INFRASTRUCTURE SUSTAINIBILITY:
EVALUATING SASKATOON'S 1912 INTERCEPTOR

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ABSTRACT

The City of Saskatoon's main Interceptor Sewer comprises some 10 km of sewer ranging in size from 600 to 2100 mm diameter and was built and commissioned in stages. The first stage was completed in 1912 to service the original town-site, but curiously wasn't commissioned when completed. The Interceptor wasn't actually put into service until 1948, after the construction of a comminuter/lift station facility and an outfall. The final stage of work was completed in 1970 which included a 4.5 km extension to a new activated sludge sewage treatment plant. The entire Interceptor was evaluated in 2005 as part of the City's on-going asset management program using the WRc approach and based upon findings from combined CCTV/Sonar inspections, manhole inspections, material testing, hydrogen sulphide monitoring and ventilation monitoring.

The purpose of this paper is to present an overview of the design and construction of the 1912 portion of the Interceptor and to show how historical investigations lead to a better understanding of the sewer's performance. Historical evidence was used to determine the materials and products integrated in the Interceptor and to determine construction techniques.

The staging of the Interceptor construction presented a somewhat unique situation in terms of assessing its performance and thereby forecasting its long term maintenance needs. In order to evaluate the current condition of the original 1912 portion of the Interceptor it was necessary to understand something about how it was designed and constructed. But more importantly, in order to forecast future maintenance and rehabilitation requirements it was necessary to understand how, and at what rate, the existing sewer might be deteriorating; and hence the need to confirm the delay between construction and commissioning.

Historical investigations enabled the engineering team to establish and confirm critical aspects of the age and life-expectancy of the sewer. This enabled the team to confidently forecast on-going maintenance needs. It also enabled the team to better evaluate performance and key characteristics of the sewer, such as joint condition, structural distress, deviations in longitudinal slope and corrosion impacts. Recommendations were made regarding maintenance issues and rehabilitation needs. Findings indicate that the 1912 Interceptor is in relatively good condition; with on-going maintenance the sewer is expected to provide useful service for many decades to come.

INTRODUCTION

The 1912 Interceptor comprises 48", 60", 66" and 72" (1200, 1500, 1650 and 1800 mm) diameter pipe as summarized in Table 1. The 1970 sections comprise 72” and 84” (1800 and 2100 mm) diameter pipe. The Spadina Lift Station is an on-line facility that lifts sewage approximately 15 m from the original outfall location adjacent to the river, to the upstream end of the new extension.

The assessment of the sewer was carried out in two steps. First a detailed internal inspection program, utilizing specialized inspection equipment, was undertaken to document existing field conditions. Second, a detailed review and assessment of the inspection findings was carried out in order to assign condition grades. It was during this later stage that historical issues were taken into consideration. Concrete cores and H_2S monitoring results were used to supplement inspection findings and refine condition assessment conclusions. Condition assessment rating and conclusions were based on the well-known WRC methodology.

Table 1 - Summary of Assessed Assets

Reach	Section	Description
1948 Interceptor	Avenue H to Avenue D MH 3914 to MH 632	600 mm pre-cast concrete pipe, installed in open cut
1912 Interceptor	Avenue D to Avenue A MH 632 to MH 2721	900 mm pre-cast concrete pipe installed in open cut
	Avenue A to 20nd Street MH 2721 to MH 3641	1200 mm pre-cast concrete pipe installed in open cut
	20nd Street to Queen Street MH 3641 to MH 1150	1500 mm pre-cast concrete pipe installed in open cut
	Queen Street to Lift Station MH 1150 to MH 3890	1650 and 1800 pre-cast pipe, installed in open cut
1970 Interceptor	Lift Station to Saguenay Drive MH 3924 to MH 3583	1800 and 2100 mm pre-cast concrete pipe and one 1800 mm concrete lined tunnel
	Saguenay Drive to Treatment Plant MH 3583 to MH 2802	1800 and 2100 mm pre-cast concrete pipe installed in open cut

CONSTRUCTION HISTORY

Overview

Age is a key characteristic when considering the condition of a sewer and is especially important when forecasting future rehabilitation needs and long term operating requirements. Since the goal of this study is to develop such long term needs then careful consideration of age is required.

Usually the age of a system is either well known or easily established. However, in the case of Saskatoon's original Interceptor there are two questions which effect the determination of age. Why was such an extensive system, including planned sewage treatment facilities, constructed in 1912 at what appears to be a premature stage in Saskatoon's development? And, given that the sewer was built, under what conditions was it not commissioned until 35 years later? Although the history of the sewer does not bear directly on its condition, it does provide useful context in which to consider the original design and construction and is therefore reviewed. Design and construction details for the 1912 Interceptor are discussed based on extant historical documents.

Since the original phase of the Interceptor wasn't commissioned until 35 years after it was built, two ages need to be considered depending on which aspect of sewer condition was under consideration. For example, corrosion due to hydrogen sulphide attack is a sewage related problem and hence doesn't become a factor until after the sewer was commissioned. Groundwater infiltration through joints, on the other hand is a factor to be considered right from the time the sewer was constructed. The relevance of age in assessing condition was fully considered in assigning condition ratings for each section of the sewer.

