responses to lake recovery in source water through a comprehensive monitoring program. Building on data mining and related activity conducted in Task 1.1, this research activity will look for changes in water chemistry and biology in response to trends found in task 1.1. Specifically, the objectives are to:

1. Evaluate the effect of lake recovery on algal activity, including algal organic matter (AOM) and the occurrence of commonly affiliated taste and odour compounds, including determination of which source water and tributaries are susceptible to experiencing algal blooms in the future, and potential management options to reduce bloom occurrence.
2. Monitor for trends in organic matter concentration and characterization in response to lake recovery.
3. Review existing watershed and deep lake sampling programs to ensure that parameters of interest are being collected with an appropriate frequency at appropriate locations.
4. Additionally, a program to monitor presence and composition of algae throughout the growing season will be developed for Pockwock, Major and Bennery, to understand areas that are vulnerable to blue/green algae, taste and odour presence and potential algal toxins.

Task 1.3 Assessment of Intake Locations and Structures

Optimizing the location of the intake structures and depth of intakes have been discussed for Lake Major, Bennery Lake, Pockwock Lake and The Shubenacadie River for Bomont. Pockwock and Lake Major both have fixed depth intakes that are susceptible to large daily fluctuations in water temperature which can pose downstream treatment challenges, and the intake at Bennery is susceptible to seasonal fluctuations in manganese concentrations.

1.3.1 Lake Major Intake Structure

The current intake for LMWSP is susceptible to significant diurnal temperature changes that pose operational challenges downstream, particularly with the sludge blanket in the UltraPulsators. A new-multi-level intake would allow for control of incoming water quality, thus reducing the operational burden downstream. In order to determine a suitable location, a research program will be initiated that involves monthly sampling year round at different depths at several locations within 200 m of the existing intake to identify an optimum location for a future intake. A bathymetric map will be developed to help in assessment of future intake locations. While conducting the bathymetric assessment, temperature profiling will also be conducted to provide an indication of areas of upwelling which could also provide a more consistent water quality.

A detailed raw water quality investigation of the existing raw water source will be used to understand water quality in terms of NOM, algal activity, and AOM in Lake Major, and to determine whether specific fractions of NOM are more pronounced compared to previous studies. Initially, this research will utilize conventional online water quality measurements in addition to novel online NOM characterization tools

in order to understand the potential changes in NOM composition. Grab samples will be collected from the raw water intake in order to confirm measurements from online instruments. A new at-line system to measure photoelectrochemical oxygen has been installed at Lake Major as part of this initiative.

If the existing transmission main will be used with the new intake, an evaluation of the manganese coating should be undertaken to ensure no negative impacts on raw water quality will occur with a change in intake location.

1.3.2 Pockwock Lake Intake Structure

For Pockwock, there is some discussion as to the impact of the berm location and structure on influent water quality, particularly because high geosmin concentrations are often found at the boat launch nect to the berm. A research program will utilize paleolimnological assessment to evaluate the impact of construction of the berm on organic loading in the intake area. Further characterization of geosmin in the area will also be done to provide indication of its impact on raw water quality and whether there are control measures that could mitigate the situation. A bathymetric map will be developed to help in assessment of future intake locations. While conducting the bathymetric assessment, temperature profiling will also be conducted to provide an indication of areas of upwelling which could also provide a more consistent water quality.

1.3.3 Bennery Lake Intake Structure

At Bennery Lake, the stratification in the summer creates an anoxic zone in the hypolimnion which leads to increases in dissolved manganese at the depth of the current drinking water intake. Concentrations increase significantly which poses downstream treatment challenges. There are two potential solutions to this seasonal problem. The first is to install a hypolimnic aeration system to prevent the formation of dissolved manganese at the intake, or to install a multi-level intake, which would allow plant staff to change the intake level to eliminate the elevated manganese levels in raw water and focus on plant removal of TOC. The current plan is to collect background information (bathymetry) and develop a design for an aeration system to submit to Nova Scotia Environment for approval.

Upon installation of the aeration system, a rigorous raw water monitoring program will be developed for 1-2 years to provide baseline water quality data to aid plant staff in understanding seasonal treatment requirements.

1.3.4 Bomont Community Water Supply Plant

Following precipitation events, there is runoff from neighbouring fields which increases turbidity in the Shubenacadie River, resulting in deteriorated water quality, which forces shutdown of the plant. While the plant is offline, water is trucked into the facility, increasing the cost of providing drinking water to customers. The possibility of installing riverbank filtration will be explored as a way to mitigate the fluctuations in raw water quality, thus eliminating the need for plant shutdown and expense of trucked water.

