2021 Management Review Report

Finalized May 05, 2022

City of Ottawa Drinking Water Quality Management System

January 1 – December 31, 2021
Review Period

DRINKING WATER
pure and simple

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Introduction

This Drinking Water Quality Management System (DWQMS) annual management review report considers the entire 2021 calendar year and, where appropriate, details activities that have continued into 2022. It is a summary of information that Top Management must annually review in accordance with the Ontario Drinking Water Quality Management Standard. The annual Management Review is a requirement of the Standard (Element 20) and covers 16 key aspects for managing our municipal drinking water systems.

The City was awarded its 'Full Scope – Entire DWQMS' accreditation in October 2011, with reaccreditation awarded in October 2014, 2017 and 2020, for each of its systems listed below*. This Management Review report encompasses the municipal drinking water systems owned and/or operated by the City of Ottawa, namely:

- Central System (Britannia and Lemieux Island Water Purification Plants and central water distribution system)
- Carp Well System
- Kings Park Well System
- Munster Hamlet Well System
- Richmond West Well System (ownership pending final acceptance from a private developer, operated, and maintained by the City of Ottawa)
- Shadow Ridge Well System (owned by a private developer, operated, and maintained by the City of Ottawa)
- Vars Well System

Management Review Meetings

In order to discuss items (a) to (p) of the annual Management Review, the City of Ottawa conducts a series of meetings that include the Operational Top Management Team (OTM) and guests, and one meeting with Corporate Top Management (CTM). It should be noted that the 2021 Management Review meetings were completed virtually via MS Teams due to the COVID-19 pandemic distancing measures that were implemented. The information included within this report reflects the topics discussed as part of these Management Review meetings. Action items that arise from these meetings are captured in the report, with a summary table of action items provided at the end of the report.

OTM Meeting #1: April 12th, 2022, @ 09h00 to 14h30	
Attendees	Position Title, Unit, Branch, Service, Department
Bradley, Lila (guest)	Supervisor, PWD Operations Support, Customer Support Unit West, Customer and Operational Support Branch, Technology, Innovation and Engineering Services (TIES), IWSD
Elliott, Joshua	Engineer (A), Drinking Water Quality Branch, WS, IWSD
Gray, Scott	Plant Manager, Water Production (WP) West Branch, WS, IWSD
Hall, Carol	Manager, Water Distribution Branch, WS, IWSD
Lafrance, Maxime (guest)	Senior Operations Engineer, Operations Engineering – WP West Unit, WP West Branch, WS, IWSD
Lamoureux, Caroline	MS Coordinator, Management Systems Unit, MMSS Branch, TIES, IWSD
Montgomery, Paul	Plant Manager, Water Production East Branch, WS, IWSD
Wilson, Penny (guest)	Water Quality Supervisor, Water Quality Monitoring Unit, Drinking Water Quality Branch, WS, IWSD
Zawada, Yvonne (guest)	Senior Operations Engineer, Operations Engineering – WP East Unit, WP East Branch, WS, IWSD

OTM Meeting #2: April 14th, 2022. @10h00 to 15h00	
Attendees	Position Title, Unit, Branch, Service, Department
Elliott, Joshua	Engineer (A), Drinking Water Quality Branch, WS, IWSD
Gray, Scott	Plant Manager, Water Production (WP) West Branch, WS, IWSD
Hall, Carol	Manager, Water Distribution Branch, WS, IWSD
Huffman, Allison (guest)	Program Manager – Infrastructure Renewal, Infrastructure Assessment – Water Facilities Branch, Asset Management Service, IWSD
Journeaux, Marilyn (guest)	Director, WS, IWSD
Lamoureux, Caroline	MS Coordinator, Management Systems Unit, MMSS Branch, TIES, IWSD

OTM Meeting #2: April 14th, 2022. @10h00 to 15h00	
Attendees	Position Title, Unit, Branch, Service, Department
Montgomery, Paul	Plant Manager, Water Production East Branch, WS, IWSD
Roy, Christopher (guest)	Program Engineer – Water Loss Program, Water Loss Management Unit, Locates, Laterals and Grants Branch, TIES, IWSD
Wilson, Penny (guest)	Water Quality Supervisor, Water Quality Monitoring Unit, Drinking Water Quality Branch, WS, IWSD
Zawada, Yvonne (guest)	Senior Operations Engineer, Operations Engineering – WP East Unit, WP East Branch, WS, IWSD

OTM Meeting #3: April 19th, 2022. @13h00 to 14h30	
Attendees	Position Title, Unit, Branch, Service, Department
Elliott, Joshua	Engineer (A), Drinking Water Quality Branch, WS, IWSD
Gray, Scott	Plant Manager, Water Production (WP) West Branch, WS, IWSD
Hall, Carol	Manager, Water Distribution Branch, WS, IWSD
Lamoureux, Caroline	MS Coordinator, Management Systems Unit, MMSS Branch, TIES, IWSD
Montgomery, Paul	Plant Manager, Water Production East Branch, WS, IWSD

OTM Meeting #4 – Item 'N': April 26th, 2022 @ 09h00 to 10h30	
Attendees	Position Title, Unit, Branch, Service, Department
Ahmad, Shohan (guest)	Project Manager – Infrastructure Planning, Infrastructure Planning Branch, Asset Management Service, IWSD
Elliott, Joshua	Engineer (A), Drinking Water Quality Branch, WS, IWSD
Feilders, Andrea (guest)	Infrastructure Assessment Engineer – Watermains, Watermain Rehabilitation Unit, Infrastructure Assessment – Water Resources Assets Branch, Asset Management Service (AMS), IWSD
Gray, Scott	Plant Manager, Water Production (WP) West Branch, WS, IWSD

OTM Meeting #4 – Item 'N': April 26th, 2022 @ 09h00 to 10h30	
Attendees	Position Title, Unit, Branch, Service, Department
Grimes, Jon (guest)	Senior Engineer – Structure Renewal, Structures Inspections Unit, Infrastructure Assessment – Transportation Branch, AMS, IWSD
Grimwood, Robert (guest)	Senior Engineer – Strategic Asset Management, Strategic Asset Management Unit, Capital Planning/Strategic Asset Management Branch, AMS, IWSD
Hall, Carol	Manager, Water Distribution Branch, WS, IWSD
Howard, Christopher (guest)	Program Coordinator – Asset Management and Investment, Capital Budget Coordination Unit, Capital Planning/Strategic Asset Management Branch, AMS, IWSD
Khawam, Walid (guest)	Senior Engineer – Infrastructure Renewal, Infrastructure Assessment – Water Facilities Branch, AMS, IWSD
Lamoureux, Caroline	MS Coordinator, Management Systems Unit, MMSS Branch, TIES, IWSD
Montgomery, Paul	Plant Manager, Water Production East Branch, WS, IWSD
Phillips, Derek (guest)	Program Engineer – Life Cycle Performance Optimization Network Unit, Engineering Support Services Branch, TIES, IWSD
Rogers, Christopher (guest)	Program Manager – Infrastructure Planning, Infrastructure Planning Branch, AMS, IWSD

Planned CTM Meeting: May 12th, 2022 @ 14h00 to 15h00	
Planned Attendees	Position Title, Branch
Brambles, Ashley	Manager, Business and Technical Support Services, IWSD
Douglas, Ian	Engineer, Drinking Water Quality Branch, Water Services (WS), IWSD
Duclos, Carina	Director, Infrastructure Services, IWSD
Elliott, Joshua	Engineer (A), Drinking Water Quality Branch, WS, IWSD
Gray, Scott	Plant Manager, Water Production (WP) West Branch, WS, IWSD
Hall, Carol	Manager, Water Distribution Branch, WS, IWSD

Planned CTM Meeting: May 12th, 2022 @ 14h00 to 15h00	
Planned Attendees	Position Title, Branch
Journeaux, Marilyn	Director, WS, IWSD
Lamoureux, Caroline	MS Coordinator, Management Systems Unit, MMSS Branch, TIES, IWSD
Montgomery, Paul	Plant Manager, Water Production East Branch, WS, IWSD
Nielsen, Gen	Manager, AMS, IWSD
Laberge, Scott	Director, TIES, IWSD
Rose, Tammy	General Manager, IWSD

Following the approval of this report by members of OTM, the final report is circulated and a presentation summarising the report is given to CTM. After this, a summarized Management Review report is prepared and presented to the City's Standing Committee on Environmental Protection, Water and Waste Management and City Council, planned for June 21, 2022, and July 13, 2022, respectively.

a) Incidents of Regulatory Non-Compliance

The ***Safe Drinking Water Act (2002)*** sets out a number of requirements for owners and operators of drinking water systems. Any deviation or failure to meet these requirements could be considered to be an incident of regulatory non-compliance. The Summary Report for all (8) municipal water systems were provided to City Council on March 31st as required by O.Reg 170/03. The 2021 Summary Report was tabled at the Standing Committee of Environmental Protection, Water and Waste Management on Sept 21, 2021.

As part of the DWQMS Management Review, the items of non-compliance noted in the 2021 Summary Report are presented for discussion and review. In preparing the reports, internal staff carefully reviewed the following records for evidence of non-compliance during the operating period January 1st – December 31st, 2021:

- MECP inspection reports for each waterworks and distribution system
- Operator certification records for Drinking Water Services
- Water flow data for raw and treated
- Water quality records
- Lead testing regulatory requirements
- MECP Officer and Environment Canada Orders
- Annual and Summary Reports
- Municipal Drinking Water Licenses
- DWQMS Continual Improvement Table

Summary of non-compliance events

The combined Summary Report prepared for the each of the (8) municipal water systems include a Compliance Table that lists all regulatory requirements for drinking water, along with a verification of compliance or non-compliance as noted. Any item of non-compliance that was observed during 2021 is described in the Section entitled 'Items of Non-Compliance' of the Summary Report (dated March 31st, 2022), along with any actions or preventive measures taken. During 2021, there were (4) incidents of non-compliance noted for Ottawa's municipal drinking water systems. Each incident is described below, including corrective actions taken and the impact on water quality.

(1) Delayed notification of Adverse Water Quality Incident (AWQI): A Category 3 watermain break occurred on March 29, 2021. Field staff verbally notified the Ministry and Ottawa Public Health, but the required written notification was not completed until several days later, exceeding the 24 hour deadline. An additional notification error occurred in relation to an adverse test result reported on July 23, 2021. Three days after the result, Water Distribution staff completed verbal and written notification to the Ministry and Ottawa Public Health which exceeds the prescribed timelines for notification. In both instances, the adverse water quality incidents were resolved through appropriate corrective actions. Additional training is being provided for Water Distribution staff to review AWQI reporting requirements.

(2) pH and Alkalinity samples in Well Systems: For the MECP Community Lead Testing Program Sch.15.1 in Ottawa's well systems, regulatory relief for lead testing has been granted since initial testing showed no presence of lead tap water taken from customer homes. However, distribution water samples must be taken from two locations every winter and summer and tested for alkalinity and pH. During 2021, only 1 sample location was tested in each of the 5 affected well systems. This non-compliance has no impact on water quality or lead concentrations. The Water Quality Supervisor has corrected the sampling schedule to ensure that required samples are taken each year.

(3) Operating without a valid license: One of the water treatment plant operators experienced a delay in receiving their new operating certificate from the licensing office and operated for three 12-hour shifts unaware that their original certificate had expired. During these shifts, the operator was under the direction of a licensed Overall Responsible Operator and their actions did not result in any risk to drinking water quality. Operator refresher training will be undertaken to reinforce the importance of maintaining valid certification at all times.

(4) Filter turbidity measurements during control system failure: A supervisory control and data acquisition (SCADA) computer system failure at the Britannia WPP resulted in the loss of filter turbidity data for a period of 30 minutes. During this time, manual readings were not taken every 15 minutes, as required by O.Reg. 170/03. Analyzers were visually monitored by the operators, and turbidity readings remained stable during the 30-minute outage. Upcoming staff training will include a review of regulatory monitoring and recording requirements. Additionally, a SCADA upgrade capital project is funded and underway that will lower the likelihood of future failures.

In each case, staff took corrective actions to promptly address each of the non-compliance issues. Most importantly, the non-compliance incidents noted were technical and/or administrative in nature and did not affect the quality of drinking water supplied to the public.

In addition, certain incidents of non-compliance are reviewed by operations staff through the DWQMS Continual Improvement process. A team of operational and technical staff review all incidents and through discussion identify any corrective measures required in order to prevent or mitigate similar incidents in the future.

No Action Items were identified as part of the Management Review Meetings

b) Incidents of Adverse Drinking Water Tests

The drinking water regulations identify several “Indicators of Adverse Water Quality” for which the waterworks must immediately notify health officials and the MECP and carry out specific corrective actions. These are key parameters that indicate a potential health concern with the water supply, such as the presence of bacteria. Adverse Water Quality Incidents (AWQIs) also include any exceedance of a health-based drinking water standard (approximately 70 parameters) or a situation that directs improperly disinfected water to consumers. In each case, City of Ottawa staff immediately notified Ottawa Public Health and the MECP as required by regulations. Corrective actions, re-sampling, and reporting were carried out in collaboration with Ottawa Public Health.

In total, 12 AWQIs occurred during 2021, all of which occurred in the central water distribution system. The table below shows the breakdown of 2021 AWQIs, listed by operational area:

Table 1 - Number of AWQI events for 2021 by operational area

Britannia	Lemieux	Distribution	Carp Well	Kings Park Well	Munster Well	Shadow Ridge Well	Vars Well	Richmond West Well	TOTAL
0	0	12	0	0	0	0	0	0	12

Most of the AWQI events were similar in number to previous years, with a few notable trends described below.

Multiple low chlorine residuals: of the 12 events in the distribution system, 4 were related to low chloramine residuals resulting from either closed valves or a dead end watermain with low flow. Once discovered, the watermains were flushed to restore the chloramine levels.

Improperly disinfected water directed to water users: 1 event was related to possible improperly disinfected water being directed to customers. This event also resulted in precautionary boil water advisories since it was a Category 3 watermain break that occurred in the vicinity of a broken sewer line in the excavation pit;

Discussion: overall, the number of AWQIs during 2021 (n=12) is similar to 2020 but lower than has been found in previous years (n=20–25 range). It has been decreasing

over the last few years, but this could be a result of decreased sample locations as a result of COVID-19 restrictions.

In comparison to previous years, the statistics for water distribution show an increase for AWQIs related to watermain breaks and low chlorine residual, as illustrated in the table below. This is due in part to heightened awareness amongst distribution operators.

Table 2 – AWQI categories for central water distribution system by type 2017-2021

AWQI type	2017	2018	2019	2020	2021
Routine WQ sampling	2	3	1	2	1
Temporary services	0	0	0	1	0
Watermain break/repair	0	6*	3	3	4*
Low Cl_2 residual	0	6*	12	4	4
Improperly disinfected water directed to users	2	1	1	4	1
Other	0	0	0	0	2
Annual Total	4	16	17	14	12

*repeat AWQI

No Action Items were identified as part of the Management Review Meetings.

c) Deviations from Critical Control Point (CCP) Limits and their Response Actions

Through the DWQMS risk assessment process, nine Critical Control Points (CCPs) are identified within Water Production and seven CCPs identified within Water Distribution. A CCP is defined as a step at which controls can be applied to prevent or eliminate a drinking water hazard or reduce it to an acceptable concentration that is within the established Critical Control Limit (CCL). Deviations from the CCLs are captured and reviewed in order to determine potential preventative measures for implementation.

Water Production CCL Deviations

Throughout 2021, the responsibility to identify and escalate water production CCL deviations rested with the WPPs' operating personnel. Investigations into those deviations were then carried out by the Production Supervisors, Operation Engineers, and the Plant Managers. These events were documented in the 2021 Continual Improvement Summary Table, aided by the following information sources:

- Communications from operating personnel
- Supervisory Control and Data Acquisition (SCADA) trends and event logs
- 2021 Operator logbooks
- 2021 Process spreadsheets for Britannia and Lemieux WPPs
- Review and discussion by plant technical staff
- Root cause failure investigation and reporting by operational and reliability engineering staff

Table 3 - Water Production CCL deviations identified during 2021

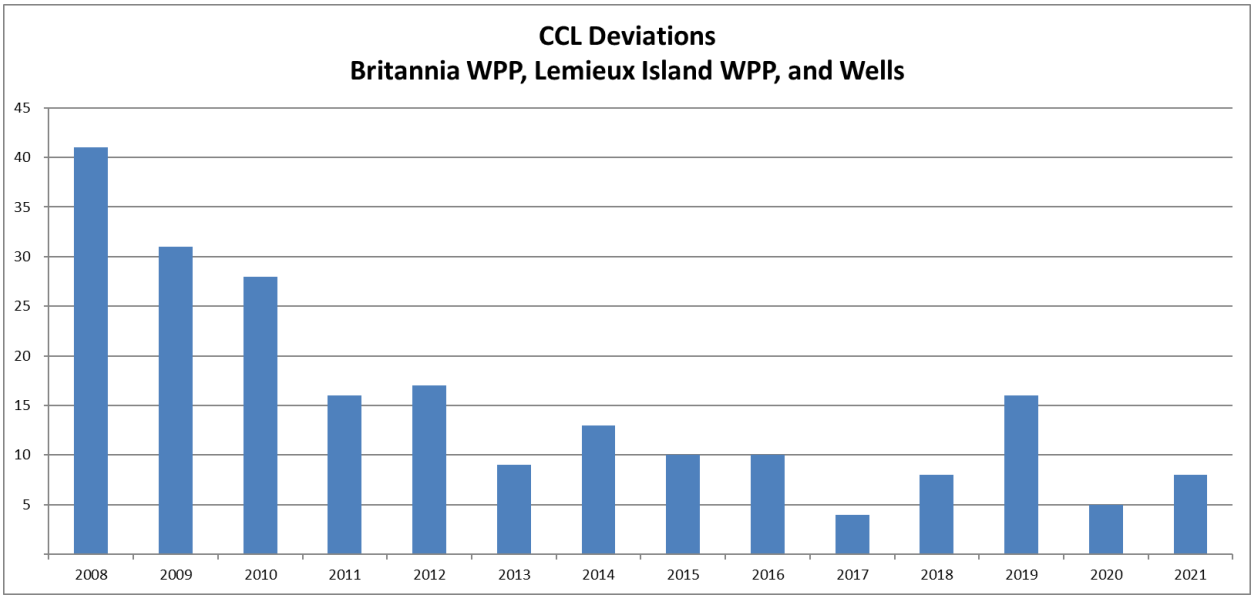
Water Production CCPs		**Number of CCL Deviations in 2021**
P1	Coagulation process upset	0
P2	Filtration process upset	7
P3	Inadequate primary disinfection	0
P4	Effluent treatment chemicals improper dosage	0
P5	Loss of pressure in the central distribution system	0
P6	Loss of pressure in a well distribution system	1
P7	Inadequate primary disinfection in a well system	0

Water Production CCPs		Number of CCL Deviations in 2021
P8	Water storage contamination due to animal presence	0
P9	Lemieux Island WPP Intake Pipe Blockage	0

In total there were eight (8) Water Production CCL Deviation events in 2021. Seven (7) events occurred in water treatment plants, and one in a communal well system.

The number of CCL deviations per year are illustrated in the trend graph below.

Figure 1 - Total number of CCL deviations per year between 2008 and 2021 (Britannia WPP, Lemieux WPP, and Well Systems)



It should be noted that CCL deviations at the well systems were included beginning in 2010, and additional CCPs were added in 2014 (P8) and 2015 (P9). In general, the following actions continue to help reduce the number and severity of CCL deviations and to assist operators in responding to these deviations:

- Regular review of CCL events by technical staff including action items to reduce risk;
- Regular review of CCL events during operator training sessions;
- Detailed analysis of potential process impacts prior to completing maintenance work on major plant systems;

- Prior to plant isolations or shutdowns, plan and coordinate the occurrence of multiple maintenance activities;
- Requirement for written submission of isolation requests from contractors prior to performing work, followed by receipt of written approval to proceed;
- Weekly coordination meetings to review all isolation requests, maintenance work and response to emergency breakdowns;
- Update and communication of lock out procedures for all system isolations; and
- Use of automated alarms and tracking for CCL events through the SCADA system.

In reviewing the CCL deviation events for 2021, it was determined that the operators responded appropriately to prevent unsafe or inadequately treated water from leaving the treatment plants throughout the year.

Water Production CCL deviation events and corrective actions

The eight (8) CCL deviation events during 2021 included the following:

- 6 filtration events (P2) at Lemieux Island WPP;
- 1 filtration event (P2) at Britannia WPP; and
- 1 loss of pressure at a well system (P6) at Shadow Ridge CW.

The eight CCL events are described in more detail below.

Table 4 – Description of Water Production CCL Deviations in 2021

CCP	Root Cause	Results	Corrective Action(s)
P2	August 26th, Lemieux Island WPP multi-filter turbidity rise causing plant shut and purge.	A spike in Raw water turbidity was observed at approximately 9:40 AM. Coagulation was running suboptimal due to ongoing silicate issues with the old diaphragm pumps. During the same time the plant was running at high load (250 ML/d). Operator	New silicate system has been in service since Sep 13, 2021 and operating with no issues. Event will be revisited in summer of 2022 under similar conditions to ensure new system has solved issues

CCP	Root Cause	Results	Corrective Action(s)
		noticed turbidity rise across multiple filters and purged the plant. Distribution water quality was not adversely affected as a result.	
P2	August 27th, - Nov 1st: four (4) CCLs Lemieux Island WPP High turbidity on Filter #7 effluent; all events were linked to the same root cause	Filter #7 turbidity rose past 0.1 NTU for more than 5 minutes post backwash during the sub-fluidization to production transition. The filter was turned off and ripened to waste. Water quality was not adversely affected in all instances.	Filter turbidimeter was found to be noisy and outputting slightly higher values which caused CCLs to trigger; turbidimeter replaced in March 2022.
P2	December 15th, Lemieux Island WPP produced a silicate feed failure sometime after a silicate flush/switch	Improper line flush led to clogging of feed line and subsequent coagulation failure. Plant was purged promptly and was back in production after approx. 5 hours. Distribution water quality was not adversely affected as a result.	Event will be reviewed in 2022 Operator Training to educate operators on line-flushing procedures for the new silicate system A SOP will be published for line flushing to avoid future repeat events
P2	June 1st, Britannia WPP High Turbidity on Filter #15 effluent	Britannia WPP load was increased due to a Lemieux Plant shut. Filter #15 had a runtime of 93 hours. The load change resulted in the Filter #15 effluent turbidity increasing above 0.10 NTU, which prompted the Operator to backwash the filter. The	The Filter Backwash Procedure will be revised to include pre-backwash requirements for filters that are in high turbidity alarm or are experiencing high turbidity, including ripening the filter to waste and/or bypassing the filter drawdown step.

