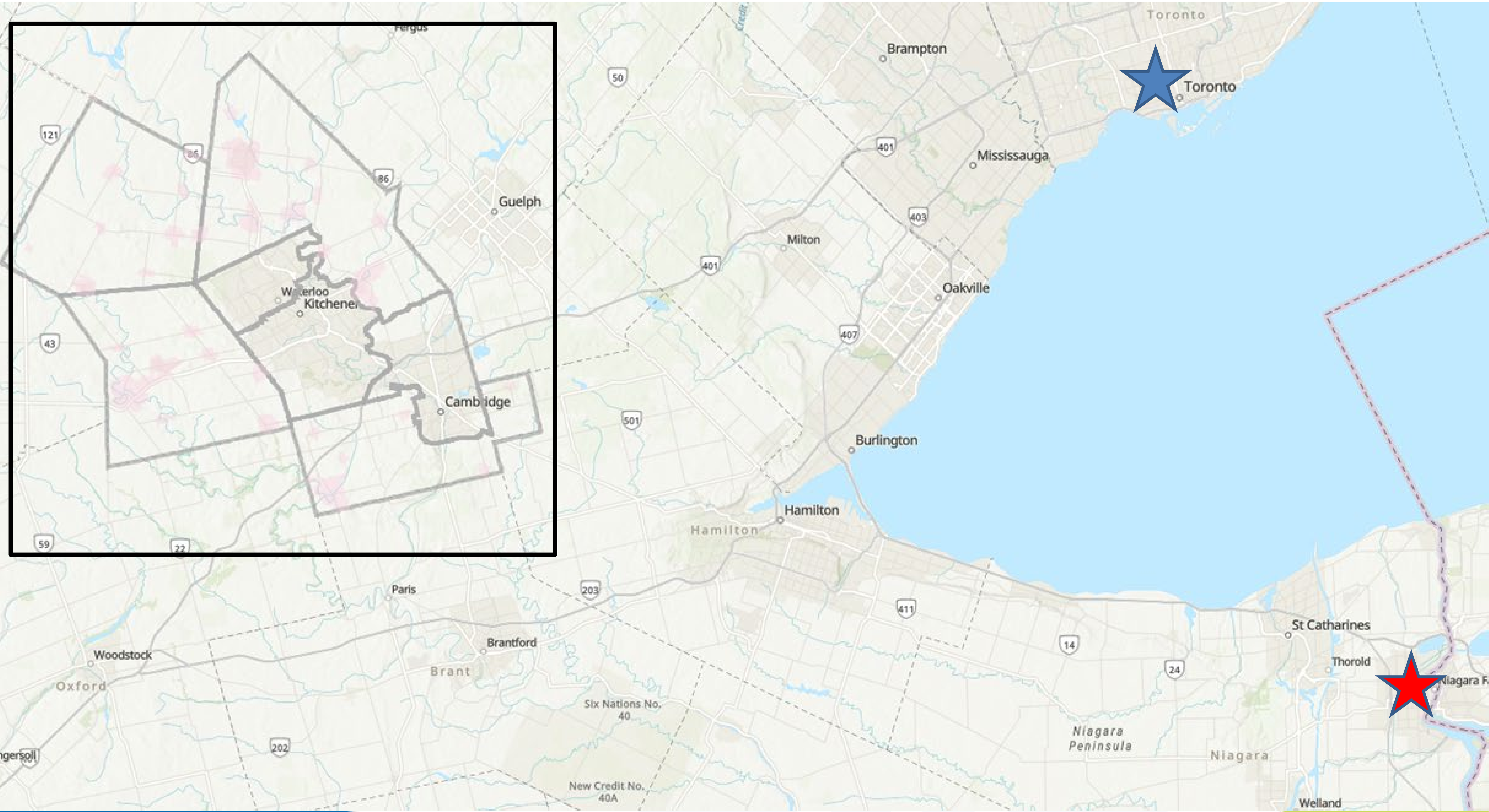
Mannheim WTP Optimization and Facility Plan

Region of Waterloo

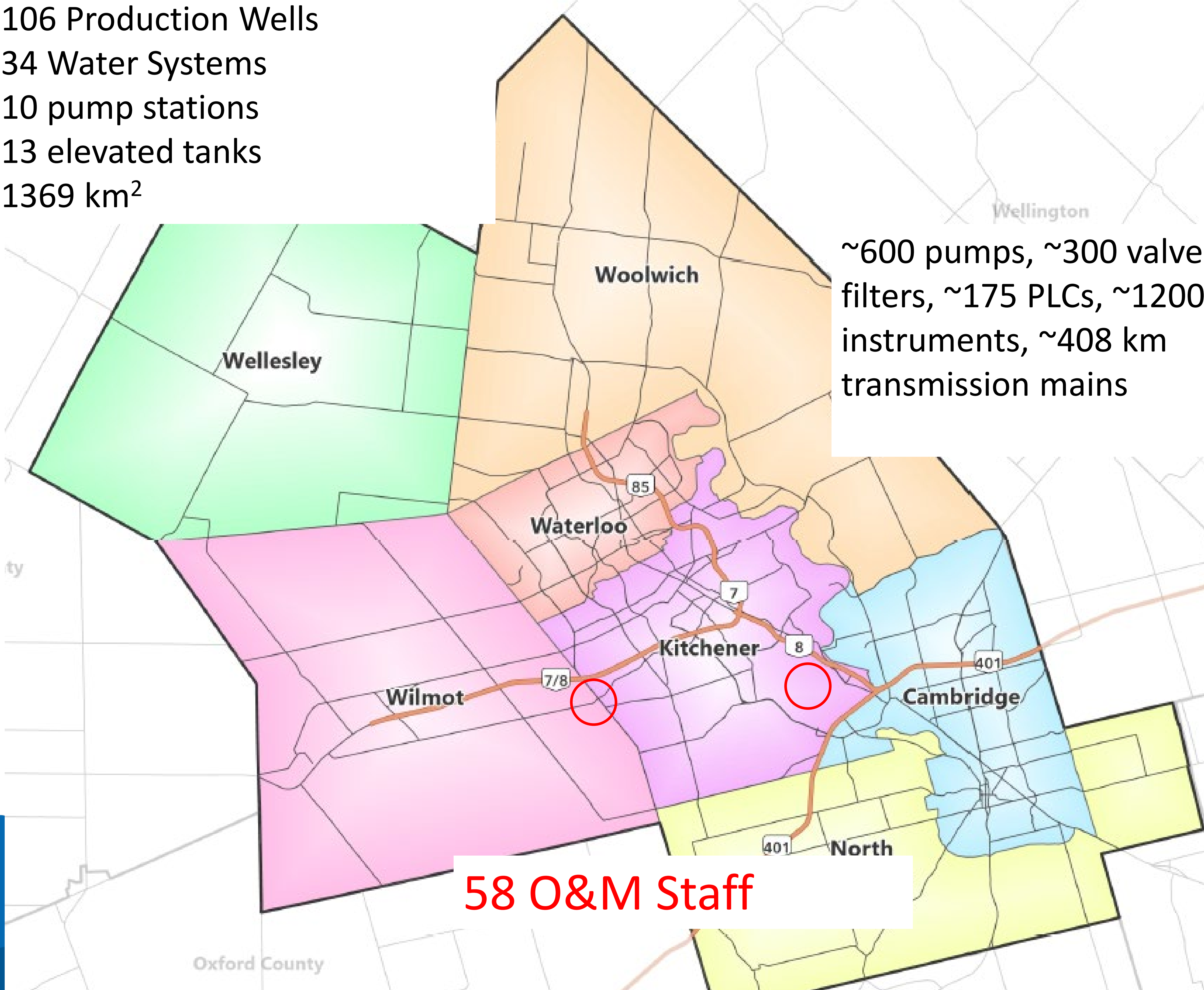
Ayman Khedr, P.Eng



Fergus
Guelph
Waterloo
Kitchener
Cambridge
Toronto
Brampton
Mississauga
Milton
Oakville
Burlington
Hamilton
Paris
Brantford
Brant
Woodstock
Oxford
Six Nations No. 40
New Credit No. 40A
St Catharines
Thorold
Niagara Peninsula
Niagara
Welland

106 Production Wells
34 Water Systems
10 pump stations
13 elevated tanks
1369 km^2

~600 pumps, ~300 valves, ~50 filters, ~175 PLCs, ~1200 instruments, ~408 km transmission mains



58 O&M Staff

Mannheim Water Treatment Plant

- Commissioned in 1992; asset renewals
- Max **design** flow of 840 L/s; maximum operational flow is ~600 to 650 L/s
- 20 – 35 % of Region Water demand

Source: Google Maps

Project Overview

Why are we doing it?