Theme 2: Treatment

Task 2.1 Roadmap for Robust Treatment Plant Design for a Changing Source Water Quality

Historically, treatment plants have been designed for a specific and narrow range of source water quality, leading to specific unit processes, often with limitations, such as those posed by direct filtration at J.D. Kline. The challenges with treating a moving target of source water quality due to lake recovery, combined with the occurrence of more extreme weather events due to climate change, is leading to a paradigm shift in treatment plant design. The need for more robust and adaptable unit processes for a wider range of water qualities is becoming increasing important for water utilities. Halifax Water has undertaken a consultant study to look at unit treatment processes for the removal of geosmin, but in looking at geosmin occurrence through the larger lens of lake recovery and changing source water quality, it has become clear that a more holistic approach to design is necessary.

To address this larger design question, Halifax Water will pursue a Tailored Collaboration project with the Water Research Foundation to bring together leading consultants and utilities in North America to develop a roadmap for robust water treatment plant design in a climate of changing source water quality. The outcome of this project will provide a path forward specifically for the J.D. Kline Water Supply Plant, but will also provide value for future considerations at all other Halifax Water surface water treatment plants.

Task 2.2 J.D. Kline Water Supply Plant

The following section describes shorter term operational tasks for optimizing existing treatment strategies to manage changing source water quality as water quality reaches the threshold for direct filtration design parameters, while longer term measures for capital improvements to treatment plant design are explored through the Tailored Collaboration in Task 2.1.

2.2.1 Improvement of pre-mix and pre-oxidation processes

With an increased TOC load in the raw water and potential changes to iron and manganese cycling, it is possible that a different pre-oxidation step (either higher permanganate dose or alternative oxidant) could provide manganese oxidation as well as provide some pre-oxidation of organics so that organics are in a more assimilable form for biofiltration.

A study conducted in 2016 identified several locations within the pre-mix that could be optimized in terms of chemical addition points, and mixing speeds. Specifically, experiments will be conducted in modified jar tests and at pilot scale to evaluate point of application of polymer to optimize floc formation. Evaluation of the premix process will be conducted to determine whether the point of CO_2 addition can be moved towards the head of the plant and away from concurrent addition with Alum to increase coagulant performance.

2.2.2 Flocculation optimization

Previous research by the Dalhousie Industrial Research Chair has shown that the conversion to mechanical mixers would provide significant benefit to the existing hydraulic mixing process. However,

this comes at an increased capital cost. Another alternative is to only run 2 of 4 floc trains at one time. As the plant is running under 50% capacity at this time, it is conceivable that running all four 4 floc trains does not provide adequate velocity for collisions and mixing and that speeding the water up by taking two trains offline might enhance mixing and eliminate the need for an increased alum dose and subsequent aluminum breakthrough.

2.2.3 Improved filter performance

2.2.3.1 Filter Surveillance

The objective of this task is to Implement a filter surveillance program to monitor existing filter performance and backwash routines, and to help identify deficiencies or opportunities for optimization. Samples will be analyzed for typical filter surveillance target parameters (i.e., turbidity and aluminum). However, the investigation will also include measurement of other inorganic and organic potential foulants by performing acid digestion and scans for additional metals (i.e., iron and manganese) and measuring NOM surrogates (i.e., TOC, DOC, PeCOD, UV_{254}, FEEM). Analysis of different FEEM regions will provide an indication of the relative fulvic, humic and protein content of NOM. To understand the fouling contribution of biological material, biomass will be quantified using ATP and cell counting, and extracellular polymeric substances (EPS) will be quantified as glucose and as proteins.

Implementation of a filter surveillance program would involve development of a filter surveillance team and data collection templates and procedures so that data is accessible and can be compiled and used by plant and water quality staff.

2.2.3.2 Biofiltration optimization

Currently the filters at J.D. Kline are running as passive biofilters as there are no chemical or nutrient enhancements to the process. Research using the pilot plant can provide insight on whether addition of pre-oxidants and/or nutrients could provide enhanced organics removal through biofiltration processes. Additionally, monitoring tools and operational controls to measure biofilter performance and health need to be developed and added to operational monitoring programs.

