THE USE OF PEROXIDE REGENERATED IRON-SULFIDE CONTROL (PRI-SC)™ FOR LONG DURATION COLLECTION SYSTEM SULFIDE CONTROL AT THE REGIONAL MUNICIPALITY OF YORK

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Abstract

Corrosion of collection system piping and components has become a big problem for many municipalities trying to handle growth while obtaining the maximum service life for existing collection system infrastructure. The goal of this paper is to present the results of a trial initiated in August 2005 by The Regional Municipality of York (York Region) to quantify the impacts of Peroxide Regenerated Iron-Sulfide Control (PRI-SC)™ for control of hydrogen sulfide (H_2S) in a long retention time section of the collection system. Results showed that PRI-SC™ technology was able to provide significant reductions of H_2S over a 12 hour retention time section of the collection system. In most sections that were monitored, the reduction of H_2S was over 90% in both the gas and liquid phase. The Aurora forcemain discharges displayed a unique dose response during the trial due to gas pocketing and high turbulence at the discharge structures. Further monitoring at manholes immediately downstream from the Aurora forcemain discharges confirmed the hypothesis of gas pocketing at the discharge structures. Sections further downstream of the areas of interest in the Southeast Collector also showed some reductions in H_2S levels. As expected, the levels of reduction were less than in the upstream sections due to additional H_2S loaded wastewater mixing with the treated wastewater.

Keywords

The Regional Municipality of York, Hydrogen Sulfide, PRI-SC™, Hydrogen Peroxide, Iron Salts, Odor Control, Corrosion Control, Collection System, Wastewater

Introduction

York Region has had odor and corrosion problems in specific segments of the collection system serving an area including the Town of Newmarket and the Town of Aurora for several years along the York Durham Sewage System

(YDSS). This section of collection system consists of two pumping stations (Newmarket and Aurora) in series and a total of about 22 km of forcemain before discharging into a gravity sewer. Retention times in this segment of the collection system average 10 to 12 hours with most of the flow in forcemains, leading to anaerobic conditions and the formation of hydrogen sulfide year round. One of the forcemain discharges in Aurora had such high levels of corrosion that the discharge structure and a section of downstream piping needed to be replaced only after several years in service.

Methodology

In order to control sulfides in this section of the collection system, the technology employed needs to be capable of maintaining sulfide control over long distances (over 22 km) and high retention times (10 – 12 hours on average). The long duration controls required limits the technologies that can be applied cost effectively. Therefore, in accordance with York Region's odor control master plan, it was decided to run the first municipal Ontario pilot project utilizing the PRI-SC™ technology. The pilot was conducted for a total of 90 days and applied to the Newmarket/Aurora stretches of the YDSS. PRI-SC™ was chosen due to its ability to control sulfides over long retention times and its proven ability in other North American municipal applications in the United States. PRI-SC™ combines the use of iron salts (ferrous chloride) with hydrogen peroxide in a unique fashion, whereby the iron salt is added as the primary sulfide control agent in the upper reaches of the collection system, and hydrogen peroxide is added at specific points downstream to regenerate the spent iron (FeS). The key to the technology is the regeneration step, which oxidizes the sulfide to elemental sulfur and in the process "frees up" the iron making it re-usable for subsequent downstream sulfide control.

The main target area for the PRI-SC™ program is a major portion of the conveyance system lines that include the Newmarket force main and gravity interceptor; the East and West lines of the Aurora force mains; and the combined Aurora discharge gravity line area before and after the Aurora Magmeter. It was anticipated that the combined approach would be most cost effective to address the odor and corrosion concerns at the priority areas identified by York Region: The key areas identified for use in this PRI-SC pilot program included: Newmarket gravity interceptor (golf course area); East line force main discharge (gravity line); West line force main discharge (gravity line before Aurora Magmeter) and the gravity line after the Aurora Magmeter. However, as part of York Region's approach for the overall understanding of this PRI-SC™ system for potential use in the entire YDSS, the area observed was expanded to include the upper reaches of the Richmond Hill area and the south-east collector. A map of the collection system with key areas labeled is shown in Figure 1.

At York Region, the iron was injected into the upper reaches of the collection system at the Newmarket Pump Station, and the hydrogen peroxide was injected downstream at the Aurora Pump Station. Gaseous and liquid hydrogen sulfide levels were measured at various locations throughout the collection system in order to assess treatment performance. Different dosing levels were also tested in order to better characterize the dose response in the collection system at key control points.