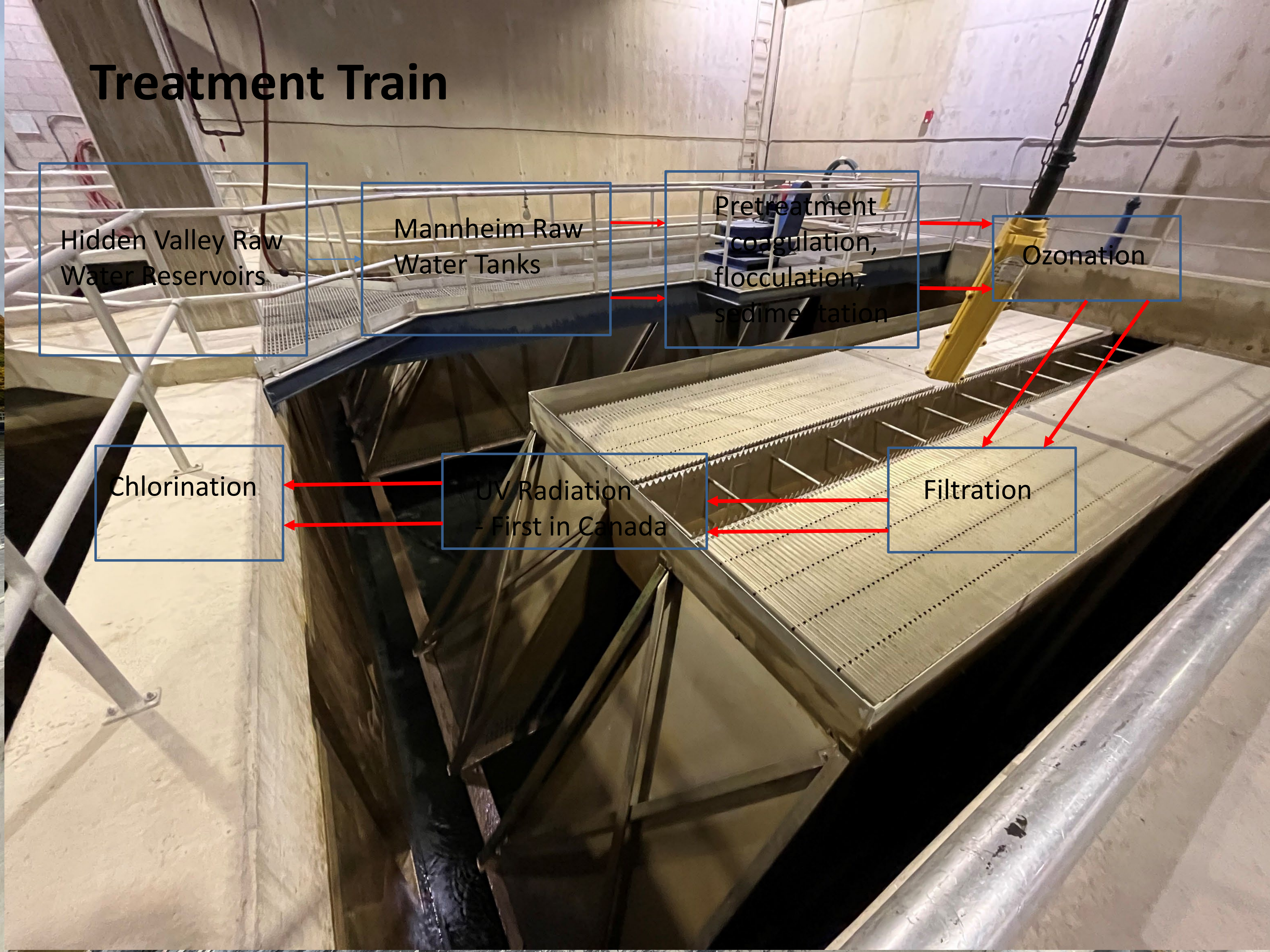
Water Services – One of the fastest growing regions in Canada; we need to maximize our supply resources

O&M – Mannheim is the most operationally intensive plant in the Region

Asset Renewals – Aging infrastructure

Holistic Approach to evaluating the Treatment plant performance

Treatment Train



Key Information

- Treatment process is robust
- Fully redundant – flow is split equally between two identical trains
- Treatment is flow paced; flow is controlled through butterfly valves
- Aging infrastructure
- pH control was implemented (H2S04) – but discontinued

PROJECT SUMMARY

Project Goals

- Complete a comprehensive Performance Evaluation to identify bottlenecks
- Develop Quantitative and Qualitative key performance indicators (KPIs)
- Baseline current performance to track potential improvements over time
- Identify process upgrades and operational improvements prioritized based on impact to KPIs
    - Opportunities for automation
    - Short term / low capital upgrades projects
    - Long term / major capital projects
- Create a 10 year facility plan to implement aforementioned projects
- **GAIN OPERATOR BUY-IN****

KEY FINDINGS

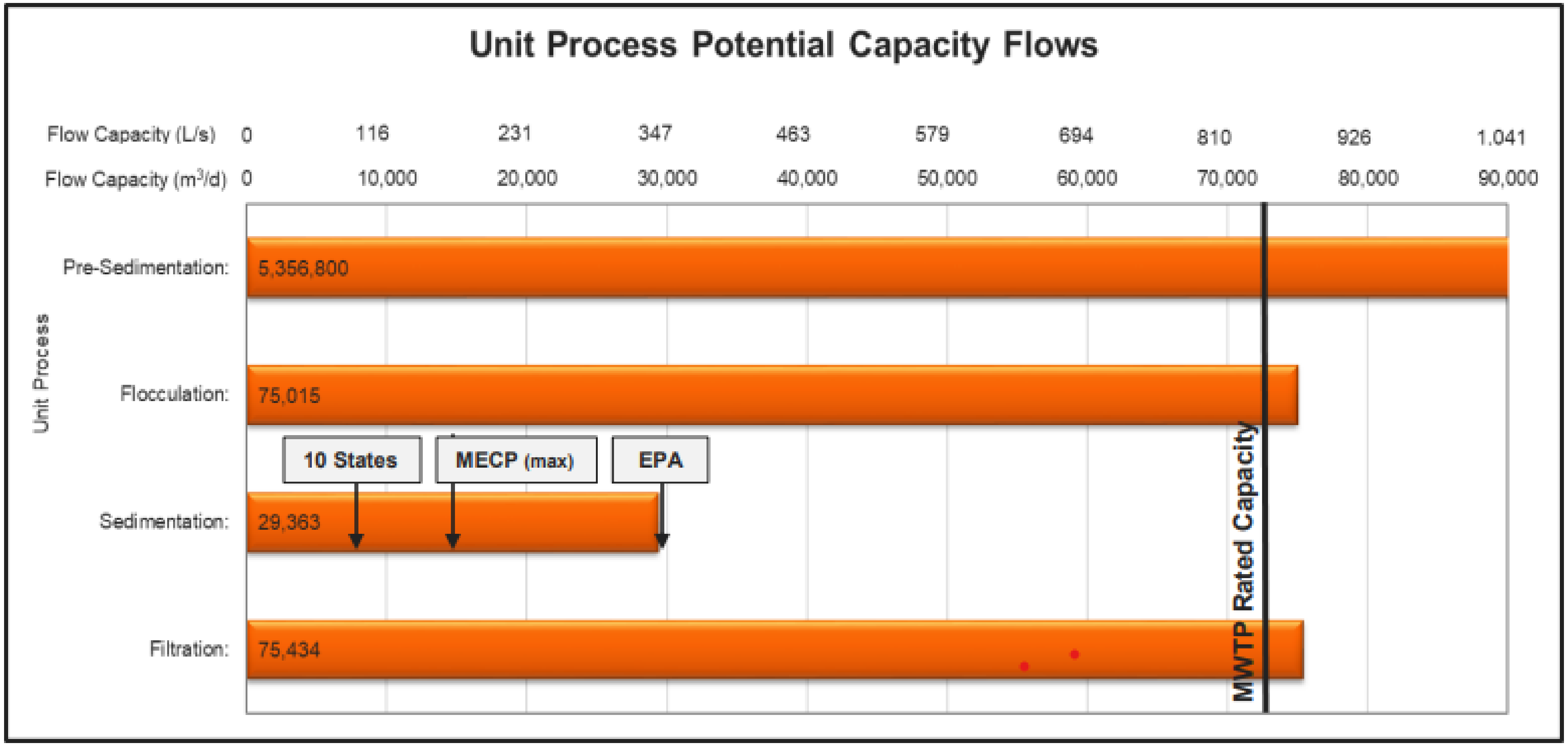
Bottlenecks/ Opportunities

1. Sedimentation basins are significantly undersized
2. Blender flow control is critical for Mannheim Operations
3. Reviewing potential for pH control (peak shaving)

1. Sedimentation Basin Sizing

Sedimentation Basins Undersized

Sedimentation is a key performance limiting factor for Mannheim WTP.