Extracellular polymeric substances (EPS) can contribute to headloss in biofilters. The direct biofiltration process at the JD Kline WTP does not incorporate sedimentation prior to filtration. The purpose of this investigation will be to understand the interaction between floc material and biomass and determine the extent to which alum floc competes with biomass for space in the filter bed and if alum toxicity limits biomass concentration (as measured by ATP), potentially reducing the capability of the filter to perform biodegradation of substrate, or impacts the formation of EPS, potentially contributing to filter clogging.

2.2.3.3 Coagulant optimization

Research conducted by Knowles in 2011 showed that coagulation with alum as currently practiced provided the longest filter run times combined with minimal downstream unintended consequences. With the change in source water quality, these studies should be revisited. Additionally, the chemical supplier recently changed the supplier and process for alum production from bauxite to trihydrate, which has had an impact on plant performance. Bauxite is being phased out as a type of alum and thus

it is important to determine an appropriate coagulant for the new source water quality which maximizes filter run times while minimizing downstream unintended consequences.

Research at the pilot scale will be conducted to determine whether increasing alum doses or using alternative coagulants can overcome increasing NOM concentrations, while given the constraints of current treatment process design (i.e. particle loads for direct filtration, downstream water quality impacts).

2.2.3.4 Backwash optimization

Following conversion of the JD Kline WTP filters to biofilters, operational strategies (e.g., backwash, loading rate) have remained fundamentally unchanged. Results following the conversion showed that the biofilters could be operated in the same manner as before and still meet effluent turbidity requirements and previous benchmarks for initial and terminal headloss, loading rate and unit filter run volume. However, recent filter surveillance shows that there is significant material remaining in the lower third of the biofilters, post backwash. Adjustments to the backwash protocol, loading rate and empty bed contact time could potentially optimize this process and increase biofiltration hydraulic performance.

2.2.3.5 Filter media replacement and addition of air scour

The existing filter media is original to the plant and recent filter assessment by consultants has indicated that both filter media and underdrains require replacement. A capital project is underway to replace both filter media and underdrains in all filters, with a completion date of March 2018. Air scour equipment will be installed at the same time to provide enhanced backwash performance. The filter media design has been altered slightly (slightly larger effective size) to be more compatible with biofiltration processes. New backwash routines for air scour will be developed post installation, and filter health will be monitored using filter surveillance techniques.

Task 2.3 Lake Major Water Supply Plant (LMWSP)

In 2015/16 a Lake Major Water Supply Plant Process Optimization Study was completed by CBCL Limited and HDR Engineering Inc. The report provides an implementation strategy based on recommendations, and research requirements. Halifax Water staff have developed a 10 year Capital Improvement Plan based on this report, which includes both capital upgrades and research requirements. The research requirements over the next five years are highlighted in the following sections.

As described in Theme 1, Lake Major has seen recent changes in source water quality which have resulted in increases in chemical dosage to remove increased organic loads. The LMWSP has been able to adapt to an increased alum dosage of approximately 50 mg/L due to the presence of upflow clarifiers prior to filtration, however the plant is experiencing challenges with coagulant performance, disinfection byproducts and residuals handling. The research and operational tasks presented below detail improvements that can be made to existing operations with enhanced monitoring of process change outcomes and bench-scale testing. The longer term research plan, beyond the scope of this 5 year WQMP, would be to install and operate a pilot plant at Lake Major to further optimize treatment processes once initial improvements have been made.

2.3.1 Premix optimization

There is a need for optimization of pre-mix chemical types and injection location as well as mixing speeds. The impact of increasing mixing intensity will be evaluated as the current mixing speed is below that of rapid mix but above a floc mixing intensity. The current lime system is in need of an overhaul, and prior to this occurring, investigation of the use of soda ash instead of lime for pH/alkalinity control should be explored in more detail at the bench scale.

2.3.2 Coagulant changeover

LMWSP has experienced the same challenges as J.D. Kline with respect to the type of alum used (bauxite versus trihydrate). With the current increased cost of bauxite and eventual discontinuation of the product, it is prudent to perform coagulant changeover studies to develop a suitable process moving forward. This research task will incorporate bench-scale jar testing to evaluate different coagulant types. However, due to the plant configuration as upflow clarification, jar tests can provide good initial insight, but results may not be representative of full-scale operation. Therefore, a way to simulate upflow clarification at the bench scale will be explored to provide more replicable data for comparison to full-scale operation. Further pilot scale testing would then be conducted upon installation of a pilot plant, beyond year 2022. In addition to evaluating filter performance and organics removal with alternative coagulants, impacts on corrosion downstream need to be evaluated to ensure that changing the chloride:sulphate mass ratio does not lead to increased corrosion in the distribution system.

