CASE STUDY: Process to Update the Region of Waterloo's Raw Water Intake Protocol during Grand River Watershed Upsets

CWWA, NWWC 2022
NOVEMBER 8, 2022

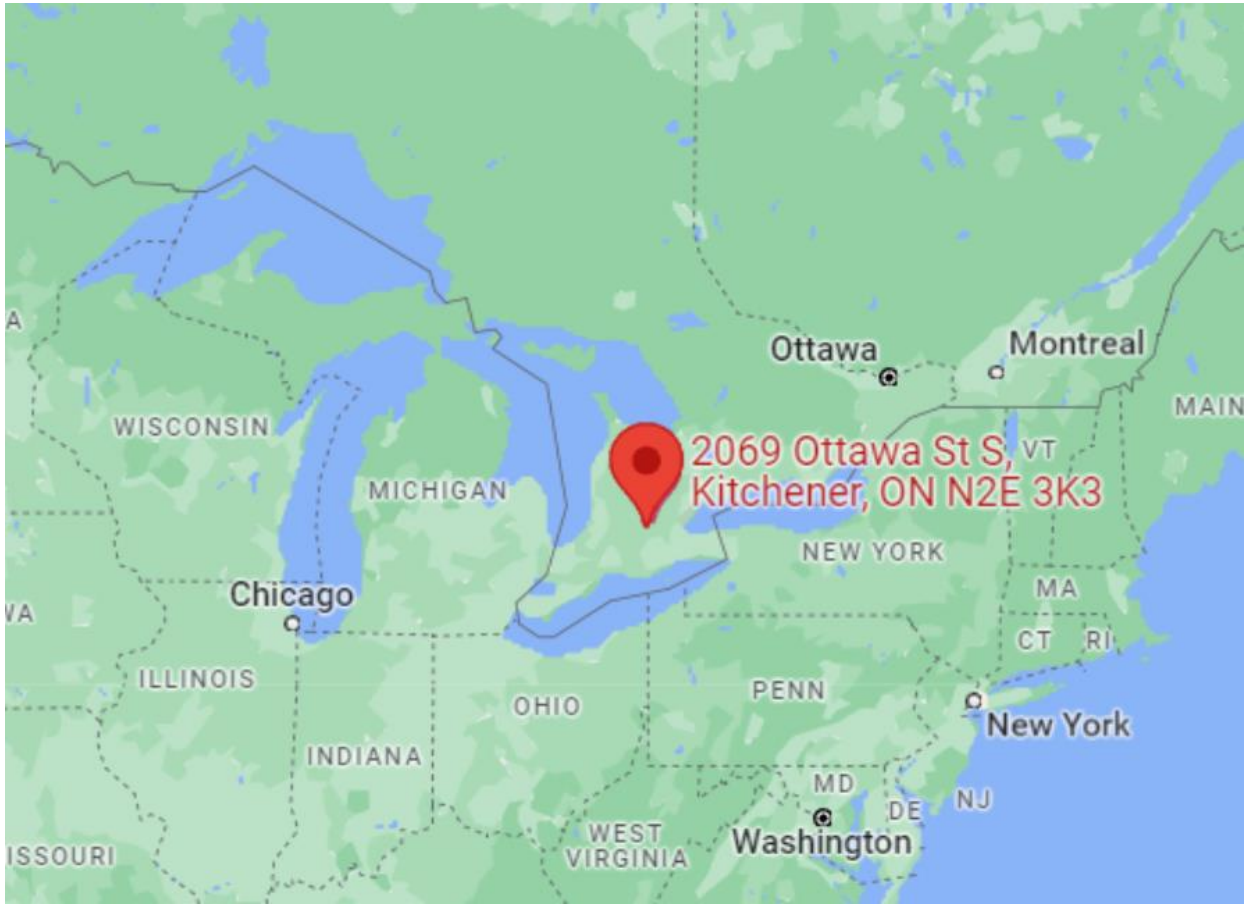
Region of Waterloo

C3 WATER

Agenda

- Mannheim WTP: A brief overview
- Protocol History
- Rational and Approach for Updating Protocol
- Operation and Updates of the Protocol
- Supporting tools and calculators developed for use
  - Time of travel calculator

