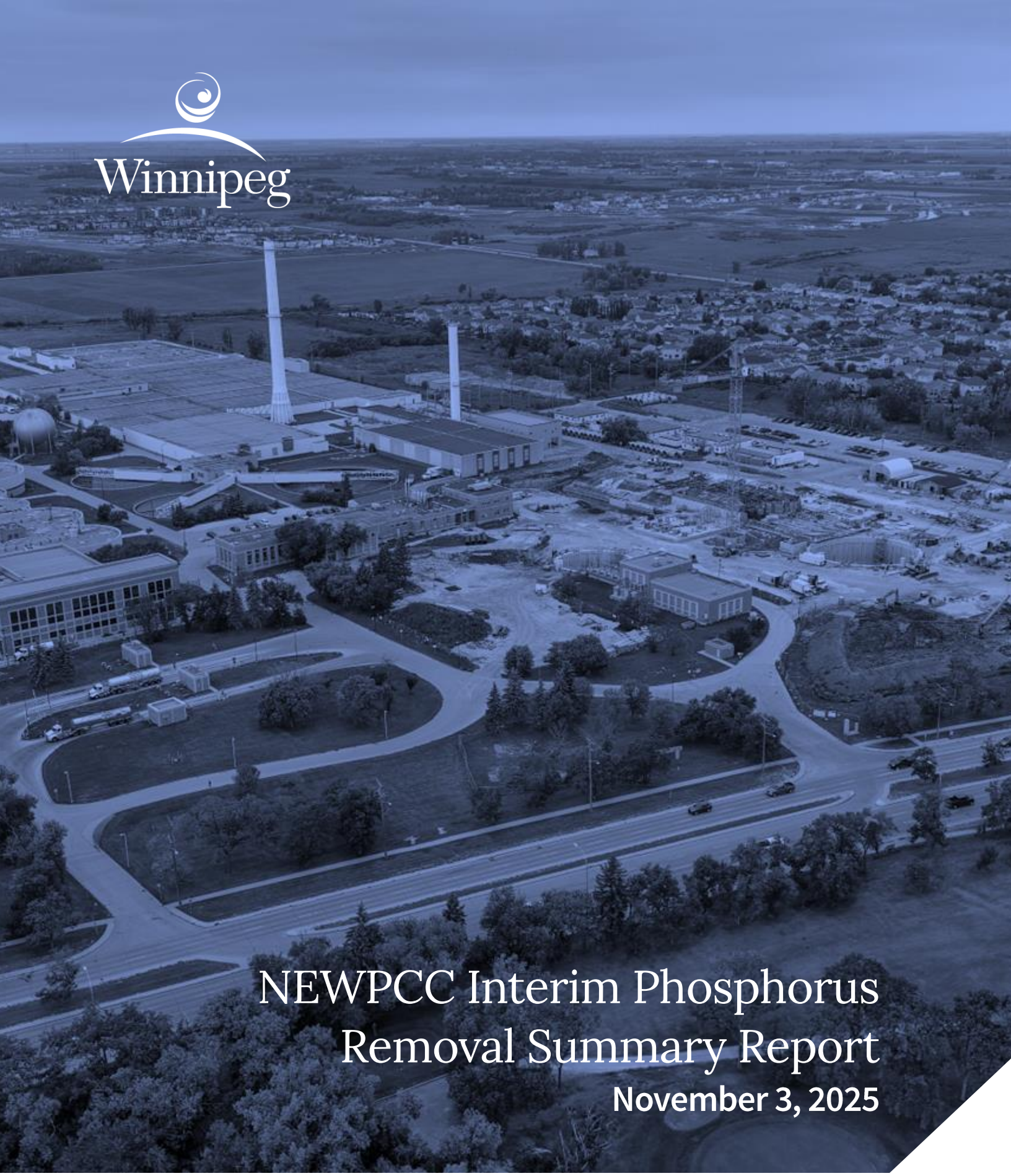

Winnipeg

NEWPCC Interim Phosphorus Removal Summary Report

November 3, 2025

Executive Summary

The City of Winnipeg's (City) Water and Waste Department (W&W) conducted a full-scale trial of interim chemical phosphorus removal at the North End Sewage Treatment Plant (NEWPCC) from June 24, 2024, to September 8, 2025. Ferric chloride was dosed into various parts of the NEWPCC, its impact on overall plant performance was evaluated and this report summarizes the results.

The trial demonstrated that the addition of ferric chloride improved phosphorous removal at the plant. The phosphorus removal rates, relative to incoming phosphorus loads, were 74% and 67% in 2024 and 2025 respectively. The total phosphorus concentration in the final effluent averaged 3.1mg/L during the trial period. The higher than expected concentration was partly caused by temporarily shutting down a dosing location due to pipe leaks.

The trial also demonstrated the NEWPCC's sensitivity to ferric chloride with dosing rates in the trial period lower than anticipated. These rates were limited, in part, due to ferric chloride's impact on ultraviolet (UV) disinfection, digester capacity and cleaning, and pipe conditions.

Moving forward, the City will continue to maximize chemical phosphorus removal in the final effluent, with ferric chloride dosing amounts varying in response to changing conditions and activities at the NEWPCC. This will balance phosphorus removal with overall plant performance until full licence compliance can be achieved with the commissioning of the future NEWPCC Upgrade: Nutrient Removal Facility.

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1. Introduction

In 2019, Manitoba Environment and Climate directed the City W&W to develop and implement an interim phosphorus removal compliance plan. The goal of this work was to enhance phosphorous removal at the NEWPCC while upgrades are underway for full nutrient removal.

The plan, approved as a Notice of Alteration (NOA) in May 2021, uses ferric chloride to remove phosphorus from wastewater as a solid. It was also included in a full-scale trial of approximately one-year within the newly constructed Interim Phosphorous Removal Facility. This report summarizes the results of the trial period which ran from June 24, 2024 to September 8, 2025.

2. Ferric Chloride Dosing and Phosphorus Removal

2.1 Dosing Locations and Quantities

Prior to the implementation of interim phosphorus removal, ferric chloride was added at three locations at the NEWPCC. An additional three locations were added as part of the interim phosphorus removal plan. Figure 1 on the next page identifies the various ferric chloride dosing locations throughout the NEWPCC plant.