2.3.3 Clarification

The UltraPulsator technology is not seen as ideal for the application of clarification at LMWSP. The current tubes and plates are in need of replacement so a capital inspection and replacement project will be initiated. With installation of a new intake with consistent daily temperatures and water quality, improvements in pre-mix chemistry and injection, optimization of coagulants and replacement of tubes and plates within the UltraPulsators, it is possible that improvements in operation and finished water quality will provide an extended life for the existing units. Enhanced water quality monitoring post tube and plate replacement will be conducted to help with optimizing performance.

2.3.4 Manganese oxidation

LMWSP was originally designed to use potassium permanganate for manganese oxidation. Shortly after plant commissioning, potassium permanganate was shutoff and manganese was oxidized with pre-filtration chlorination. This has allowed the filter media to become coated with manganese dioxide over time which acts as a catalyst for manganese oxidation. Although effective for oxidizing manganese, pre-filter chlorination can lead to increased disinfection byproduct formation through reactions between remaining organics and chlorine prior to filtration. With the anticipation of replacement of filter media, it is a good time to remove the pre-filter chlorination step and provide manganese oxidation at the head of the plant. The filter media has been operating with pre-chlorination for so long that it is likely that manganese from the filter media could leach into finished water if the pre-chlorine is turned off while existing media is still in place. Different manganese oxidation strategies will be tested to determine a suitable process moving forward for post filter media replacement.

2.3.5 Improved filter performance

2.3.5.1 Filter Surveillance

LMWSP has implemented a filter surveillance program to monitor existing filter performance and backwash routines, and to help identify deficiencies or opportunities for optimization. As mentioned for J.D. Kline, a team and consistent data collection procedures and templates will be developed so that data is accessible and can be compiled and used by plant and water quality staff. In addition to the regular filter surveillance program, additional parameters may be measured periodically to provide a more detailed picture of filter performance. This will be important once new filter media is installed and pre-chlorine is shut off to monitor the conversion to passive biofiltration. In order to monitor the performance of the biofilters, the investigation will also include measurement of other inorganic and organic potential foulants by performing acid digestion and scans for additional metals (i.e., iron and manganese) and measuring NOM surrogates (i.e., TOC, DOC, PeCOD, UV_{254}, FEEM). Analysis of different FEEM regions will provide an indication of the relative fulvic, humic and protein content of NOM. To understand the fouling contribution of biological material, biomass will be quantified using ATP and cell counting, and EPS will be quantified as glucose and as proteins.

2.3.5.1 Filter media replacement

Filter excavation box tests indicate that there is poor stratification of filter media, and that garnet layers are mismatched with sand and anthracite. Additionally, as previously described, there is a likelihood that manganese dioxide has built up on the media due to pre-filter chlorination. Further sieve analysis and characterization of organics and metals through filter surveillance will be conducted to determine whether media should be replaced, or whether washing media to remove manganese dioxide could be adequate to restore filter integrity. Following a conversion in manganese oxidation strategy and media wash or replacement, the filters will then begin to operate as passive biofilters like those at Pockwock. Monitoring of performance and establishment of biofilm will be conducted through filter surveillance.

2.3.5.2 Backwash optimization

Existing filter surveillance data suggests that media particularly between 18-24 inches is not being sufficiently cleaned, and thus optimizing backwash rates and times to achieve enhanced particle removal would be beneficial. Extended subfluidization terminal wash (ETSW) procedures could also be investigated to determine whether ETSW would reduce filter ripening times. Additionally, upon conversion to passive biofiltration, buildup of EPS and biofilm could lead to changes in filter operation and performance as well as a requirement for different backwash procedures.

2.3.6 Waste residuals management study

The current waste residuals process does not meet the water quality discharge guidelines for aluminum. There are two options moving forward to address this issue. The existing residuals management process could be modified in order to meet the existing water quality discharge guidelines and maximize treatment efficiency, reliability and capacity. Alternatively, the residuals could be discharged to a new sanitary sewer without treatment. Both of these options will be explored in detail from a cost/benefit perspective.

Task 2.4 Bennery Lake Water Supply Plant (BLWSP)

2.4.1 Installation of plate settlers

The sedimentation basins were originally designed to contain plate settlers, but the plates were never installed. The basins currently operate under a high overflow rate and particles are travelling through the sedimentation basin and being deposited in the filters, compromising filter integrity. Plate settlers will be installed in 2016-2017. Upon installation, detailed water quality investigations throughout the treatment train will be conducted to help with process optimization. Installation of the plate settlers will likely improve filter turbidity and runtime and will also require optimization of the backwash process with the new water quality reaching the filters.