Mannheim Water Supply



Mannheim Water Supply

- Master plan completed in the 1980's
- Recommendation to augment groundwater supply with surface water from the Grand River
  - Continued growth of the surface water supply via aquifer storage and recovery (ASR)
- Planned increase of plant capacity
- Grand River contributes 20 to 25% of supply

Mannheim Water Supply

Hidden Valley

- Intake weir and low lift pumping station
- Raw water reservoir
- High lift pumping station and transmission main

Mannheim Water Supply

Mannheim WTP

- Fully conventional plant with: High-rate sedimentation, ozonation, deep bed biologically active filtration, UV and chlorine disinfection

Protocol History

- April of ‘93 *Cryptosporidiosis* outbreak in Milwaukee identified
  - Confirmed to be linked to the surface water treatment plant.
    - 400,000 customers affected.
    - 69 deaths
    - Over $0.5 B spent to upgrade the WTP, ozone implemented
  - Long-lasting change to treatment objectives in the industry

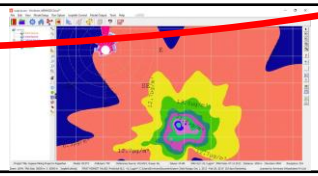
Protocol History

- Spring of ‘93 *Cryptosporidiosis* outbreak in the Region of Waterloo flagged by Medical Officer of Health
  - Very similar timing to Milwaukee
  - Suspected link to surface water sources
    - K70’s and K80’s, Winterbourne and Mannheim taken off-line as a precaution
  - Never positively linked to the surface water supply