CCP	Root Cause	Results	Corrective Action(s)
		AUTO backwash drawdown step was initiated and sent filtered water with a turbidity of 0.11 NTU to the clearwell for 5-6 minutes before the effluent valve was closed.	
P6	April 9th – Power blip caused UPS failure leading to loss of comms to Shadow Ridge well, resulting in system depressurization	UPS failure at Shadow Ridge well caused chlorine pumps to go into GA. System reached neutral pressure at ~11:00 am. Remote operator was dispatched and reset the alarm, restoring pressure by 11:30 am.	Faulty UPS was discovered to be the culprit; UPS was replaced, and issue has not reoccurred. After system was repressurized, distribution water samples were taken by the operator and water quality was found to be adequate with sufficient chlorine residual and negative bacteriological results.

In all central system events, the treated water quality was continuously monitored to ensure inadequately treated water was not reaching the distribution system, and in the events where the treated water quality was unacceptable the plant was purged in order to ensure the water quality in the distribution system was unaffected.

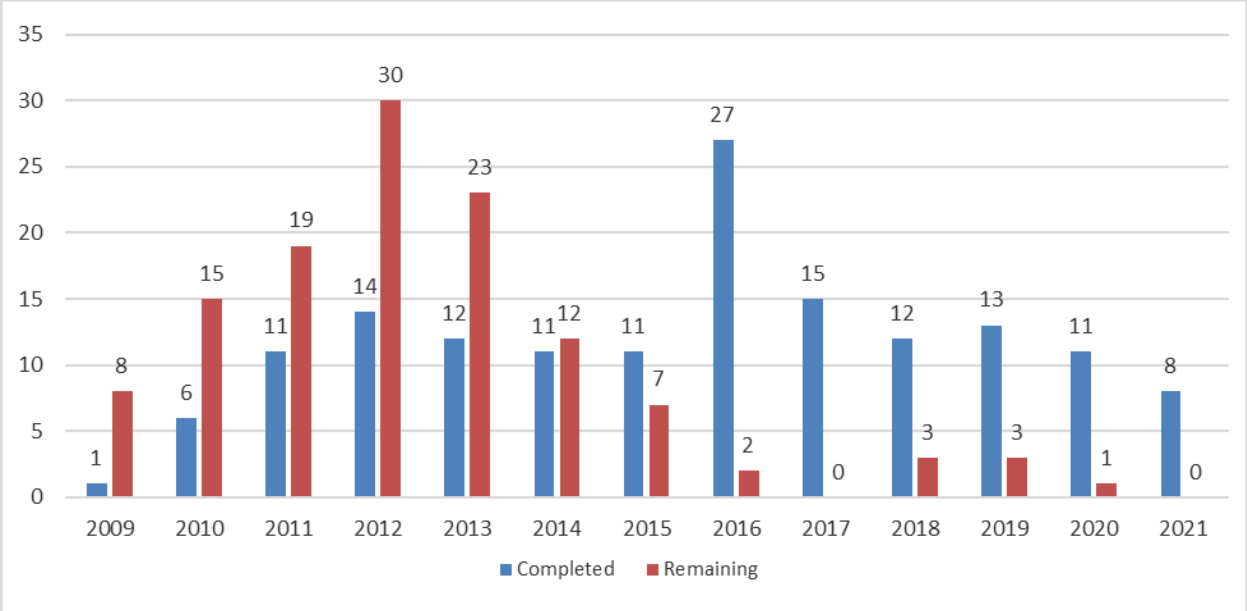
Following the Shadow Ridge depressurization event, distribution water was sampled and tested, and was verified to be in compliance.

All CCL deviations, corrective actions and improvements are tracked and reviewed as part of the DWQMS Continual Improvement process. During 2021, 61 new Priority 1, 2 and 3 action items were identified as part of the Continual Improvement process. A total of 59 action items were completed, including eight Priority 1 action items; one identified in previous years and all of the seven Priority 1 action items identified* in 2021.

**Note that this does not include Priority 1 action items identified and completed as a result of CAPAs.*

Since 2008, a total of 149 Priority 1 action items have been identified and 149 of them have been completed.

Figure 2 - Status of Priority 1 Action Items from 2009 to 2021



Some important Continual Improvement actions that have been completed in 2021 include the following:

- Settled Water Conduit level transmitters at Lemieux Island have been wired to a second PLC for redundancy in the event of PLC failure;
- Maintenance work procedures in SAP have been revised for well stations to eliminate potential for returning wells to service without functional chlorinators;
- Britannia settling basin high flow trials were conducted to quantify settling capacity improvement made to settling basins 4 and 5 plate packs, verifying operation of the new plate settlers installed in these basins;
- Completed individually-tailored chemical unloading SOPs for bulk chemicals in consultation with operations staff;
- Identified training opportunities for operators, topics including: critical control point awareness training, manual chemical dosage adjustments, and

operating strategies during challenging conditions (e.g. cold water, changing water temperature) for upcoming operator training;

- Started trial of different pumps for sulphuric acid service at both Lemieux and Britannia for potential permanent installation, in order to find a suitable long-term replacement for the old discontinued gear pumps which are proving hard to find parts for;
- New silicate gear pump table was commissioned and placed into operation at Lemieux Island in September 2021 to fix silicate dosage stability issues caused by pulsation in the old diaphragm pumps.

Water Distribution CCL Deviations

The Critical Control Points for Water Distribution are shown in the table below, along with the number of CCL deviations noted during 2021.

Table 5 - Water Distribution CCL deviations identified during 2021

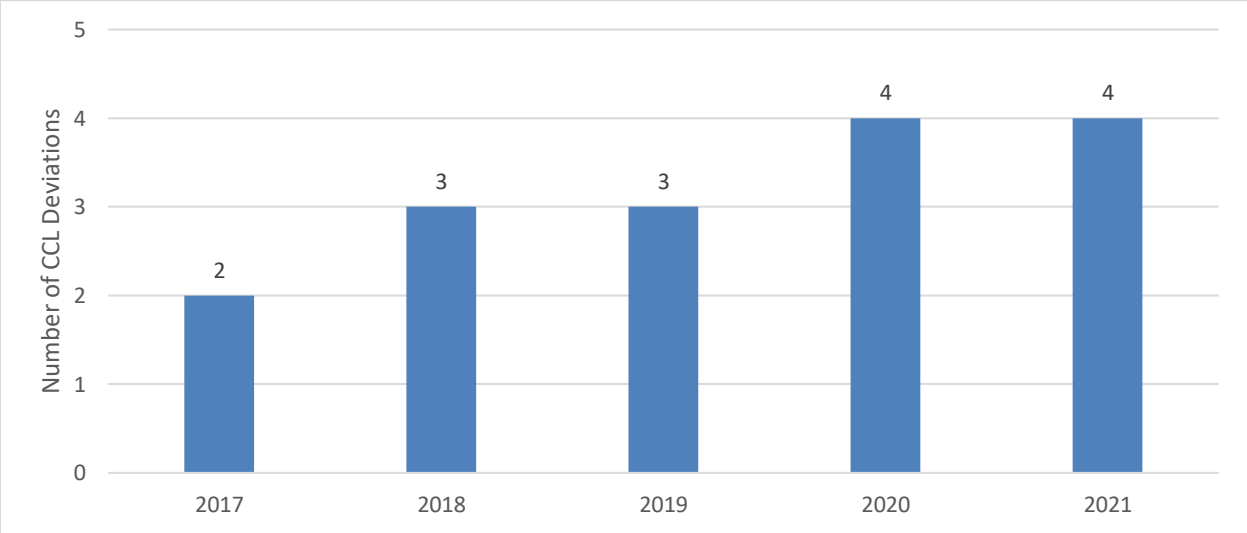
Water Distribution CCPs		**Number of CCL Deviations in 2021**
D1	Known or suspected contamination in the distribution system due to a watermain break (e.g. *E. coli* confirmed, sewers, fuel or other chemicals resulting in contaminated groundwater, explosion)	3
D2	Potential contaminant infiltration from uncontrolled loss of pressure greater than 60 min. in the distribution system (due to loss of power, equipment failure, component failure or by overdraw on hydrant, fire fighting, closed valves, etc.), Backbone watermain break.	0
~~D3~~	~~Known or suspected contamination in the distribution system associated with a temporary service~~ *****	~~0~~
D4	Contamination in the distribution system due to a backflow caused by operational activities in the distribution system	0
D5	Contamination - high levels of lead in water due to leaching from pipe/plumbing	0

Water Distribution CCPs		Number of CCL Deviations in 2021
D6	Contamination in the distribution system associated with a new watermain installation (high chlorine slug, non-potable water, contractor operates valves or completes connections, debris left in w/m from construction, etc.)	1
D7	Contamination during contractor hydrant use (dirty hose, lack of backflow prevention)	0

* CCP D3 has been struck through, as this CCP was eliminated during the 2018 Risk Assessment exercise. To minimize confusion, with regards to numbering, it is still listed but it has been deleted.

The figure below illustrates the total number of water distribution CCL deviations per year for the period 2017 – 2021.

Figure 3 - Total number of water distribution CCL deviations per year 2017 to 2021



CCL deviations detected in the distribution system have been relatively consistent since 2012 in the range of 2 to 4 per year. During 2021, CCL deviation events were noted, as described below.

Table 6 - Description of Water Distribution CCL Deviations in 2021

CCP	Root Causes	Results	Corrective Action(s)
D1	Hanlon @ Connaught	Category 3 repair	• Precautionary Boil Water Advisory

CCP	Root Causes	Results	Corrective Action(s)
	broken sewer lateral during repair of leaking watermain cap		• The watermain was flushed using high velocity flushing, the watermain cap and sewer lateral were repaired. A continual flush was set up overnight • Two sets of clear Bacteriological samples were taken
D1	Simcoe watermain break	Total coliform > 0	• watermain was flushed and resampled
D1	Delong watermain break	Total coliform > 0	• watermain was flushed and resampled
D6	bypass not installed on valve	low chloramine residual	• watermain was flushed to restore chloramine residual • Bypass was installed

Aging Report for CCL Deviation and DWQMS Priority 1 Action Items

The 2015 Management Review report recommended that a report be sent to OTM for aging Priority 1 action items that remain *In Progress*. These action items may have resulted from past CCL deviation incidents or general DWQMS actions. For the purposes of this report, aging action items are items that have been *In Progress* for ≥ 2 years. An aging report has been presented on a quarterly basis to OTM, beginning in 2018.

At the end of 2021, there were a total of seven Priority 1 action items that remained *In Progress*, all of which were derived from DWQMS triggers. A summary table below summarizes these items:

Table 7 - Aging Priority 1 Action Items

Year	Action	Target Date
2015	Backflow Coord will work with WD, AMI Network staff to develop a process to 1) create report using AMI data, 2) investigate and 3) require backflow preventer installation where requd. 4) Process to be documented	
2015	"Technical review of CCL limits for treatment plants and well systems; Document risk calculation and rationale for each*. Review meeting with WP/WQ Tech Group	2022

Year	Action	Target Date
	(*NOTE public health criteria document should be updated as part of this risk assessment) "	
2017	Create a checklist that identifies access points to treated water storage at WPPs for inspections. Add these points to existing inspections completed by Facilities.	2022
2018	Chemical design review project – WQ to provide tech memo indicating work to date, areas of concern, chemical design areas needing review/upgrade. Report to include technical reference table for various feed chemicals; Further work on chemical design to be completed as individual projects;	2022
2019	Project: review and update distribution sampling program to include: (i) adequate sampling sites in each pressure zone, (ii) adequate # of regulatory samples + buffer for compliance, (iii) route streamlining for weekly coverage, etc. (iv) integration with other customer testing, leads, etc. (v) integrity of each sample location (access, bacteriological contamination), (vi) tap fixture upgrades where needed, (vii) standardized disinfection procedure for each tap, if required at that site (eg. free flowing continous sample vs. tap shut off) (viii) documentation for all to reference;	2022
2019	TBD: The need to install flushers by the City (without prior consultation with the Developer) should be specified in the permit approval documents issued to the Developer following incidents of repeated failed sample results for TC. Including this requirement in the permit approvals would accelerate the installation of flushers and minimize the instances of adverse water quality issues.	2022
2020	Develop procedures for disinfection and reinstatement of following: a) SOP for disinfection of reservoirs and tanks in central distribution - CLOSED b) SOP for disinfection of well system water storage reservoirs c) SOP for disinfection of treatment plant basins (mix chamber, filters, high-lift)	2022

The action items described above are being tracked for completion by the QMS Coordinator. Three Priority 1 action items were closed in 2021. A re-prioritization activity occurred in June 2020, which led to DWQMS action items being re-evaluated and re-scored; some Priority 2 were changed to Priority 1.

No action Item identified as part of the Management Review Meetings:

d) Effectiveness of the Risk Assessment Process

The DWQMS Risk Assessment process that has been implemented at the City of Ottawa reviews existing hazards and potential new hazards where applicable. At least once every calendar year, or following a major process change, the QMS Coordinator facilitates a formal review with the risk assessment team. Since the specific nature of processes and risks differ between water treatment and distribution, the Risk Assessments for Water Production and Water Distribution are carried out by two different teams. In 2021, an annual risk assessment review was completed.

In the first stage of the annual risk assessment exercise, participants reviewed incidents from 2021 that had the potential to impact water quality (Continual Improvement Summary Table for 2021 and DWQMS incident investigations, as applicable). Any newly identified hazards were added to the Risk Assessment Outcomes tables and ranked for likelihood (L) or consequence (C).

During the final stage of the risk assessment exercise, participants assessed the remaining hazards that were previously identified in 2020 (2020 Risk Assessment Outcomes Table) with a Risk Number of ≥8 for validity by reviewing historical occurrences and improvements made to operations.

As part of the risk assessment review, hazards are considered for inputs for the infrastructure review discussions that occur throughout the year and if required, included as part of the Management Review meeting for item ‘n’. This would be documented under column ‘K – Consider for Infrastructure Review’, where deemed necessary.

Outcome

Tables for the 2021 Risk Assessment Outcomes and Summary of CCPs were updated as part of the review. Changes (i.e., increases/decreases to likelihood or consequence resulting in a critical risk) were captured in the “notes” column in the Risk Assessment Outcomes.

Below is a summary of the significant changes made to the 2021 Risk Assessment Outcomes Table for Water Distribution:

- **CHANGE Category 2 Watermain Break**: The likelihood rating was changed from 4 to 5, to reflect the 2019 MECP Watermain Disinfection procedure and a similar rate of occurrences in 2021. The answers to Q1 and 2 were also changed from *No* to *Yes* since the hazard has an RN ≥ 8 and control or preventive measures can be applied as a response. This hazard was assigned to the existing CCP D1.
- **UPDATE Contamination in the distribution system associated with a new watermain installation**: In the *Control and Preventive Measures*, mention of a draft SOP for Lock out Tag Out was deleted, since the document was finalised.
- **CHANGE Inability to locate/operate underground infrastructure**: Since the hazard had an RN ≥ 8, we confirmed the answer to Q1 changed from *No* to *Yes* and that no CCP was identified for it.

Below is a summary of the changes made to the 2021 Risk Assessment Outcomes Table for Water Production:

- **No changes** to the Risk Assessment Water Production Outcomes table

Items Flagged for Infrastructure Review

No new items were flagged for consideration for infrastructure review for Water Distribution and Water Production.

Action Items derived from the Risk Assessment

No new action items were derived from the 2021 Risk for Water Distribution and Water Production.

Further details regarding the 2021 annual risk assessment exercise is provided in the 2021 Risk Assessment Report. The items described above and action items resulting from the risk assessment exercise are being tracked for completion by the QMS Coordinator.

No action Item identified as part of the Management Review Meetings:

e) Results of Internal and External Audits

The Ontario Drinking Water Quality Management Standard requires the Operating Authority to conduct an internal audit of each element at least once every calendar year. As well, external desktop surveillance (annual) audits and on-site verification audits (every 3 years) of the Management System must be completed by a recognized accreditation body.

Internal Audits

The objective of the internal audit is to document evidence of conformance to the Quality Management Standard, the current version of the Operational Plan, and other controlled documents, such as SOPs. Corrective Actions (CAs) are created to address non-conformances. CAs, Preventive Actions (PAs) and Opportunities for Improvement (OFIs) are discussed with auditee teams and if accepted, follow-up action items are generated. Action items are tracked as part of the DWQMS Continual Improvement process. The 2021 internal audit results are summarized in the table below:

Table 8 - Internal Audits and Findings for 2021

Internal Audit Process	Completion Date	Findings		
		CAs	PAs	OFIs
2021-036 Plant Purge Procedure	July 2021	1	3	1
2021-037 Depressurization of closed pressure zones in the central system	November 2021	4	1	4
TOTAL		**5**	**4**	**5**

As a result of the COVID-19 pandemic restrictions, all internal audits had to be completed virtually using MS Teams meetings and electronic sharing of documents/records to maintain social distancing. Limitations of the virtual audits included:

- Secondary observations were less likely to be observed. For example, during live audits, audit issues can often be detected when reviewing records and documents for alternate purposes; and
- Records observed would have been limited to what was provided by the auditee and may not have allowed for a more random sample of records.

Below is a summary of the non-conformances and resulting action items:

- **2021-036 Plant Purges:** The non-conformance for this audit related to updating the green binders used to store the hard copies of procedures, to be located in the control rooms at both plants. An obsolete version of P000237 dating from 2016 was still found in the green binder; this document would have to be replaced with the most recent version of the procedure dated 2019. This item was completed and closed in July 2021.
- **2021-037 Depressurization of closed pressure zones in the central system:** The non-conformances for this audit related to:
  - An obsolete flowchart was still available on Ozone; this link would have to be removed. This item was completed and closed in November 2021.
  - The AWQI Procedure not being properly followed. No action was defined at the time of this report.

In total, 262 actions have been created in response to internal audit findings since 2009, 236 of which have been closed by the end of 2021; this represents a completion rate of 90%. The Priority 1 action items that remain in progress relate to:

- Creating a checklist that identifies access points to treated water storage at WPPs for inspections. This action item is being led by the Water Production Senior Operations Engineers and is expected to be completed in 2022.
- Developing a business process with WQ for managing log sheets at remote facilities and implement it. This action item is being led by the Water Production Supervisors and is expected to be completed in 2022
- Including language related to the need to install flushers by the city in permit approval documents issued to the Developer. This action item is being led by the Water Distribution Manager and the Water Distribution Senior Operations Engineer and is expected to be completed in 2022.

External Audit

The City was awarded its ‘Full Scope – Entire DWQMS’ accreditation on October 3, 2011 for the seven existing municipal water systems, with reaccreditation awarded on September 4, 2014, on October 2, 2017 and on September 24 2020. It is subject to a tri-annual re-accreditation process, as well as annual surveillance audits.

The 2021 third-party accreditation body (NSF International Strategic Registrations (NSF)) conducted their off-site surveillance audit of the City's DWQMS via virtual meetings with City of Ottawa personnel and electronic submission of requested documents and records, due to COVID-19 pandemic restrictions. The results of this audit demonstrated zero findings of non-conformance for the City's drinking water systems.

The 2021 external audit marked the 9th year of receiving 0 non-conformances for its DWQMS.

No Action Items were identified as part of the Management Review Meetings.

f) Results of Relevant Emergency Response Testing

The DWQMS, specifically *Element 18 – Emergency Management*, requires the Operating Authority to conduct an annual exercise to evaluate the drinking water Incident Escalation and Response Plan (IERP).

Water Services (Drinking Water) conducted an emergency desktop exercise on Tuesday, October 19, 2021. The exercise desktop scenario consisted of a chemical contaminant introduced at the Lemieux Island Water Production Plant (WPP), contaminating the City water distribution system. The exercise included participants from Ottawa Public Health, Water Distribution, Water Quality and Water Production.

Based on observations made during the emergency exercise and in consequent debrief discussions, it was concluded that the group generally achieved the identified objectives and practiced effective decision-making processes.

Recommendations for continual improvement were determined by Water Services Management team and implemented as applicable. These recommendations are documented in the 2021 DWQMS Emergency Exercise Report.

No Action Items were identified as part of the Management Review Meetings.

g) Operational Performance

In order to track operational performance, Key Performance Indicators (KPIs) have been developed in the following categories: Customer Service, Water Distribution, Water Production and Water Quality. Operational KPIs are tracked and described below.

Customer Service KPIs

Water Quality on-site customer investigations: The number and type of water quality investigations during 2021 are summarized in the table and graph below.

Table 9 - Number of Water Quality Customer Complaints Investigated

KPI	2017	2018	2019	2020	2021
Lead Testing	129	127	534	460	1070
Discoloured Water	63	105	87	39	55
Taste and Odour	34	44	37	46	56
Health	37	26	17	11	20
Chlorine	4	3	2	11	6
Cloudy	16	16	30	15	26
Metals	9	5	41	43	27
Pink Bacteria	4	7	10	6	7
Sediment	11	18	8	9	12
Basic WQ	9	22	21	22	24
Other (canvassers, appearance, White particles, hardness)	12	6	11	20	10
Total Water Quality Investigations	**328**	**378**	**798**	**682**	**1313**

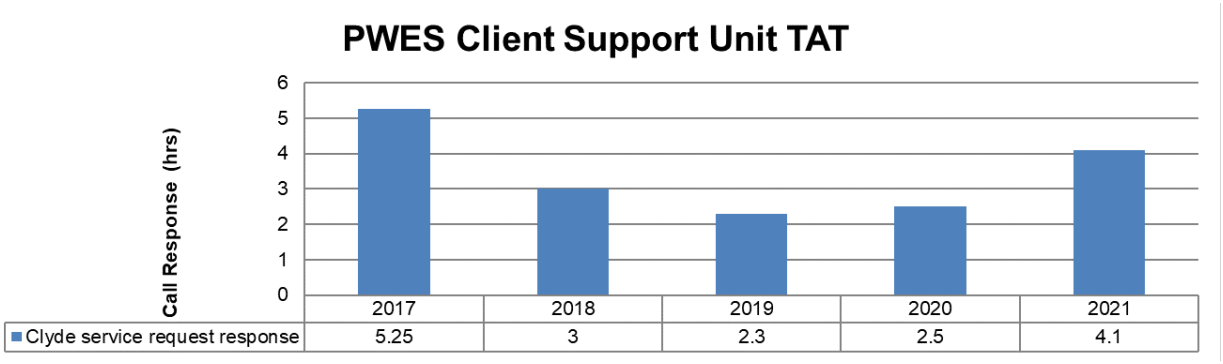
The number of water quality investigations in the last few years have been consistent except for lead testing. Customer interest in lead testing showed a sharp increase due to heightened public awareness and frequent media reports in 2019 following the change in the Maximum Acceptable Concentration (MAC) of lead by Health Canada from 10 ppb to 5 ppb. In 2020 and 2021 the Lead Pipe Replacement Program (LPRP) was updated and as a result 30,000 letters and brochures were mailed to customers in areas that it was thought to have lead services (pre-1955 homes). In 2020, 5,000 were mailed out but due to COVID-19 pandemic restrictions, the mail out was suspended until July 2021 which time the remaining 25,000 letters were mailed over a 2 month period.