2.4.2 Filter Surveillance

The 2013 optimization study completed by Stantec suggests that the media should be evaluated due to its age. Similar to JD Kline, and LMWSP, BLWSP will implement a filter surveillance program to monitor filter performance, health and backwash routines, and to help identify deficiencies or opportunities for optimization, as well as to determine whether media needs to be replaced. The same suite of biotic and abiotic parameters will be evaluated as part of filter surveillance to provide the same breadth of analysis as mentioned for J.D. Kline and LMWSP.

Theme 3: Distribution System Water Quality

Task 3.1 Lead – Implementing NDWAC Recommendations

In 2015, the USEPA convened the National Drinking Water Advisory Council (NDWAC) to advise the USEPA on how to change the way lead in drinking water is regulated. The NDWAC recommended to the USEPA that the only truly effective solution is for utilities to commit to replacing all lead service lines (public and private) by 2050. To accomplish this, utilities must: develop an accurate inventory of lead service lines, reach out to customers who have lead service lines, work with customers to find a way for them to replace the private portion, and do much more sampling for customers. The NDWAC recommendations were endorsed by the American Water Works Association in March 2016.

Halifax Water has an estimated 2500 public lead service lines, most of which are in Halifax. The number of private lead service lines is unknown but expected to be much higher. Developing strategies for both public and private renewals is a major culture shift, as historically utilities have not taken responsibility for private lead service lines from an ownership, or inventory perspective.

Halifax Water's new approach to manage its customer's exposure to lead is designed to be consistent with the NDWAC recommendations, to the degree they can be applied in Canada and do not conflict with local regulatory requirements. The following five sections describe the research and operational approach that will be taken to address each of the main NDWAC themes:

1. Development of an inventory of lead service lines – both public and private
2. Development of a LSL replacement strategy to meet complete LSL removal by 2050
3. Enhanced public outreach on risks, shared responsibility, results, programs

4. Enhanced customer based sampling, using a variety of types of sampling, chosen from a menu to reflect certain uses. All customer sampling will be used to develop a 3-year continuous 90th percentile that must be below a specified system action level.
5. Enhanced water quality parameter monitoring and evaluation of corrosion control treatment.

3.1.1 Lead Service Line Inventory

The NDWAC recommendations require that utilities inventory the amount and location of LSL's and further take the approach that in areas developed before the cessation of LSL's that the service should be assumed to be made of lead unless proven otherwise. This makes development of an inventory complex but is crucial to other programs and ensuring all of the lead service lines are removed by the target date.

For public services, the existing inventory is fairly reliable but is still populated with a number of "unknown" services. The private inventory is much less reliable. This is due to the fact that there is no positive mechanism that requires a customer to contact us upon renewal of a service but also due to the fact that the pre-existing utilities exercised varying and inconsistent levels of attention to the private service lateral database.

As a first step, areas of the distribution system that would have been serviced by a central water system and potentially had lead service lines installed prior to 1960 has been developed. This is a baseline map that can be used to narrow down the presence of lead on a house by house basis. Some techniques that will be used to update the inventory include:

- Analysis of existing records for anything that contains lead or unknown on the public or private portion of the service lines.
- When new meters are being installed as part of the Advanced Metering Infrastructure (AMI) program, all staff that will be in homes will be trained to identify lead service lines, and will report information back to be included in service cards.
- Gathering and recording information anytime there is work done on a sewer line or a service box in the area with potential lead service lines.
- Participation in industry research to explore and test methodologies for non-intrusive identification of LSL material.
- Conducting a pilot trial for successful identification using more invasive techniques (i.e. hydro-vac excavation at the service box) to determine composition of both public and private portions.

3.1.2 Lead service line replacement strategy

HW will develop a strategy for replacing all public and private lead service lines by 2050. The current rate of 20-30- replacements per year will need to be tripled to about 100 per year in order to replace all of the public portions of the lead service line within this timeframe. The number of private renewals requiring replacement per year is expected to be much higher as there are significantly more private than public lead service lines.