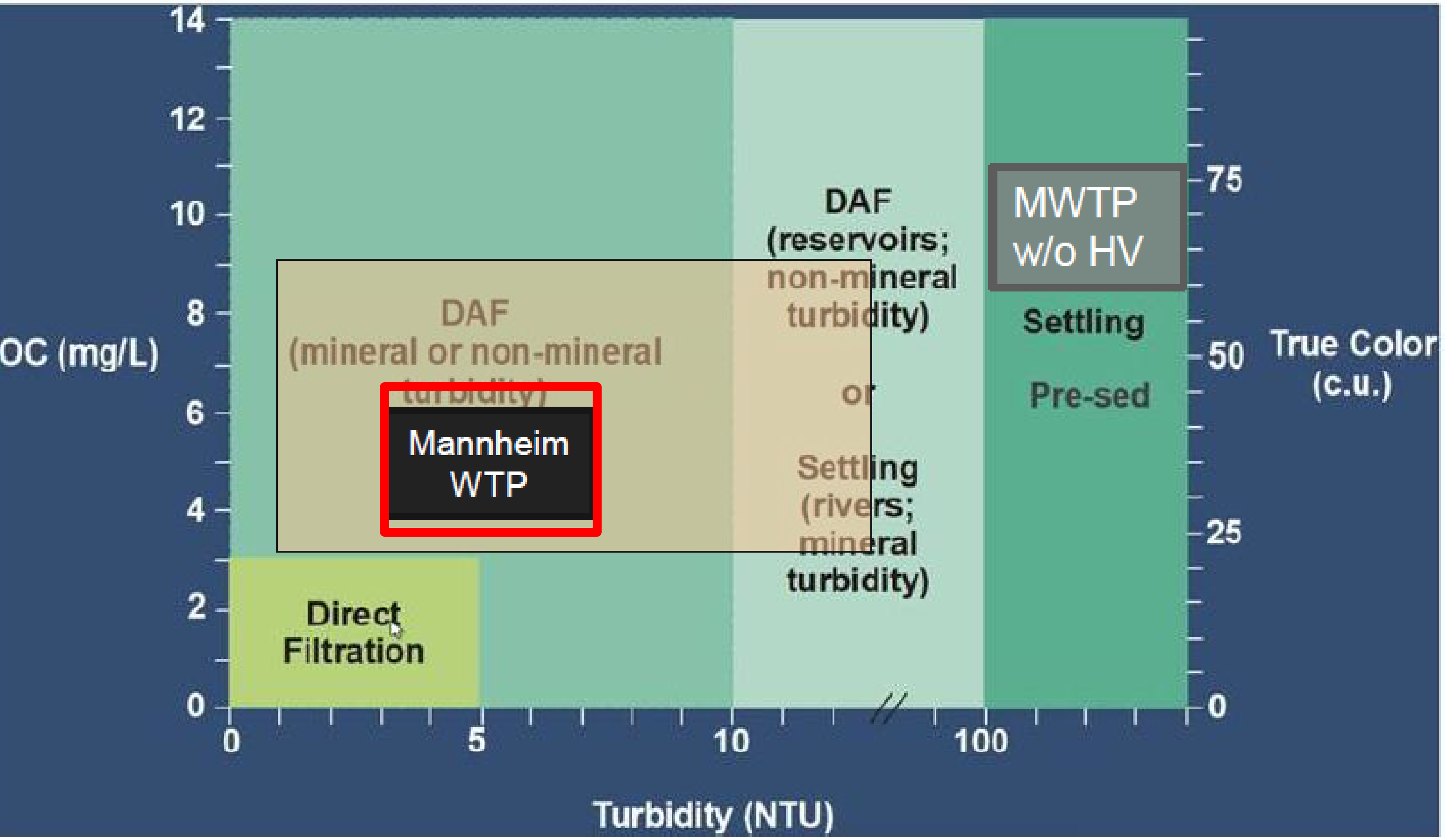


RECOMMENDED PLATE SETTLER SOR VALUES

Source	SOR (m/h)	Capacity (m³/d)	Capacity (L/s)	Notes
10-State Standards	2.4	7,206	86	
MECP	2.5 - 5.0	15,012	180	(5 applied)
EPA	9.78	29,363	352	




Pre-Treatment



- **Black box:** Average; Orange box: Range
- **Grey box:** MWTP without Hidden Valley

- DAF is recommended for relatively high quality waters with average river turbidity <10NTU, or <100NTU from settled reservoirs
- No upper limit of TOC or colour for DAF processes
- Ballasted flocculation is recommended for water with highly variable water quality and maximum non-mineral turbidity >200NTU

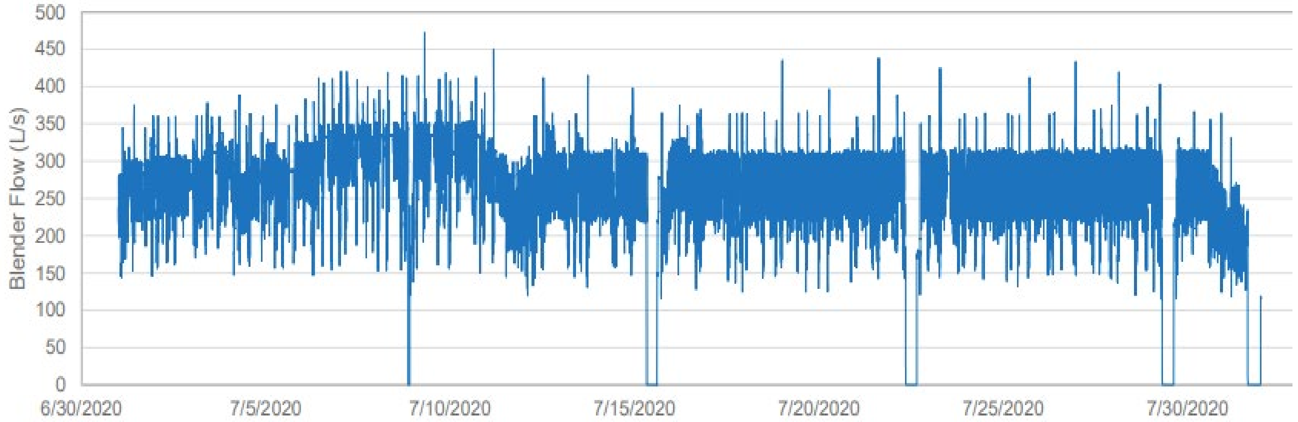
Valade, M. T., W. C. Becker, and J. K. Edzwald. "Treatment selection guidelines for particle and NOM removal." *Journal of Water Supply: Research and Technology—AQUA* 58.6 (2009): 424-432.

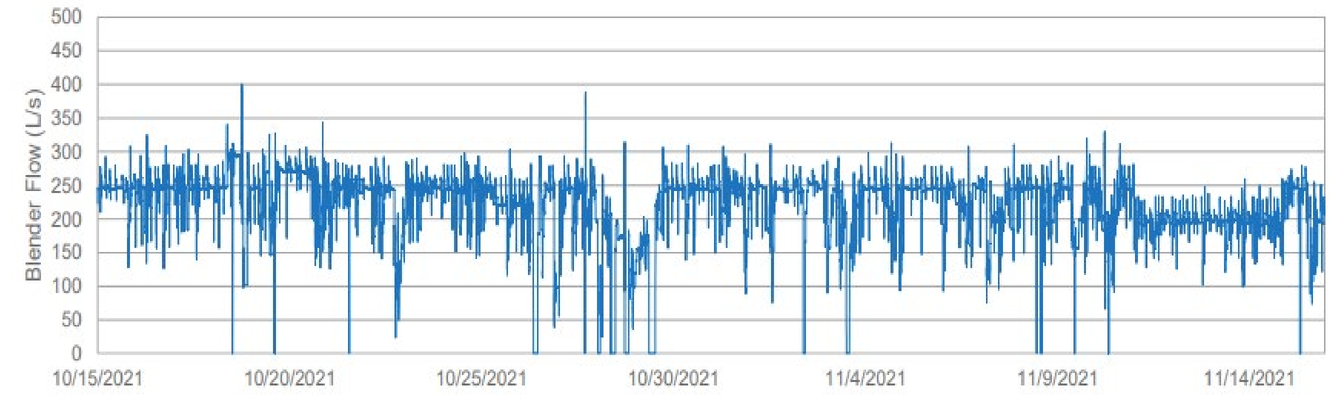
Site Visits

Parameter	Typical Range			
	Mannheim	Belleville	Brantford	Union
Temp (C)	0.5 to 25	0.5 to 32	3 to 29	4 to 24
Turbidity (NTU)	5 to 15	4 to 25	2 to 200	1 to 117
pH	7.8 to 8.5	7.4 to 8.8	7.4 to 8.5	7.25 to 8.23
DOC (mg/L)	5 to 7	4 to 7	4 to 6	2
Alkalinity (mg/L)	160 to 230	90 to 150	164 to 256	94
Hardness (mg/L)	210 to 315	115 to 145	293 to 411	106
Pre-treatment	Plate Settlers	**DAF**	**Ballasted Flocculation and pH control**	**DAF and pH control**