Discoloured water calls were lower in 2020/2021 because of employee turnover and as a result, discoloured water calls were sent to the first response group for flushing purposes.

Customer investigation changes due to COVID-19 pandemic restrictions: In March of 2020, as a result of the COVID-19 pandemic, all in-home sampling was suspended in order to protect both the homeowner and City employees. Customers were notified of the situation and for homeowners requesting lead samples, a modified sampling procedure was developed, where water operators dropped off sample bottles and homeowners were able to take their own samples for lead only. For all other issues, homeowners were contacted to discuss/troubleshoot the issue and if sampling was required, samples were taken from a hydrant on the customers street and in some instances from outside taps of homes (during warmer weather). For customers requiring only metals analysis, sampling was carried out using the modified lead sampling procedure.

Response times for the PWES Client Support Unit (located at Clyde Avenue) for sending service requests to the Water Quality following initial contact from 311. During 2021, the average PWES (Clyde) response time was 4.1 hours.

Figure 4 - PWES Client Support Unit response time



Water Distribution KPIs

Watermain breaks: Breaks per 100 kilometer is an industry standard used when comparing watermain break rates to other utilities. 2021 was an average year with 183 watermain breaks and a break per 100 km rate of 5.6. 67% of the watermain breaks experienced occurred in older cast iron watermains. These watermain breaks typically occur during freeze/thaw cycles. As older infrastructure is renewed and cast iron

watermains are replaced, it is expected that the annual number of watermain breaks will decrease; however, climate change may increase the number of freeze/thaw cycles, which can contribute to the number of watermain breaks in the remaining cast iron watermains in the distribution system. Pipe length (public) increases on average by 35 km/year.

The following graphs illustrate the 2021 results in comparison to previous years, presented as # of breaks per 100km of watermain and monthly trends.

Figure 5 - Number of watermain breaks, per 100 km of pipe, from 2017 to 2021

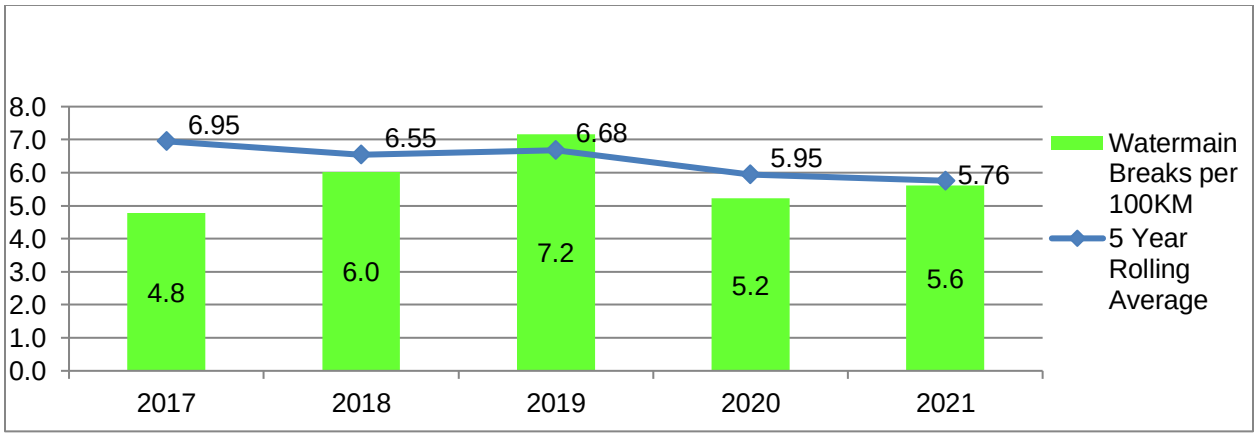
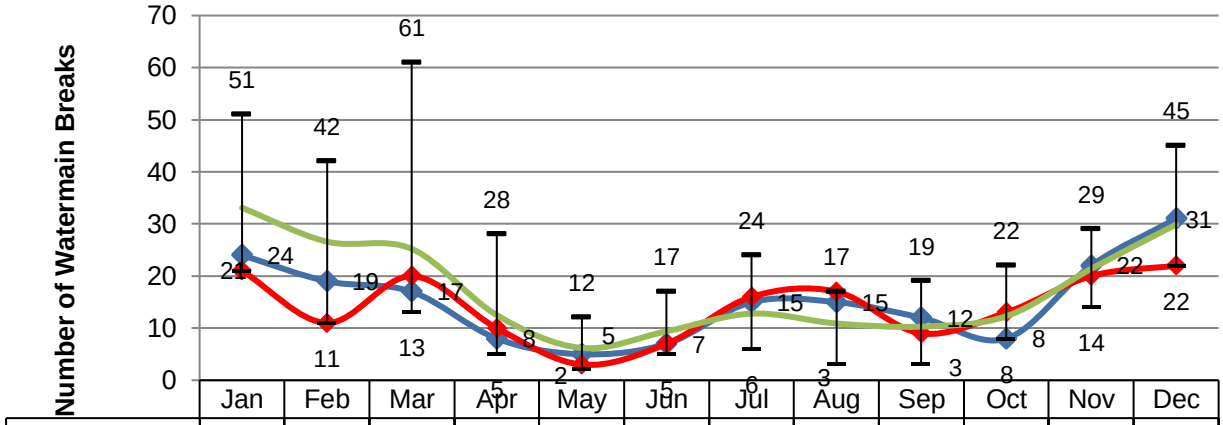


Figure 6 illustrates the number of watermain breaks by month in the current year compared to the previous year. The 10-year average, 10-year maximum and 10-year minimum for each month is also illustrated in this figure. 2021 was typical of the 10-year trend.

Figure 6 - Watermain Break Monthly



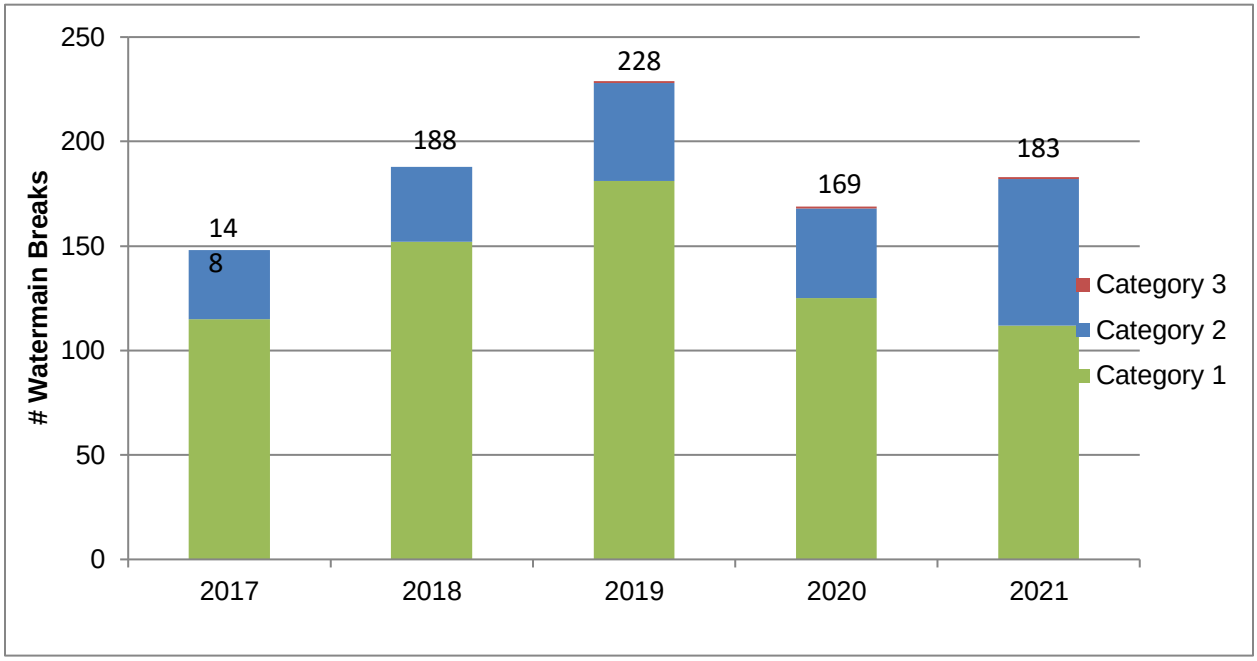
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	24	19	17	8	5	7	15	15	12	8	22	31
2020	21	11	20	10	3	7	16	17	9	13	20	22
10 Yr Ave	33	27	25	13	6	9	13	11	10	12	21	30
10 Yr Max	51	42	61	28	12	17	24	17	19	22	29	45
10 Yr Min	21	11	13	5	2	5	6	3	3	8	14	22

Watermain break categories: A risk assessment to assess the potential for contamination in the watermain is undertaken throughout the repair process to categorize the repair type. The resulting disinfection measures are based on these repair categories defined below:

- **Category 1** (very low risk): positive flow is maintained through the break area during excavation until an air gap is created. The exposed pipe is free and clear of pit water and there is no visual evidence of contamination into the watermain
- **Category 2** (low risk): the watermain is isolated during the excavation and positive flow is not maintained. There is a minor potential for soil/water intrusion during the excavation, and contamination is either evident or suspected
- **Category 3** (potential risk): there is evidence of suspected sewage or chemical contamination in the excavation.

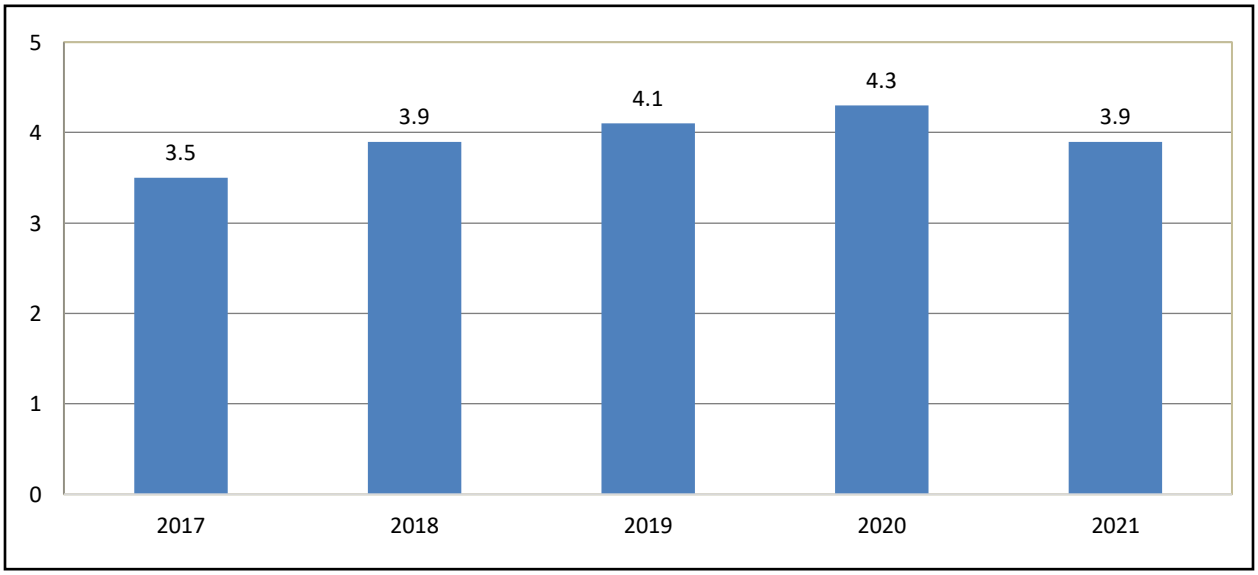
In 2021, 61% of repairs were assessed to be very low risk Category 1. The following graph indicates the annual number of watermain breaks and the distribution of Category 1,2,3 watermain breaks from 2017 to 2021.

Figure 7 - Watermain break categories



Infrastructure Leakage Index :

Figure 8 - Infrastructure Leakage Index



The Infrastructure Leakage Index (ILI) is the industry-wide key performance indicator that compares the amount of leakage in the water distribution system to the amount that is theoretically unavoidable. Leakage can occur anywhere from the point water exits the

production plants up to the point of customer water meter consumption. In 2021, the ILI improved to 3.9 (9.3%) from 4.3 in 2020. This improvement may be due to a change in the calculation methodology.

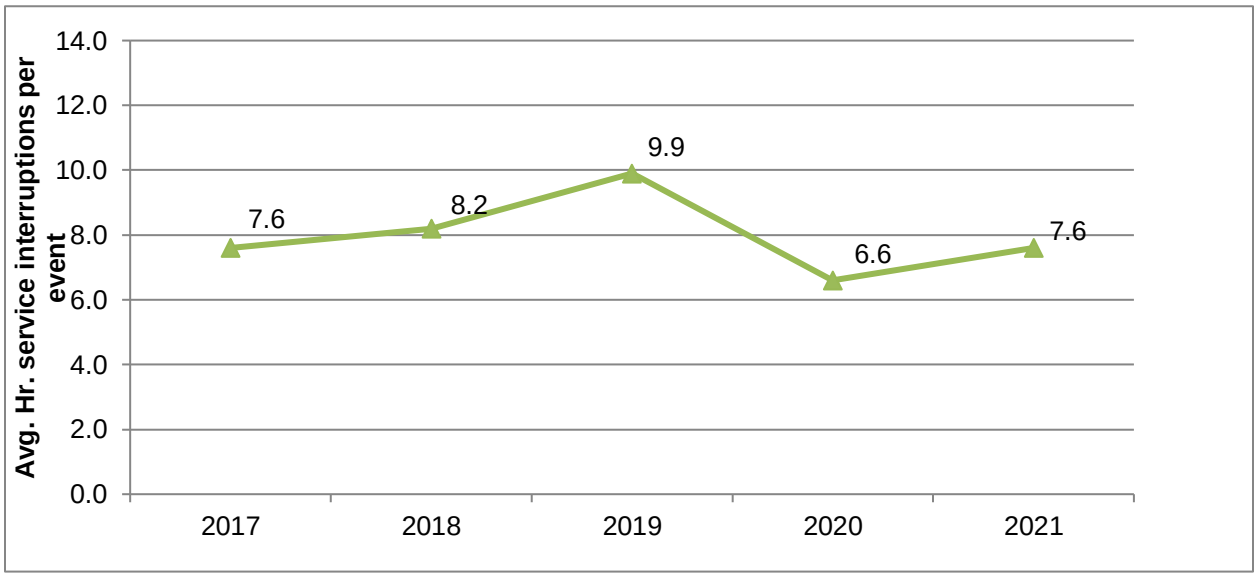
Although it is it is reassuring to see an improvement, Ottawa's ILI performance is still below average and needs to be improved when compared to other municipalities in Canada. A recent industry article indicates that the median ILI of 33 Canadian municipalities is 2.7, and 33% of municipalities reported an ILI of less than 2.0. Based on the water production cost ($298.8/ML) referenced in Figure 17, the cost associated with leakage in Ottawa is $6.2 million annually. A significant amount of work remains to be done to further reduce system losses and annual water production costs.

The Water Loss group developed a proactive data driven approach to identify and reduce system leakage in 2021. Customer water meter data was compared with water production data to determine the leakage rate in every water pressure zone. Since every zone's leakage level is now known relative to one another, water loss and leak detection activities can be prioritized in zones with the highest leakage. Zone monitoring with AMI data has also led to increased leakage awareness and understanding. By comparing the runtime, volume, and costs associated with different types of leaks in one area of the city, the information gained can be applied to additional areas of the city with similar characteristics.

Finally, the Water Loss Group developed and tested a new experimental approach in 2021, using an AMI water balance on private property, in order to identify the amount of leakage and potential unaccounted-for water in the approximately 780 km of private watermain in the distribution system. Only about 120 km of this private watermain is already perimeter water metered, where the customer is charged for leakage at the retail rate ($4010/ML), leaving 660 km of unmetered private watermain with potential leakage. It would therefore be important for policies and bylaws to be redeveloped to level the playing field in this area, as there is a significant potential revenue stream for the City of Ottawa if existing water losses could be turned into billed meter consumption. Customers would also have significant financial incentive to repair leaks that do not impact service at a much faster rate, further reducing ILI and water production operating costs for the City. This work has informed our next project, which focuses on the re-development of bylaws and standards that could impact water loss.

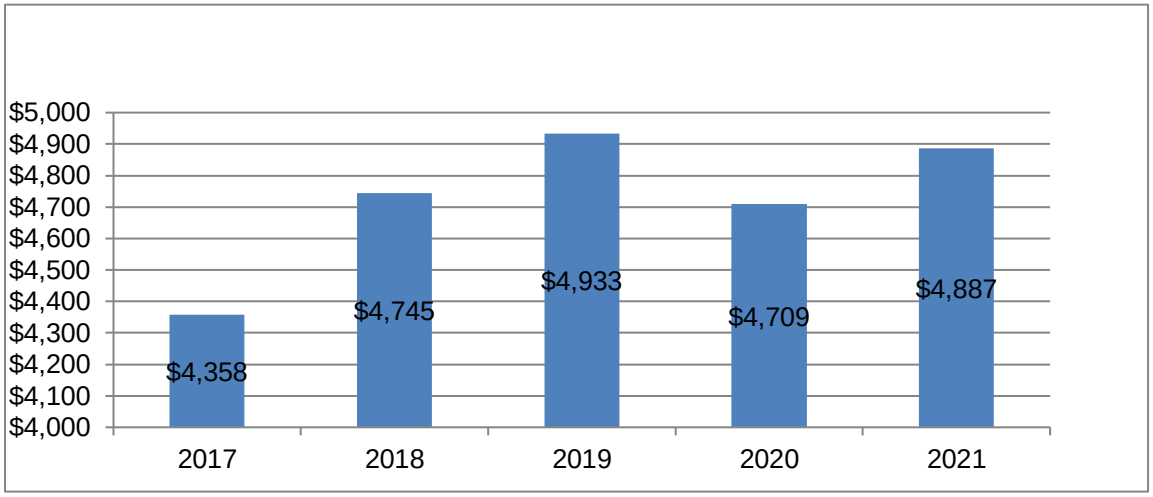
Water service interruption: The average service interruptions hours resulting from a watermain break repair increased slightly in 2021. Category 1 watermain breaks resulted in an average service interruption of 6.65 hours, while for Category 2 watermain break repairs, the average service interruption was 9.14 hours. 42 watermain repairs resulted in service interruptions of 4 hours or fewer, while there were 15 watermain break repairs that resulted in interruptions of greater than 12 hours. Many of these longer-duration repairs were repairs of multiple breaks on the same or adjacent length of watermain in cast iron watermains and were considered to be one repair when viewed from the customer perspective. In these cases, the additional breaks were discovered during the flushing process, so customers did not experience a restoration of water service for any length of time prior to the watermain being placed out of service for the additional repairs. A total of 4145 customer connections experienced water service interruptions due to watermain breaks in 2021.

Figure 9 - Average Number of Hours that Water Service Interruption per Event from 2017 to 2021



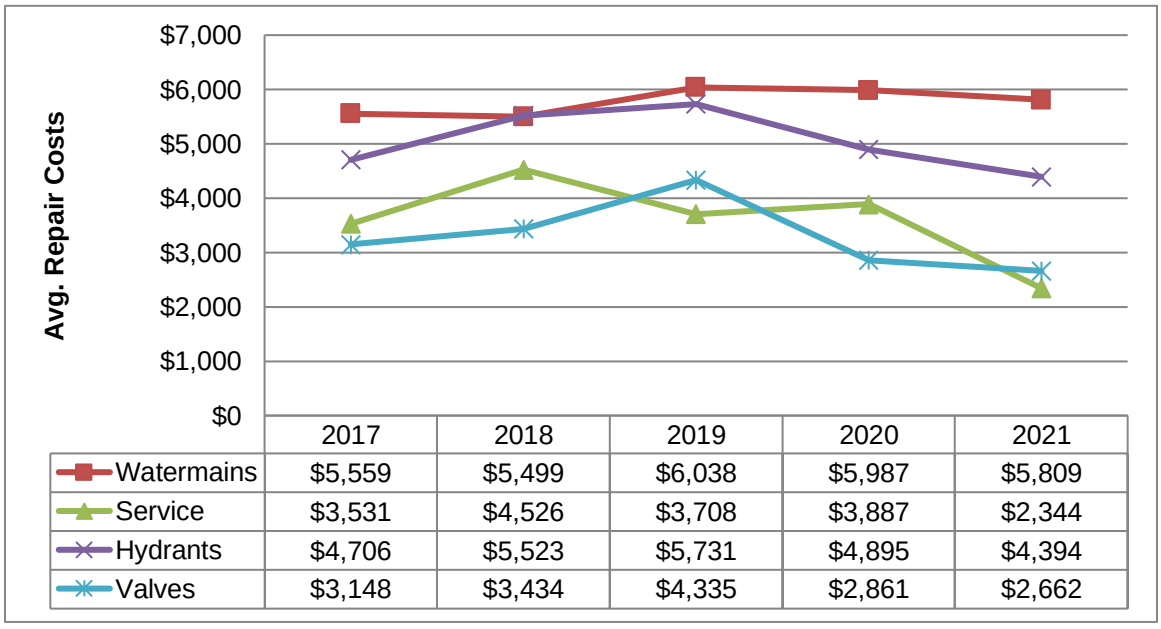
Water Distribution operating and maintenance costs: The average Water Distribution cost per kilometer of watermain for 2021 was $4,887, which is slightly higher than the 5-year average of $4,726. The increase is attributed to higher fuel costs, higher reinstatement costs, normal compensation increases as well as a slight increase in overtime required due to an increase in frozen services and the number of watermain breaks.