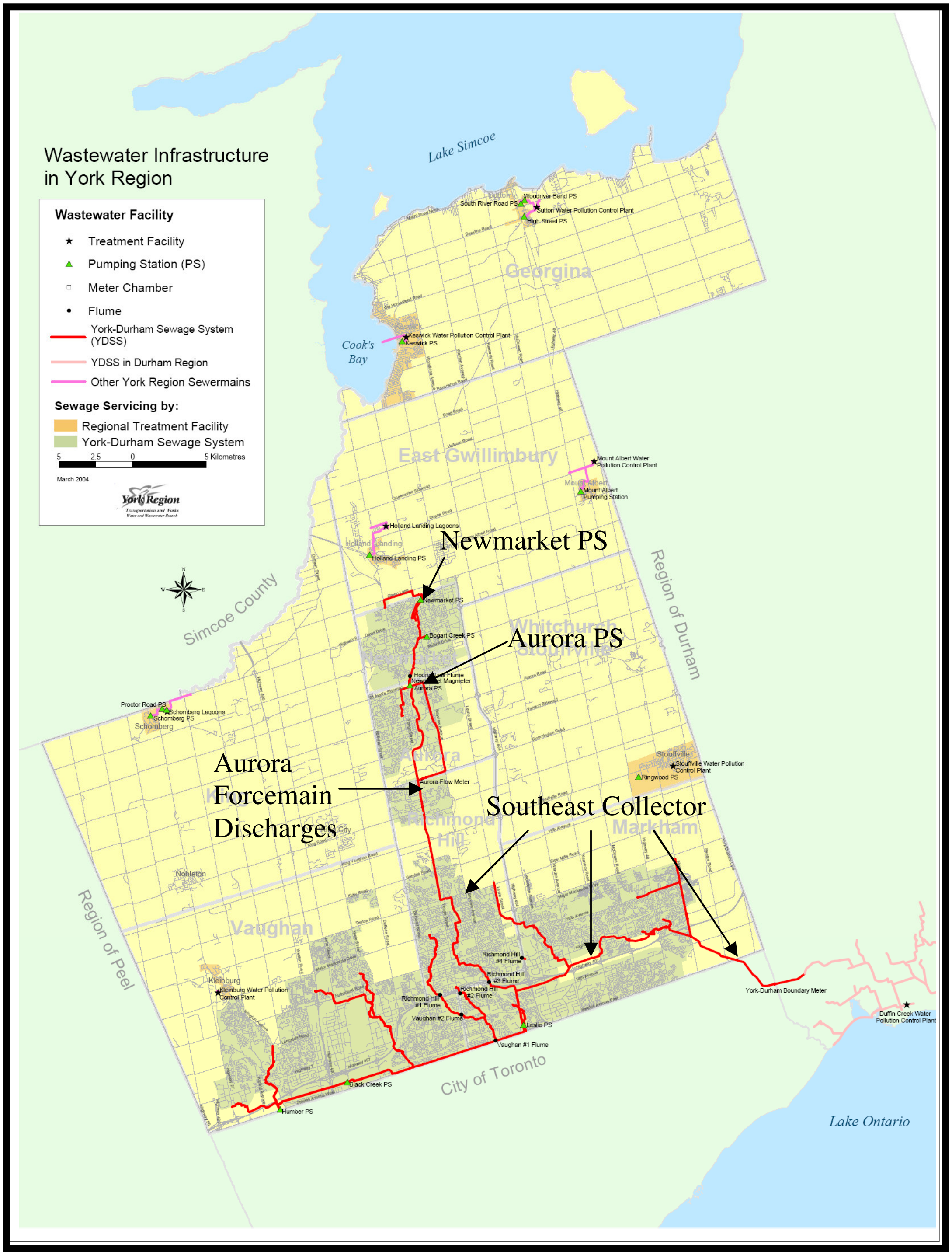

Figure 1. York Region Collection System Map

Results & Discussion

During the demonstration, gaseous and liquid hydrogen sulfide levels were measured at various locations throughout the collection system in order to assess treatment performance. These locations included the Newmarket forcemain discharge, the Aurora East and Aurora West FM discharges, the Aurora East/West Combined discharge at T 42-11/15 and the YDSS Downstream manhole. Also studied, though not as frequently, were sample locations throughout the Southeast Collectors.