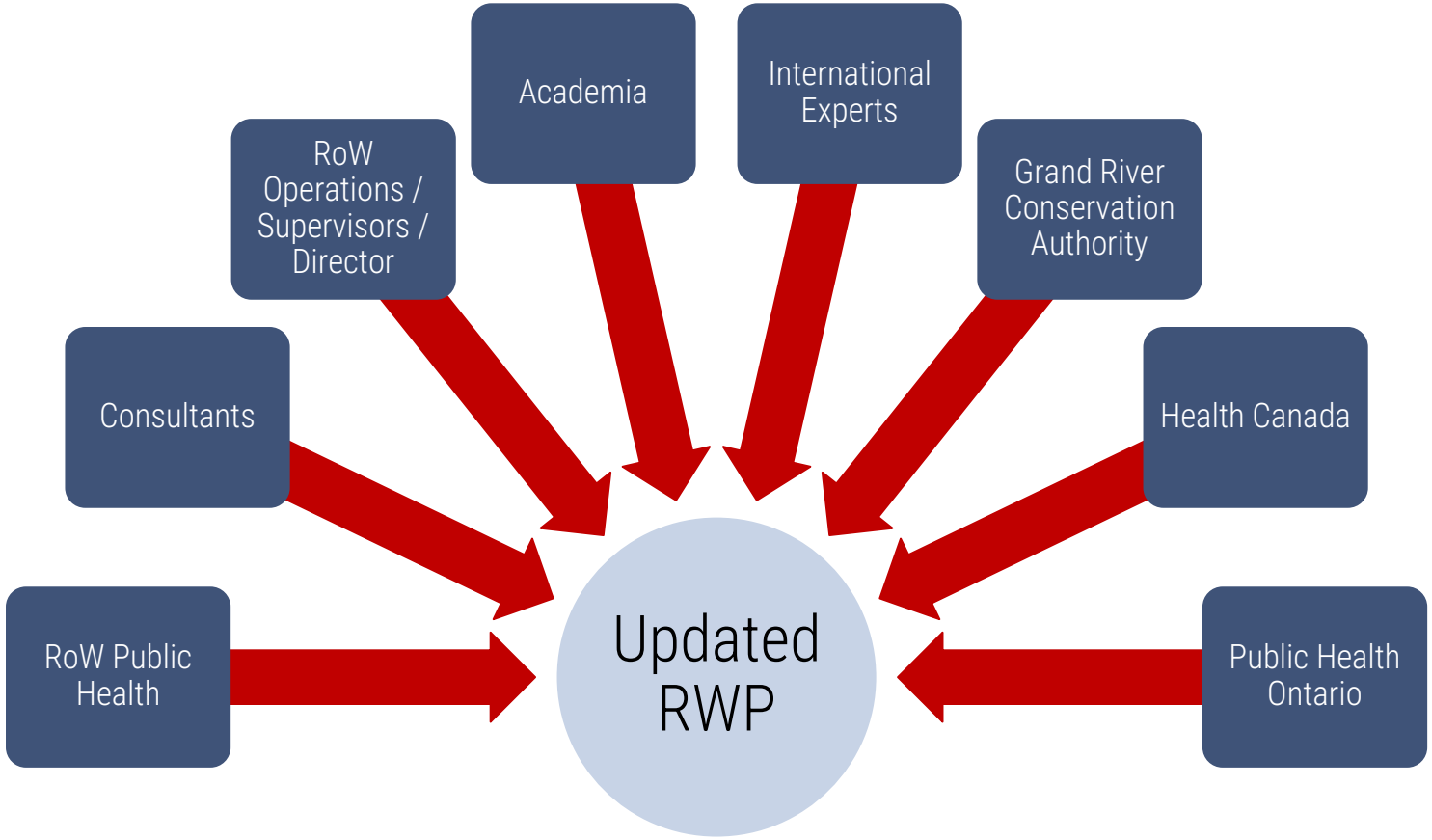
Protocol History

- Spring of ‘93 *Cryptosporidiosis* outbreak in the Region of Waterloo flagged by Medical Officer of Health
  - First SOP developed to bring these sources back on-line which evolved into the current SOP.
  - Very conservative approach taken to get the plant and other sources back on-line ASAP prior to peak water demand - many of these measures remained in place for close to 30 years
    - Close for all WWTP by-passes and spills
    - Shut-down at 25 NTU

Rational and Approach for Updating Protocol

Advances in treatment barriers: i.e. UV disinfection, Advanced oxidation treatment, enhanced filtration, etc.	
Source Water Protection Legislation	
Advancement of QMRA to assess health related risk to source water pathogens.	
Advancement of hydrologic modelling (estimating watershed time of travel and particulate dispersion)	
Advancement of monitoring technologies (early warning system)	

Rational and Approach for Updating Protocol



Rational and Approach for Updating Protocol

'The central purpose of this protocol review and updating exercise was to determine if more operational flexibility can be supported by the current understanding of the pertinent technology and science.'