Up until 2012, Halifax Water proactively replaced lead service lines in the distribution system in conjunction with municipal street-paving and sidewalk renewal projects, water main replacement

projects and other distribution system infrastructure upgrades. In light of recent national and internal research initiatives, including research with Dalhousie University, which demonstrate the increase in lead concentrations at the tap following partial service line replacements, Halifax Water has changed its policy regarding service line replacements to minimize the occurrence of partial lead service lines in the distribution system. This practice is expected to continue even with the increased replacement goals. Following are some strategies that will be used to increase the number of lead service lines replaced each year, while continuing to avoid partial replacements to protect public health.

- Halifax Water will explore options with the UARB to allow access to private property to replace the full service line during emergency events when Halifax Water replaces the public portion due to a leak or work on the main.
- Halifax Water will develop a business case to present to UARB that will identify potential cost savings of doing full LSL replacement (private and public) in coordination with HRM paving and sidewalk renewal projects. Cost savings on the public portion would include only one mobilization for multiple services, and a significant reduction in reinstatement costs as this would be covered by the HRM paving project. Being able to coordinate with HRM paving projects would allow for a significant increase in the numbers of renewals per year.
- Halifax Water will continue to provide a program where there is a standing contract with several contractors to replace the public portion of the service line in conjunction with the private portion. This program was initiated in 2016, and provides the option to minimize any potential time with a partial replacement between coordination of the private and public renewals, and also streamlines the process for customers.
- Following any disturbance or replacement of a lead service line, home owners will be provided with instructions for appropriate flushing procedures to carry out immediately following disturbance and protocols to follow to minimize lead exposure for a defined period of time following a LSL replacement. Homeowners will also be provided with a pitcher style water filter and cartridges for one year following disturbance. Different pitcher style filters will be tested for removal of high concentrations of lead post-disturbance to ensure filters provided are adequate for the conditions expected.
- A significant barrier to private uptake of lead service line replacement is expected to be financial challenges. HW will develop a financial enabling program for residents to pay for private LSL replacement. HW will work to ensure that financial enabling strategies are accessible to all customers, to ensure that all demographics have access and ability to replace lead service lines. It is expected that challenges will exist with low-income households, long-time homeowners and also rental units.

3.1.3 Communications

Communications and outreach will be critical components to the success of the lead service line replacement program. Customers must have access to transparent, easy to understand information on the risks associated with lead, and programs available to help with getting lead out of the system. Contact with customers will need to occur through the website, through mail-outs and targeted campaigns in areas that may have lead service lines and vulnerable populations. Significant efforts will be placed on meeting with realtor groups, building inspectors and plumbers to disseminate information

about lead service lines. A real estate transaction is a great opportunity to renew service lines. As such, customer service staff will flag any new customers in the lead hot spot areas so that appropriate information can be mailed out to them when they open an account.

A research program will be initiated to determine effective means of customer communications, so that programs put into place will be an effective use of resources and will provide positive outcomes for private side LSL replacement.

3.1.4 Corrosion Control Treatment

Halifax Water maintains an effective corrosion control program to minimize the corrosion of lead and other materials in the distribution system by controlling pH and using zinc ortho-phosphate for corrosion control.

Recent changes have been made to the corrosion control product and the dose. In 2015, poly phosphate was removed from the product due to research showing it can negatively impact lead release, and in April 2016, the dose was doubled from 0.5 to 1.0 mg/L as PO_4 for both J.D. Kline and Lake Major based on recommendations from consultant reviews of Halifax Water's programs, and research conducted by Dalhousie that shows a decrease in lead concentrations after an increased dose of orthophosphate.

There is a need to further understand the influence of general water chemistry, presence of other metals (i.e. iron, manganese and aluminum) and seasonality on lead release. Research is also required to understand lead phosphate deposition rates following adjustment of orthophosphate dose or changes to source chemicals (i.e. zinc orthophosphate, orthophosphate and phosphoric acid to optimize corrosion control), while balancing costs, minimizing lead release and minimizing unintended consequences.

3.1.5 Water Quality Monitoring

Currently, the effectiveness of the corrosion inhibitor is monitored by Water Quality Inspectors through:

- biweekly distribution system sampling at 25 sites for pH, orthophosphate, zinc, iron, manganese, alkalinity, chloride, sulphate, aluminum and turbidity
- quarterly monitoring of metal coupons (copper, lead and steel placed at 10 locations in the distribution system; and
- bench and pilot scale research conducted in coordination with Dalhousie University,

Additionally, samples are taken from residential homes through three different programs:

- Annual Health Canada lead and copper residential program
  - 100 homes, half lead and half copper, 4 L profile and a flush sample, in August
- Customer initiated sampling
  - Year-round, 4 L profile and a flush sample, any time of year
- LSL replacement sampling program
  - Pre and 72 hrs, 1 month, 3 months and 6 months post construction samples, 4 L profile and flush sample.