Comparable data was collected on baseline (no chemicals added) and during the use of the PRI-SC™ technology at three different sets of chemical dosage rates, Test Conditions A, B and C. As an added optimization tool, profile dosing was implemented during the last part of the demonstration to show how full optimization can drive down costs by taking advantage of modern telemetry and computer control. Further temperature turndown effects were measured at the last part of the demonstration to assess the year-round requirements for full-scale implementation of PRI-SC. The theory and practice of profile dosing shifts chemical loading out of periods where sulfide levels are low and puts it into periods where the levels are peaking. This is always done while keeping retention times in mind so that chemical dose changes upstream coincide with the sulfide levels that are being addressed downstream. Tests D through G used profiles dosing rates which built upon knowledge gained from flat dosing in Test A, B and C in order to maximize effectiveness and potential savings on chemical usage.

During the demonstration months of August through the last week of November 2005, the wastewater flow rates were 250 l/s at the Newmarket LS and 477 l/s at the Aurora East/West Combined Magmeter. The treatment program levels tested during the demonstration with their corresponding dosage rates and time frames are shown in Table 1 below. The iron and peroxide doses chosen were based on baseline testing performed by US Peroxide and York Region in October 2004 and July 2005.

Table 1. PRI-SC™ Chemical Dose Rates

Treatment	FeCl2, LPD (GPD)	H2O2, LPD (GPD)	Time Frame
	Newmarket	Aurora	
Test A	1647 (435)	204 (54)	8/26/05-9/17/05
Test B	1457 (385)	170 (45)	9/18/05-10/7/05
Test C	1836 (485)	238 (63)	10/8/05-10/25/05
Test D*	1836 (485)	238 (63)	10/26/05-10/31/05
Test E*	1741 (460)	220 (58)	11/1/05-11/10/05
Test F*	1741 (460)	220 (58)	11/11/05-11/17/05
Test G*	1647 (435)	204 (54)	11/18/05-11/23/05

*Dosing set in profile mode

Over the course of the demonstration, a significant amount of data was collected, which allowed for a better understanding of the various zones in the collection system and how they react to the various treatment programs defined by Tests A, B and C and the subsequent profiled dosing Tests D, E, F and G. The Newmarket FM was expected to create 23.1 kg/day sulfide. The Aurora East and West lines were expected to create 49.9 kg/day and 41.7 kg/day sulfide respectively. The treatments used were chosen to be able to provide control for this amount of sulfide over the long durations in the forcemains. For example, wastewater traveling from the Newmarket PS along the Aurora East line was shown to take a minimum retention time of 12 hours with most of that time spent primarily in the forcemains.

Any upstream treatment on the Newmarket line needs to reduce the dissolved sulfide to levels below an average of 0.2 mg/L at the force main discharge in order to control the gaseous H2S to reasonably low levels (average <5 ppm) thereby reducing the odor problems at the golf course. The treatment needs to be able to maintain sulfide control over a long 3-7 hour period, which correlates to the calculated retention times in this section of forcemain before discharge to gravity.

With the long retention times in both the Aurora East and West lines, upstream treatment needs to be capable of maintaining control over a 10 to 12 hour period. This control needs to be maintained at the forcemain discharge of both the Aurora East and West lines in order to reduce the current high corrosion rates to an acceptable level as specified by York Region. Preliminary upper targets based on the measured baseline levels were to maintain an average liquid sulfide to less than 0.5 mg/L and an average gaseous hydrogen sulfide to less than 25 ppm. Lower targets were explored during the demonstration program in order to determine the cost effectiveness of the additional control.

The total mass in kg/day of gaseous sulfides released at the Aurora FM discharges is presented. These figures show that higher chemical levels have an increasingly positive impact on reducing the amount of H2S released per day. At Test C conditions a further 89% reduction of released H2S with all dissolved sulfides being released at the Aurora FM discharges prior to the Aurora Combined manhole is evident. The same is true for Tests D and G. Test G which utilized a 12 % reduction in chemicals from Test C while Test D utilized the same dosing rates. Tests D, E, F and G as mentioned prior, are profiled dose studies. Data presented shows profile dosing has succeeded in attaining equivalent or better sulfide reductions with 6-12% lower chemical usage than using a flat dose rate. What is interesting to note is that even though the amount of gaseous H_2S being released at the discharge structures is reduced by over 75% from Test A to Test C, the gaseous H2S levels measured by the Odalogs did not change significantly. This may be an indication that the Aurora East and West discharge structures are prone to gas build-up.