Operation and Updates of the Protocol

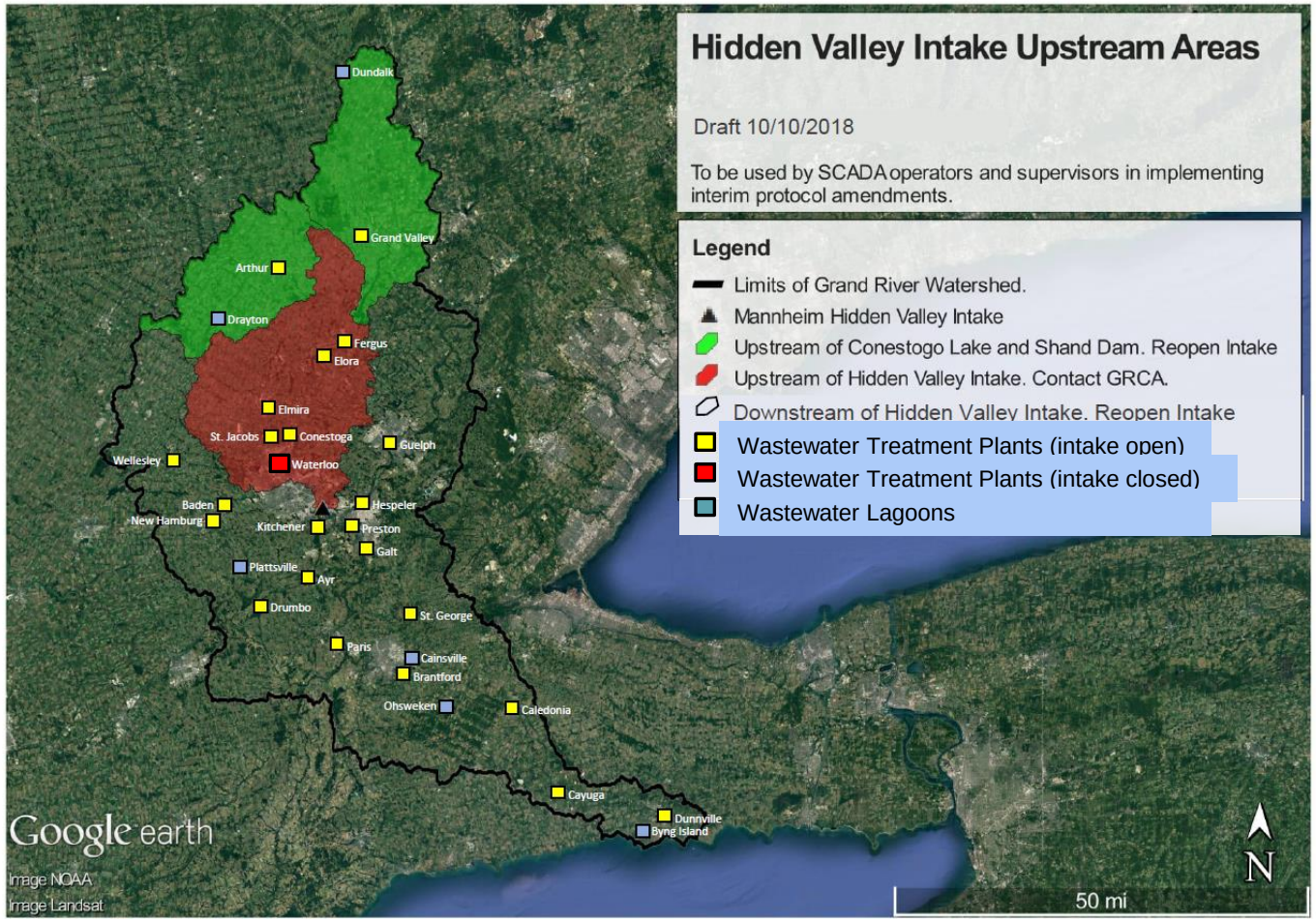
- Three scenarios to trigger use of the SOP
  - High turbidity
  - WWTP bypass
  - Chemical/biological spill
- Dictates shutting down of HV and WTP
  - Upstream OR downstream
  - Director’s approval require to re-open

Operation and Updates of the Protocol

SOP CHANGES – GOVERNANCE

- An annual review of the type and severity of spills resulting in intake shutdowns that have occurred over the year
  - If warranted by this review, a review team will be assembled to update the SOP.
- If a significant or unusual event occurs in the system, after following the SOP, a special review of the SOP will immediately follow.

Operation and Updates of the Protocol



Operation and Updates of the Protocol

SOP Changes – Significant Changes

- Decentralization of decision making where possible
- **Intake can remain open for all WWTP by-passes except Waterloo WWTP**
  - Justified using a QMRA assessment
- HVR minimum operating level adjusted upward
- **Time of travel calculator**
- CT disinfection calculator updated

QMRA Analysis in Support of Protocol Changes

Scenario	Coaggulation/ Flocculation / Sedimentation	Filtration (Rapid Granular)	Ozone Disinfection	UV Disinfection	Chlorine Disinfection
1	✓	✓			
2	✓	✓		✓	
3	✓	✓	✓	✓	

Process Sensitivity

Parameter	Minimum	Maximum
Initial Ozone Concentration	0.0 mg/L	5.0 mg/L
UV Disinfection	0.0 mJ/cm^2	22 mJ/cm^{2*}
Water Temperature	0.5°C	30 °C
Blending With GW	18.9%	70.1%
Population	79,514	294,918

* UVDGM 4-log Cryptosporidium inactivation

Process and population ranges

QMRA Analysis in Support of Protocol Changes

Treatment Barrier	Scenario 1 (Winter& Summer)	Scenario 2 (Winter & Summer)	Scenario 3 (Winter)	Scenario 3 (Summer)
Coagulation, Flocculation & Sedimentation	1.86	1.86	1.86	1.86
Filtration – Rapid Granular (coagulation/sedimentation)	2.41	2.41	2.41	2.41
Primary Disinfection 1 – Ozone	0.00	0.00	1.01	1.83
UV Disinfection	0.00	4	4	4
Overall Log Reduction	4.27	8.27	9.28	10.10

Unit Process and
Total Performance

Scenario	*Cryptosporidium* Oocysts per 100L
Scenario 1 (Winter & Summer)	40
Scenario 2 (Winter & Summer)	1.0×10^6
Scenario 3 (Winter)	9.0×10^7
Scenario 3 (Summer)	$>9.0 \times 10^7$

Maximum oocyst concentration in raw water that plant can handle while meeting Health Canada DALY.