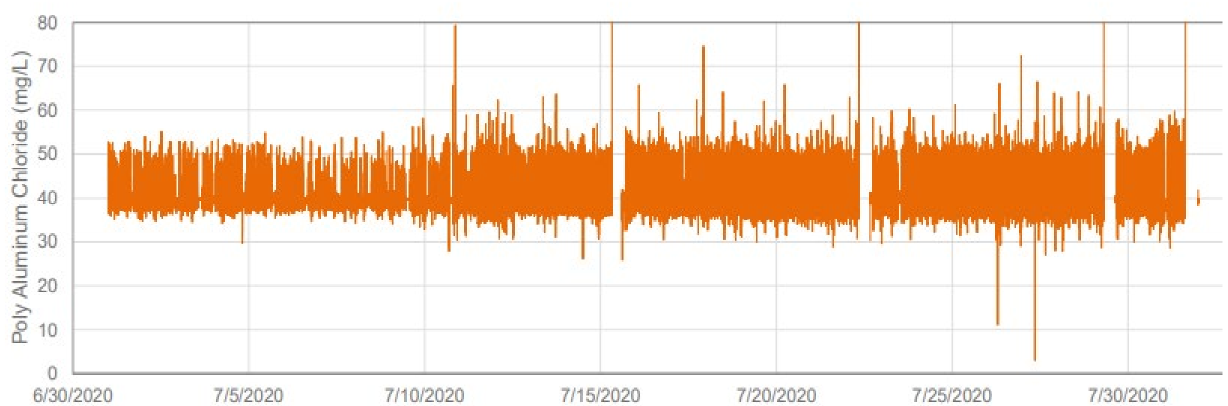
2.0 Blender Flow Control

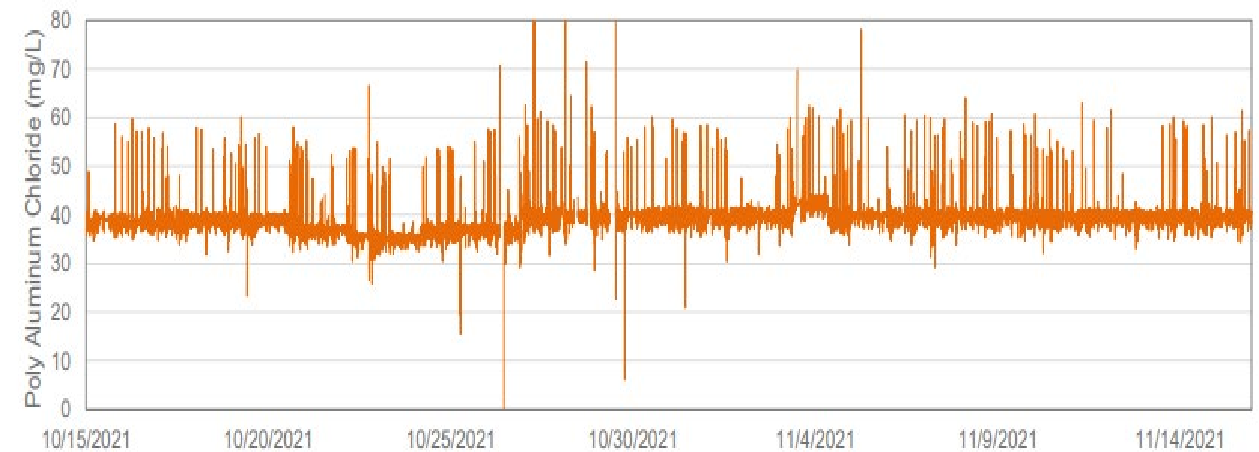
Blender #1 Flow – 31-Day Trend



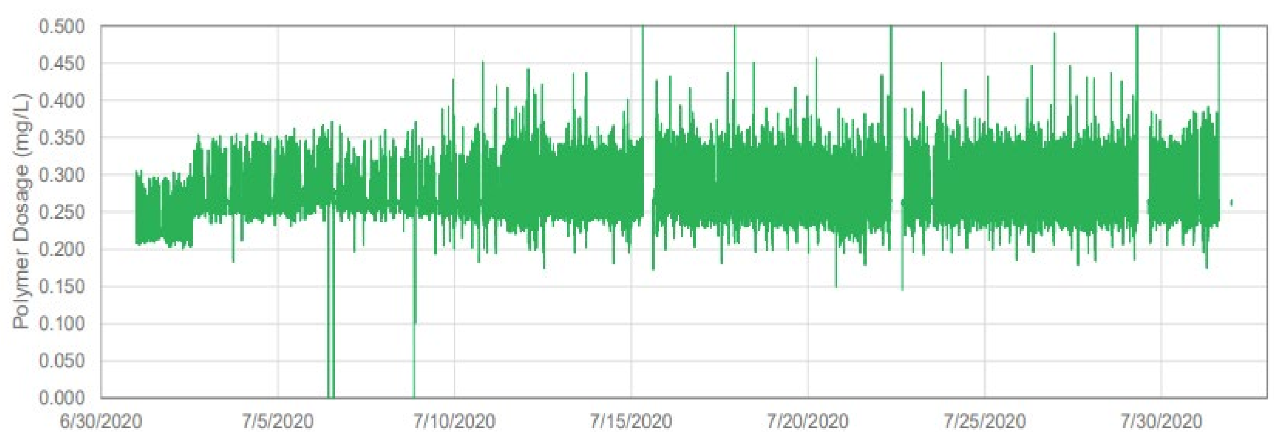


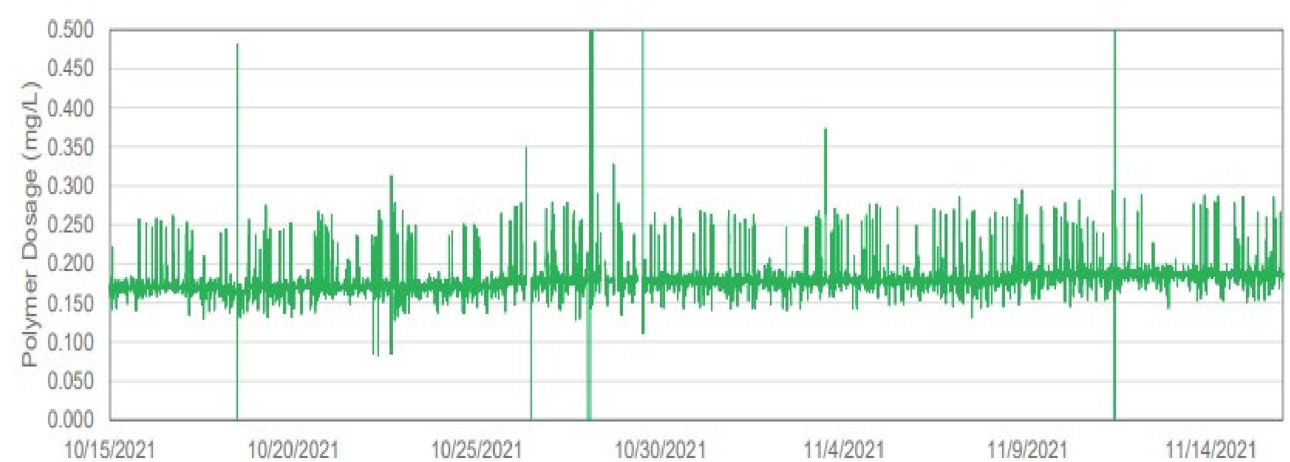
Side 1 Coagulant Dose – 31-day Trend





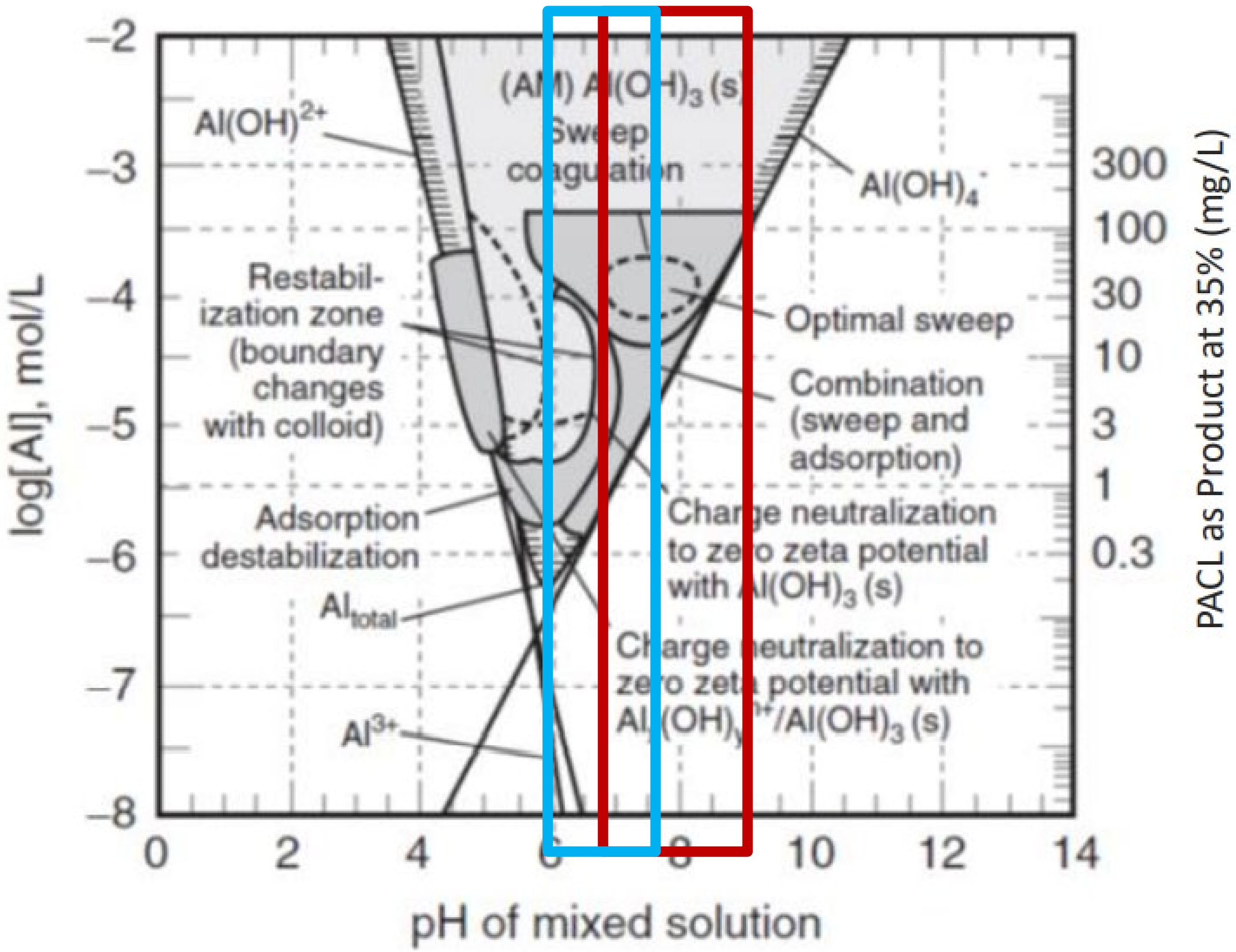
Side 1 Polymer Dose – 31-day Trend



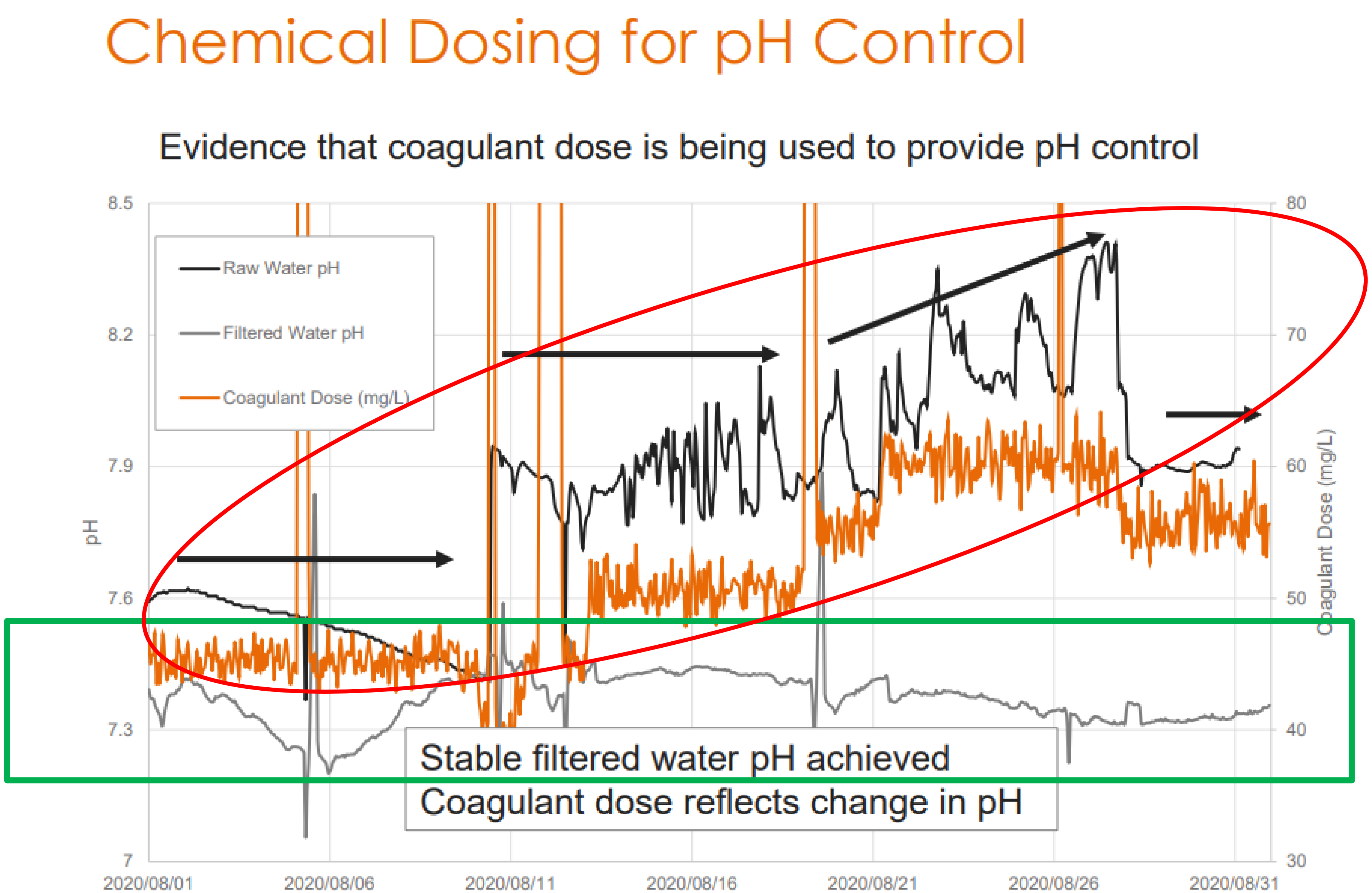


3.0 pH control

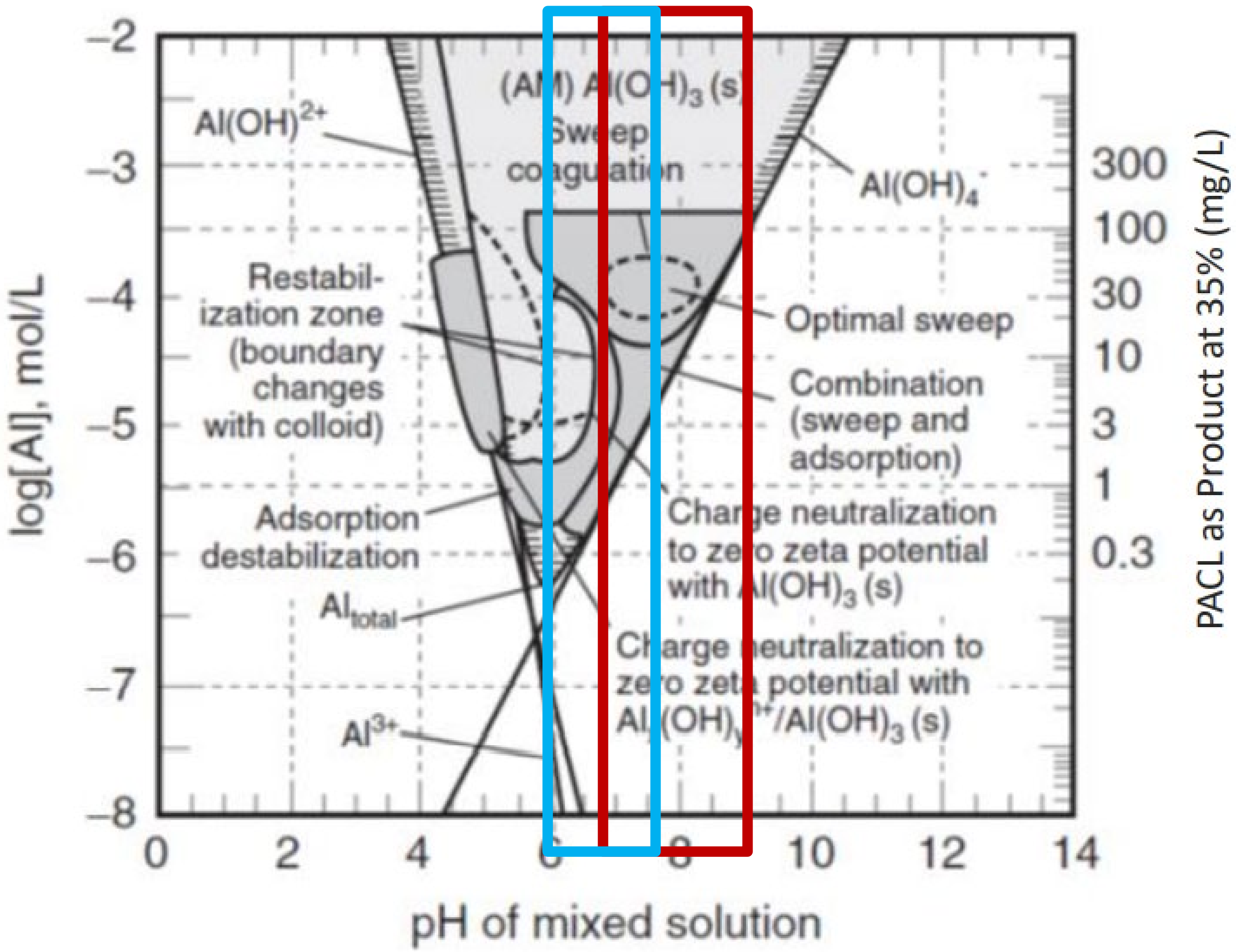
Coagulation is pH Dependent



Inherent pH control



ph Shaving

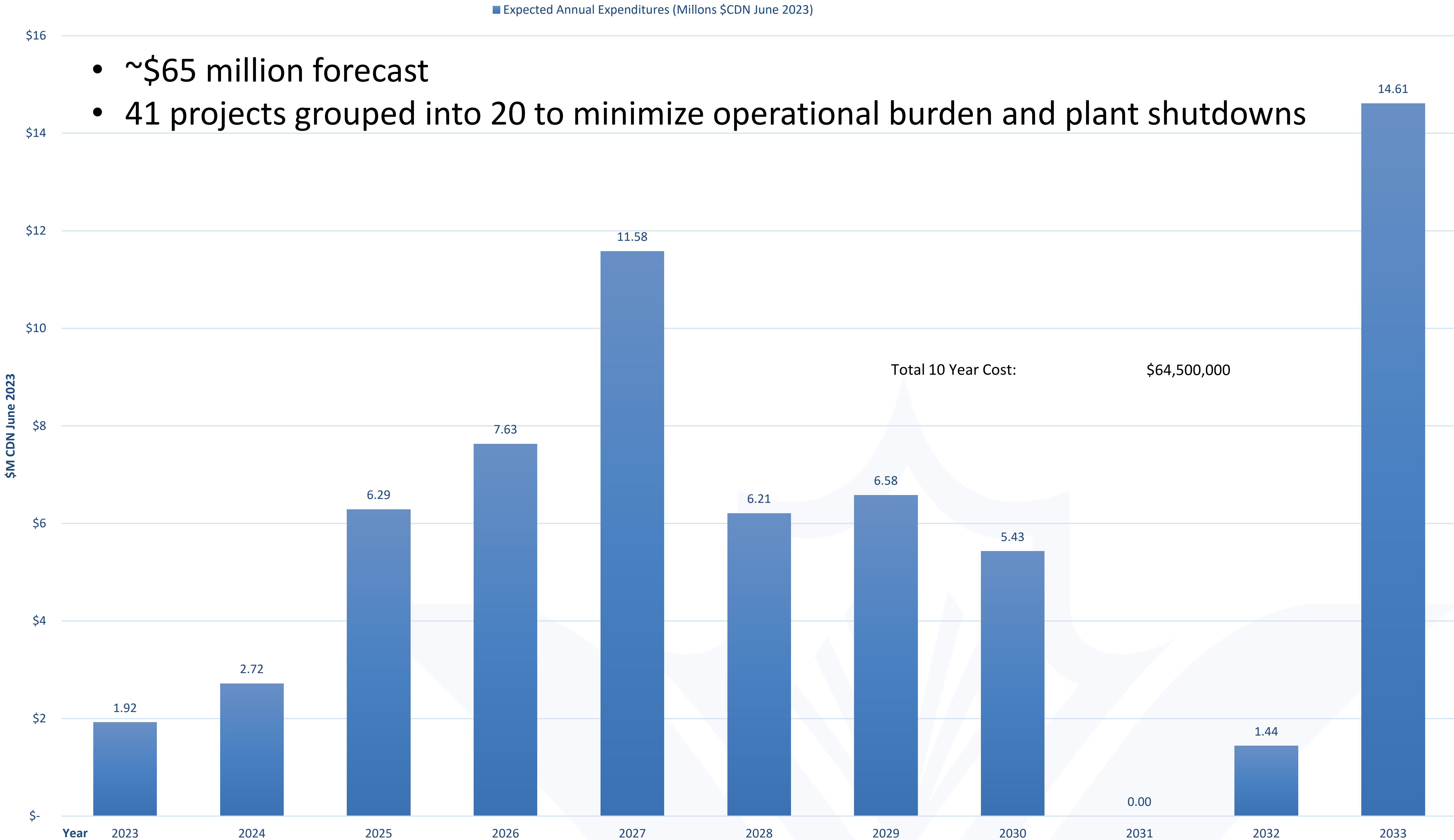


(AM) Al(OH)$_3$ (s)
Sweep coagulation
Al(OH)$^{2+}$