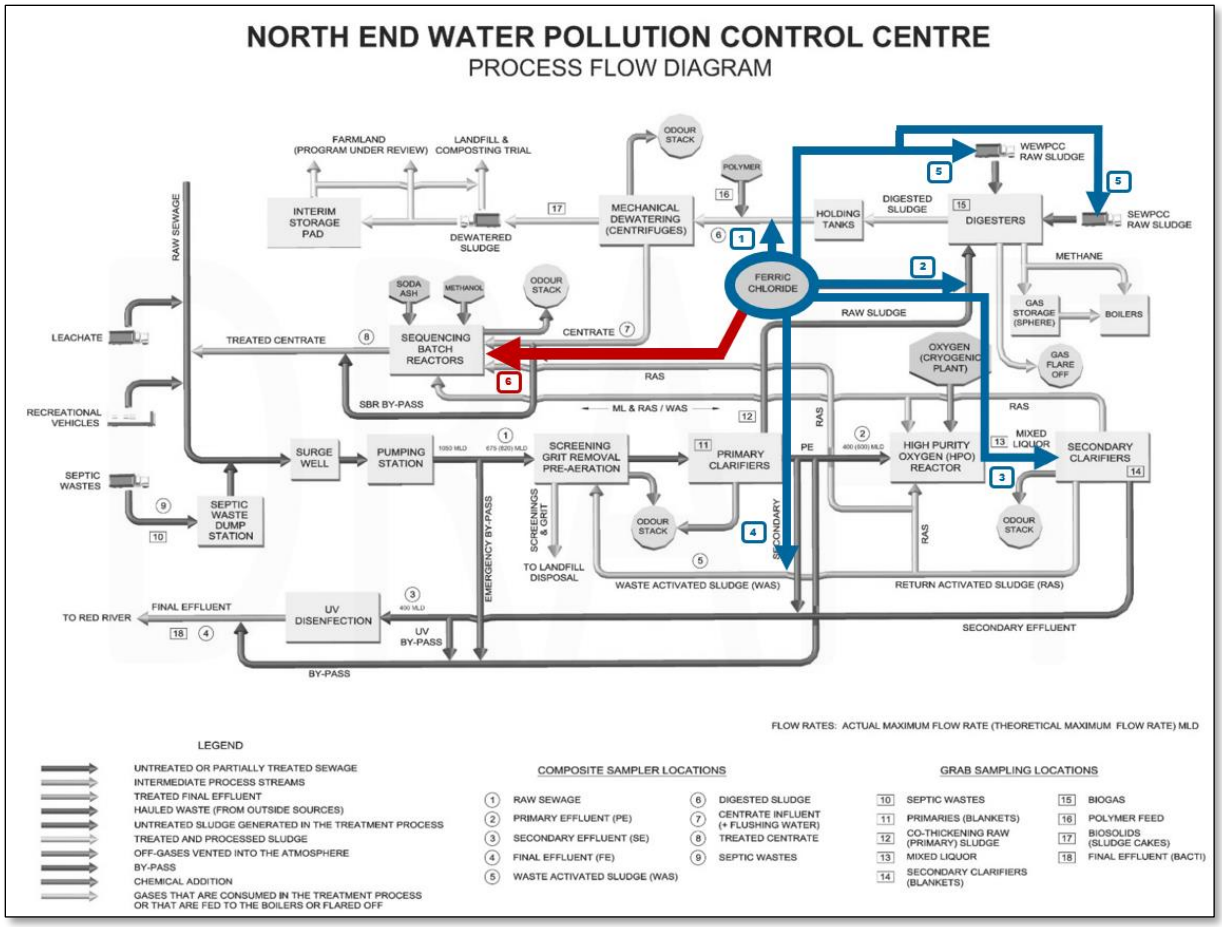

Figure 1: NEWPCC Ferric Chloride Dosing Point Locations

Location 1 'Centrifuges': Pre-existing dosing location to remove phosphorus

Location 2 'Primary Sludge Line': Pre-existing dosing location to remove corrosive hydrogen sulfide gas

Location 3 'Secondary Clarifiers': A new dosing location in the secondary effluent channel to remove phosphorus

Location 4 'Waste Activated Sludge (WAS) Line': A new dosing location that flows into the primary clarifiers via co-thickening; also known as Chemically Enhanced Primary Treatment (CEPT)

Location 5 'Hauled Sludge Line': A new location that doses ferric chloride into the digester sludge line. This line receives hauled sludge from the City's two other sewage treatment plants - the South End Sewage Treatment Plant (SEWPCC) and the West End Sewage Treatment Plant (WEWPCC)).

Location 6 Pre-existing location that is not in use. This location was shut down indefinitely in favour of Location 1 'Centrifuges'

Ferric chloride dosing during the trial period focused on Location 3 ‘Secondary Clarifiers’ and Location 4 ‘WAS Line’. Dosing at Location 5 ‘Hauled Sludge Line’ was briefly trialed in the spring of 2025 but was shut down in favour of the two other dosing locations which had better mixing and reaction times.

A graph showing phosphorous concentrations and ferric dosing over time is shown in Figure 4 and Figure 5 in the Appendix. A summary table of average dosing rates for various time periods are listed in Table 3 of the Appendix.

The intent of the trial period was to start dosing at a single location and make small incremental changes in dosing over time so that the impacts of ferric chloride on the sewage treatment plant and final effluent could be monitored.

The trial started with a low dose (11% of the recommended dose for that location) of ferric chloride at Location 3 ‘Secondary Clarifiers’; this was increased a couple of weeks later. The higher rate of ferric chloride coloured the final effluent and coated the ultraviolet (UV) bulbs. This interfered with the UV disinfection and led to licence exceedances for E.Coli. The ferric chloride dose at this location was subsequently reduced.

Ferric chloride dosing into Location 4 ‘WAS Line’ started on November 18, 2024. It was stopped on June 1, 2025 due to corrosion-related leaks in the WAS pipe that were caused by the addition of ferric to the older steel pipes. After several investigations and reviews with the design engineers, a plan was developed to replace the steel pipe with a high density polyethylene (HDPE) pipe to prevent corrosion. Construction is expected to be complete in November 2025 after which Location 4 ‘WAS Line’ will be returned to service.

During the Location 4 ‘WAS Line’ shutdown, ferric chloride dosing at the other locations was increased so that overall ferric chloride dosing levels remained similar (as shown in Figure 4 and Figure 5).

2.2 Phosphorus Removal During Trial Period

The amount of phosphorus removed by the NEWPCC, relative to incoming loads, is shown in Table 1. The amount removed during the trial is similar to what was originally predicted in the City’s NOA submitted April 30, 2021.