QMRA Analysis in Support of Protocol Changes

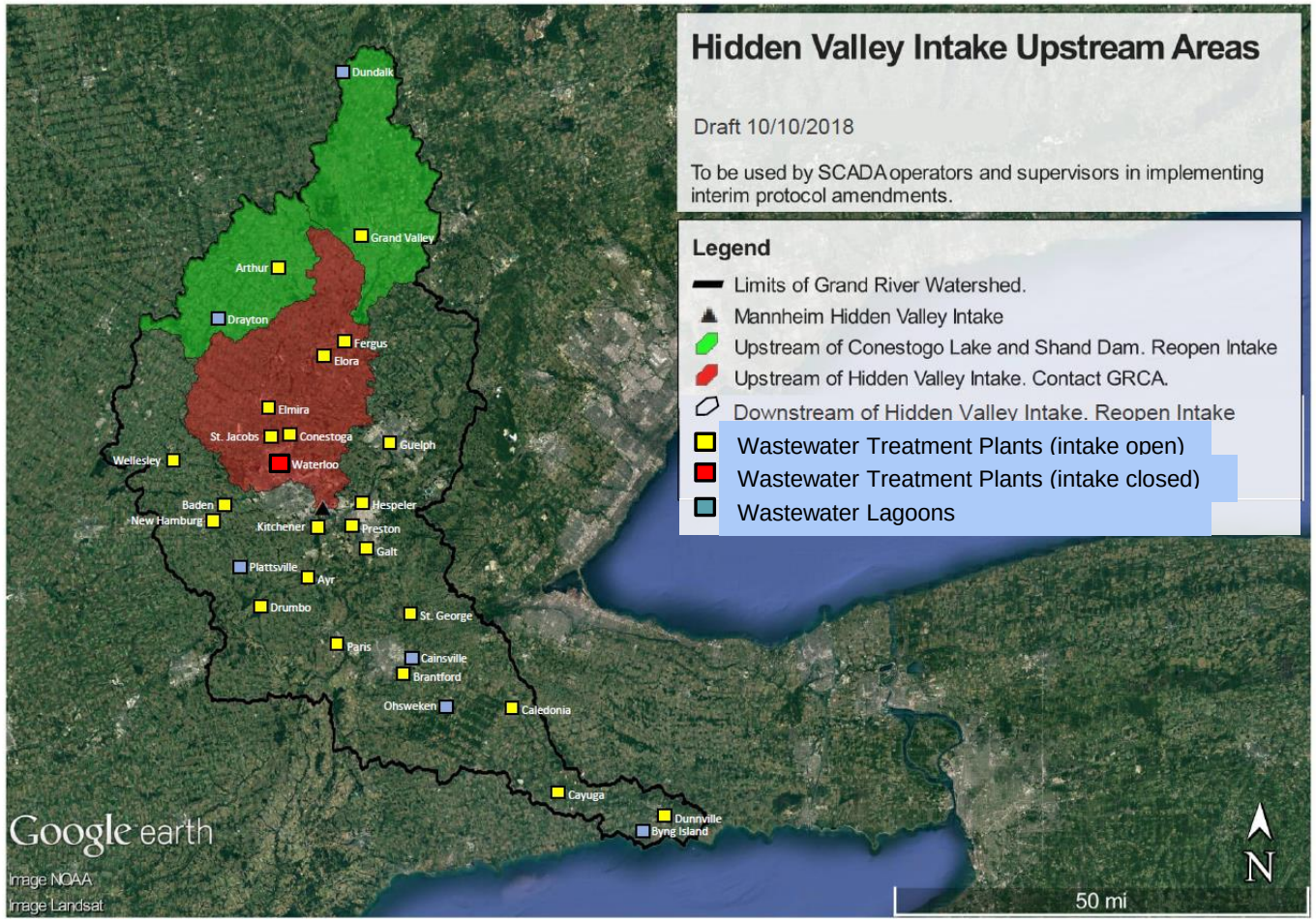
In 6 major studies from 2002 to 2014, hundreds of samples, the worst-case *Cryptosporidium* concentration recorded – **900** oocysts per 100L.