Figure 10 - Total water distribution costs per km of watermain from 2017 to 2021



The average repair costs of all water distribution components decreased by approximately $600 in 2021, with the best improvements noted in service repairs and hydrant repairs. This in part is due to planning these repairs rather than treating them as emergencies. As a result, these repairs could take advantage of efficiencies realised by scheduling staff and equipment on multiple repairs during the same day. It is expected that component costs may increase through 2022 as a result of global manufacturing and supply challenges related to COVID-19.

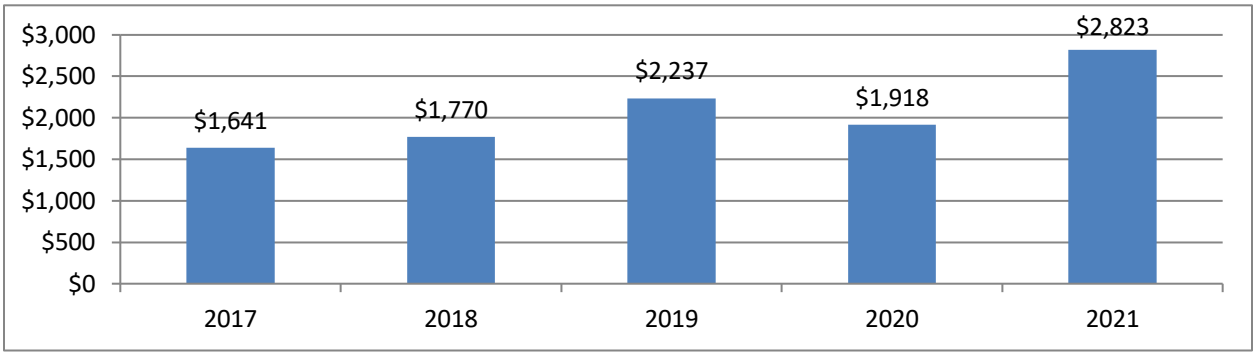
Figure 11 - Average Repair Costs by Water Distribution System Component



	2017	2018	2019	2020	2021
Watermains	$5,559	$5,499	$6,038	$5,987	$5,809
Service	$3,531	$4,526	$3,708	$3,887	$2,344
Hydrants	$4,706	$5,523	$5,731	$4,895	$4,394
Valves	$3,148	$3,434	$4,335	$2,861	$2,662

The average reinstatement cost increased significantly in 2021. There were 16 large area (greater than 125m^2) or more complicated (involving asphalt and concrete) reinstatements that each resulted in costs greater than $10,000/reinstatement. The average area of all repairs was approximately 32.4 m² in 2021. Additionally, contractors passed on fuel, labour and material costs that saw a sharp increase as a result of COVID-19 related shortages.

Figure 12 - Average costs of reinstatement per year (all excavation activities)



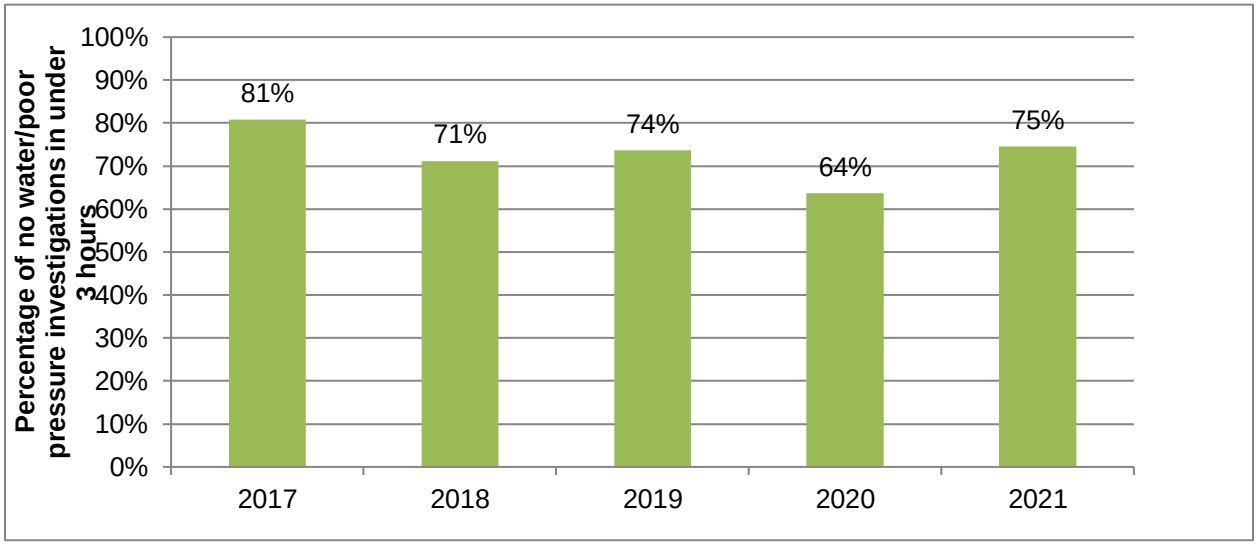
Improvements to processes and programs as well as a focus on cross-training and effective planning of resources has allowed Water Distribution to continue to deliver safe drinking water with 3.7 FTE/100km. 3 new Council-approved FTE were added to Water Distribution in 2020/2021 to be able to maintain the same level of service despite system growth.

Table 10 - Number of full-time employees per 100KM of distribution pipe

	2017	2018	2019	2020	2021
FTEs per 100KM	4.1	3.8	3.7	3.7	3.7

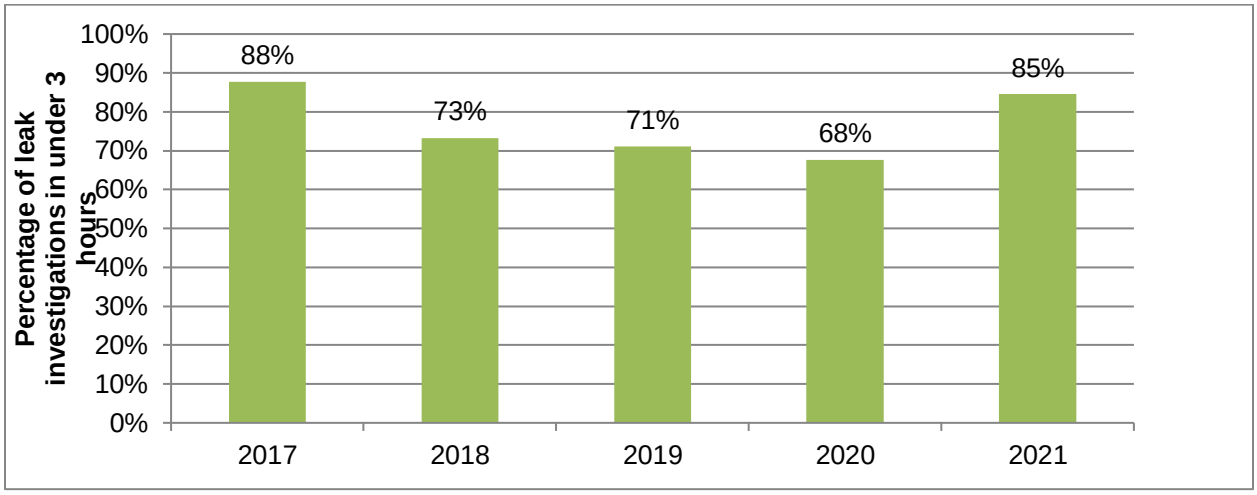
First Response Investigations: In 2021, 75% of the service requests related to either no water or poor pressure met the service level target of under 3 hours. 59% of all requests were addressed in under 1.5 hours. The majority of requests over 3 hours were either due to work processing issues or Maximo outages and the automated time stamp was not updated manually.

Figure 13 – % Number of No Water/Poor Pressure Investigations initiated within 3 Hours of service request receipt



In 2021, 85% of the requests related to leak investigation met the service level target of under 3 hours. 66% of all requests were addressed in under 1.5 hours. Similar to the low pressure investigations, the majority of requests over 3 hours were either due to work processing issues or Maximo outages and the automated time stamp was not updated manually. In November 2020, the Leak Detection team members of First Response were transferred to the Water Loss group, which also impacted the ability to gather data and report on this metric due to a change in work units. This will continue to be monitored in 2022 to determine how best to report on service delivery.

Figure 14 - % Number of Leak investigations initiated within 3 hours or service request receipt



Water Production KPIs

The annual inspection ratings are shown below for 2017 to 2021, by system.

Table 11 – MECP Annual Inspection Ratings for municipal water systems

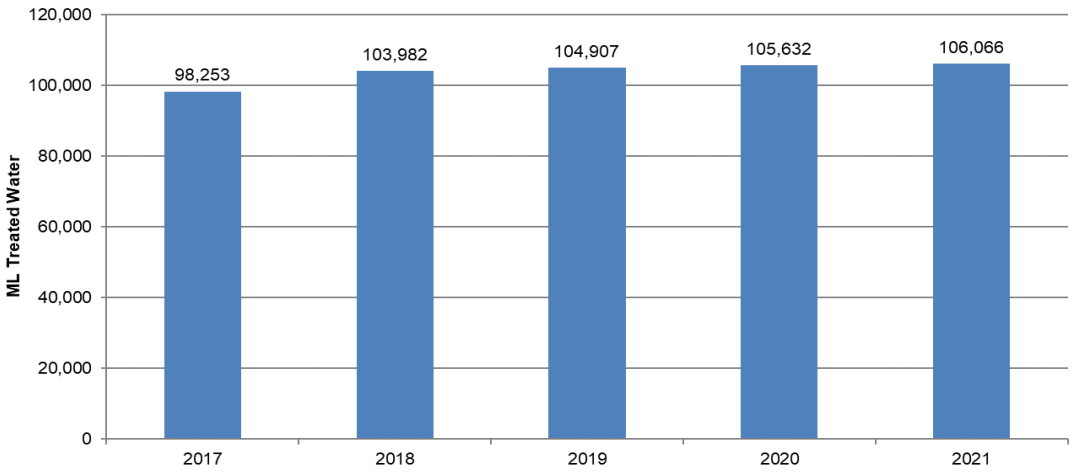
Water System	Target	2017	2018	2019	2020	2021
Britannia and Central Distribution System	**100%**	100%	100%	100%	100%	95.9%
Lemieux Island	**100%**	100%	100%	99.3%	100%	100%
Carp Well	**100%**	100%	100%	100%	100%	100%
Kings Park	**100%**	100%	100%	100%	100%	*100%
Munster	**100%**	100%	99.1%	100%	100%	*100%
Vars	**100%**	100%	100%	100%	100%	*100%
Shadow Ridge	**100%**	100%	98.4%	100%	100%	100%
Richmond West	**100%**	-	-	100%	100%	100%

*2020 inspection rating cited since 2021 final inspection report not yet received

MECP Inspection Ratings: All eight Ottawa municipal water systems were inspected for 2021 and final inspection reports have been received for five systems to date, showing excellent ratings. Ontario's Chief Drinking Water Inspector indicated that 4 of the systems achieved 100 per cent while the Britannia Water Treatment Plant and Central Distribution System achieved a rating of 95.9 per cent. The lower rating was due to incorrect reporting procedures that did not impact the quality of Ottawa's drinking water. The inspection rating is a comprehensive risk-based score based on more than 100 inspection and compliance questions covering 15 aspects of water operations and management.

Annual water production: the annual water production (measured in million liters (ML)) increased by 0.4% in 2021 vs. 2020 but remains consistent with the general trend in the past several years. The graph below shows the total water production rates over the last five years.

Figure 15 - Total Annual Water Production



Operating costs: When compared to 2020, the total cost per ML for water production has decreased by 2.6% (to $298.8, see Figure 17 below). This decrease was skewed due to a new accounting system (Ariba) being implemented in 2019. Invoice processing delays, due to the 2019 Ariba implementation, resulted in a significant number of 2019 invoices being resolved in 2020. Consequently, 2020 costs were artificially inflated, and 2021 costs are more representative, when all outstanding invoice processing delays had been resolved. Since 2017, normalized costs have increased by 4.4% and remain

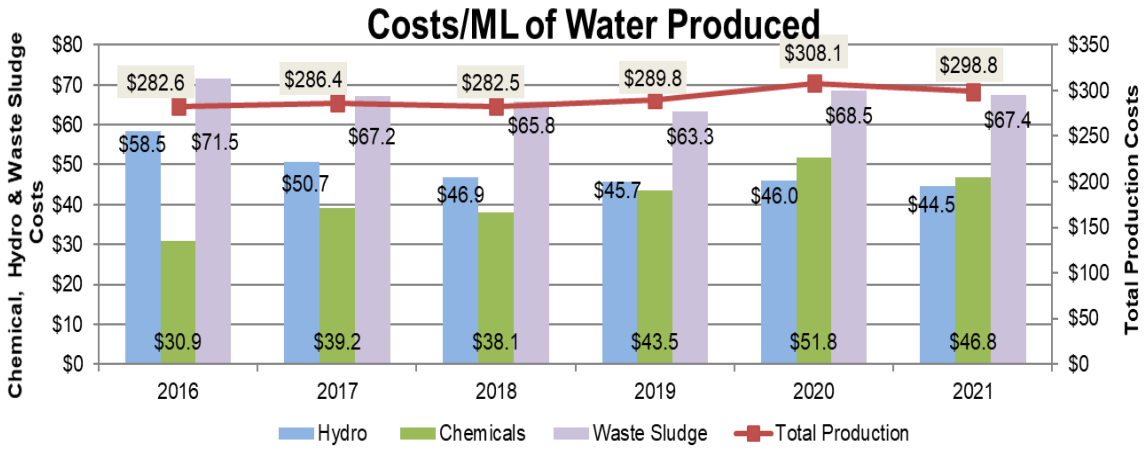
less than the rate of inflation over this five-year period. For this same period, the annual increase is approximately 0.9%

In 2021, the cost of electrical energy per ML of water production decreased compared to 2020 and can generally be attributed to the Britannia Water Purification Plant Operations team's implementation of a demand management process to reduce the use of electricity during peak demand periods. These processes reduced greenhouse gas emissions and decreased hydro costs by approximately $185k; an8.7% decrease in electricity costs for 2021. For these efforts, the Britannia team was chosen as the winner for the 2021 Environmental Excellence Award (internal category). The City also continues to benefit from the ongoing savings through the utilization of the City's water powered Fleet Street Pumping Station. Overall, the total cost of electrical energy necessary to treat and distribute drinking water, from the City's Central supply system decreased by approximately 6.4% when compared to 2020. Overall, total water production volumes increased by 0.4%, in 2021 and when compared to 2020.

The cost of water treatment chemicals per ML of water produced decreased by 9% in 2021, when compared to 2020, but this decrease can largely be attributed to the accounting issues and invoice payment delays resulting from the 2019 Ariba implementation. Consequently, it is more appropriate to consider actual treatment chemical usage, water production volumes and chemical unit pricing to better understand the overall trend of chemical costs per ML of water produced. Treatment chemical usage is generally a function of source water requirements and, with 2021 being a typical year for source water quality, chemical usage tracked consistently with the 0.4% increase in water production volumes. Chemical unit prices steadily increase each year, and 2021 total chemical costs also reflect this change. Specifically, and in 2021, tendered prices for sodium hypochlorite increased by 1.1%, sodium silicate increased by 11.6% and sulphuric acid prices increased by 36.4%. With the above factors considered, in can be seen that the overall trend, of cost of water treatment chemicals per ML of water production continues to increase.

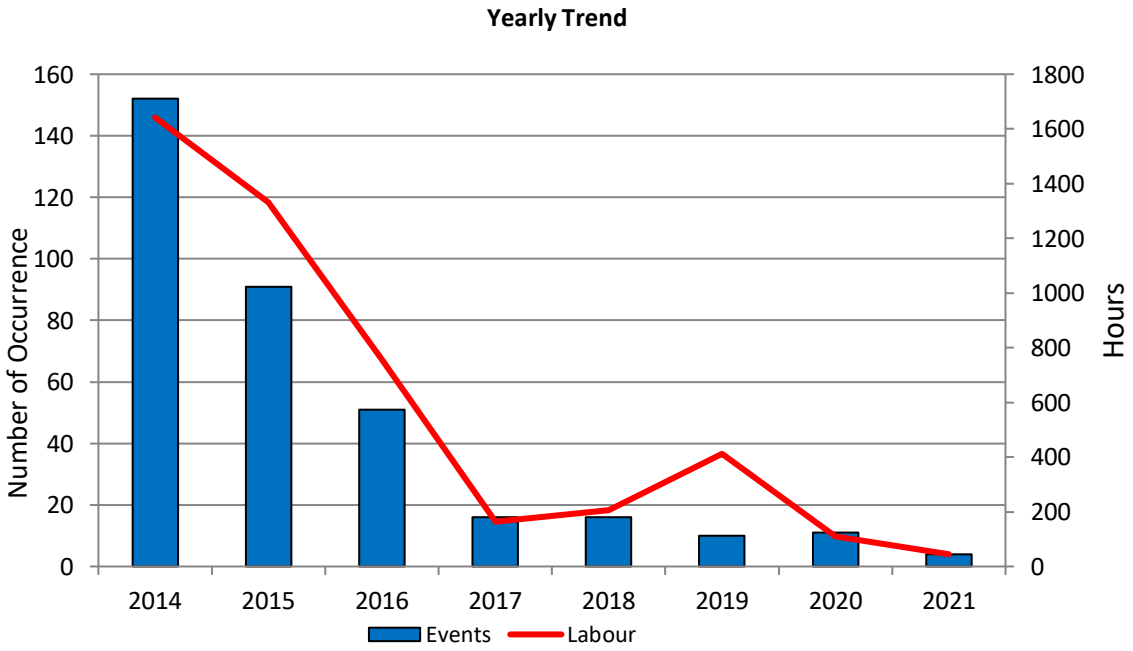
In 2021, the cost per ML, for the treatment of process waste sludge (or treatment residuals), decreased by 1.2%, when compared to 2020. This cost includes both a volumetric charge, as well as a solids charge and this decrease is attributed to Britannia WPP optimizing and reducing their sludge production. This is a true decrease, as these costs are tracked outside of Ariba system and were not impacted by the system change.

Figure 16 - Annual Production Costs (costs/ML of water produced at WPPs and Remote Pumping Stations)



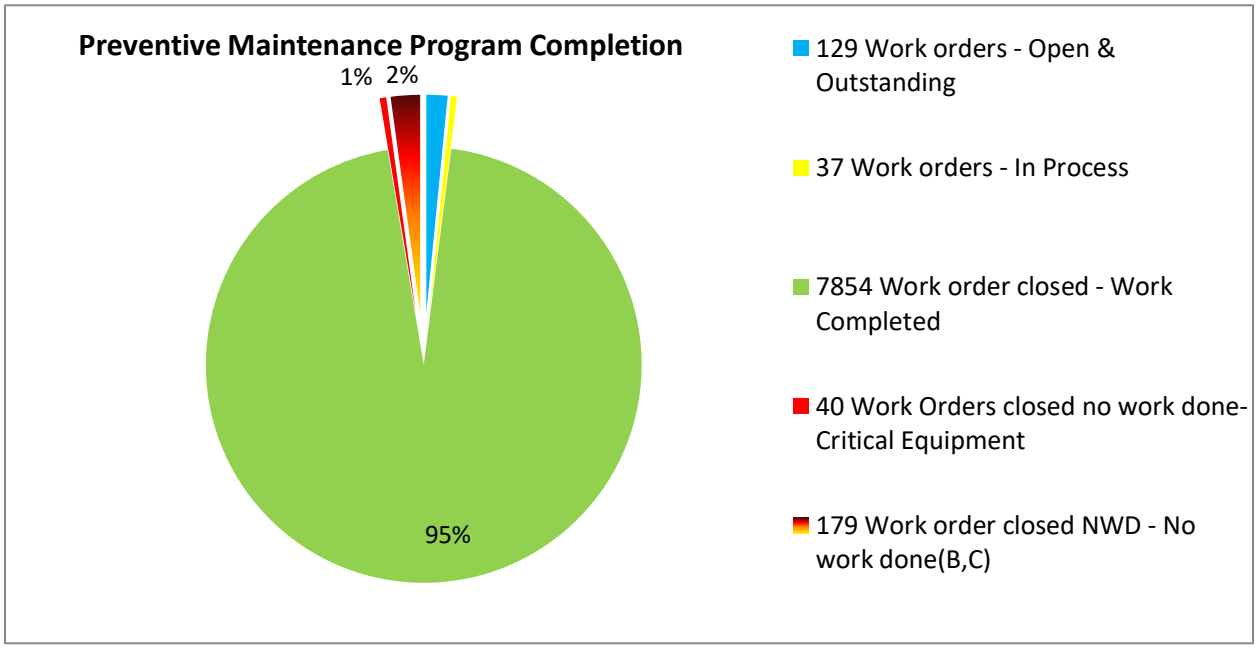
Maintenance Programs: As recommended in the 2016 Management Review report, additional KPIs have been included in this year's report to provide a brief overview of the maintenance activities for Water Production, including breakdown emergencies and preventive maintenance program completion.

Figure 17 - Breakdown Emergency Occurrences and associated Labour Hours



From the above figure, the number of breakdown emergencies, as well as the total amount of labour hours resulting from the repair of emergency breakdowns has been stable and well managed for the past 5 years. The trend from 2013 is attributed to a sustained increase in the completion of the planned preventative maintenance program, as well as continued efforts to improve the definition and coding of breakdown emergencies.

Figure 18 - Preventive Maintenance Program Completion for 2021



The above figure demonstrates that the completion of the planned preventive maintenance program remains a key priority, for Water Production's maintenance teams. The following initiatives, beginning in 2016, have contributed to a positive trend in the completion of preventive maintenance:

- Communication of an established guideline promoting a consistent approach to assigning priorities
- Reviewing of the priority 1 or 2 notifications in weekly meetings
- Increase of maintenance planning activities with more maintenance planners

The overall preventive maintenance completion ratio has been 95% or above since 2018, contributing to better equipment reliability.

Water Quality KPIs

Water quality and operating staff conduct more than 100,000 tests per year to ensure the safety of Ottawa's drinking water supply. As a composite measure, two water quality index scores have been developed covering both the microbial and chemical quality of Ottawa's drinking water. The index values for 2017 – 2021 are summarized in the table below.