Although this is a robust monitoring program, there is room for improvement through evaluation of the program. There is some question as to the value of the coupon monitoring, which will be explored. Additionally, the corrosion sampling sites should be reviewed to ensure their representation of the system. Finally, customer sampling is the only way to provide an indication of lead concentrations in homes, however it relies on the customer to take the sample, which can lead to sample integrity issues. Furthermore it is difficult to compare data from year to year because customers often opt to replace their service line once they find out their lead concentrations. To provide a more robust and stable way to monitor lead concentrations at the tap, Halifax Water will install permanent lead pipe racks in at least 4 places in the distribution system (one in Dartmouth and three in Halifax) to mimic lead levels at the tap. These pipe racks would be similar to those used by Dalhousie University at J.D. Kline previously but would be located in Halifax Water infrastructure in the distribution system to be more representative of at the tap concentrations. This would allow for routine lead sampling to monitor corrosion control, and would also allow for exploration of different stagnation time sample regimes. Pipe racks would also allow monitoring of changes to corrosion control chemistry and impacts from seasonal variations in water quality, including metals, temperature, etc.

Task 3.2 Distribution System Water Quality and Integrity Monitoring

Halifax Water has a comprehensive program to actively monitor and assess both distribution system water quality and physical integrity, through programs such as HPC monitoring, reservoir water quality monitoring, and corrosion monitoring. Data is currently compiled into technical memos and distributed to appropriate staff for review. The monitoring programs are constantly being reviewed for relevance and completeness and this should continue, to ensure that there is appropriate data collection but also interpretation to help understand and predict water quality in the distribution system. One example would be the use of ATP to monitor biological growth in correlation with HPCs. ATP is a rapid test that can be done within minutes versus 7 days for an HPC test. Therefore, understanding the correlation between ATP and HPCs would be very useful for monitoring biological health when low chlorine residuals are present in the warmer months. ATP data collection has started, but should continue to develop a database that provides relationships between ATP and other water quality parameters in the distribution system.

A fluoride tracer study for LMWSP distribution system showed that water age depends on a number of factors including distance from the plant, time of day and reservoir operation. A fluoride tracer study will be repeated on targeted areas within the LMWSP to determine whether there are operational changes that can be made (operation of valves) to decrease water age to some regions of the distribution system. A fluoride tracer study will also be completed for the JDKWSP to provide an overview of water age within the distribution system. Having an indication of water age, particularly at extents of the system and around reservoirs provides valuable information and insight for optimizing water quality, maintaining chlorine residuals and minimizing DBP formation.

As part of the Partnership for Safe Water program, conducting a review of existing chlorine residual monitoring sites and ensuring that sites are representative of the distribution system, including extents, is an important part of understanding distribution system integrity. The fluoride tracer studies will also provide valuable information for assessing the relevance of existing monitoring locations.

Task 3.3 Disinfection efficiency and minimizing disinfection byproduct formation

Although significant work has been done on minimizing distribution system disinfection byproducts both through treatment process changes (removal of pre-chlorine at JDKWSP) and installation of chlorine booster stations on reservoir outflows (North Preston), there is still work that can be done to both reduce DBP formation and also manage reservoir operation to ensure adequate chlorine residuals in all extents of the distribution system, throughout all seasons. Targeted chlorine investigations and review of reservoir monitoring data will provide insight on changes to reservoir operation processes such as installing rechlorination stations, changes in reservoir cycling (volume and timing), installation of mixers, or point of use treatment for removal of disinfection by products that can be implemented to increase disinfection efficiency while minimizing DBP formation.

Theme 4: Theme 4: Data Management

Task 4.1 Adoption of a Data Management Tool

Water Quality Data collected by Halifax Water staff currently gets stored in several different places. Some is entered into WaterTrax, some exists in Pi, and some is stored in spreadsheets at various locations on the K Drive. There is no central place to store, extract and analyze data. Similarly, all water quality data generated by consultants, IRC students and staff is generally contained within reports, student theses, and on personal computers. As this dataset grows, it is becoming clear that there needs to be a mechanism to manage and store all of these data sources, so that data is not lost and both staff and students have access to historical data. This is also becoming increasingly important in the context of Lake Recovery and changing source water quality.