Table 1: Comparison of Predicted and Actual Phosphorus Removal from the NEWPCC

Year	Predicted Phosphorus Removed – No Change	Predicted Phosphorus Removed – Interim P Removal	Actual Phosphorus Removed
2019 – 2022 Average			61%
2023[1]	61%	65%	68%
2024[2]	60%	69%	74%
2025[3]	59%	68%	67%
2026	59%	67%	
2027	58%	66%	
2028	57%	65%	

[1]Assumed interim phosphorus removal start date September 2023
[2]Actual start for interim phosphorus removal in June 2024
[3]2025 based on data from January to September 2025

The 30-day rolling average total phosphorus concentration in the NEWPCC final effluent is shown in Figure 2. During the trial the final effluent total phosphorus concentration averaged 3.1 mg/L, varying from approximately 1 mg/L to 5 mg/L.

The variance in phosphorus concentrations was influenced by ferric chloride dosing and other factors, such as incoming loads, digester cleaning, and the performance of the City's two other sewage treatment plants. Incoming loads can vary year to year depending on industrial activity and weather patterns. As well, during digester cleaning periods, the digester contents are returned to the head of the plant which increases phosphorus loads.

Changes at SEWPCC can also influence final effluent concentrations and removal rates at NEWPCC. In August 2024, SEWPCC converted to a fully biological nutrient removal plant. The phosphorus collected and removed biologically from SEWPCC was transferred in the sludge to the NEWPCC digesters where it can be released back into the plant. The ferric chloride

dosed as part of interim phosphorus removal is likely capturing some of that phosphorus and preventing it from reaching the final effluent at NEWPCC.

The total final effluent loadings from all three sewage treatment plants are shown in Figure 3, with 2024 having the lowest annual loading from the plant. The interim phosphorus removal at Location 3 ‘Secondary Clarifiers’ can take partial credit for this lower loading having started in June 2024. Location 4 ‘WAS Line’ came online on November 18, 2024 so likely did not contribute significantly to the lower loading levels at the plant for that year.

Figure 3 loading for 2025 is based on data up to September 8, 2025, with an estimate made for the remainder of the year. The year 2025 shows an increased level when compared to 2024 which may be caused, in part, by the shutdown of the Location 4 ‘WAS Line’.

The overall performance during the trial shows that chemical phosphorus removal is achievable. The percentage removed, relative to incoming loads, is similar to or greater than what was estimated in Table 1 even though the final effluent concentrations varied throughout the trial.

Sewage treatment plants are subject to many different conditions and variables, including weather, the operations of the NEWPCC, SEWPCC and WEWPCC, and changes in industrial and residential loadings to the plant. These variables make it difficult to trace the cause of varying phosphorus concentrations. The Location 4 ‘WAS Line’ shutdown also makes it difficult to gauge its effectiveness, having been online for only half the trial period.

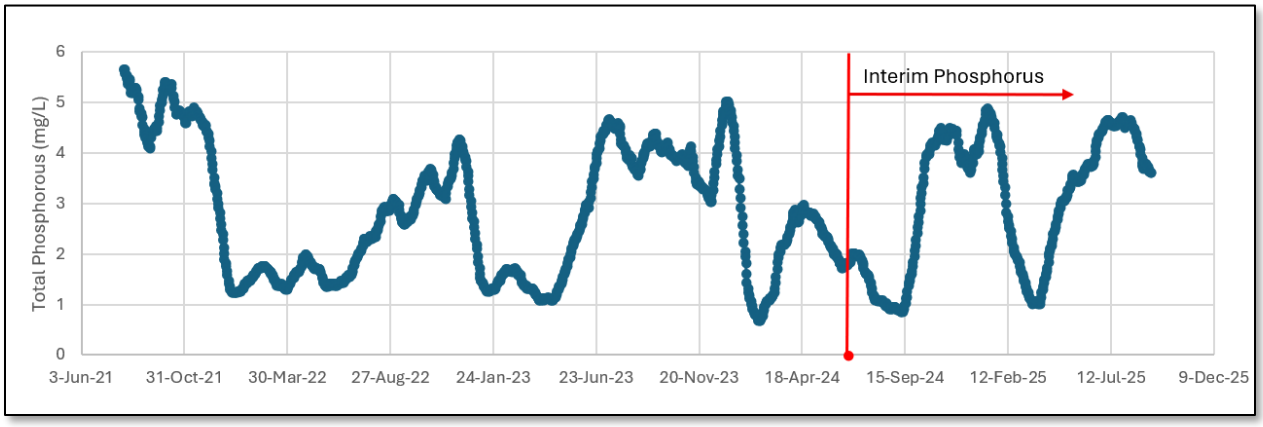

Figure 2: NEWPCC Final Effluent Total Phosphorus (30-day rolling average)

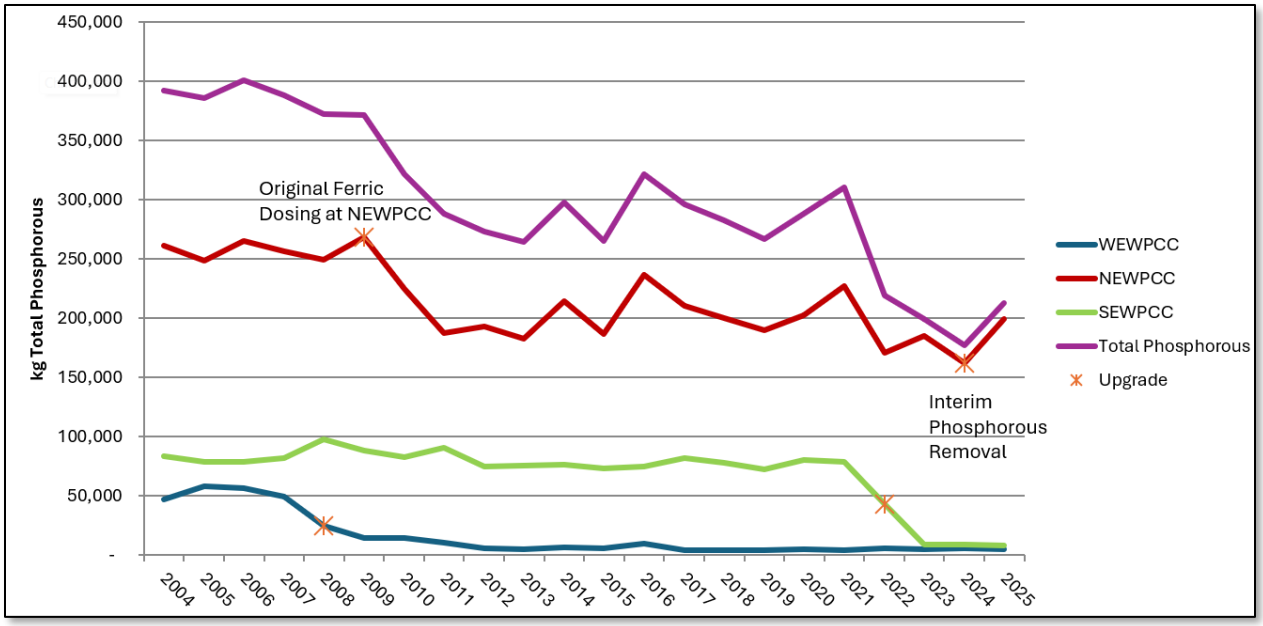

Figure 3: Historic Annual Total Phosphorus Loads from 2004 to Present
Note: 2025 data is an estimate based on actual loads to September 2025 and historic trends.