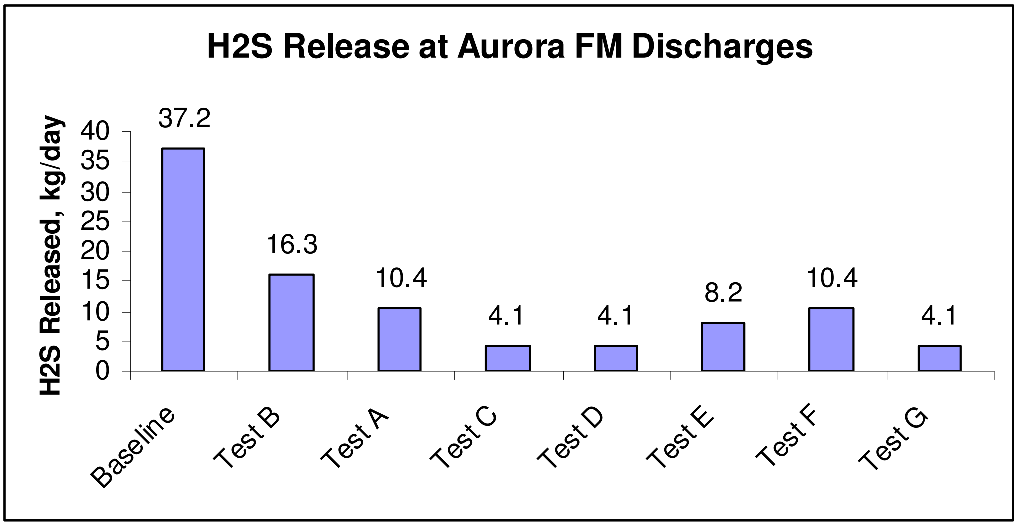

Figure 2. Gaseous H_2S Released at Turbulent Aurora Forcemain Discharges

Within 12 hours of initiating dosing, immediate reductions in both gaseous and liquid sulfide were measured at the various control points in the collection system. This is seen in the dramatic gaseous reduction at the Aurora Combined Discharge Manhole 42-09 just 12 hours after beginning chemical addition at Test A conditions. See Figure 3 Odalog Chart below.