Table 12 - Water Quality Health Index (WQHI) KPIs

KPI	Target	2017	2018	2019	2020	2021
Water Quality Health Index – **Microbial:** Percent treated water that met pathogen removal targets	**100**	100	100	100	100	100
Water Quality Health Index – **Chemical:** 0 – 100 index score	**100**	100	100	100	100	100

Water Quality Health Index – Microbial: the index is a score from 0 to 100 that indicates the percentage of treated water produced that met all pathogen removal targets. The index is based on a calculation of pathogen removal performance for 5 reference pathogens used in the Health Canada Quantitative Microbial Risk Assessment (QMRA) model. The index applies to the central water supply (Britannia and Lemieux) as well as the 6 municipal well systems. A value of 100% indicates that treated water met all pathogen removal targets. For the two surface WPPs (Britannia and Lemieux), this would include log-inactivation/removal rates for 5 reference pathogens: *Cryptosporidium, Giardia, Virus, Campylobacter, E.coli O157*.

For the municipal well systems, pathogen reduction targets (internal) are based on 5-log inactivation of virus for the (5) non-GUDI well systems: Carp, Richmond West, Kings Park, Munster, and Vars. These disinfection targets are beyond the minimum requirement of 2-log virus inactivation as per the MECP Procedure for Disinfection and 4-log for Richmond West but are based on actual virus concentrations measured in the source wells. Furthermore, the 5-log virus target better aligns with the newly revised MECP directive of minimum 4-log virus inactivation in secure non-GUDI groundwater sources and Health Canada's guidance on virus inactivation. For the Shadow Ridge Well System, an overall removal/inactivation target of 5-log virus and 3.0-log *Giardia* is

used as a benchmark since the source wells are considered GUDI (groundwater under the direct influence of surface water).

If a score below 100% is noted, it means that the treated water directed to the distribution system had the potential for presence of pathogenic organisms and would likely have resulted in a drinking water advisory through consultation with Ottawa Public Health. A score of 100% indicates that the treated drinking water met pathogen removal targets at all times during the year.

During 2021, a WQHI-Microbial score of 100% was achieved for all 8 drinking water systems.

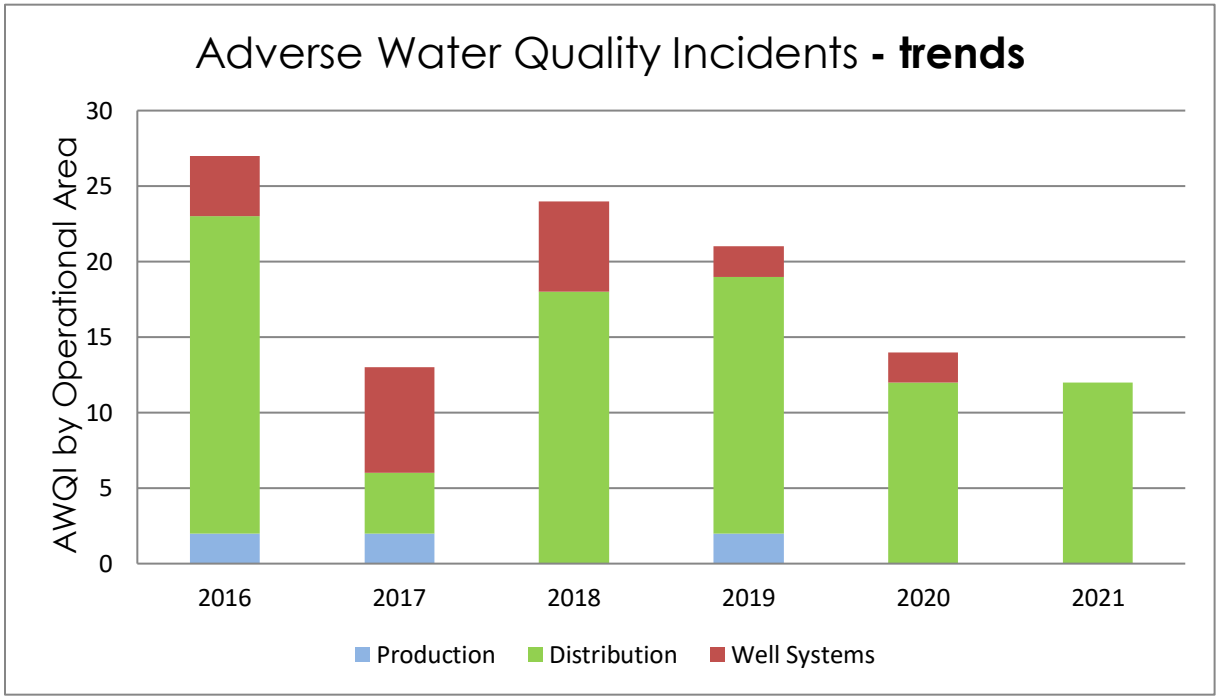
Water Quality Health Index – Chemical: This index is based on the number of water quality test results during the year that exceeded a health-based standard (Ontario Drinking Water Standards O. Reg 169/03). There are currently 67 chemical substances for which a health-based MAC (Maximum Acceptable Concentration) has been established in Ontario. The index ranges from 0 to 100 and is a composite value that reflects the frequency, scope, and amplitude of any MAC exceedances observed during the year. A score of 100 for the Chemical WQHI would indicate that all test results were below drinking water MAC values during the year. This measure is applied to the central water supply and the 6 municipal well systems.

During 2021, a WQHI-Chemical score of 100 was achieved for all 8 drinking water systems.

Number of Adverse Water Quality Incidents (AWQIs)

The trend for the number of AWQIs is shown on the graph below for reference, by operational area.

Figure 19 - Number of AWQIs by operational area (2016 to 2021)



It can be seen from the graph that the year-to-year trend for number of AWQIs has been decreasing during 2016 – 2021 except for a sharp decrease in 2017. Specific causes and trends for AWQIs are discussed previously in Section b) incidents of adverse drinking water tests of the report.

Drinking Water Advisories

During 2021, there was one Drinking Water Advisory (DWA) events as described in the table below:

Table 13 – Summary table of DWA events during 2021

Date	System	Description	~ # of households	~ # of people affected	duration of DWA (days)	~ # of person days
Mar 29/21	Central	*Hanlon Ave:* Category 3 watermain break involving a broken sewer	30	84	3	252

Hanlon Ave watermain break (March 29th, 2021) - this event occurred as result of a broken sewer pipe that was observed in the excavation during a watermain break repair on Hanlon Ave. Since this represented a Category 3 main break, Ottawa Public Health issued a precautionary boil water advisory for the localized portion of the distribution system that was isolated for the watermain repair. The advisory affected approximately 30 households and was lifted after three days once two sets of clear bacteriological samples were obtained.

In the above case, as soon as clear water quality test results were obtained, the advisory was lifted, and residents were directly notified. It is important to note that the advisory was issued on a precautionary basis and there was no evidence of contamination in the water supply.

The following table lists the number of Drinking Water Advisories issued over the last five years as well as the impact in terms of “person-days” (number of persons affected times the number of days the advisory was in effect).

The following table lists the number of Drinking Water Advisories issued over the last five years as well as the impact in terms of “person-days” (number of persons affected times the number of days the advisory was in effect).

Table 14 - Drinking Water Advisories and impact in person-days

KPI	2017	2018	2019	2020	2021
Number of Drinking Water Advisories	1	1	2	4	1
Number of Person Days Impacted	100	150	454	281	252

An Action Item was identified as part of the Management Review Meetings.

- For Water Production costs, i) investigate possibility of separating water production costs for individual systems (i.e., central vs well systems), and if possible, then ii) report regularly as new KPI for Water Production (quarterly report) iii) add to the Management Review report item g) Water Production KPIs.

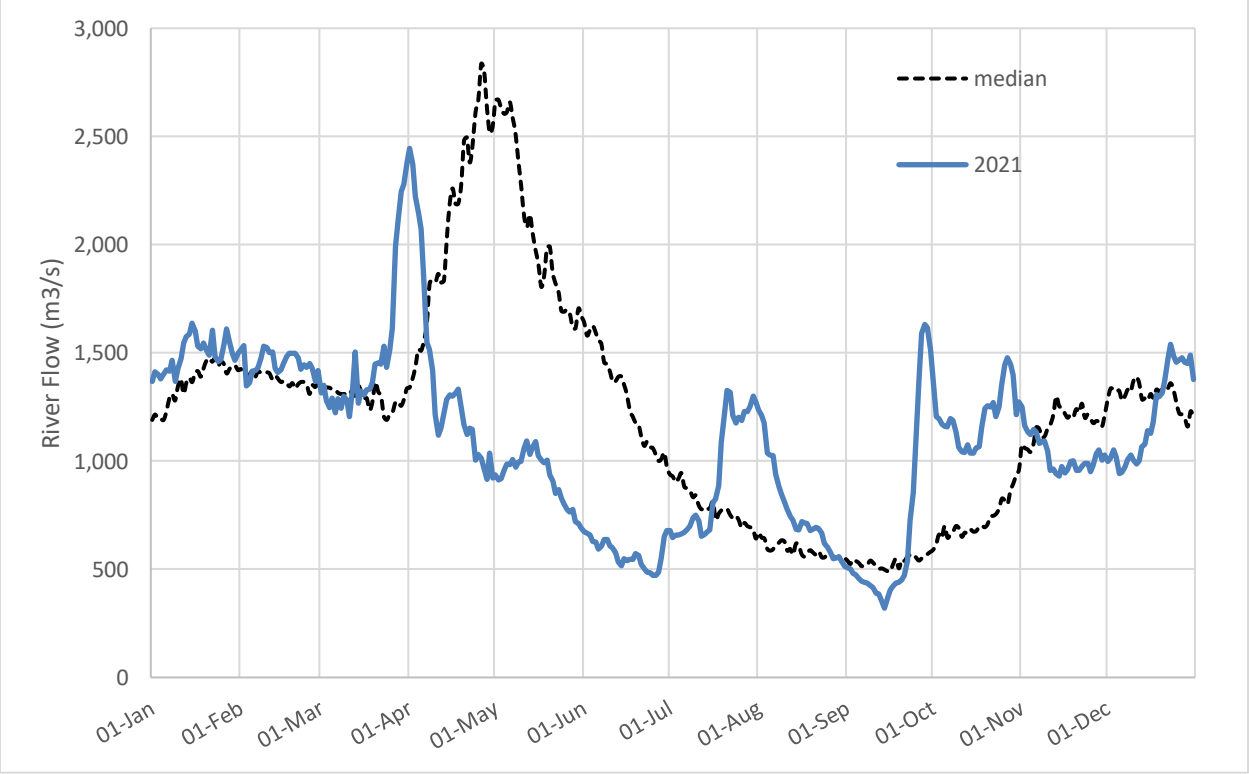
h) Raw Water Supply and Drinking Water Quality Trends

Britannia and Lemieux WPPs

General: During 2021, there were no chemical or radiological substances detected that exceeded Ontario Drinking Water Standards (ODWS) or Health Canada Guidelines for Canadian Drinking Water Quality (GCDWQ). With regard to raw water microbiological quality, pathogen levels were similar to previous years and were easily handled by the treatment barriers at both water purification plants.

Flows, levels, and physical characteristics: Ottawa River flow rates and levels were typical of long-term average values. The graph below shows the 2021 river flowrate compared to median values. The spring freshet arrived earlier than most years and peaked much lower. The average river flow rate was 1,093 (m^3/s) which is slightly lower than the long-term average (1,230 m^3/s). The spring freshet arrived earlier than normal, and was shorter in duration.

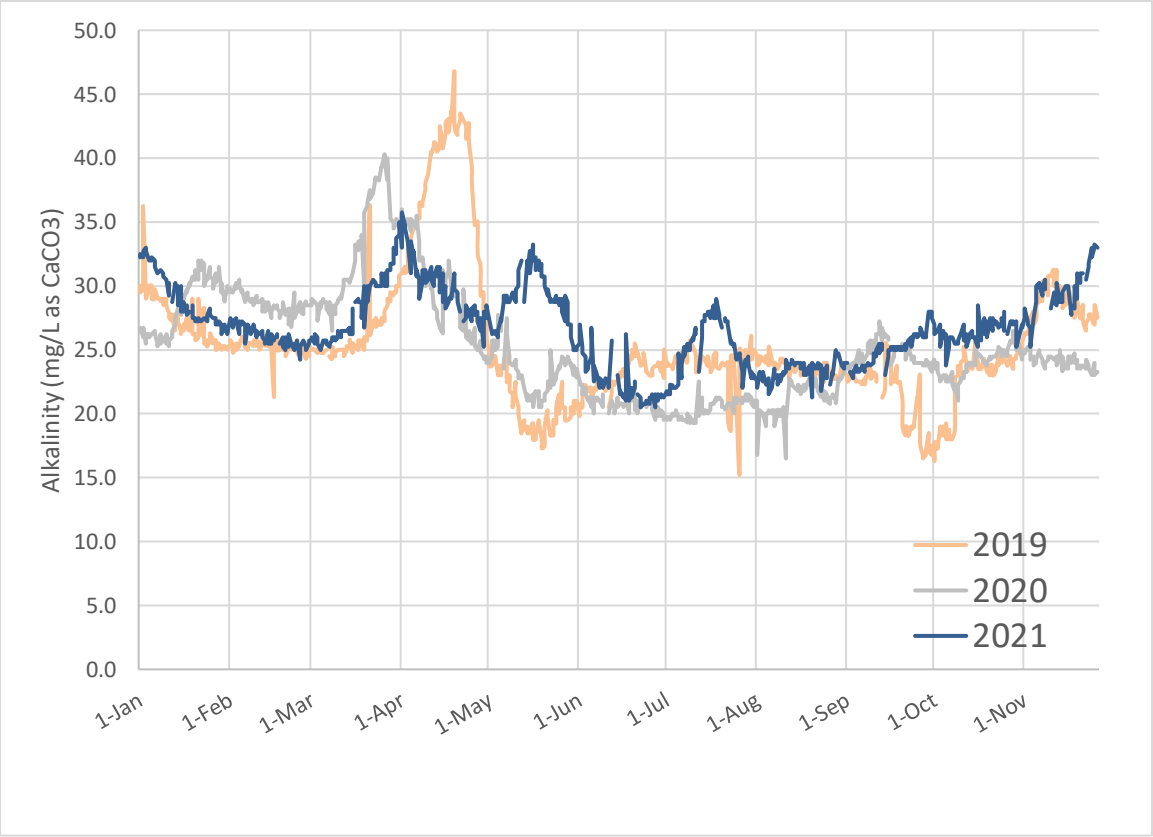
Figure 20 - Ottawa River flowrates (m3/s) during 2021 in comparison to long-term median flow (1960 – 2020)



The minimum daily flow rate of 320 m^3/s was observed on Sept 14, 2021, however the river quantity was more than sufficient to meet water demand. For example, even during the minimum flow condition, Ottawa's average daily water demand (287.8 ML/d) represented only 1 % of the total river flow. Our permitted water taking allowance is 760 ML/d between both plants.

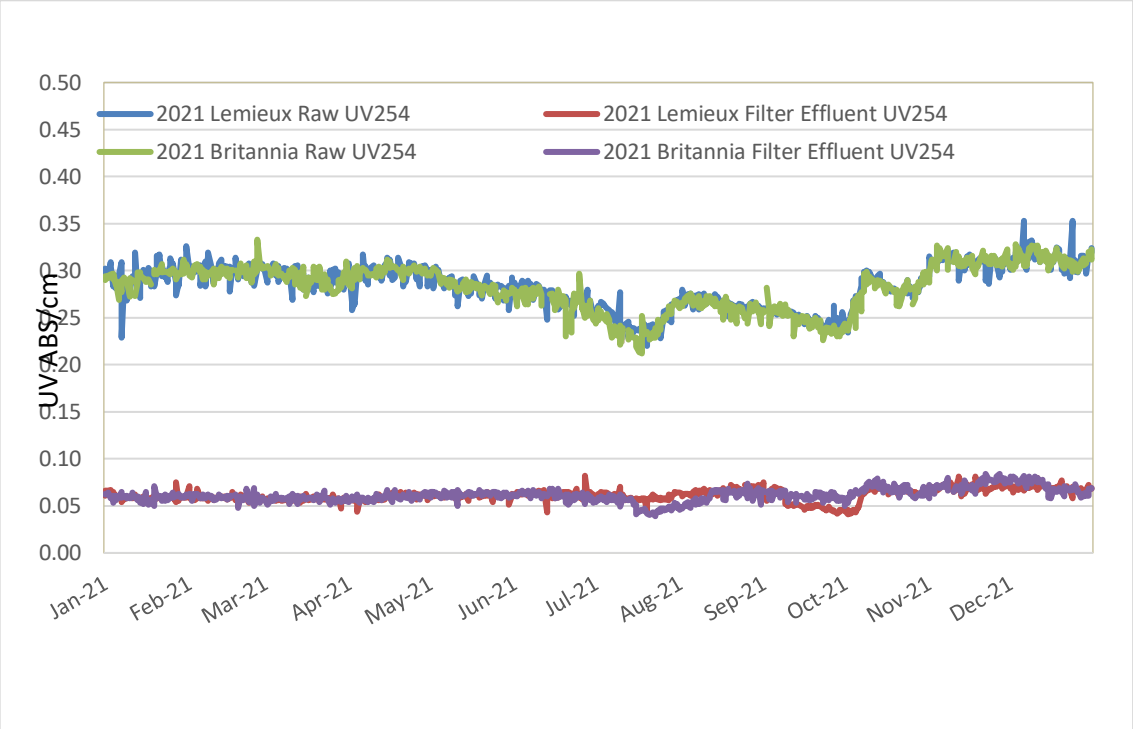
Raw water turbidity levels reached a maximum of 23.5 NTU at Britannia and 29.7 NTU at Lemieux, which is typical of the spring run-off period. The remainder of the year saw average turbidity values of around 3 NTU. The WPPs experienced moderate levels of alkalinity throughout the year with an average raw water alkalinity was 27.3 mg/L which is comparable to previous years (26.8 mg/L for 2019 & 25.5 mg/L in 2020). The graph below shows the alkalinity trend comparison.

Figure 21 - Raw water Total Alkalinity trend for 2019, 2020 & 2021



In terms of dissolved organic content, the source water UV254 values were similar to previous years. The filter effluent UV254 levels were consistent through the year indicating optimal coagulation during 2021.

Figure 22 - Raw water and filter effluent UV254 absorbance values for 2021 at both treatment plants



Microbiological: *Cryptosporidium/Giardia*: pathogen concentrations of protozoa are tested in the raw water at Britannia and Lemieux during the winter months (November to March). During 2021, *Giardia* cysts were present in a total of 5 out of 10 samples of raw water with a peak concentration of 16 cysts/100L. *Cryptosporidium* oocysts were present in 1 out of 10 samples or raw water at a concentration of 7.2 cysts/100L. These pathogen levels were similar to last years but lower than previous years. These levels are consistent with the 4-log *Giardia* treatment requirement for Britannia and Lemieux plants specified in the MDWL.

Total Coliforms / E.coli: Raw water bacteria levels were similar to previous years in both Britannia and Lemieux raw intakes. E.coli levels reached just over 100 (cfu/100mL) during summer months with Lemieux showing higher levels during early summer due to seagull nesting upstream of the intake. Significant rain events during the Fall months may have contributed to the maximum observed levels for E.coli of 276 (cfu/100mL) and 207 (cfu/100mL) at Britannia and Lemieux respectively. Overall, the source water microbial levels observed during 2021 did not pose a threat or challenge for the water treatment process.

Figure 23 - Britannia and Lemieux Raw Water - Total Coliform levels 2021

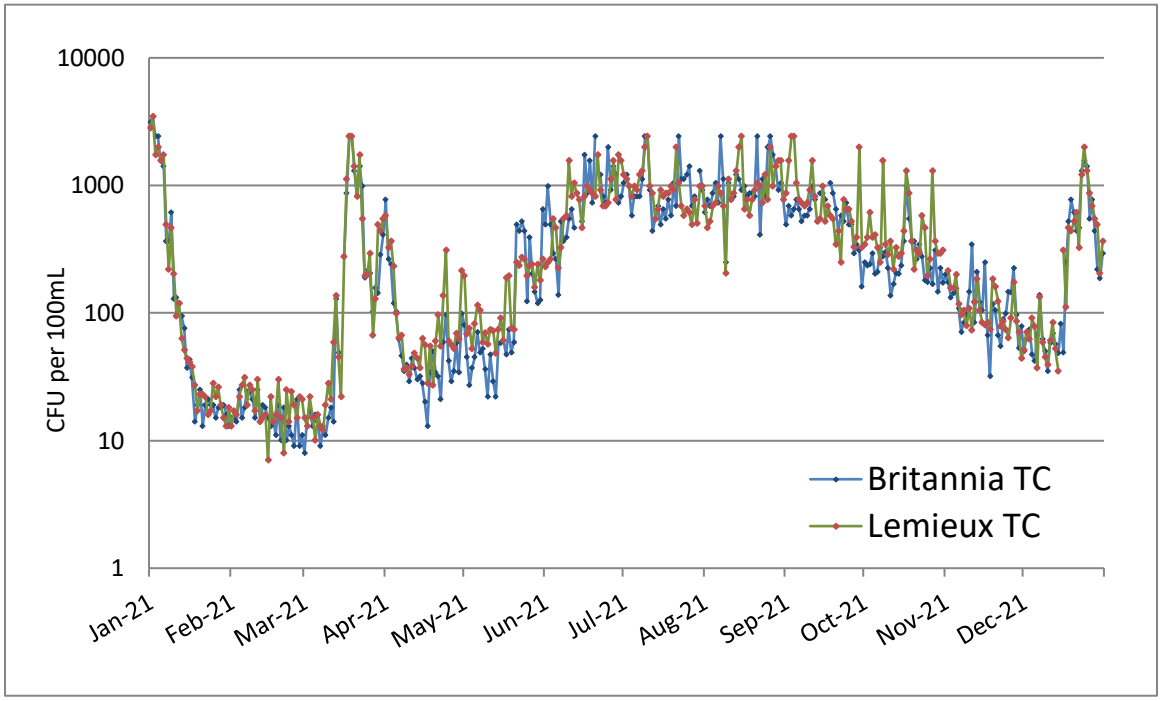
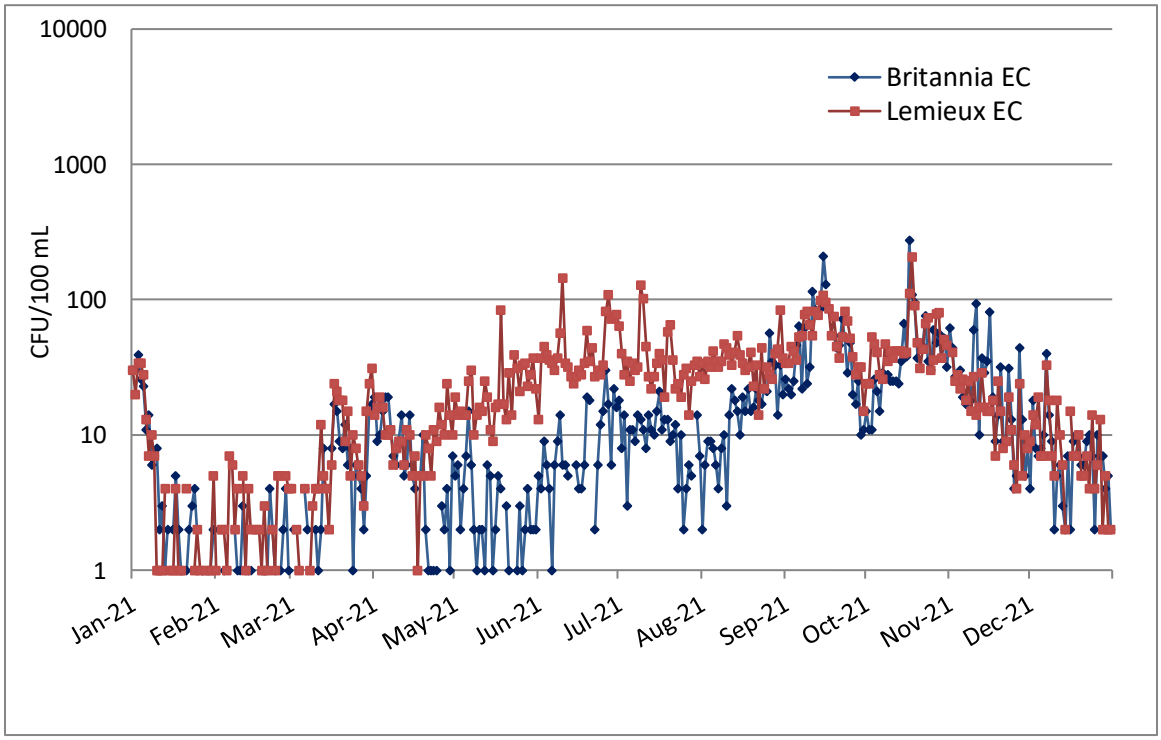


Figure 24 - Britannia and Lemieux Raw Water – *E.coli* levels during 2021



Chemical: Test results for inorganic and trace organic parameters showed normal values that were well within drinking water standards and guidelines. There were no MAC exceedances observed during 2021. There was a routine reporting event noted for an exceedance of the health advisory level for sodium (20 mg/L) which is required every 60 months. However, the average sodium concentration remained at 17.9 mg/L which is below the health advisory level. There were no significant taste/odour events during 2021.