2.3 Comparison to Model Predictions

In 2020, AECOM generated two BioWin models to simulate ferric chloride dosing at NEWPCC. One model was used to represent dosing at Location 3 'Secondary Clarifiers' and one model for Location 4 'WAS Line.' A comparison of the model outputs and the results from the interim phosphorus removal trial are shown below in Table 2.

Table 2: Anticipated Maximum Final Effluent Total Phosphorus

	2020 AECOM Report and Modeling	**Interim Phosphorus Trial**
Primary Sludge Volume (KL)	1550	1,730 (with Location 4 online) 1,480 (with Location 4 offline)
Primary Sludge Mass (kg per day)	55,000	58,000
Final Effluent Phosphorus (mg/L)	2.5	3.1
Final Effluent Phosphorus (kg/day)	458	529
Average Digester SRT during Cleaning	14.5	13.1 (with Location 4 online) 14.5 (with Location 4 offline)
Ferric Chloride Dose (L/day)	[1]Location 3 SC: 1800 [1]Location 4 WAS: 4600	[2]Location 3 SC: 334 [2]Location 4 WAS: 480

[1]BioWin modeling doses, assuming one dosing location at a time (i.e. not simultaneous dosing at both locations)
[2]Represents maximum continuous dose during trial period that could be sustained

The trial demonstrated that the NEWPCC is more sensitive to the effects of ferric chloride than what the model predicted. Both primary sludge mass and volume were greater during the trial despite having smaller ferric chloride dose levels.

Phosphorus in the final effluent during the trial was higher relative to the model. This is likely due to the lower ferric chloride dose compared to what the models suggested.

3. Impacts of Interim Phosphorus Removal to the Treatment Plant and Process

The health and performance of the NEWPCC was monitored throughout the trial period to determine what impacts interim phosphorus removal would have on it. Overall plant impacts, aside from phosphorus removal, were found in UV disinfection, WAS piping, primary clarification, and in digester operation and cleaning.

3.1 UV Disinfection

During the planning period the addition of ferric chloride was identified as a risk to disinfection because it can interfere with UV performance. Ferric chloride has red tones that make it difficult for UV light to penetrate the water column and can also leave a residue on UV lightbulbs that further block the light.

This risk was associated with Location 3 ‘Secondary Clarifiers’ since this location is closest to the UV system. To track this risk the UV transmissivity (UVT) and colour in the secondary effluent were compared to disinfection levels (Table 4 in the Appendix). Operators also monitored the UV bulbs for buildup and colour change. Results showed that at higher ferric chloride dosing levels (e.g. 25% of the BioWin model) the buildup on the bulbs and UV transmissivity were impacted. Disinfection decreased to the point where the licence limits for E.coli (200 MPN on a geometric mean) were exceeded. In response, the dosing level was lowered and disinfection returned to normal levels.

3.2 Waste Activated Sludge Line

Another potential risk that was identified during the planning phase related to the steel WAS Line. Ferric chloride is acidic in nature and can corrode metals. Ferric chloride dosing at

Location 4 ‘WAS Line’ began mid November 2024. The steel pipe feeding WAS into the grit removal area and ultimately to the primary clarifiers, corroded and started to leak while Location 4 ‘WAS Line’ was in operation. This location had to be shut down on June 1, 2025. Plans are underway to replace the pipe in November 2025 following which the dosing will resume at this location.

3.3 Primary Clarifiers

When a clarifier was taken out of service for cleaning, NEWPCC Operators observed iron deposits had accumulated on the various mechanisms and metal surfaces (shown in Figure 7 and Figure 8 in the Appendix). These deposits had to be scraped off and removed during regular clarifier shutdowns, adding to maintenance efforts and shutdown times.

The deposits did not interfere with clarifier operation while in service, but this location only had ferric chloride dosing at low levels over a six-month period. Further observations are needed to determine the impact on day-to-day operations for the primary clarifiers.

3.4 Solids Treatment and Digester Operation

Ferric chloride generates an inert sludge that can consume capacity in downstream processes, such as sludge treatment. To track this, the sludge volume and solids retention time (SRT) were monitored and are shown in Figure 6, Table 5, Figure 9 and Figure 10 of the Appendix).

The sludge volume and sludge mass were higher than predicted in the BioWin model (Table 2), showing that ferric chloride had a greater-than-expected impact on digester operation and capacity. The impact of dosing at Location 4 ‘WAS Line’ was significant with sludge volumes increasing 17% during its operation. This correlated with an average digester SRT of 13.1 days during cleaning, compared to an SRT of 14.5 days when this location was not in operation.

NEWPCC Operators also observed changes in sludge composition during interim phosphorous removal while cleaning the digesters. The sludge with ferric chloride was heavier and stickier and more difficult to flush out and remove from the digesters.

Digester capacity, and its ability to impact growth, is a current concern in Winnipeg. The noticeable increase in sludge production may impact future dosing at Location 4 ‘WAS Line.’

For example, this location may be able to tolerate higher dosing rates during low flow winter periods but may require lower dosing rates during digester cleaning and shutdown to mitigate capacity concerns.

4. Overall Findings and Next Steps

The results of the Interim Phosphorus Removal full scale trial period demonstrated that chemical phosphorus removal at NEWPCC is achievable. The percentage removed, relative to incoming loads, is similar to or greater than what was estimated in Table 1 even though the final effluent concentrations varied throughout the trial.

The ability to dose ferric chloride and remove phosphorus, however, is impacted by many variables such as digester capacity, UV disinfection, and primary clarifier operation. The asset condition of the NEWPCC, such as the WAS steel pipe, also limited phosphorus removal during the trial period.