Al(OH)$_4^-$
Restabil-ization zone (boundary changes with colloid)
Optimal sweep
Combination (sweep and adsorption)
Adsorption destabilization
Charge neutralization to zero zeta potential with Al(OH)$_3$ (s)
Al$_{total}$
Charge neutralization to zero zeta potential with Al$_x$(OH)$_y^{n+}$/Al(OH)$_3$ (s)
Al^{3+}
log[Al], mol/L
−2
−3
−4
−5
−6
−7
−8
0
2
4
6
8
10
12
14
pH of mixed solution
300
100
30
10
3
1
0.3
PACL as Product at 35% (mg/L)

NEXT STEPS & LESSONS LEARNED

C2021-10 Mannheim 10-Year Facility Spending Plan

- ~$65 million forecast
- 41 projects grouped into 20 to minimize operational burden and plant shutdowns



Lessons Learned

- Permitted/design flows may not accurately represent plant capacity
- Change is hard!
- Operator input is essential through out the process;
  - Site Visits
  - Workshops
  - Demonstration Study

Thank you!

- Nicole McLellan – Stantec
- Dennis Mutti – C3 Water
- Perry Decola – Belleville
- Duane Ayres – Brantford
- Rodney Bouchard – Union WTP

A common thread through surface water WTPs in Ontario…

- **Typical design loading rates** for horizontal flow sedimentation basins do not account for **cold water conditions** where this process is **less efficient**