Radiological: With increasing awareness of the Chalk River Laboratories and the proposed Near Surface Disposal Facility, daily/weekly radiological monitoring continued for gross alpha, gross beta, and tritium. Since tritium is considered the most likely and relevant radionuclide for our treatment plants and public concern, the low-level tritium method (<1.1 Bq/L) was continued to be used through the Andre E. Lalonde AMS Laboratory. Tritium levels were typically found to be in the 1.4 – 4.0 Bq/L range with 2021 average values of 2.5 Bq/L (Britannia) and 2.4 Bq/L (Lemieux). The DW guideline for tritium is 7000 Bq/L.

Pharmaceuticals: Testing is conducted quarterly for 45 trace pharmaceutical substances. Similar substances were observed as in previous years, with 2 substances detected in at least one sample of raw or treated water. The drug metformin (anti-diabetic drug) continued to be the most persistent compound detected at an average concentration of 14.6 ng/L (ppt - parts per trillion) in treated water. The maximum concentrations of pharmaceutical compounds observed in treated water were as follows: *metformin 24.4 ng/L, carbamazepine 0.4 ng/L.* There were a few substances that were present in previous years just above the detection limit and as result this year were not detected. These results were similar to previous years, and do not indicate any significant change in water quality. These substances continue to be unregulated in drinking water.

Perfluorinated alkyl substances (PFAS): The presence of perfluorinated alkyl substances have become an increasing concern for the environment and human health. These substances are stable and persistent organic compounds that are widely used in industry and consumer products: Teflon, furniture fabric, and firefighting foams. Health Canada recently established guidelines for (2) PFAS substances: PFOS with a MAC of 600 ng/L and PFOA with a MAC of 200 ng/L. Other jurisdictions have established more stringent MAC values in the range of 70 ng/L (US EPA). Treated water samples were previously collected annually from all eight municipal water systems and sent to AXYS

Laboratory (British Columbia) for analysis of 33 PFAS substances but were missed in 2021. Annual sampling will resume in 2022. Sampling was focused on the Carp well system since previous years have shown the presence of PFAS substances in the source water. In 2021, a GAC (Granular Activated Carbon) filter system was installed for taste/odour removal and are also effective for removal of PFAS substances. Sampling was performed on the Carp raw water well#2 and the filtered water to monitor the PFAS removal. It was found that all PFAS substances were removed with the exception of one; PFPeA (Perfluoro-n-pentanoic acid) which is a breakdown product of stain- and grease-proof coatings on food packaging, couches, carpets.

Carp, Kings Park, Munster, Shadow Ridge, Richmond West and Vars Well Systems

The source wells for the Carp, Kings Park, Richmond West, Munster, and Vars water supplies are considered to be secure groundwater. For the Shadow Ridge system, the source wells are deemed to be GUDI wells (groundwater under the direct influence of surface water), since a formal GUDI study was not conducted. Therefore, treatment requirements applicable to a GUDI source have been designed and implemented for Shadow Ridge.

Total coliform / E. coli testing in raw water: in each system, “raw” wells are sampled and tested for the presence of bacteria twice per week. During 2021, there were 4 raw water samples that were positive for the presence of Total Coliform bacteria. 1 at Carp (Well #1), 2 at Shadow Ridge (Well #2) and 1 sample at Richmond West (Well#2). There was 1 raw water sample that was positive for *E. coli* bacteria at Richmond West (Well#2). These low occurrence rates are not of concern and may be related to biological growth on the sample pipe surface rather than in the bulk water of the source well. The table below summarizes the raw water bacteriological results obtained during 2021.

Table 15 - Raw water bacteriological test results at well systems during 2021

Location	# of positive Total Coliform results	# of positive *E.coli* results	Total number of samples
Carp: Well #1 and #2	1	0	206
Kings Park: Well #1 and #2	0	0	132
Munster: Well #1 and #2	0	0	206
Shadow Ridge: Well #1 and #2	2	0	206

Location	# of positive Total Coliform results	# of positive *E.coli* results	Total number of samples
Vars: Well #1 and #2	0	0	206
Richmond West #1 and #2	1	1	206

The table below provides a longer-term trend of weekly raw water bacteriological test results for each municipal source well during the period 2012 – 2021. Carp #1 Well, Munster #2 Well, and Vars #2 Well have historically been the most notable in terms of positive Total Coliform results.

Table 16 - Number of positive total coliform tests in raw source wells 2012 – 2021 (10yr)

	Carp		Richmond West		Kings Park		Munster		Shadow Ridge		Vars	
	Well #1	Well #2	Well #1	Well #2	Well #1	Well #2	Well #1	Well #2	Well #1	Well #2	Well #1	Well #2
2012	0	0			0	0	0	0	0	1	0	0
2013	3	0			0	0	0	0	0	0	0	0
2014	8	0			0	0	1	10	0	0	1	0
2015	0	0			0	0	0	1	0	0	0	1
2016	2	1			0	0	0	2	0	0	0	0
2017	0	0			0	0	1	0	1	0	0	0
2018	0	0			0	0	2	0	0	2	0	0
2019	8	1	0	0	0	1	1	0	0	0	0	0
2020	5	0	3	0	0	0	0	0	0	0	0	1
2021	1	0	0	1	0	0	0	0	0	2	0	0
Total:	**27**	**2**	**3**	**1**	**0**	**1**	**5**	**13**	**1**	**5**	**1**	**2**

Chemical characteristics: Test results for trace organic and inorganic parameters showed normal values that were well within drinking water guidelines. During 2021, there were no MAC exceedances with the exception of sodium, which is above the health advisory concentration of 20 mg/L in all five well systems. Sodium occurs naturally in groundwater wells.

The nitrate concentrations in the Shadow Ridge well system continue to be elevated, in comparsion to water quality from the other well systems. Nitrate concentrations in the source wells have shown a gradual but steady increase from approximately 1.5 mg/L in 2008 to levels in the range of 3.5 – 4.6 mg/L during 2018 but have leveled off in 2019 to 2021. The treated water nitrate concentration averaged 3.36 mg/L during 2021, which is within the Ontario Drinking Water Standard of 10 mg/L as a Maximum Allowable Concentration.

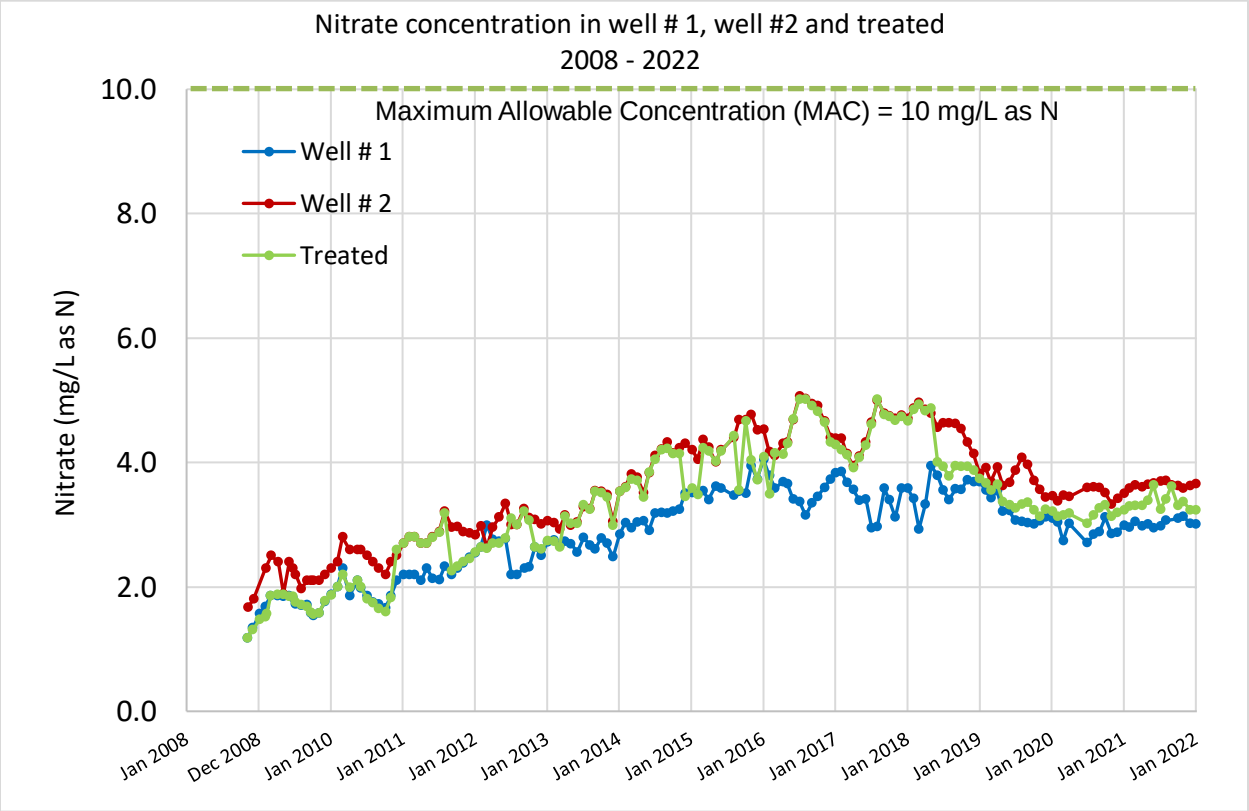
Table 17 - Shadow Ridge annual average nitrate concentrations (mg/L as N)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Well #1	2.24	2.55	2.68	3.11	3.56	3.57	3.41	3.54	3.25	2.94	2.93
Well #2	2.86	3.03	3.20	3.95	4.38	4.60	4.50	4.64	3.77	3.47	3.63
Treated	**2.67**	**2.80**	**3.11**	**3.83**	**4.01**	**4.47**	**4.45**	**4.30**	**3.41**	**3.18**	**3.36**

The graph below provides a long-term trend of nitrate levels in the Shadow Ridge individual wells and treated water. Recent years have shown a stabilization of nitrate levels in the treated water.

In order to provide a long-term solution for the presence of nitrate, the City has initiated an Environmental Assessment (EA) to examine solutions to establish a safe and reliable source of drinking water, for the established community. Options to be considered in the EA include a connection to the City's central water supply system, supplemental on-site treatment and the drilling of a new well source from a deeper aquifer. Initially testing of the deeper aquifer indicates that any new, deep wells would be free of nitrates but will have low levels of iron, manganese, and ammonia; issues which could pose some additional operational challenges.

Figure 25 - Nitrate level in Shadow Ridge treated water and source wells (2008 – 2022)



Radiological characteristics: treated water samples from each well system are tested quarterly for gross-alpha and gross-beta and tritium radioactivity. In 2021, all results were within the screening values for **gross-alpha** (0.5 Bq/L) and **gross-beta** (1.0 Bq/L) and tritium was also tested using Andre E. Lalonde AMS Laboratory in Ottawa (detection limit <1.1 Bq/L). Using this "low-level" analytical method provided a more detailed picture of the tritium levels in the City of Ottawa communal wells. Tritium was detected at or above the detection limit (1.1 Bq/L) at least once in all the wells systems except Munster. The highest level found was at Richmond West (2.5 Bq/L) in May 2021.

Volatile Organic Compound (VOC) testing: approximately 60 volatile organic compounds are tested annually in each of the source wells and treated water. All of the test results were non-detect during 2021, except NDMA (N-nitrosodimethyl amine) which was detected once in the Munster well system at a level of 0.0043 ppb. This level is well within the Ontario Drinking Water Standard of 0.009 ppb for NDMA. This compound is typically detected as a disinfection by-product resulting from ammonia/chlorine reactions during the treatment process.

COVID19 Impacts on water quality monitoring

Water sampling and testing activities were modified during 2021 in order to better protect staff and Ottawa residents. Routine sampling sites were shifted to water facility locations without public access or person-to-person contact. All in-home water quality testing activities was suspended, and modified sampling procedures were adopted to test water quality without entering the resident's home. In this way, a total of 1,313 customer inquiries and complaints were handled during the year, including 1,069 residences tested for lead concentrations in their tap water.

Due to the suspension of in-home testing protocols, the City of Ottawa applied for and received regulatory relief for the winter and summer sessions of lead sampling in the Central distribution system and the Richmond West well system (Dec 15, 2020 – Apr 15, 2021 and Jun 15 – Oct 15, 2021).

Summary

Overall, the test results indicate that safe drinking water quality was maintained throughout 2021. Due to the COVID19 pandemic, the water quality testing program was modified slightly in order to protect staff and Ottawa residents. Based on the review, there are no outstanding concerns with source or treated water quality trends or emerging contaminants, with the exception of the ongoing presence of nitrate in the Shadow Ridge Well System. To address this problem, the City is actively working on solutions to provide an alternate water source, for the Shadow Ridge water system.

No Action Items were identified as part of the Management Review Meetings.

i) Follow-up Action Items from Previous Management Review

Between 2009 and 2021, a total of 147 action items have been generated from the Management Review Process. A total of 5 Management Review action items were closed during 2021, with 5 Management Review action items remaining In Progress at the end of the year. The table below illustrates the action items developed through the annual Management Review process from previous years that remain *In Progress*:

Table 18 - Action Items from Previous Management Review that Remain *In Progress*

Mgt Review Year	#	Action Required	Priority	Owner (Services)	Target Completion Date
2013	296	Establish a training framework for operators and trades staff that would identify training requirements within the 3-year cycle.	2	TIES	2022
2013	308	Develop and implement design standards for communal wells	2	Water Production, Water Services	2022
2017	600	Chemical design review project - provide tech memo indicating work to date, areas of concern, chemical design areas needing review/upgrade. Report to include technical reference table for various feed chemicals; Further work on chemical design to be completed as individual projects;	1	Water Quality, Water Services	2022
2017	604	Prepare an operations guidance document for Operators to achieve optimal coagulation in water treatment	3	Water Quality, Water Services	2022

Mgt Review Year	#	Action Required	Priority	Owner (Services)	Target Completion Date
2018	698	Project: review and update distribution sampling program to include: (i) adequate sampling sites in each pressure zone, (ii) adequate # of regulatory samples + buffer for compliance, (iii) route streamlining for weekly coverage, etc. (iv) integration with other customer testing, leads, etc. (v) integrity of each sample location (access, bacteriological contamination), (vi) tap fixture upgrades where needed, (vii) standardized disinfection procedure for each tap, if required at that site (eg. free flowing continuous sample vs. tap shut off) (viii) documentation for all to reference;	1	Water Quality, Water Services	2022

Of the 5 action items from past management reviews that remained *In Progress*, two were scored as Priority 1. The 2020 Management Review resulted in 2 action items for implementation, with one item still *In Progress*.

Continued efforts to address and complete these items are underway and tracked by the QMS Coordinator through regular meetings with the responsible delegates.

No Action Items were identified as part of the Management Review Meetings.

j) Status of Management Action Items Identified Between Reviews

Aside from the Management Review process, no additional management action items were identified in 2021.

No Action Items were identified as part of the Management Review Meetings.

k) Changes that Could Affect the QMS

COVID-19 Pandemic Impacts to Operations and the QMS

The City of Ottawa, including Water Services (Drinking Water), entered into a State of Emergency on March 25, 2020, for the COVID-19 Pandemic. Declaring a State of Emergency helped the City deploy its emergency operations and staff, enabled a flexible procurement process, as well as the redeployment of resources and staff to support essential services and adapt to a rapidly evolving situation, all while ensuring the continuity of drinking water operations and maintaining drinking water for the residents of Ottawa.

During 2021, the protection of our essential workers that operate and maintain our drinking water systems was a significant focus throughout the year. Continuation of safety features such as proper PPE, physical distancing, air/ventilation improvements, shift-change procedures, self-screening, disinfection of work surfaces, mandatory vaccination policy and staff isolation remained in place during 2021 Through these efforts, an uninterrupted supply of safe drinking water was delivered to Ottawa residents throughout 2021.

Corporate restructuring

As a result of a corporate restructuring at the City in December 2021, changes were made to the City's departments and management structure. The QMS Coordinator has been collaborating with the Operating Authority to revise the DWQMS Operational Plan to reflect these changes, including:

- PWESD was changed to PWD and IWSD; some services and branches were moved within the organisation (ex: PIED-IS to IWSD-IS).
- New members have been identified as Corporate Top Management.
- Responsibilities regarding the support and maintenance of the DWQMS have been altered.
- Water Services, TIESS and Asset Management Services will continue to work collaboratively to implement asset management within the new organization (IWSD)

The release of the revised DWQMS Operational Plan is expected in Q2 2022.

Technological changes for documentation and archiving

Starting in 2020, ITS rolled-out SharePoint as a tool to address issues with remote access by staff when COVID protection measures included a major transition to work-from-home. Many groups that support DWQMS migrated their documents from the shared corporate servers to the SharePoint cloud-based servers with guidance from ITS. This led to the creation of many collaborative SharePoint sites. Staff would now navigate between these many sites to access or input data; however, the amount of different sites has grown significantly and the permissions structure has often not accounted for consultation by other services. As well in January 2022, the corporate intranet was moved from Ozone (Stellent) to My City (SharePoint), which affected the consultation by staff of DWQMS-required documents (ex: SOPs). ITS has also informed staff of the planned BIMS decommissioning.

Collaborative projects involving ITS staff to address these changes are currently on-going:

- ITS-led project to identify and restructure the multiple collaborative SharePoint sites of used by groups supporting the DWQMS and the production and delivery of safe drinking water, as well as to standardize the site permissions structure. An action item was added to the DWQMS CAPA database for tracking progress.
- TIES-led project to correct the non-compliances relating to the Intranet modernization project and create an intranet website for DWQMS-supporting staff to easily access DWQMS-required and -controlled documents. An investigative report is currently awaiting approvals, and the identified action items will then be added to the DWQMS CAPA database for tracking progress.
- TIES-led project to identify the impacts of the BIMS decommissioning on DWQMS document storage and the required actions. As this was newly identified, it is still in the research phase.

MECP addition of cybersecurity threats to Potential Hazardous Events list

In April 2022, the Ministry of the Environment, Conservation and Parks updated the *Potential Hazardous Events for Municipal Residential Drinking Water Systems to consider in the DWQMS Risk Assessment* (MECP Potential Hazardous Events list) to

"… explicitly consider cybersecurity threats. This will help ensure Ontarian's drinking water remains safe, secure and reliable."

The current City DWQMS Risk Assessment (Water Production) table includes #237 – Act of Terrorism (SCADA – denial of service or take-over disabling critical instrumentation), which was added in 2019 during a Full Scope Risk Assessment exercise; this followed a Vulnerability Assessment in 2016.

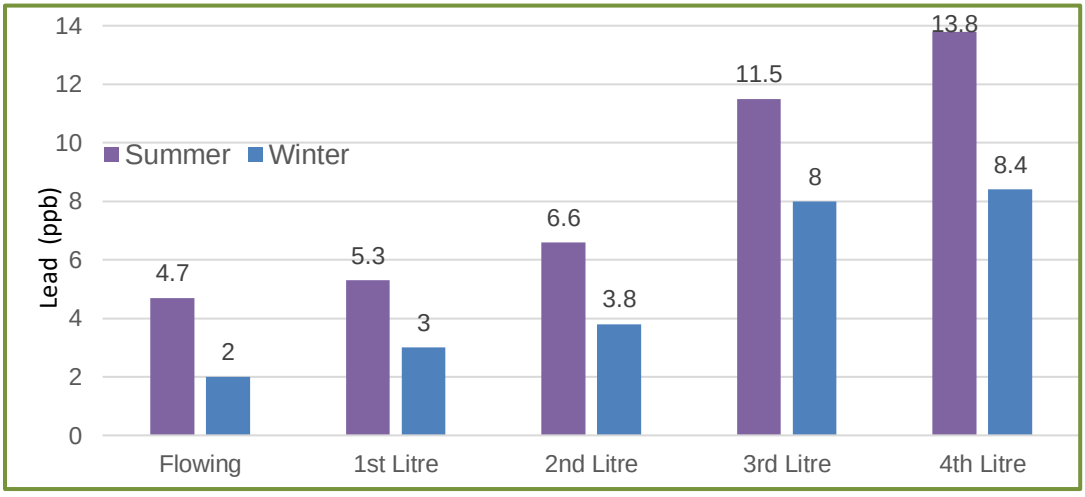
Due to this change, it is recommended during this Management Review that an action item be created to evaluate the impact of this addition.