Moving forward, the City will continue the ferric chloride dosing program at various locations and concentrations to remove phosphorous. Some current planned actions include:

- Plant operators and staff will continue to monitor and adjust dosing as needed to respond to the various conditions seen at the plants
- With the UV system currently offline until spring 2026, the City will take advantage of the shutdown by gradually increasing dosing levels at Location 3 “’Secondary Clarifiers’ to observe secondary effluent colour and UVT levels. This will provide additional information on temporary phosphorus removal potential for this location and serve as a benchmark for potential future UV impacts.
- Dosing levels at Location 4 ‘WAS Line’ resumed on October 20 after the pipe was repaired and will gradually increase as plant operations are monitored.

The City will continue to adjust ferric chloride dosing at both Location 3 ‘Secondary Clarifiers’ and Location 4 ‘WAS Line’ to optimize both phosphorus removal and overall plant performance. This will balance compliance of other licence parameters with phosphorous removal until biological nutrient removal can be brought online.

APPENDIX

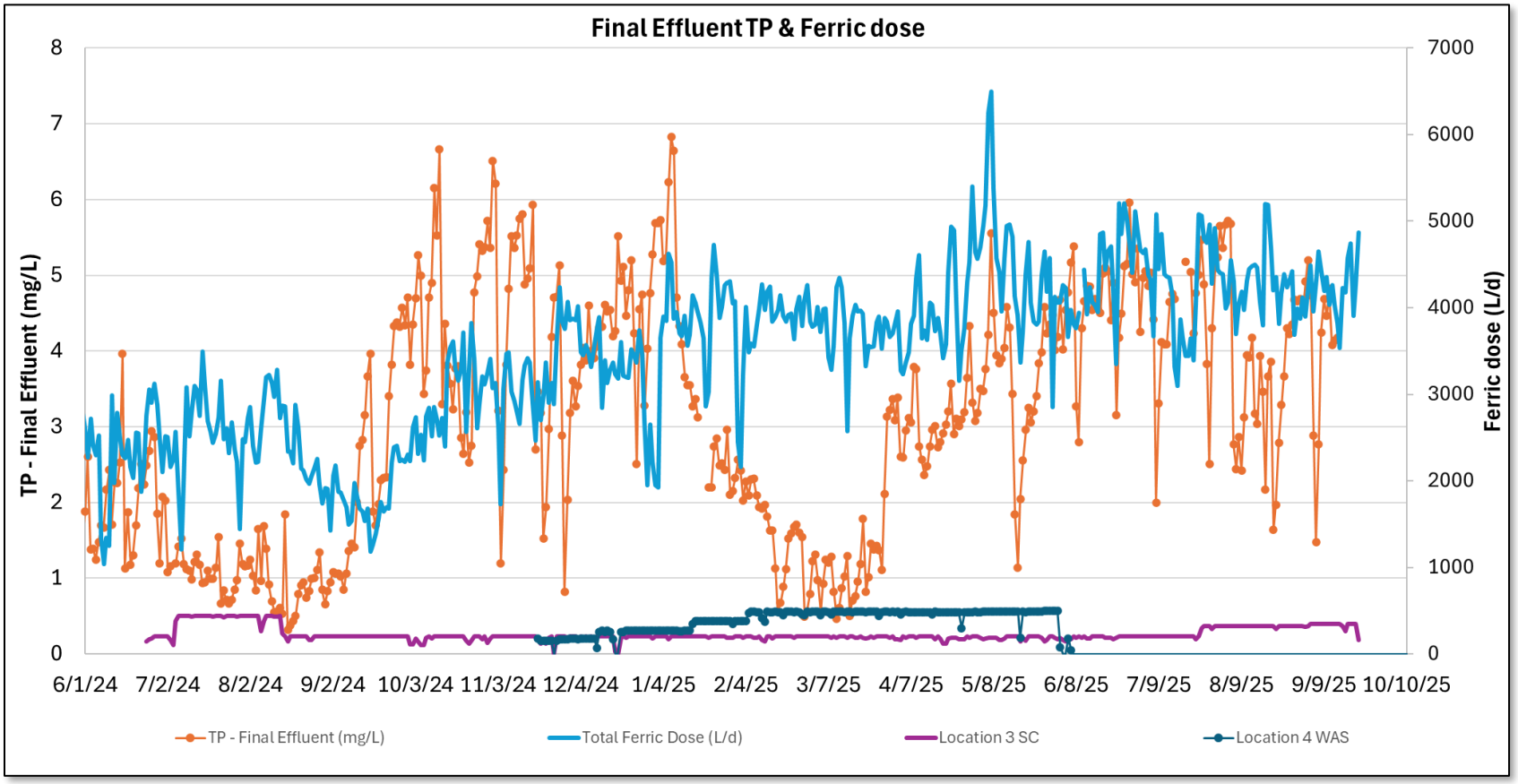

Figure 4: Final Effluent Total Phosphorus Concentration and Ferric Chloride Dosing
Note: total ferric dose includes Location 1 'Centrifuges' and Location 2 'Primary Sludge Line'.