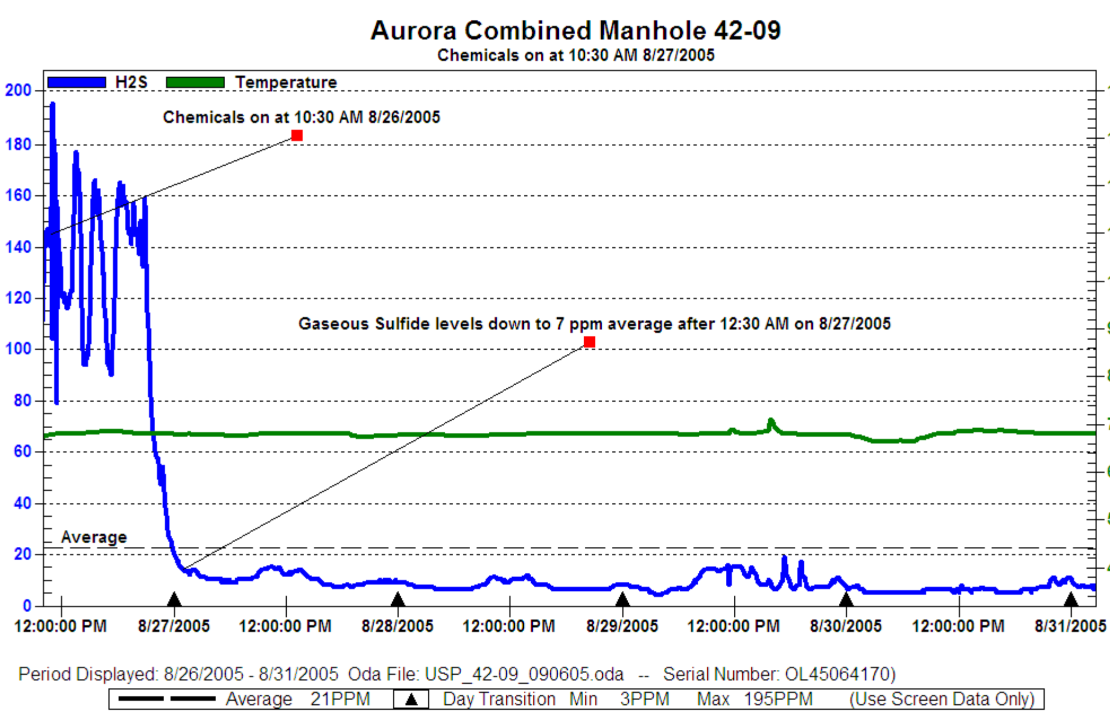

Figure 3. Gaseous H_2S Measured at Aurora Combined Forcemain Discharge

Liquid levels at all key control points were reduced to below 0.5 mg/L dissolved sulfide with most of the levels averaging 0.1 mg/L to 0.2 mg/L dissolved sulfide. This represented a reduction of over 70% and in many cases over 90% reduction in liquid sulfide levels. See Table 2.

Table 2. Dissolved Sulfide Levels

Dissolved Sulfide Levels, mg/L				
	75-07	**42-17**	**T9934-7AE**	**42-09**
No Treatment	0.5	1.3	1.5	0.5
Test B	0.1	0.6	0.6	0.2
Test A	0.1	0.3	0.4	0.1
Test C	0.0	0.1	0.1	0.0
Test D*	NA	0.1	0.2	0.0
Test E*	NA	0.2	0.2	0.0
Test F*	NA	0.3	0.1	0.0
Test G*	NA	0.1	<0.1	0.0

*Dosing set in profile mode

Gaseous H_2S levels at the Newmarket forcemain discharge were reduced from an average of 17 ppm down to a range of 0-2 ppm on average depending on the dosing condition tested. Gaseous H_2S at the problematic Aurora East forcemain discharge were reduced from an average of 170 ppm down to a range of 34-46 ppm depending on the dosing conditions tested. Gaseous H_2S at the problematic Aurora West forcemain discharges were reduced from an average of 184 ppm to a range of 39-51 ppm. Average gaseous H_2S levels at the Aurora discharges may be affected by stagnant air flow at the discharge structure and Odalog placement.

The liquid levels have been reduced down to 0.1 mg/L on average under some conditions, but the gaseous H_2S has maintained a level greater than 10 ppm which suggests the discharge structures are extremely turbulent and prone to gas buildup.

Gaseous H_2S levels at the Aurora combined discharge (Aurora East and West lines) were reduced from an average of 86 ppm down to a range of 0-7 ppm on average depending on the dosing condition tested. This location is close to the Aurora East and Aurora West discharge structures and is mainly comprised of their flow. The significant reduction of gaseous H_2S at this location further suggests that the numbers at the Aurora East and Aurora West forcemain discharge structures are a localized phenomenon.

As a secondary confirmation of the reduction of H_2S in the sewer, the use of sodium hypochlorite was reduced at Aurora PS scrubber. Table 3 is a summary of the percent reduction per day of sodium hypochlorite usage at the Aurora PS odor control scrubber system under several documented test conditions. At Test B conditions the average amount of sodium hypochlorite used was reduced by 18% and 31% at Test C conditions versus baseline with the program off. This data demonstrates reduction of hypochlorite with PRI-SC™ chemical addition and shows a response to dosage increase as well. Although this is only a little over one month of data it shows documented scrubber chemical reduction which is directly correlated to reduction of gaseous H_2S in the sewer.

Table 3. Aurora PS Scrubber Daily Sodium Hypochlorite Use

Treatment Program	**# Days**	**Avg L/day**	***% Cost Reduction***
Baseline Program Off	9	335	*0*
Test B	13	274	*18*
Test C	*14*	*231*	*31*

The corrosion rates of sewer pipes at different levels of gaseous and liquid sulfides are not easily quantifiable due to the many variables that can influence them in the specific collection system. Some of these variables include sewer pressures and airflow, pipe diameter, pipe material, slope, pH, wastewater velocity and the air gap in the pipe. These variables change from collection system to collection system and even within different sections of the same collection system. Figure 4 from the American Concrete Pipe Association shows the general relationship between dissolved sulfide, pipe diameter and concrete pipe life expectancy.