Lead in drinking water

Due to increasing concerns about health impacts from lead, Health Canada, on March 8th, 2019, published a new stringent guideline of 5 ppb for lead in drinking water, expressed as a Maximum Acceptable Concentration (MAC). The new guideline also included the provision of ALARA (as low as reasonably achievable), to encourage water providers to make every effort to minimize lead exposure beyond the MAC.

Ottawa has been using pH adjustment to minimize lead corrosion and leaching in homes with lead service pipes. The lead concentrations (90th percentile values) are shown below for the 2008 – 2020 testing period. No testing was done in 2021 as a result of COVID-19. The graph indicates that lead concentrations in Litre1 and Litre2 would exceed the 5 ppb standard if adopted in Ontario.

Figure 26 - Tap Water Lead Levels in Ottawa Homes with Lead Service Lines (90th Percentile Values)



Based on pilot experiments conducted in Ottawa, a low-dose phosphate treatment process has been selected to update the corrosion control strategy at both water treatment plants. The project is currently in design phase and expected to be commissioned in 2022/2023. Tap water lead concentrations of 5 ppb still carry some health risk for children, and the project seeks to achieve lead concentrations <1 ppb for older homes with lead service pipes. In Ottawa, there are approximately 27,945 homes that have lead service lines currently in use.

During 2021, there were 89 older homes that had their lead service lines (LSL) replaced and were converted to non-LSL service. Of these, 68 were full [City + Private] LSL replacements (through LPRP program) and 21 were for Private LSL replacements only. In addition, there were 414 replacements of lead service pipes through watermain rehabilitation during 2021, although it is important to note that the Private LSL portion remains in service for these homes. To put this into context, there were an estimated 28,028 homes with City + Private LSL portions at the start of 2021. With 89 homes were converted to non-LSL during 2021, there are an estimated 27,945 LSL homes remaining.

A spreadsheet maintained by Water Quality is used to track the number of LSL homes in order to evaluate the potential lead exposure for Ottawa residents. The table below summarizes the tracking of LSL homes in Ottawa during 2021.

Table 19 - Lead service line (LSL) replacements during 2021.

# [City] LSLs replaced through w/main rehab	414
# [City + Private] LSLs replaced by LPRP	68
# [Private] LSLs replaced by LPRP rebate	21
Total number of [City] LSLs replaced	482
Total homes converted to non-LSL supply	**89**
Total homes with LSL (City and/or Private) at year end	**27,945**

In addition to the phosphate project, revisions to the LPRP and outreach communications have been implemented by staff, starting in 2020. The mail-out program was halted due to COVID19 but resumed summer 2021. Committee and Council approved additional funding for the LPRP. These measures will assist residents to replace lead service pipes and minimize their exposure to lead in tap water.

Shadow Ridge New Source Wells

As noted in item *h) Raw Water Supply and Drinking Water Quality Trends* of this report, nitrate levels are levelling off in the Shadow Ridge (Greely) source wells. Although the 2021 annual average of 3.36 mg/L meets the Ontario Drinking Water Standard of 10 mg/L, the City has initiated a project to examine an alternative source of water supply; one that is less susceptible to nitrates.

Initial testing of wells, from a deeper aquifer, was completed in late 2020 and the results showed both good water quality and quantity Consequently, a project charter was completed in early 2021 and the undertaking is now with ISD - Design and Construction as an engineering consultant assignment, to examine options for an alternative water supply. If, through a public Environmental Assessment process, a new deep well source is selected as the preferred alternative, a revised well head protection study will also be required, to support the project and meet agency requirements.

Once finished, this project will provide a more secure source of water for the Shadow Ridge water supply. The consequence of such works, to the Shadow Ridge Facility, will be reviewed as part of ongoing risk assessment reviews.

Spring Flooding Mitigation Measures, at the WPPs

In preparation of the 2021 Spring Freshet, flooding contingency plans were developed and temporary flood mitigation supplies were acquired, for the Lemieux Island and Britannia WPP sites. Training, on these plans, was delivered to staff in April of 2021. Final design of non-return valves, on several storm outfalls at the WPPs, was completed in 2021 and installation is planned for the summer of 2022. Larger, more permanent mitigation strategies are being investigated, as part of the later described WPP Comprehensive Development Plan undertaking. The consequence of such works, to the WPPs, will be reviewed as part of ongoing risk assessment exercises, as part of the water facilities asset management program.

Lemieux Island Intake Replacement

The design of a new, deeper raw water intake, for Lemieux Island, continued through 2021. This Council approved project was initiated to further mitigate the risk of frazil ice shutting down the Lemieux Island WPP. With a proposed intake location on the Quebec side of the Ottawa River, the design for this new intake is essentially complete, and the

project team continues to work with Quebec and Ontario regulatory approval agencies, prior to starting construction. Upon completion of this new infrastructure, the consequence of these works will be reviewed as part of ongoing risk assessment reviews.

Changes to Asset Management Legislative Requirements

As part of O.Reg. 588/17, “every municipality shall prepare an asset management plan in respect of its core municipal infrastructure assets by July 1, 2022, and in respect of all of its other municipal infrastructure assets by July 1, 2024.” Core municipal infrastructure is defined in the regulation to include assets related to water, wastewater, stormwater management, road, bridges and culverts. Staff in Asset Management Branch have been working to develop the service level asset management plan for Water Service assets related to collection, production, treatment, storage, supply and/or distribution of water, including the definition of current levels of service to meet the 2022 deadline.

Best Management Practices

As a requirement of the MECP Standard 2.0 under *element 21 – Continual Improvement*, the Operating Authority shall review and consider applicable best management practices (BMPs), including any that may be published by the MECP. The MECP had not released any BMPs by the end of 2021.

The Operational Top Management team has not reviewed any applicable best management practices since 2019. However, Water Services personnel continue to participate in water industry conferences, workshops, seminars and webcasts, including the Ontario Water Works Association, the Canadian Water Works Association, the Water Research Foundation, American Water Works Association. In addition, the QMS Coordinator regularly attends DWQMS Workshops and engages with other municipalities to discuss relevant practices, when required.

In February 2021 the City implemented the changes required in the updated MECP Watermain Disinfection Procedure. Key areas impacted through these amendments included improved requirements for backflow preventors, changes to microbiological sample locations and spacing, and elimination of the City practice of using pre-chlorinated pipe on connections greater than one pipe length. Water Distribution staff worked with City partners and industry stakeholders to identify common scenarios and

develop options to support watermain installations and meet the requirements of the updated procedure.

An Action Item was identified as part of the Management Review Meetings.

- Ensure that the 2022 Risk Assessment exercise addresses the addition of “All systems – Cybersecurity threats” to the MECP Potential Hazardous Events list.

l) Summary of Consumer Feedback

Customer inquiries and complaints related to drinking water are typically received and answered by the 3-1-1 Call Centre. The 3-1-1 Call Centre, either forwards call to the PWES Client Support Unit-West staff (Clyde Avenue) that are more familiar with specific water quality issues or will create a service request.

Customer Inquiries, Investigations and Service Requests

Table 20 – Customer Inquiries, Investigations and Service Requests from 2017 to 2021

Type of Inquiry	Description	2017	2018	2019	2020	2021
Total of all General Information requests concerning drinking water	Calls or service requests received into the PWES Client Support Unit-West (3-1-1, Revenue, info water, etc.)	15,238	9,929	7,032	5,258	4,784
DWS Service Requests (Water efficiency, AMI, Lead Pipe Replacement Program (LPRP), Water pressure, WQ requests, etc.)	Service requests including tracking and customer information requests dealing with DWS	1,458	826	1,660	685	3,454
Water Quality service requests (info or service)	Service requests created by the PWES Client Support Unit-West that relate to drinking water quality	424	412	867	712	1,391
Water Quality site investigation requests	Water Quality requests received by the WQ group that require a site investigation	328	378	798	682**	1,313

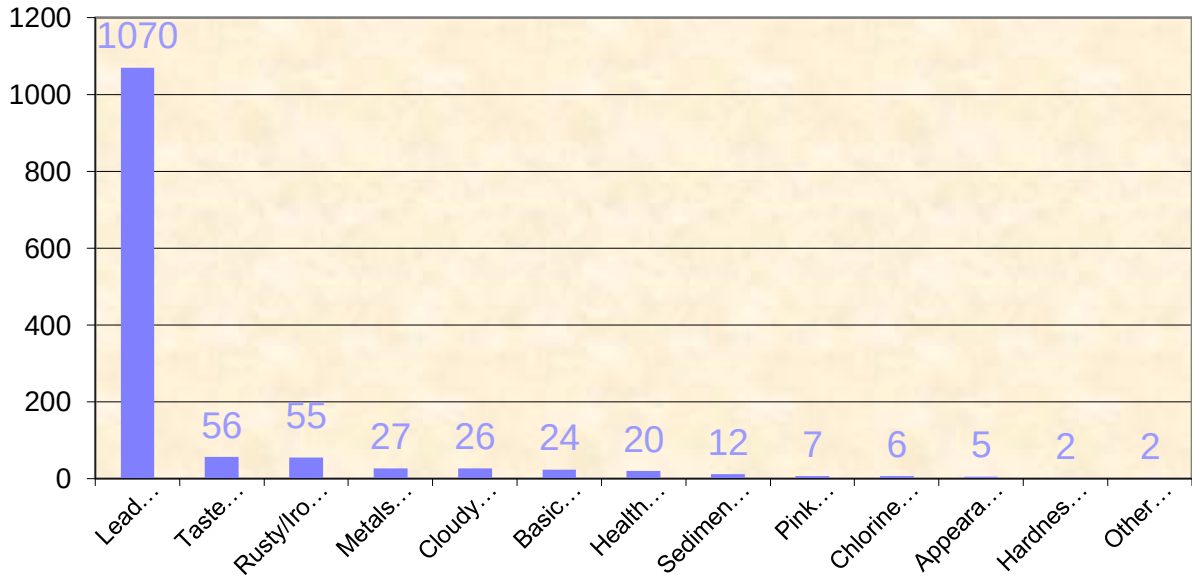
In 2021 the overall number of general information calls/service requests received by the PWES Client Support Unit (Clyde) staff and the resulting service requests was again lower than previous years. The drop in 2018 and 2019 was a direct result of the Water Meter Group moving to Water Billing and Systems Unit, as a large amount of the calls received related directly to the appointments and maintenance of water meters as well

as account information. These calls are now being received by a separate extension supporting the Water Meter Group. In 2021, the drinking water service requests was increased as a result of the Lead pipe replacement program (LPRP) mail out and the Service line Canada information. This increased calls and service requests for lead appointments and the applications for the LPRP.

**Water Quality site investigations were tracked differently in 2021 as a result of COVID-19. This is discussed earlier in the report in section G.

During 2021, the number of water quality service requests and investigation requests increased as a result of the increased requests for lead testing. Following the update to the Lead Pipe Replacement Program the remaining 25,000 of the 30,000 letters were mailed out to homes built prior to 1955. Of the 1,391 service requests for water quality, 1313 service requests were handled by the water quality group. The chart below shows the nature of 2021 water quality investigations, by category:

Figure 27 - 2021 Water Quality requests received



Water quality inquiries and investigations provide an excellent opportunity to resolve concerns, demonstrate the quality of City services, and to enhance public confidence in Ottawa's drinking water. During 2021, even though home testing was suspended responding to customer concerns was still a top priority. As discussed previously all customers who had a concern were contacted to discuss their concerns.

The City of Ottawa website also provides information related to water production, water distribution, water quality, and water efficiency. Customers can email information requests to info-water@ottawa.ca or waterwise@ottawa.ca.

No Action Items were identified as part of the Management Review Meetings.

m) Resources Needed to Maintain the QMS

As a result of a corporate restructuring at the City in December 2021, changes were made to the City's departments and management structure. This led to the development of the "Building a Thriving IWSD" initiative. This initiative will set departmental direction and create alignment. This will result in aligning and integrating business areas which support the DWQMS.

Additionally, the resources necessary to support capital project delivery, by Water Services staff, is significant and will be addressed during the IWSD initiative.

Water Services has conducted a review of key initiatives that have significant impacts to build capacity for further enhancements. A number of priority areas where there is opportunity to enhance technical and operational effectiveness were identified. Project teams have been established for SCADA Practices and Standards, Engineers and Operational Support, and Water Distribution Leadership. The resource needs will continue to be assessed and monitored.

MECP addition of cybersecurity threats to Potential Hazardous Events

As described in item k), the Ministry of the Environment, Conservation and Parks updated the MECP Potential Hazardous Events list to add persistent cybersecurity threat. While the City has a hazard identified in its Risk Assessment table relating to cybersecurity, this update has prompted a review to identify if new additional SCADA resources may be required to respond to this persistent threat. The Management Review action item identified in item k) will help identify these resources.

No Action Items was identified as part of the Management Review Meetings.

n) Results of the Infrastructure Review

DWQMS 2021 Risk Assessment Outcomes

As required by the Drinking Water Quality Management Standard (version 2.0, released 2017), outcomes of the DWQMS Risk Assessments must be considered during the review and provision of infrastructure. During the 2021 Risk Assessment review, no hazards and hazardous events were identified as requiring Infrastructure Review discussions.

Table 21 – List of active Risk Assessment hazards and hazardous events identified for Infrastructure Review Discussions

#	Hazard Description	Note from Risk Assessment Meeting with WD	Update
8	Release of stagnant water into the distribution system through the opening of a closed (seldom operated) valve (dead ends or new developments with low activity)	Watermains in new developments with projected low activity are at risk of degraded water quality due to stagnation	There is language in the development permits to require that water quality is maintained, usually through the installation of an autoflusher unit.
16	Contamination - high levels of lead in water due to leaching from pipe/plumbing	Need to report on the amount of lead service pipe removed from the system every year as a result of the LRP and the capital renewal projects	Water Distribution Management will work with corporate stakeholders to implement the reporting of lead service pipes removed from the system during the LRP and capital review projects
#	**Hazard Description**	**Note from Risk Assessment Meeting with WP**	**Update**
69	CCP P1 - Coagulation failure or non-optimal capture of particles/ microbial pathogen	Identify a need for the replacement of low lift venturi with Mag meters @ Britannia – WPP Comprehensive Development Plan	Include the need for the replacement of the low lift venturi with Mag meters @ the Britannia WPP in the WPP Comprehensive Development Plan – as part

			of the infrastructure review discussion

Action items identified in previous years are tracked as part of the DWQMS Continual Improvement process.

Water Production Infrastructure

A number of activities were undertaken in 2021 in order to improve or maintain the reliability and performance of the water production plants and remote facilities. The work completed was prioritized using a risk-based approach that focuses on important factors that could affect the operation such as health and safety, regulatory impacts, environmental impact, among others. This framework continues to be used to prioritize the sequencing of capital projects.

State of Local Infrastructure

The City's water infrastructure assets are safe. The City continues to apply recognized asset management practices to maintain its water infrastructure in a state of good repair, and proactively inspects and maintains assets using a risk management approach, considering the likelihood and consequence of failure and risk to service.

Greater than 90% of drinking water assets (by replacement value) are in fair, good, or very good condition. The remaining assets that are in poor or very poor condition indicate a higher priority for future funding needs. The City's water assets in fair or good condition are performing to meet the required level of service but may require attention periodically as condition worsens over time.

Table 22 - Drinking Water Asset Overall Condition Ratings from 2022 and 2017

Asset Category	2022 Rating	2017 Rating	Change
Treatment Plants	Fair-Good	Good	Decrease
Pump Stations	Fair-Good	Fair	Increase
Communal Well Systems	Good-Fair	Good-Fair	None
Storage	Good-Fair	Good-Fair	None
Transmission Mains	Fair-Good	Good-Fair	Decrease
Distribution Pipes	Fair-Good	Good-Fair	Decrease

Drinking water linear needs are analyzed and prioritized based on several factors such risk assessments, inspection results, integrated renewal opportunities, stakeholder/operator expertise, water quality issues, and based on the results from the Critical Infrastructure Identification Study. City infrastructure projects scheduled for renewal are reviewed annually and are based on an assessment of competing priority needs and available funding based on the City's Annual Budget. Infrastructure projects are prioritized based on several factors, including existing condition, risk to service, traffic volumes, costs and affordability, coordination with other nearby projects, and public concerns.

Based on the Drinking Water Asset Management Plan, the overall condition of drinking water assets is Good. The Drinking Water Asset Management Plan will be reviewed and updated at least every five years, and the next update is expected in 2025 to align with provincial requirements for target levels of service .

Structural Condition Assessments

Structural condition assessments for the various bridges under which watermains reside have also been completed. The City of Ottawa undertakes inspections of its bridge structures on a two-year cycle in accordance with the Ontario Structure Inspection Manual (OSIM) procedures and requirements. Maintenance and repair items identified through the visual assessments are reviewed, programmed and acted upon as necessary. Structures that have larger potential rehabilitation needs identified through the bi-annual inspections are scheduled for a detailed condition assessment and renewal options analysis study. The outcome of the detailed assessments are recommendations for both minor and major bridge renewals that are programmed as part of the City’s capital construction programs. The investments needed for repairs or renewals are prioritized based on risk to the service from a social, environmental and economical perspective. The latest results are summarized in the table below:

Table 23 – Structural Condition Assessments for Bridges Situated Above Watermains

Structure	Total Span Length	Year Built	Type	# of Spans	Last Rehab	Renewal program	Comments
017150, Fleet St Pumping Station Access Bridge	7.10 m	1910	Steel beam	1	2013	n/a	The 2020 OSIM inspection carried out by Morrison Hershfield states that the bridge is in 'Good' overall condition, however, the bridge has a Bridge Condition Index (BCI) of 58 due to the severity of localized defects. There is currently no rehabilitation scheduled for this structure in the 5-year renewal forecast. A major renewal (strengthening) was completed in 2013 by IWSD as part of the Tailrace Structural Rehabilitation.
017170-1, Lemieux Island Road Bridge [South Span]	80 m	1989	Steel Open Spandrel Arch	2	2008	none	The 2020 OSIM inspection carried out by Morrison Hershfield states that the bridge is in 'Good' overall condition with a BCI of 73. There is currently no rehabilitation scheduled for this structure in the 5-year renewal forecast. The bridge was retrofitted to seismic design standard in 2008.

Structure	Total Span Length	Year Built	Type	# of Spans	Last Rehab	Renewal program	Comments
017170-2, Lemieux Island Road Bridge [Bell Island]	54 m	1989	Concrete Rigid Frame	1	2008	none	The 2020 OSIM inspection carried out by Morrison Hershfield states that the bridge is in 'Good' overall condition with a BCI of 74. There is currently no rehabilitation scheduled for this structure in the 5-year renewal forecast. The bridge was retrofitted to seismic design standard in 2008.
017170-3, Lemieux Island Road Bridge [North Span]	80 m	1989	Steel Open Spandrel Arch	2	2008	none	The 2020 OSIM inspection carried out by Morrison Hershfield states that the bridge is in 'Good' overall condition with a BCI of 73. There is currently no rehabilitation scheduled for this structure in the 5-year renewal forecast. The bridge was retrofitted to seismic design standard in 2008.
017160, Lemieux Island Pipe Bridge	187 m	1936	Steel Truss	6	2019	Substructure renewal completed substantially	According to the 2020 OSIM inspection, the bridge is in 'Good' overall condition with a BCI of 75. The substructure renewal was completed in 2019 based

Structure	Total Span Length	Year Built	Type	# of Spans	Last Rehab	Renewal program	Comments
						on October 6, 2019	on the 2010 joint AMB & ISD action plan following the recommendation of the 2010 CH2MHILL Risk Assessment Study. The other action-plan item, to conduct an advance EA for bridge replacement, is currently being revisited by IWSD and likely to be postponed. AMS Structures is planning to use the 2020 budget to conduct preliminary engineering studies to facilitate the upcoming EA.

WPP Comprehensive Development Plan

Work on the Water Purification Plants Development Plan (WPPDP) continued through 2021. The WPPDP was last updated in 2012 and an update is now required for the upcoming planning horizon, which will be up to the year 2046.

As Ottawa experiences population and economic growth over time, infrastructure requirements for the WPPs need to be assessed periodically to ensure capital works occur in a timely manner to meet the increased drinking water demands. The two WPPs currently have an amalgamated Water Purification Plants Development Plan (WPPDP), which assesses the ability for the plants to meet future growth demands from a capacity perspective, and lists capital works that are required over the forecasted planning horizon due to growth, renewal and process upgrades. Along with the WPPDP, the plants have SCADA and Electrical master plans that look at respective capital upgrades required for SCADA and electrical components within the plants.

The purpose of this assignment is to develop a document that will allow the City to comprehensively understand the growth, renewal and capacity related infrastructure requirements at the two WPPs for the 2046 planning horizon, along with understanding the respective costs, funding sources and risks. This will in turn support the development of the City's overall Infrastructure Master Plan, in addition to developing a comprehensive master projects list for the WPPs.

Drinking Water Asset Management Plan

The development of the Drinking Water Asset Management Plan (DWAMP) continued through 2021. The Infrastructure for Jobs and Prosperity Act (2015), and Ontario Regulation 588/17 have legislated the practice of asset management in Ontario. Regulatory requirements specify that each municipality must create an Asset Management Plan, the first version of which must be developed by July 2022 for core assets, which includes water infrastructure.

As part of its asset management journey in 2017, the City of Ottawa published its Strategic Asset Management Plan (SAMP), which developed several core components of its overall Asset Management System. Building on the success of the SAMP, the City is endeavoring to develop service-focused asset management plans (AMP), which will detail the City's strategies to manage, maintain and fund infrastructure in order to

achieve each service's objectives. The primary objectives of the DWAMP will be to provide the City with an understanding of its drinking water asset portfolio as well as strategies to maintain levels of service, mitigate risk and provide efficient and financially sustainable service delivery.