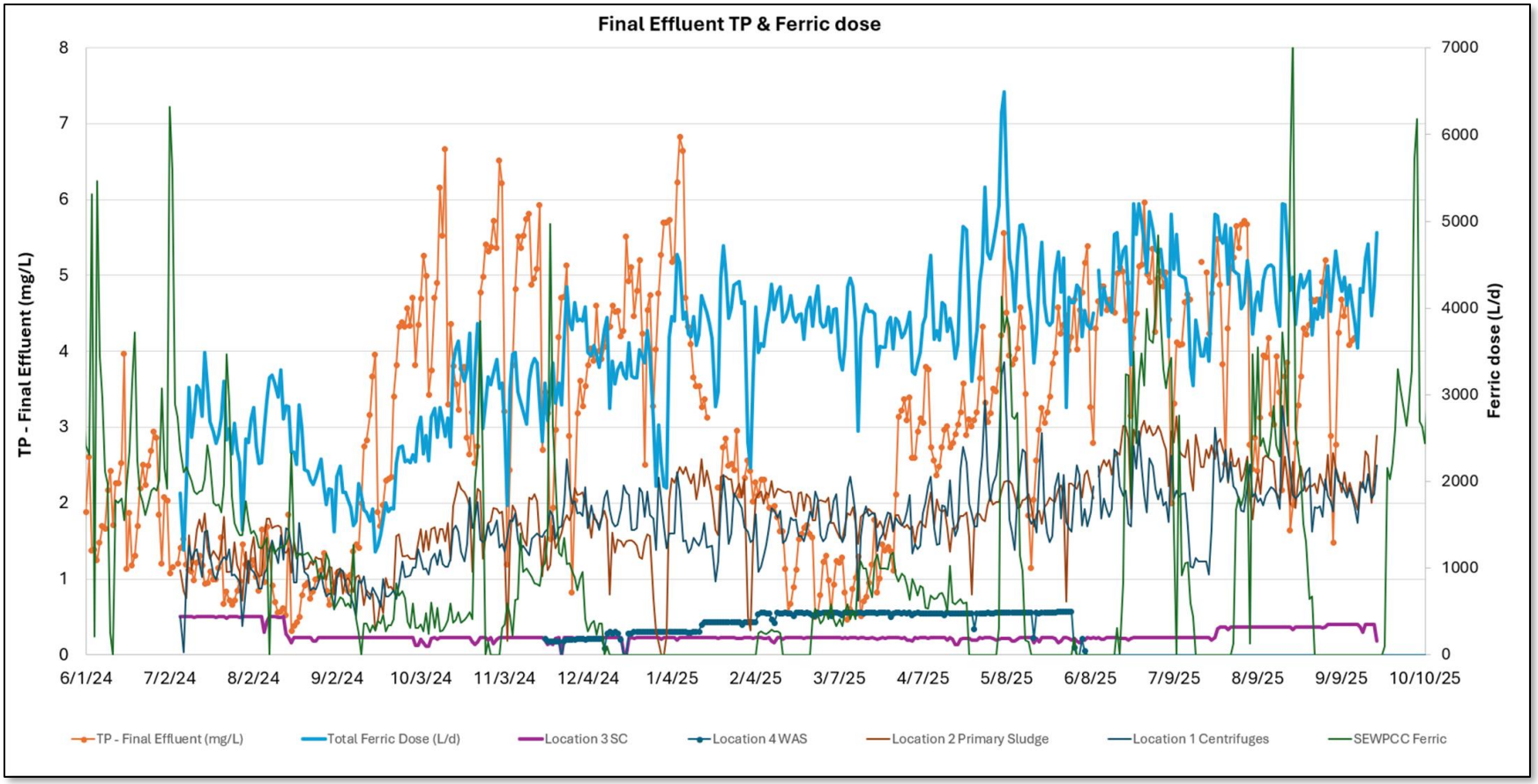

Figure 5: Final Effluent Total Phosphorus Concentration and Ferric Chloride Dosing including Location 1 'Centrifuges', Location 2 'Primary Sludge Line'. and SEWPCC

Table 3: Average Ferric Chloride Dose During Each Dosing Period

	Location 3 Secondary Clarifiers (L/d)	Location 4: Ferric to WAS Line (L/d)	Total Plant-Wide Ferric Dose (L/d)	Final Effluent TP (mg/L)	TP Load in the Final Effluent (kg/d)
2 years before commissioning (2022 &2023)	0	0	3244	2.44	488
11% Location 3 Secondary Clarifiers[1] (June 24 – July 04 2024)	177	0	2437	2.04	579
25% Location 3 'Secondary Clarifiers' (July 5 – Aug 13 2024)	431	0	2177	1.06	216
11% Location 3 (Aug 14 – Nov 17 2024)	191	0	2451	3.19	491
11% Location 3 'Secondary Clarifiers' 4% Location 4 WAS Line (Nov 18 – Dec 10)	177	157	3504	3.49	584
11% Location 3 'Secondary Clarifiers' 6% Location 4 WAS Line (Dec 11 – Jan 15)	193	266	3385	4.66	644
11% Location 3 'Secondary Clarifiers' 8% Location 4 WAS Line (Jan 16 – Feb 5)	198	383	3762	2.49	336
11% Location 3 'Secondary Clarifiers' 10% Location 4 WAS Line (Feb 6 – Apr 16)	194	479	3828	1.72	288
11% Location 3 'Secondary Clarifiers' 10% Location 4 'WAS Line' Location 5 Hauled Sludge Line Test (Apr 17 – May 14)	181	478	4541	3.60	582
11% Location 3 'Secondary Clarifiers' 10% Location 4 'WAS Line' (May 15 – June 1)	185	476	4081	3.36	593
11% Location 3 'Secondary Clarifiers' (June 2 – July 24)	194	6	4266	4.57	732
15% Location 3 'Secondary Clarifiers' (July 25 – Sept 3)	318	0	4333	3.98	707
16.5% Location 3 'Secondary Clarifiers' (Sept 4 – Sept 23)	334	0	4254	3.80	590

[1]The relative dosing percentages are in reference to the recommended ferric chloride doses provided by KGS consulting and the University of Manitoba.

Table 4: Final Effluent E. Coli and Ultraviolet Transmissivity (UVT) during Interim Phosphorus

	Final Effluent E.coli (MPN)	Secondary Effluent UVT(%)
2 months before commissioning	135	58
11% Location 3 'Secondary Clarifiers' (June 24 – July 04 2024)	1131	57
25% Location 3 'Secondary Clarifiers' (July 5 – Aug 13 2024)	465	52
11% Location 3 'Secondary Clarifiers' (Aug 14 – Nov 17 2024)	245	52
11% Location 3 'Secondary Clarifiers' 4% Location 4 'WAS Line' (Nov 18 – Dec 10)	197	53
11% Location 3 'Secondary Clarifiers' 6% Location 4 WAS Line (Dec 11 – Jan 15)	316	53
11% Location 3 'Secondary Clarifiers' 8% Location 4 WAS Line (Jan 16 – Feb 5)	99	47
11% Location 3 'Secondary Clarifiers' 10% Location 4 WAS Line (Feb 6 – Apr 16)	83	50
11% Location 3 'Secondary Clarifiers' 10% Location 4 'WAS Line' Location 5 Hauled Sludge Line Test (Apr 17 – May 14)	76	51
11% Location 3 'Secondary Clarifiers' 10% Location 4 'WAS Line' (May 15 – June 1)	80	51
11% Location 3 'Secondary Clarifiers' (June 2 – July 24)	224	52
15% Location 3 'Secondary Clarifiers' (July 25 – Sept 3)	252	57
16.5% Location 3 'Secondary Clarifiers' (Sept 4 – Sept 23)	150	54