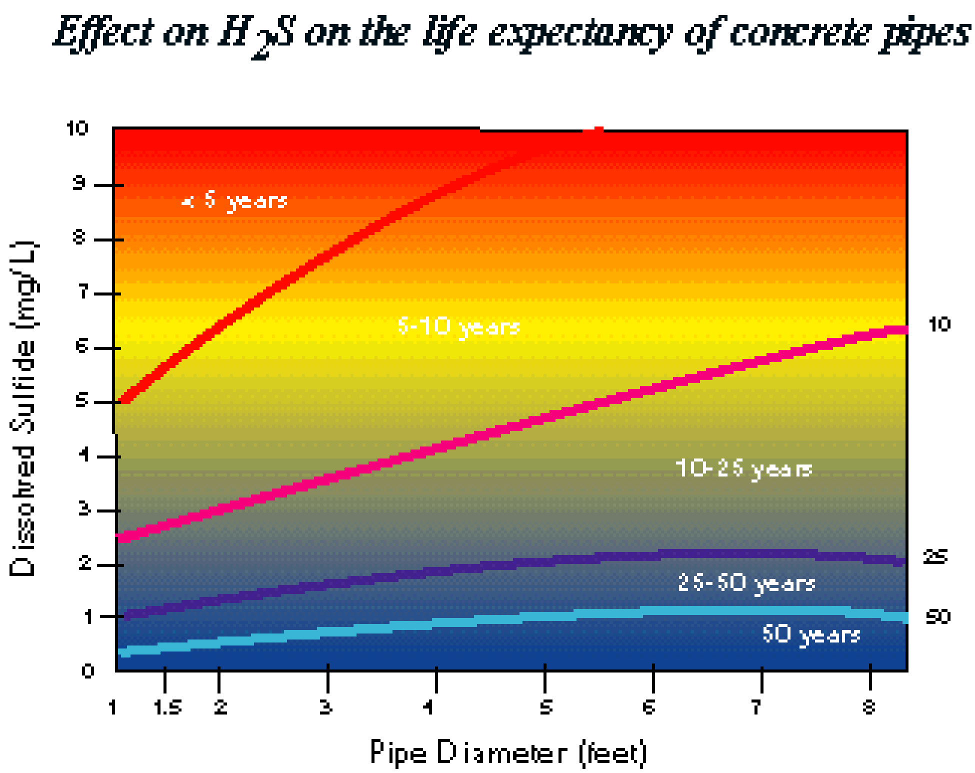

Figure 4. Effect of H_2S on Concrete Pipe (American Concrete Pipe Association)

Using this figure, reduction of the dissolved sulfides below 0.5 mg/L at the Aurora forcemain discharges will increase the service life from a range of 25 to 50 years to an expected life of 50+ years. Although this is semi-quantitative, it does give an idea of the potential service life extension of the York Region collection system through the reduction of dissolved sulfide in the wastewater. It is known that the lower the dissolved sulfide, the longer the expected life although Figure 4 cannot help quantify extension of service life below levels of 0.5 mg/L dissolved sulfide. York Region is currently conducting more detailed analysis that will quantify the cost of implementing a program such as PRI-SC™ versus the expected benefit of pipe service life extension and the subsequent delay of infrastructure expenditures, as part of their asset management odor and corrosion program.

Conclusion

The results of this trial showed that PRI-SC™ was able to provide significant reductions in H_2S levels in main target areas of Newmarket and Aurora. Liquid sulfide levels at all key control points were reduced to below 0.5 mg/L dissolved sulfide with most of the levels averaging 0.1 mg/L to 0.2 mg/L dissolved sulfide. Use of the Test G dose levels and profile during the peak loading months of June through early November should allow for maintaining the dissolved sulfide levels below 0.1 mg/L while optimizing the amount of chemical used. Future testing to determine the level of dosing required during the off-peak sulfide loading months between late November and May may be conducted in order to better quantify actual annual program costs. Future work to better quantify extensions in service life at different H_2S levels should also be explored. This could be done through more detailed sewer system modeling and through the use of coupon testing in the sewer system sections of interest.

Acknowledgements

We would like to thank the York Region co-op students Bryan Bingham, Melloney Syrotiuk and Sandrina Rodrigues for their efforts in field sampling in all weather conditions. The York Region operations staff for their continued assistance throughout the study, with special thanks to David Dion.

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American Concrete Pipe Association (ca. 1985)