Worst case oocyst concentration measured in literature in raw sewage, assume by-pass and summer (most conservative) dilution rates – 700 oocysts/100L at Elmira, 1150 oocysts/100L Waterloo

Waterloo WWTP excluded

- Close proximity with potentially very low dilution factor at Waterloo WWTP (19%)

Operation and Updates of the Protocol



Supporting Tools

TIME OF TRAVEL CALCULATOR

Why needed?

- Chemical/biological spill
  - Environmental Enforcement and Laboratory Services (EELS) takes the call and notifies water services
  - Water services calls GRCA for river ToT
  - Assess location of leading edge of plume – US or DS of intake at time of closing of intake
    - If DS, use ToT Tool to determine location of plume in the Mannheim Water Suppy system

Supporting Tools

TIME OF TRAVEL CALCULATOR

- Includes Hidden Valley system and Mannheim WTP
- Estimates travel time from the Grand River to the Mannheim WTP clearwell
- Calculations are conservative
  - using T_{10} contact time concept
  - Maximum flow through one side of plant is entered
- Data validation included

Automated Calculator for ToT to Elements of the Hidden Valley System

USER INPUT
CALCULATED VALUE

Enter Flow through the Hidden Valley High-Lift in L/s
Q = 500 L/s

Enter HV Reservoirs Cells 1 - 4 On/Off Status and Levels in %

Cell 1 =	☑ Online/Offline	90	%
Cell 2 =	☑ Online/Offline	90	%
Cell 3 =	☑ Online/Offline	90	%
Cell 4 =	☑ Online/Offline	90	%

Cells past the water draw point are not included in the travel time calculation, and will be greyed out.

HV Reservoir Cells 1 - 4 Baffling Factor (T10/T Ratio) determined by which cell is used to draw water.

Cell 1 =	○ Water Draw	0.3	BF
Cell 2 =	○ Water Draw	0.3	BF
Cell 3 =	○ Water Draw	0.3	BF
Cell 4 =	◉ Water Draw	0.1	BF

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Automated Calculator for ToT to Processes of the Mannheim WTP

Enter maximum single-train flow:
Q= 400 L/s

Assumptions for Mannheim WTP ToT:

1. Plant operating at 100% water level (not overflow)
2. Texbook porosity value of 0.5 for GAC filters (Table 8-1, Water Quality and Treatment, AWWA, 4th Ed.)

Calculated ToT to Reach HV System Element:

Reservoir Cell 1	=	0 hrs	28 mins
Reservoir Cell 2	=	5 hrs	47 mins
Reservoir Cell 3	=	11 hrs	7 mins
Reservoir Cell 4	=	16 hrs	27 mins
Raw Water Main	=	18 hrs	14 mins
Raw Water Storage	=	24 hrs	26 mins

Calculated ToT to WTP System Processes:

Cumulative Time:

Flocculators (first in series)	=	14 mins	24 hrs	40 mins
Flocculators (second in series)	=	16 mins	24 hrs	42 mins
Plate Settlers	=	17 mins	24 hrs	44 mins
Settler Trough	=	20 mins	24 hrs	46 mins
Ozone Contactors	=	20 mins	24 hrs	46 mins
Filters	=	23 mins	24 hrs	49 mins
Treated Water Cell (Clearwell)	=	32 mins	24 hrs	58 mins

In Summary:

- Incorporated latest understanding of science and technology
  - Ex. QMRA analysis for leaving intake open
- Decentralization of decision-making process
- Reduce downtime of the WTP
- Tools to supplement decision-making process

Region of Waterloo	**WATER SERVICES STANDARD OPERATING PROCEDURE (SOP)**	SOP#	3597727
		Revision Date	NOVEMBER 16, 2021
		Approved by	WATER SERVICES
		Section	O&M
PROTOCOL FOR OPERATING THE HIDDEN VALLEY LOWLIFT INTAKE DURING GRANDRIVER WATERSHED UPSETS			

Thank You!

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