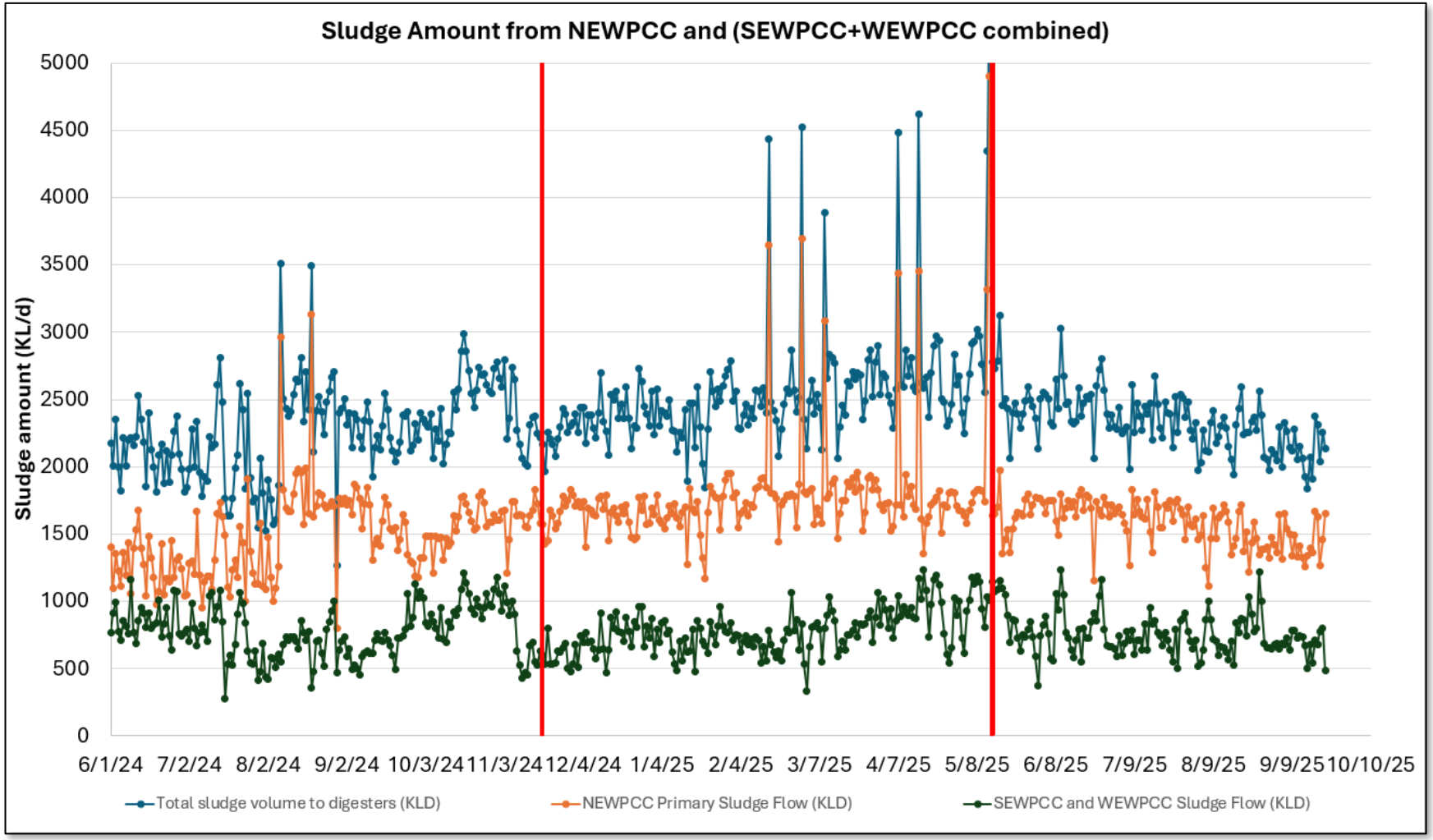

Figure 6: Sludge Volume to Anaearobic Digesters from the City's Sewage Treatment Plants
Note: Location 4 'WAS Line' dosing period is highlighted by the red bars

Table 5: Average Sludge Volumes in each Dosing Period

	Total sludge to digesters (KLD)	From NEWPCC (KLD)	From SEWPCC &WEWPCC (KLD)
2 months before commissioning	2236	1341	894
11% Location 3 'Secondary Clarifiers' (June 24 – July 04 2024)	2055	1230	825
25% Location 3 'Secondary Clarifiers' (July 5 – Aug 13 2024)	2102	1404	698
11% Location 3 'Secondary Clarifiers' (Aug 14 – Nov 17 2024)	2394	1610	784
11% Location 3 'Secondary Clarifiers' 4% Location 4 'WAS Line' (Nov 18 – Dec 10)	2279	1657	622
11% Location 3 'Secondary Clarifiers' 6% Location 4 WAS Line (Dec 11 – Jan 15)	2378	1637	741
11% Location 3 'Secondary Clarifiers' 8% Location 4 WAS Line (Jan 16 – Feb 5)	2438	1690	748
11% Location 3 'Secondary Clarifiers' 10% Location 4 WAS Line (Feb 6 – Apr 16)	2667	1878	789
11% Location 3 'Secondary Clarifiers' 10% Location 4 'WAS Line' Location 5 Hauled Sludge Line Test (Apr 17 – May 14)	2834	1876	958
11% Location 3 'Secondary Clarifiers' 10% Location 4 WAS Line (May 15 – June 1)	2475	1644	831
11% Location 3 'Secondary Clarifiers' (June 2 – July 24)	2427	1664	763
15% Location 3 'Secondary Clarifiers' (July 25 – Sept 3)	2259	1508	751
16.5% Location 3 'Secondary Clarifiers' (Sept 4 – Sept 23)	2134	1450	684