- May be overlooked as settled water turbidity is not a regulated parameter

Sedimentation Capacity Loading Rates

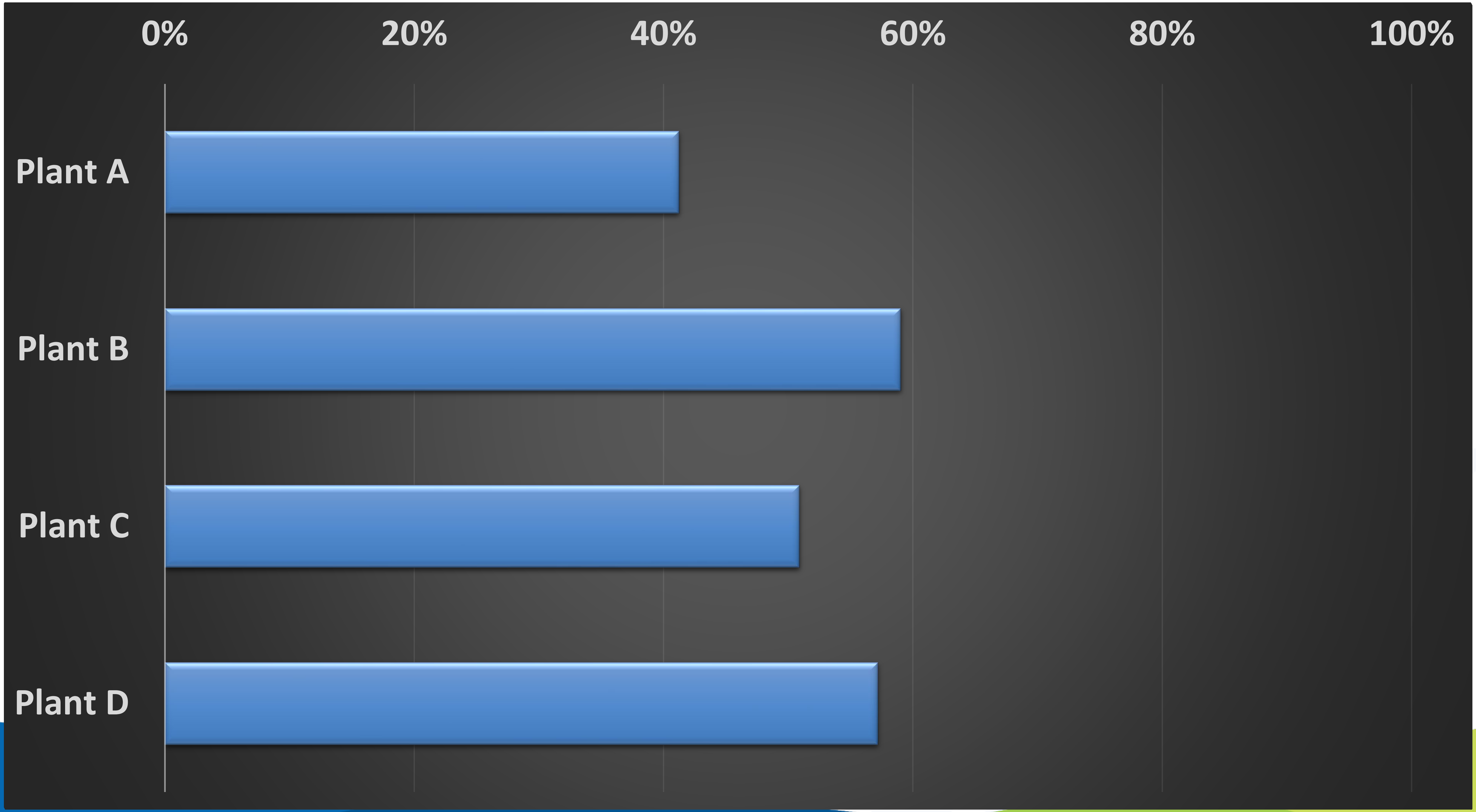
Loading Rates (m/h)	Plant A Lamella Plates [1]	Plant B Lamella Plates [1]	Plant C Horizontal Flow	Plant D Horizontal Flow
Ontario Design Guideline [2]	2.5 to 5.0	2.5 to 5.0	<1.0 to 2.4	<1.0 to 2.4
At Rated Capacity	**9.9**	**14.5**	**1.96**	**3.77**
At Peak Flow	**7.7**	**8.9**	**1.38**	**1.75**
At Average Day Demand	**4.6**	**5.4**	**0.96**	**0.86**

[1] based on gross basin area

[2] lower range recommended when operating <10 degrees C

Red text: exceeds recommended range in warm water conditions

Sedimentation Capacity Shortfalls



Key Takeaways & Next Steps

- Optimal sedimentation loading rates particularly in **cold-water conditions** may be lower than typical design guideline values

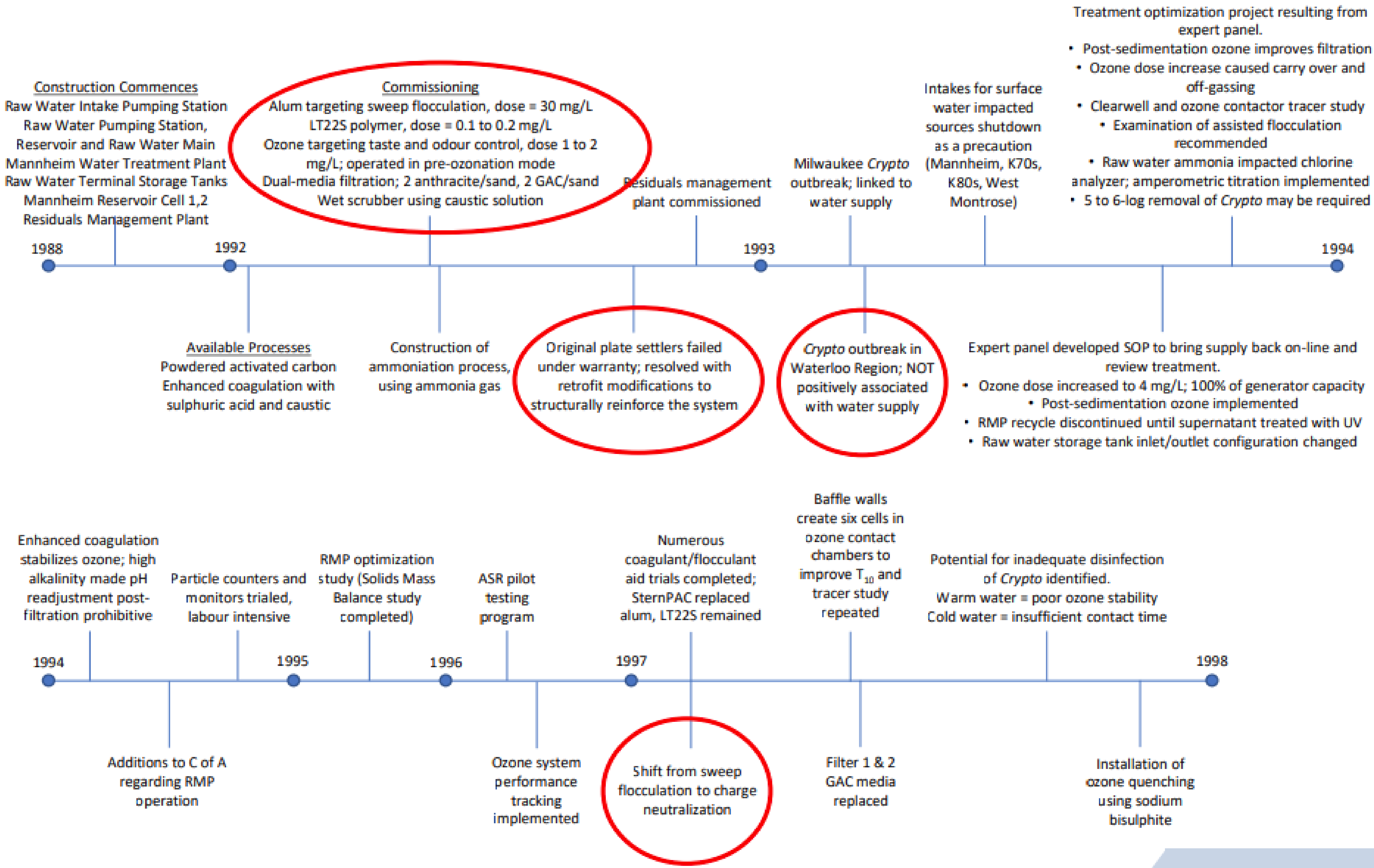
- **Full-scale stress testing** can help confirm existing capacity bottle-necks (which may differ from desktop estimates)

- Identifying preferred solutions to address capacity shortfalls should involve a **multi-objective decision analysis (MODA)** to incorporate the interests of a range of stakeholders and municipal priorities in addition to technical considerations and cost
  - Labour burden
  - Implementation & Permitting
  - Piloting Needs