This task will aim to identify, compare, select and integrate a data management approach for water quality data. There exist commercial solutions, provided by companies such as Kisters, EarthFX, Locus Technologies, Aquatic Informatics, Etc. that provide geocoded solutions to water quality data management and analysis. Other options could include development of a Laboratory Information Management System (LIMS), or design of a custom solution. This data management tool will be used to pull all data sources into one central system.

The primary objective of this exercise is to ensure that the valuable resource of water quality data is utilized both as an operational tool to make sound day to day operating decisions and also to ensure that sound investment decisions are made when considering capital improvements to treatment plants and other water quality investments.

Appendix B - Research and Operations Approach

Theme and Task	Halifax Water Role	Dalhousie Role	Comments
Theme 1: Source Water: Lake Recovery and Variable Source Water Quality			
Task 1.1: Identification of Changing Source Water Quality	Sampling	Research lead	
Task 1.2: Lake Recovery Monitoring	Program Evaluation	Research lead	
Task 1.3: Assessment of Intake Locations and Structures			
Task 1.3.1: Lake Major	Bathymetry	Research lead	
Task 1.3.2: Pockwock Lake	Bathymetry	Research lead	Paleolimnological studies
Task 1.3.3: Bennery Lake	Bathymetry and equipment installation	Research lead	HW and Dal to develop raw water monitoring program
Task 1.3.4: Bomont	Lead investigation		
Theme 2: Treatment			
Task 2.1: Roadmap for Robust Treatment Plant Design for a Changing Source Water Quality	Lead tailored collaboration through WRF	Act as in-kind partner	
Task 2.2: J.D. Kline Water Supply Plant			
Task 2.2.1: Improvement of pre-mix and pre-oxidation processes	Capital improvements	Pilot research lead	
Task 2.2.2: Flocculation Optimization	Implement process changes	Monitoring lead	
Task 2.2.3: Improved Filter Performance			
Task 2.2.3.1: Filter Surveillance	Develop and lead Filter Surveillance Team	Lead filter WQ analysis	
Task 2.2.3.2: Biofiltration Optimization		Lead pilot research	
Task 2.2.3.3: Coagulant Optimization		Lead pilot research	
Task 2.2.3.4: Backwash Optimization	Full-scale testing	Lead pilot research	
Task 2.2.3.5: Filter media replacement and addition of air scour	Capital improvements and filter surveillance	Lead filter WQ analysis	
Task 2.3: Lake Major Water Supply Plant			
Task 2.3.1: Premix Optimization	Capital improvements	Lead bench-scale testing	Bench-scale testing for pH/alkalinity control
Task 2.3.2: Coagulant Changeover		Research Lead	
Task 2.3.3: Clarification	Capital improvements and optimization	Monitoring lead	
Task 2.3.4: Manganese Oxidation		Research Lead	
Task 2.3.5: Improved Filter Performance			
Task 2.3.5.1: Filter Surveillance	Develop and lead Filter Surveillance Team	Lead filter WQ analysis	
Task 2.3.5.2: Filter Media Replacement	Capital improvements	Lead filter WQ analysis	
Task 2.3.5.3: Backwash Optimization	Make process changes	Lead filter WQ analysis	
Task 2.3.6: Waste Residuals Management Study	Lead study		Will utilize previous Dal research
Task 2.4: Bennery Lake Water Supply Plant			
Task. 2.4.1: Installation of Plate Settlers	Capital improvements and optimization		
Task 2.4.2: Filter Surveillance	Develop and lead Filter Surveillance Team	Lead filter WQ analysis	
Theme 3: Distribution System Water Quality			
Task 3.1: Lead - Implementing NDWAC Recommendations			
Task 3.1.1: Lead Service Line Inventory	Initiate and manage program, participate in WRF projects		
Task 3.1.2: Lead Service Line Replacement Strategy	Initiate and manage program	Provide technical guidance	
Task 3.1.3: Communications and Outreach	Initiate and manage program	Lead research on customer buy-in	
Task 3.1.4: Corrosion Control Treatment		Research lead	
Task 3.1.5: Water Quality Monitoring	Evaluate and update program		
Task 3.2: Distribution System Water Quality and Integrity Monitoring	Conduct review and research		
Task 3.3: Disinfection Efficiency and Minimizing Disinfection Byproduct Formation	Monitoring lead	Research Lead	
Theme 4: Data Management			
Task 4.1: Adoption of a Data Management Tool	Research, procurement and adoption	Partner as appropriate	Dal to develop integrative data tools