Figure 7: Ferric Deposits on Primary Clarifiers

Figure 8: Ferric Deposits in Primary Clarifiers

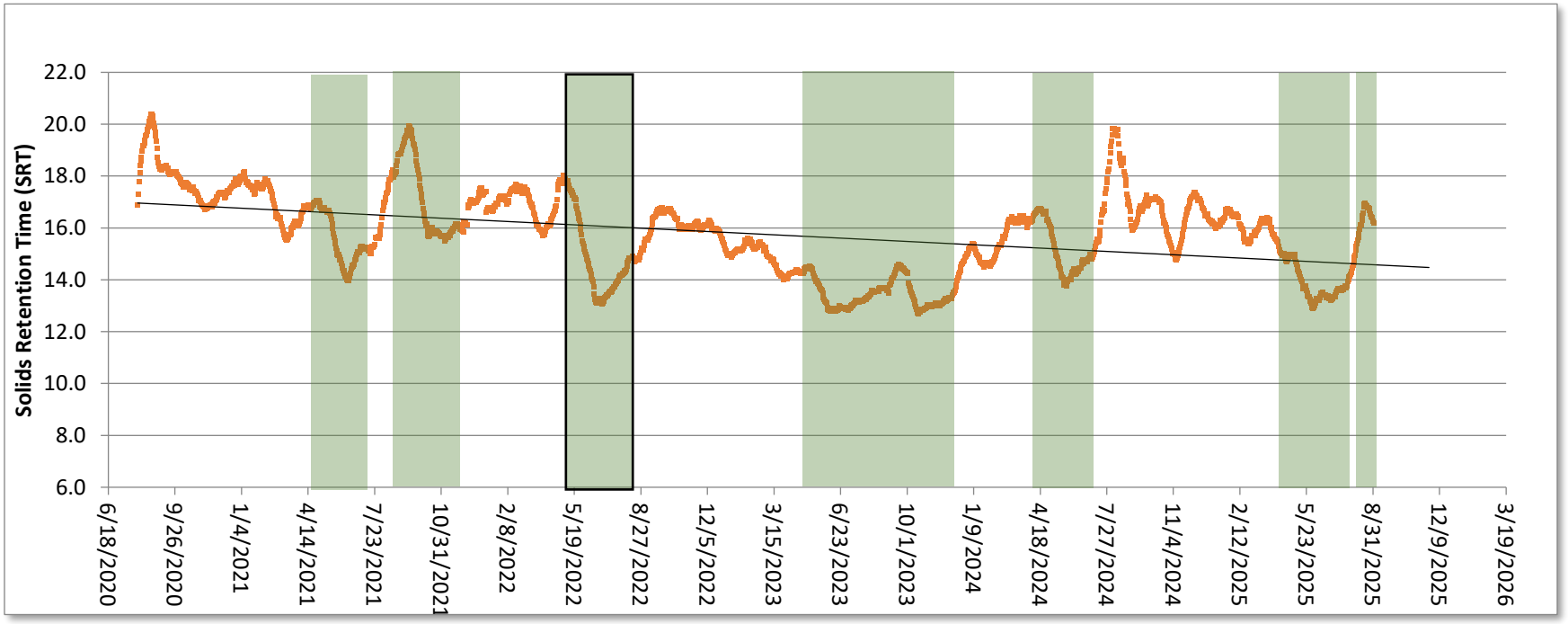

Figure 9: Digester Solids Retention Time (SRT) as a 30-day Rolling Average
Note: Cleaning shutdowns (5 digesters online) are highlighted in green

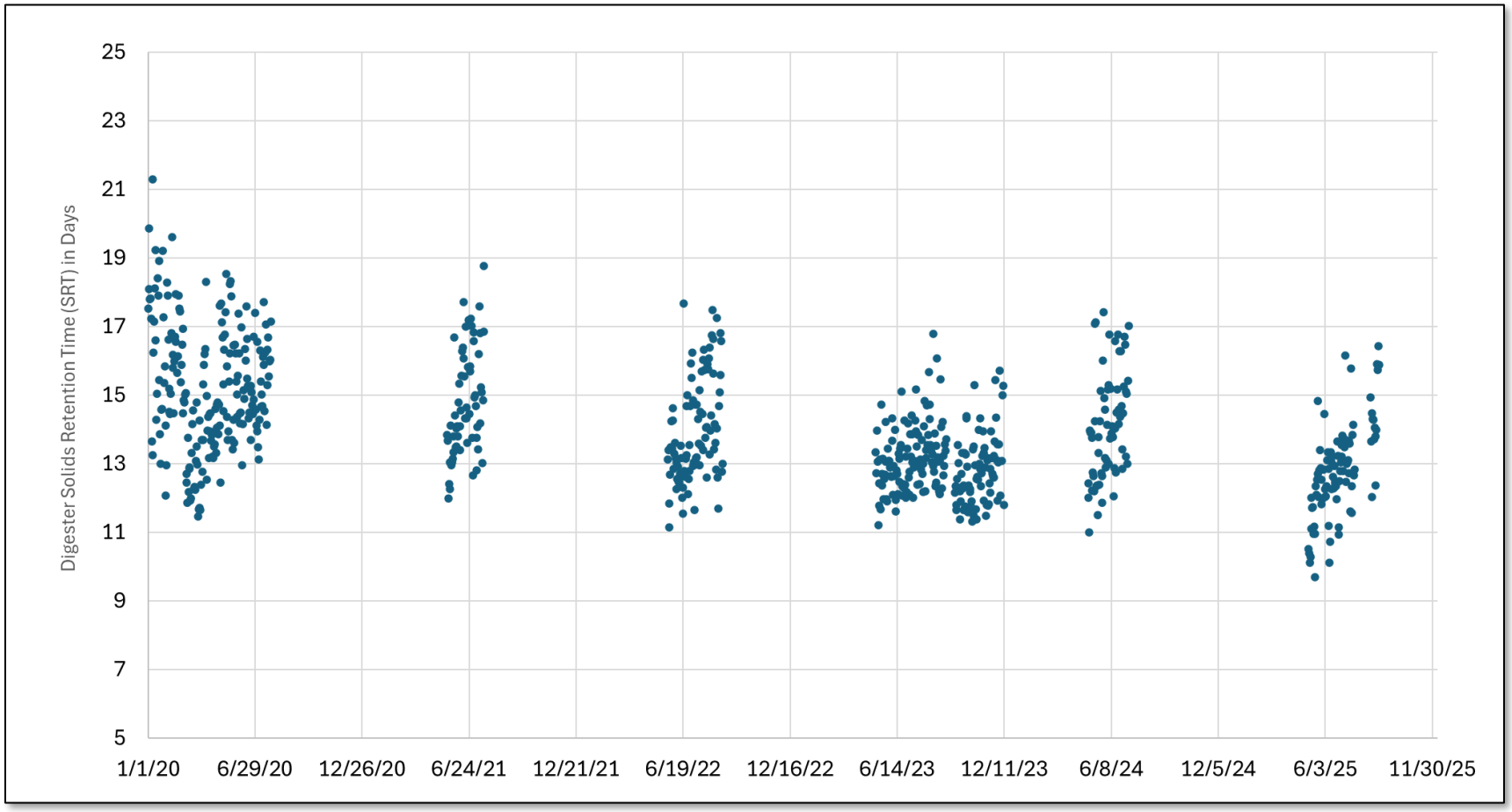

Figure 10: Digester Solids Retention Time (SRT) during Digester Shutdown and Cleaning