Water Distribution Infrastructure

Large-Diameter Watermain Condition Assessment Program

The City has continued to move forward with the large-diameter watermain condition assessment program. The main benefit of this program is the ability to proactively assess and identify deficiencies that can be addressed in a planned and controlled fashion without negatively impacting customers. There are currently 235 km of large-diameter watermains (≥610mm) in the City. The expected service life is between 80 and 110 years and the average age is approximately 32 years.

Although the program was formally established in June 2012, IWSD has been engaged in watermain condition assessment activities since 2007.

The program continues to be governed by a working group composed of technical experts and management representatives from multiple City branches, including PIED Asset Management, WS Production and Distribution and TIESS Network Implementation and Support. The working group discusses alternatives and puts forth recommendations for the inspection program. They take into consideration the risk-based prioritization and competing priorities within the drinking water system. A risk-based prioritization approach, considering competing priorities within the drinking water system, is used to establish the annual program. Of particular priority for inspection is approximately 52.6 km of pipeline that was installed from ~1972 to 1979 that has experienced a higher degree to wire breaks leading to premature failure. It is recognized industry-wide that the 1972-79 C301 pipe, have experienced a modest tendency for premature failure, as compared to CPP material manufactured and installed before and after this period. To date, the City has completed 40.1 km (76%) of unique structural condition assessment and 43.2 km (82%) of unique leak detection on this cohort of pipes. In total, 44.2 km (19%) of unique structural condition assessment and 103.9 km (44%) of leak detection have been completed on large-diameter watermains (≥610mm) in the City.

The following inspections were completed in 2021:

- Orleans C and D from Blair to East of Hart Rd - Structural inspection = 3.9 km (1.9 km was re-inspection)
- Kanata B from Kanata Ave to Katimavik - Leak detection = 1.8 km
- Fallowfield A/ B from Woodroffe to Fallowfield Reservoir- Leak detection = 3.9 km
- Britannia B and Woodroffe A/C from Carling to Nepean Sportsplex - Leak detection = 5.5 km

Through this program, 11.2 km of large-diameter watermain was inspected for leaks and 3.9 km for structural deficiencies in 2021. Each type of inspection provides unique condition information upon which rehabilitation and replacement decisions are made. Completion of both types of condition assessment often takes multiple years. A watermain segment is considered to be completely inspected when both leak detection and structural condition have been assessed, as appropriate based on engineering analysis, pipe material and current technology available on the market. In 2021 7.5 km of watermain were considered fully completed. While the amount of EM inspections was lower in 2021, this was accomplished by leak inspecting a number of watermains which only had EM inspections completed previously. The group continues to look for opportunities to increase the amount of structural inspections completed each year. The table below provides a summary of the completed assessments.

Table 24 – Inspection Distances by Year (km)

Year	Structural	Leak Detection	Fully Completed
2007	n/a	1.0	n/a
2008	3.8	n/a	n/a
2011	8.5	3.5	3.5
2012	4.1	3.6	3.6
2013	4.2	n/a	n/a
2014	1.9	2.2	3.3
2015	9.7	10.8	7.0
2016	1.5	16.8	11.4
2017	7.2	22.4	3.7
2018	0.9	10.9	8.2
2019	3.6	17.6	9.7
2020	3.2	11.9	6.2
2021	3.9	11.2	7.5

The figure below illustrates the progress to date for the Large Watermain Condition Assessment Program - the left-side shows the total large diameter watermains

(including the cohort of pipes installed from ~1972 to 1979) and the right side shows the cohort of the pipes installed from ~1972 to 1979.

Figure 28 – Large Diameter Condition Assessment Progress Unique Inspections to Date (km)

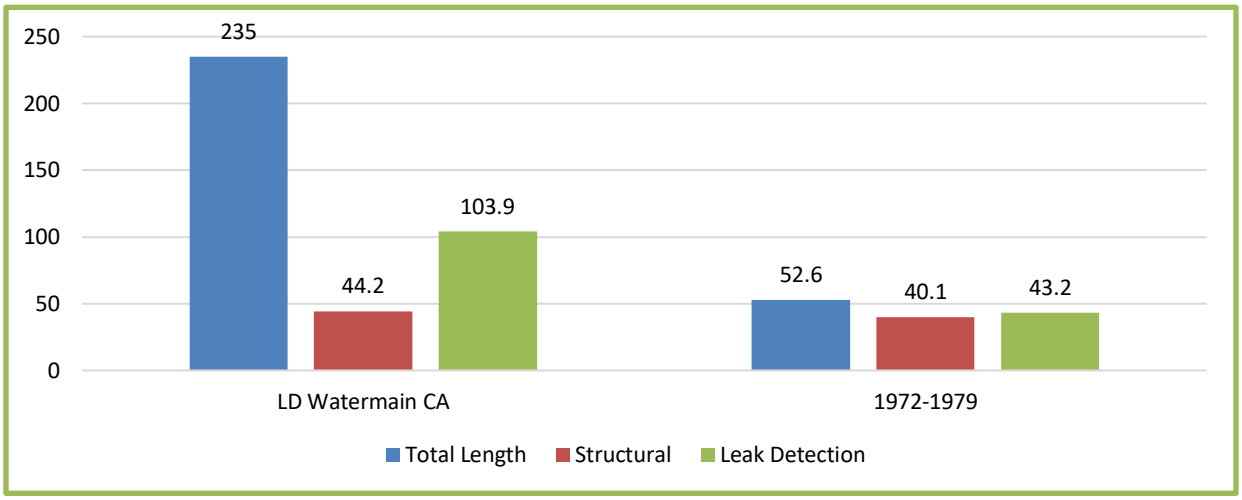


Table 25 - Summary Condition Assessment Results from 2015 to 2021

Description	Total Distance (m)	# of Distressed Pipes				Total # of Pipes inspected	% of Distressed Segments	Last Inspection Date
		Immediate action Required	Short-Term Action n Required	To be Monitored Long-Term	Total			
Orleans C & D	3940	0	0	0	0	740	0	2021
Eagleson A and B	1250	0	2	3	5	261	1.9%	2020
Ottawa South A	1988*	0	0	3**	3	342	0.9%	2020
Morgan's Grant Ph 2B	383	0	0	1	1	63	1.6%	2019
Morgan's Grant Ph1	938	0	0	1	1	149	0.7%	2019
Bridlewood B	1309	0	3	7	10	186	5.4%	2019
Baseline 4	890	0	1	0	1	153	0.7%	2019
Morgan's Grant Ph 2A	394	0	0	0	0	63	0.0%	2018

Bridlewood A Ph1	1451	0	0	2	2	222	0.9%	2017
Britannia B	2615	0	0	45	45	555	8.1%	2017
Woodroofe A North	1009	0	0	3	3	179	1.7%	2017
Morgan's Grant Ph 3	867	0	0	0	0	108	0.0%	2016
Loretta North	602	0	9**		9**	192	4.7%	2016
Orleans A	1680	0	0	3	3	287	1.0%	2015
Lorry Greenberg	300*	0	0	0	0	41	0.0%	2015
Bridlewood A Ph 2	616	0	0	0	0	89	0.0%	2015
Ogilvie	315	0	0	0	0	65	0.0%	2015
Ottawa South A/B	6984	0	2	6	8	1227	0.7%	2015

** Distance estimated*

*** includes pipes exhibiting anomalous signals with distress-like properties and/or longitudinal cracking, further inspection may be required to confirm results*

It should be noted that the Pure Technologies has found that the current average % of distressed segments across all of their inspections is around 3.00% (The Water Research previously published industry distress rate in 2012 was 3.7%). To provide more details regarding the actions taken based on assessment results, the following definitions were used:

- Immediate Action Required: Pipe segment condition is such that it needs to be repaired or replaced before bringing the pipe back into service. Urgent Repair.
- Short-Term Action Required: Pipes should be scheduled for repair or replacement in the next few years. The timeline depends on the severity of the distress and professional opinion of the structural engineer. The pipe can be put back in service, but steps should be taken to repair or replace it. Planned Repair

- To Be Monitored Long-Term: There is distress in the pipe section, but it is relatively minor. No repair or replacement intervention planned. The pipe will be reassessed after the next inspection. The timing of the next inspection is to be determined through regular program planning.

Table 26 – Summary Leak Detection Results for 2021

Description	Total Distance (m)	# of Leaks	Management Strategy
Kanata B	1798	1	A leak was detected at a joint at Terry Fox and Katimavik. The repair will be completed by the Design and Construction Branch.
Fallowfield A/B	3864	0	-
Britannia B and Woodroffe A/C	5534	1	A leak was detected at Woodroffe and Meadowlands and was repaired.

All inspections happen in Q4 of the inspection year, this is to allow time for the inspections and, if required, any repairs before May of the following year when water demands typically increase. As such, repair and replacement occur in the following year(s). Repair to be completed include:

Eagleson A and B - 5 distressed pipes were found in 2020. A Failure Risk Analysis was performed by SG&H. Although the SG&H report recommended repair, the repair is not required within next 5 years. However, it was decided that two of the distressed pipes with the higher number of wire breaks will be repaired/replaced sooner to avoid the risk of unplanned failure. This decision was made considering this watermain has a cohort of pipes installed between 1972 and 1979 and the location of the distressed pipes are in a busy intersection. A repair project was initiated by Asset Management in 2020 and will be completed by Design and Construction at the end of 2022.

Woodroffe A/C- In the spring of 2021 the AFO(Acoustic Fibre Optic cable), which monitors wire breaks in the watermain, identified a rapid increase in the number of wire breaks on 2 pipes, 782 and 783, indicating they were potentially in the process of failing. These pipes were repaired by Design and Construction using carbon fibre wrap. In the fall of 2021, a leak was identified by the Smartball at Woodroffe and Meadowlands (Pipe# 28 and 29). Additionally, a pipe (Pipe# 754) was identified by the AFO as having a rapid increase in the number of wire breaks indicating it was potentially in the process

of failing. Both of these issues were repaired by Design in Construction in December 2021. Additionally, pipe 45 which was identified as having a high number of wire breaks on the original EM inspection was opportunistically replaced at the same time due to its close proximity to pipe# 28 and 29.

Kanata B- In 2021 a leak was found at Terry Fox and Katimavik. Water Distribution is currently evaluating how the repair work should proceed.

The plan for 2022 is to build upon existing initiatives, including the following:

- Continue to look for opportunities to increase the length of structural inspections performed each year.
- Continue to work with Asset Management to refine the frequency and level of inspection each watermain requires.
- Explore potential for new technology and vendors
- Pilot new condition assessment technologies
- Continue program planning over a 3 to 5-year horizon
- Continued improvement on inspection planning
- Formalize documentation process for storing inspection reports
- Continue to work with Water Distribution on aligning the watermain condition assessments with large valve and chamber condition assessments and repair to reduce the downtime of the watermains

The plans provided in the table below are impacted by some constraints such as:

- Level of service expectations
- Resources
- Hydraulic impacts
- Other concurrent capital construction projects

Table 27 - Proposed 2022, 2023, 2024 Large Watermain Condition Assessment Program

Pipeline Name	Age (Yrs)	Risk Rank	Inspection Length (km)	
			Condition Assessment	Leak Detection
2022				
Britannia Discharge A	46	20	0	1.4

Woodroffe D	45	11	0	2.9
Woodroffe C	11	44	0	0.9
Woodroffe B	31	48	0	4.7
Vanier B	47	45	2.2	0
David Drive	46	38	0	7.7
Baseline Phase 3	45	13	1.2	0
Eagleson B	45	13	1.1	0
Ogilvie	57	53	0	4.8
2023				
Laurier	18	31	1.4	1.4
Gloucester	21	58	0	1.3
Britannia Discharge* BA*	44	5	2.6	0
St. Joseph A	47	20	2.3	2.3
Hazeldean A2	48	19	1.2	1.2
Hazeldean B2	8	68	0	0.9
2024				
Britannia Discharge A	46	20	1.4	0
Kanata B	45	39	1.8	0
Robertson Phase 0*	50	18	0	1
Robertson Phase 1*	47	2	2.6	2.6
Orleans Res	48	10	2.2	0

Watermain Renewal [tie in watermain break KPIs]

The City continues to apply recognized asset management practices to maintain its water infrastructure in a state of good repair. The repair and replacement of watermains is completed through watermain only and integrated programs in order to provide continued service and prevent failures. Our approach to watermain renewal is to operate watermains as long as possible, taking into account sewer and road needs. In general, the number of annual watermain breaks has been decreasing as a result of the renewal program (watermain only or integrated) and the application of strategic cathodic protection to existing mains.

A risk assessment model for the City’s distribution and transmission mains has been established which provides a refined method to identify watermain needs and addresses both the likelihood of a watermain failure as well as the consequence of

failure. Risk assessment provides a repeatable and defendable method of choosing renewal candidates. Risk assessment is particularly important for transmission mains where the scoring is used to identify and select higher risk watermains for condition assessment as opportunities and funding permit. The results of the condition assessment allow the City to correct and repair any issues in good time to prevent premature failure of the infrastructure.

Table 28 – Watermain Renewal Work Undertaken in 2021 [summarize list of projects]

Project	Status in 2021
Integrated Road, Sewer & Water Program	
Oakhill and Corona (Acaia - Beechwood)	In Design
Summit Ave (Alta Vista - Fairbanks)	In Design
Arnhem St and Apeldoorn Ave	In Design
Clare Dovercourt (Churchill - Hilson & T	In Design
Ferndale Ave (Churchill Ave N - Selby Av	In Design
Glebe (Bank - O'Connor)	In Design
Drouin Ave (North River - West Presland)	In Design
James St Kent St (Bronson - Bank)	In Design
CWWF Queensway Terrace North Sewer	In Construction
CWWF Deerpark-Hilliard-Fisher et al.	In Construction
Ashburn - Hogan - Wigan - Ness	In Construction
Borthwick-Quebec-Gardenvale	Construction Complete 2021
Fairbairn-Bellwood-Willard-Belmont	In Construction
Gibson-Denver-Tampa-Orlando	Construction Complete 2021
Grove Ave & Grosvenor	In Design
Larkin-Larose-Lepage	In Design
Valley Dr Storm Sewer	In Construction
St Denis - Lavergne - Ste Monique	In Construction
CWWF Vanier Parkway - Presland Rd et al	Construction Complete 2021
Arch - Canterbury - Plesser	In Design
Bel-Air Dr, Bedbrooke St et al	In Design
Broadview Ave	In Design
Caroline Ave - Huron Ave N	In Design
Claymor & Senio	Construction Complete 2021
Longpre - Marquette- Michel Cir	In Design
Monk - Oakland -Wilton	In Design
Winona Ave & Wilmont Ave	In Design
Piccadilly Ave (Wellington - Bassett)	In Design
Maclaren St - Lyon St	In Design

Project	Status in 2021
Pretoria Ave (Metcalfe-Bank)	In Design
Integrated Rehab-Intensification Areas	
Breezehill Ave N (Gladstone - Somerset)	In Design
CWWF Avenue N-O-P-Q-R-S-T-U	In Construction
O-OTM Carling Ave (Bronson-Bayswater)	In Design
Bank St (Riverside-Ledbury)	In Design
Elgin (Lisgar - Isabella)	Construction Complete 2021
Main Greenfield Echo Concord et al	In Design
CWWF ORAP - Loretta Ave N&S - Laurel St	In Design
Montreal Rd (N River Rd-St Laurent Blvd)	In Construction
City Centre Ave & Elm St	In Design
ORAP Albert St-Bronson Ave-Slater St	In Design
CWWF McLeod - Florence	Construction Complete 2021
Byron-Athlone-Highcroft	In Design
N River Rd (Montreal-Dead EndNof Coupal)	In Construction
Mann-Range-Russell-Templeton	In Construction
Bronson Ave (Imperial-Rideau Canal)	In Design
Scott St. (West of Smirle Ave)	In Construction
Carling Ave - Churchill Ave - Kirkwood	In Design
Water System Rehabilitation Program	
2021 Water System Improvements	General Account - Ongoing Projects
2021 WM Transmission/Distribution Rehab	General Account - Ongoing Projects
Stanley Ave. (Sussex - Union St)	In Design
2018 Watermain Improvements	General Account - Ongoing Projects
Bank St (Rideau Rd-Mitch Owens)	In Construction
LRT2 W1 Hwy 174 - Shefford Rd	Construction Complete 2021
2018 Transmission/Distribution WM Rehab	General Account - Ongoing Projects
2019 Watermain Improvements	General Account - Ongoing Projects
2019 WM Transmission/Distribution Rehab	General Account - Ongoing Projects
Water System Improvements	General Account - Ongoing Projects

Project	Status in 2021
2020 WM Transmission/Distribution Rehab	General Account - Ongoing Projects

Growth Related Infrastructure

The City of Ottawa's 2021 capital budget process identified adjustments to project funding needs based on progress on several major water supply projects that are required to support growth, as identified in the 2013 Infrastructure Master Plan (IMP).

In 2021, several major growth-related water infrastructure projects were active at various stages of planning, design and construction. These projects include the following:

Functional Design –

- Campeau Drive, Solandt Road and March Road watermain FDR completed 2020
- Kanata West Feedermain FDR completed.

Preliminary and Detail Design –

- Manotick Feedermain Phase 2
- Greenbank Road Watermain
- Carlington Heights Pump Station Upgrade
- Ottawa South Pump Station Upgrade

Construction –

- Manotick Feedermain Phase 1 under construction
- North Island Link watermain under construction
- Strandherd Drive watermain construction completed.
- The Brittany Drive Pump Station now under construction.
- Carlington Heights Pump Station tender anticipated in 2022
- Hurdman Bridge Pump Station Zone 2C Upgrade: Commence work – Jan 2022, Substantial completion Jul 2023
- Ottawa South Pump Station Expansion: Now in tender, Substantial Completion date Q4 2023.

- March Rd Pipe Upgrade (Zone 2W West Feedermain): Developer driven, In construction now.
- Kanata West Feedermain construction - implemented in part only.

The Ottawa South Pump Station project is the last major infrastructure upgrade associated with the planned reconfiguration of pressure zones in the City's South Urban Community. The Fallowfield Reservoir Pump Station project (completed in 2016), and the Barrhaven Pump Station project (completed in 2017) also supports the reconfiguration. Final design of the Ottawa South Pump Station Project was delayed pending a resolution to local servicing issues on the Ottawa International Airport campus and is now expected to be completed in Q4 2023. Resolution of these issues has resulted in an adjustment to the planned zone reconfiguration.

Planning Level Studies

Work on a City-wide Infrastructure Master Plan (IMP) was initiated in 2020 to update the current version of the plan, which was completed in 2013. This plan will support the City's New Official Plan, which is expected to be adopted by Council in Q2 2023. But there will likely be a minor update which will likely result in additional areas to the urban boundary within a coulple of years through the implementations of Bill 109. The IMP will review the need for any projects from the 2013 plan which have yet to be implemented and identify new trunk-level projects that will be needed to support urban intensification and expansion.
Master servicing work was carried out in a number of future development areas in 2019, 2020 and 2021. The bulk of this work is carried out by proponents of development, subject to City review and approval. In terms of water supply, this planning work identifies the principal watermain networks to be constructed in Greenfield areas. For intensification areas, development projections typically provide input to the local watermain renewal program. In 2022, progress on Master Servicing Studies were active in the following geographic areas of the City:

- Village of Manotick
- Village of Carp
- Village of Richmond

Future Infrastructure review reports will continue to track and comment on the IMP and the timeliness and success of project delivery.

An Action Item was identified as part of the Management Review Meetings.

- At next planned OTM meeting, discuss level of detail to review in item n) of Management Review, with regards to Water Production and Water Distribution projects, condition assessments, funding, etc. Refer to 2021 DWQMS Management Review Report, Table 30 for WD projects, vs lack of similar break down for WP.

o) Operational Plan Currency, Content, and Updates

The DWQMS Operational Plan was revised and released on April 16, 2021 (version 6.0). Revisions made to the DWQMS Operational Plan included the following changes:

- Update: change to QMS Representative, from WS Director to QMS Coordinator, with Performance and Management System Specialist as alternate.
- Removal: removed EMR from Central Distribution System description.
- Removal: removed required approval by OTM for the Risk Assessment outcomes and for the Internal Audit Plan and Schedule.
- Addition: added MDWL numbers for each system (Element 1)
- Addition: added requirement, for all members of CTM to sign-off on DWQMS Operational Plan endorsement during each CTM Management Review meeting

For each major revision of the Operational Plan, a memo containing a summary of the changes is distributed to the Operating Authority and the DWQMS General Awareness Training presentation is updated, as required.

No Action Items were identified as part of the Management Review Meetings.

p) Summary of Staff Suggestions

Employee suggestions are generated and recorded through different routes outside of the Management Review process:

- Brilliant Ideas – In 2021 Water Distribution launched an innovation initiative called “Brilliant Ideas” to encourage staff to submit and share ideas and innovations. Suggestions submitted in 2021 included investigating various technologies for valve and watermain inspection, creation of stations for valve maintenance and repair, and digital display of Water Distribution Operator certificates.
- During internal audit discussions, employee suggestions are captured in the audit findings by the Lead Auditor. These OFIs are then recorded as part of internal audit continual improvement action items and tracked by the QMS coordinator.
- Water production solicits ongoing feedback through weekly planning meetings, regular process-on-call meetings and continuous improvement meetings, as well as Water Production-led operator training sessions (OJT).

No Action Items were identified as part of the Management Review Meetings.

Summary of Management Review Action Items

The following action items were identified as part of the meetings completed during the 2021 Management Review discussions and will be tracked by the Quality Management Coordinator as part of the DWQMS Continual Improvement process:

Table 29 - 2021 Management Review Action Items

Item	Management Review Action Item	Target Date	Owner
g)	For Water Production costs, i) investigate possibility of separating water production costs for individual systems (i.e., central vs well systems), and if possible, then ii) report regularly as new KPI for Water Production (quarterly report) iii) add to the Management Review report item g) Water Production KPIs.	2022	OTM
k)	Ensure that the 2022 Risk Assessment exercise addresses the addition of “All systems – Cybersecurity threats” to the MECP Potential Hazardous Events list.	2022	Caroline Lamoureux, QMS Coordinator
n)	At next planned OTM meeting, discuss level of detail to review in item n) of Management Review, with regards to Water Production and Water Distribution projects, condition assessments, funding, etc. Refer to 2021 DWQMS Management Review Report, Table 30 for WD projects, vs lack of similar break down for WP.	2022	OTM