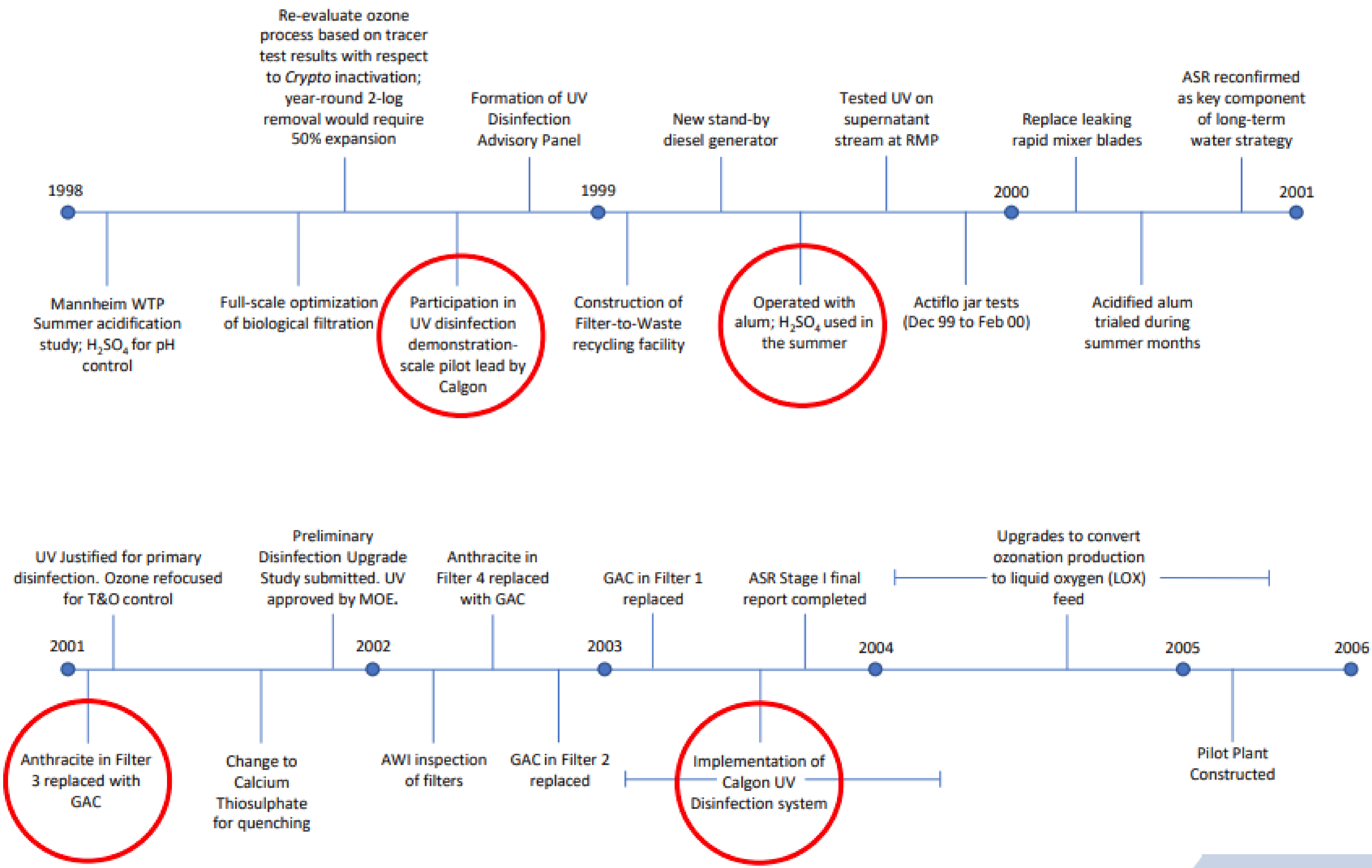
PLANT OVERVIEW

Plant History

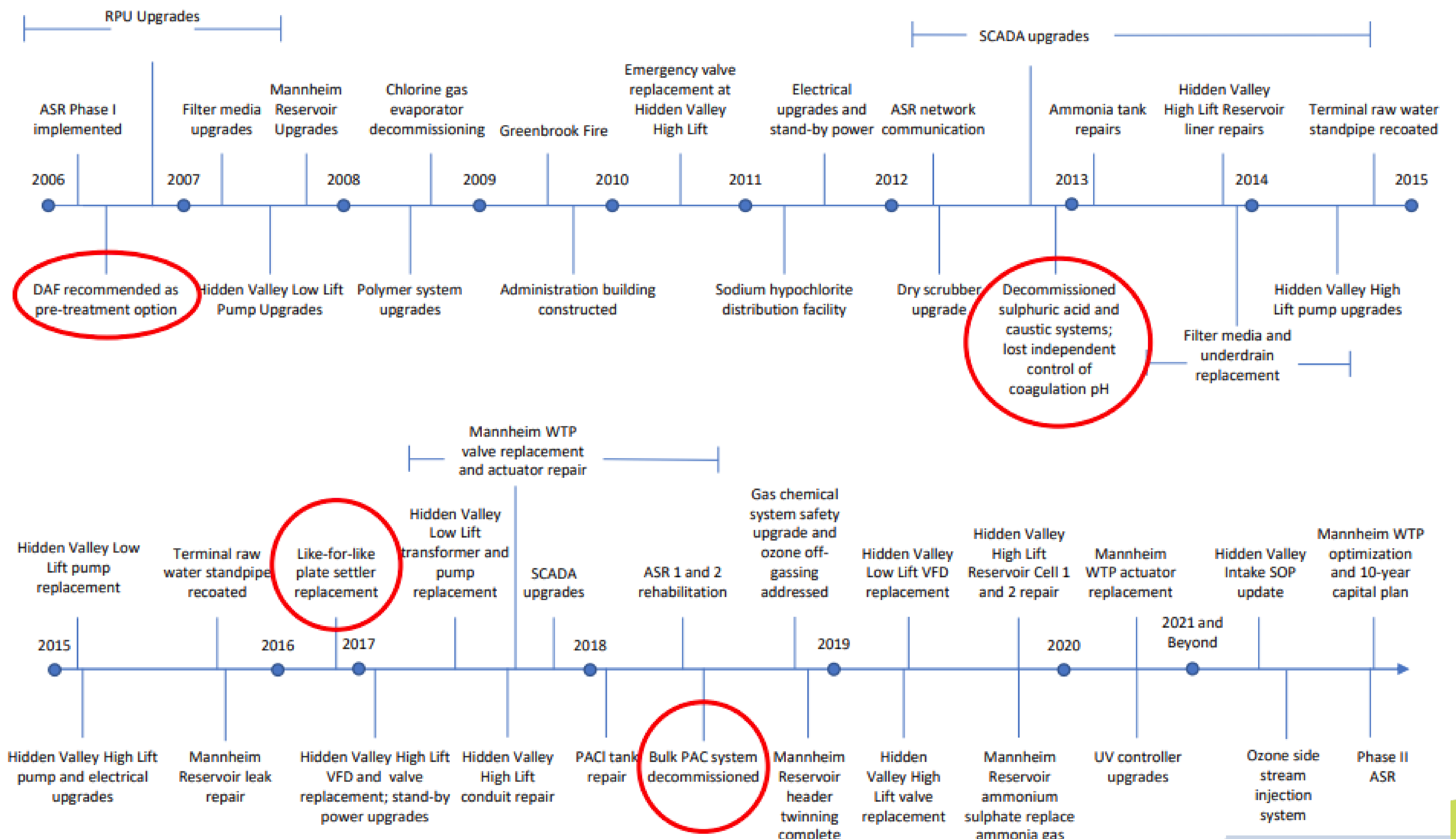
Mannheim Water Supply History – 1988 to 1998



Mannheim WTP History – 1998 to 2005



Mannheim WTP History – 2006 to present



KPMs

Tier 1 KPMs	Units
Maximum Plant Flow	L/s
UFRV	m3/m2
UVT Increase - MWTP Intake: Filter Effluent	% increase
Cost per Cubic Meter Treated Water	$/m3
GHG Emissions	Tons CO2
Backwash / Sludge Production Volume	m3
Tier 2 KPMs	
Settled Water Turbidity	NTU
Settled Water UVT	%T
Frequency of Plate Cleaning	Event/y
Ozone Mass-Transfer Efficiency	%
Headloss Accumulation Rate	%/hour
UVT, Post-Ozone	%T
Filter Effluent Turbidity, 95th percentile	NTU
Backwash Water Efficiency	%
Off-Spec Discharges	# / quarter
ASR Injection / Recovery Switch	# / month

Previous discussions have indicated that over/underdosing by 10% can significantly impact performance.

% of all data		January 2020		July 2020		October – November, 2021	
		Side 1	Side 2	Side 1	Side 2	Side 1	Side 2
Coagulant Dosing	>110% Average Dose	6.4	9.3	15.8	2.6	2.3	0.3
	<90% Average Dose	3.1	5.3	7.5	4.0	0.009	0.14
	Combined	9.5	14.6	23.3	6.6	2.31	0.44
Polymer Dosing	>110% Average Dose	3.8	9.9	16.2	3.0	1.9	2.8
	<90% Average Dose	2.1	9.2	4.3	2.5	1.7	4.8
	Combined	5.9	19.1	20.5	5.5	3.6	7.6

Blender Flow Control Success

Coagulant dosing significantly improved

- January 2020 –outside of range 9 to 14% of the time
- July 2020 – outside of range 6 to 23% of the time
- October 2021 – outside of range 0.4 to 2.3% of the time

Polymer dosing significantly improved

- January 2020 –outside of range 6 to 19% of the time
- July 2020 – outside of range 5 to 21% of the time
- October 2021 – outside of range 3.6 to 7.6% of the time
    - Correction for batch strength required

Note: data does not account for changes in dose setpoint

- Improvements still evident!

Manheim WTP

Process Flow Diagram