Historical Background

Saskatoon has seen numerous "boom and bust" cycles in its development. From the very beginning of Saskatoon's history, civic promoters and land speculators repeatedly overstated growth forecasts. A quote from "Saskatoon: A History in Photographs" provides a sense of this speculation:

"The population jumped from around 10,000 in 1909 to a staggering 28,000 by the end of 1912. The total assessed property value quadrupled to $36 million. Otherwise reasonably sober individuals were confidently predicting a city of 50,000 by 1915 and 100,000 by 1920. The Church Union Committee forecast a population of 65,000 by 1921, and no less a personage than the president of the university predicted that Saskatchewan as a whole would have 2,000,000 inhabitants by 1931" (O'Brien, Millar, and Delainey, publication pending).

Saskatoon in 1910

It is in this context of projected growth that in 1905 Mr. Willis Chipman, Consulting Engineer, was commissioned to prepare a sewerage, water and electric lighting master plan for the expanding town site (Board of Works Report, 1906 and O'Brien, 2006). Chipman's plan was based in part on earlier plans prepared by the City and was submitted in late 1906. Work began in 1907 on sewers in the central area of the city. A fully separate system of storm and sanitary sewers was adopted[a]. In keeping with the practise of the day, sanitary sewers simply discharged raw sewage directly to the South Saskatchewan River. Chipman made no provision for sewage treatment nor for a centralized discharge point.

But the unprecedented growth experienced between 1910 and 1912, coupled with extravagant population forecasts and new Provincial requirements for wastewater treatment, lead to a grander sewerage scheme. A report prepared in 1910 by the just-formed City Engineer's office outlined the details for an Interceptor Sewer and Sewage Treatment Plant. The Interceptor would collect flow from Chipman's local sewers and carry it to a central treatment facility. The treatment plant would treat the sewage to meet Provincial guidelines prior to discharge to the South Saskatchewan River. The system was designed to accommodate an ultimate population of 150,000 people based on a daily sewage generation rate of 70 gallons per capita. The interceptor was laid out along the west and north bank of the river commencing at the planned treatment works (0.5 mile north of 33rd Street) and terminating at Avenue H at 11th Street (a schematic plan illustrating construction staging of the Interceptor is shown in Figure 1). Initially it was planned to stop the Interceptor short at Avenue D; the extension to Avenue H would occur later. Two river crossings were also planned in 1910; one at Lorne Avenue and one at 14th Street. The estimated cost of the interceptor was $300,000. A further $92,000 was estimated for the treatment works. Construction commenced on the Interceptor in 1911 and was completed in December 1912.

While the Interceptor Sewer was being installed through 1912 the economy began to turn down. Plans were started for the treatment works and construction of the plant was expected to start in 1913 (Department of Main Drainage, 1912). But by 1913 the City government was experiencing serious financial difficulty; by 1914 it was approaching bankruptcy. The value of building permits issued in the City illustrates the severity of the downturn; between 1912 and 1915 values plummeted from $7,640,000 to a mere $20,000 (Kerr and Hanson, 1982). In the same period the City's payroll was cut in half. Virtually overnight, the City found itself unable to proceed with the treatment works as planned and also found itself saddled with an un-useable sewer.

For the next three decades the sewer remained unused. In 1942 the Interceptor was extended from Avenue D to Avenue H in order to reduce the risk of contamination of the water treatment plant intake (City Engineer’s Annual Report, 1942). Since the Interceptor still had not been commissioned, a temporary outfall directly to the river was constructed at Avenue A. The Interceptor was then put into service from Avenue H to Avenue A. A year later (1943) the balance of the interceptor, which remained unused, was pumped out, cleaned and joints repaired. In response to an injunction by the Rural Municipality of Cory (RMC) to restrain the dumping of raw sewage into the river, the City entered into negotiations with the Provincial Department of Health to select a method and timing for full sewage treatment.

The complaints from RMC appear to have been more related to objectionable floating material in the river, and on the shore at low flow, than with low dissolved oxygen or high bacteria counts in the river. As a result, in 1944 the Province agreed to the installation of partial treatment, in the form of comminution, in order to break up solids to mitigate the immediate problem. Plans for a lift station/comminution facility were prepared in 1945 and construction started the next year. The station was completed and put into service, together with the 35-year old Interceptor, in 1948. A considerable percentage of flow, especially during periods of peak flow, was by-passed without treatment due to lack of capacity (a problem that wasn’t rectified until the station was expanded in 1970).

On July 17, 1951, petroleum dumped in the sewer system caused an explosion in the lift station which destroyed the superstructure and several mechanical systems. Although some damage occurred in the substructure, it was repaired and retained when the lift station was re-constructed.

As the City’s population grew, plans were developed to provide more substantive sewage treatment. Various treatment methods, sites and collection system expansion options were considered by the City through the 1960's. A final scheme was selected in 1970 which involved the northerly extension of the Interceptor and the construction of a conventional activated sludge treatment plant.

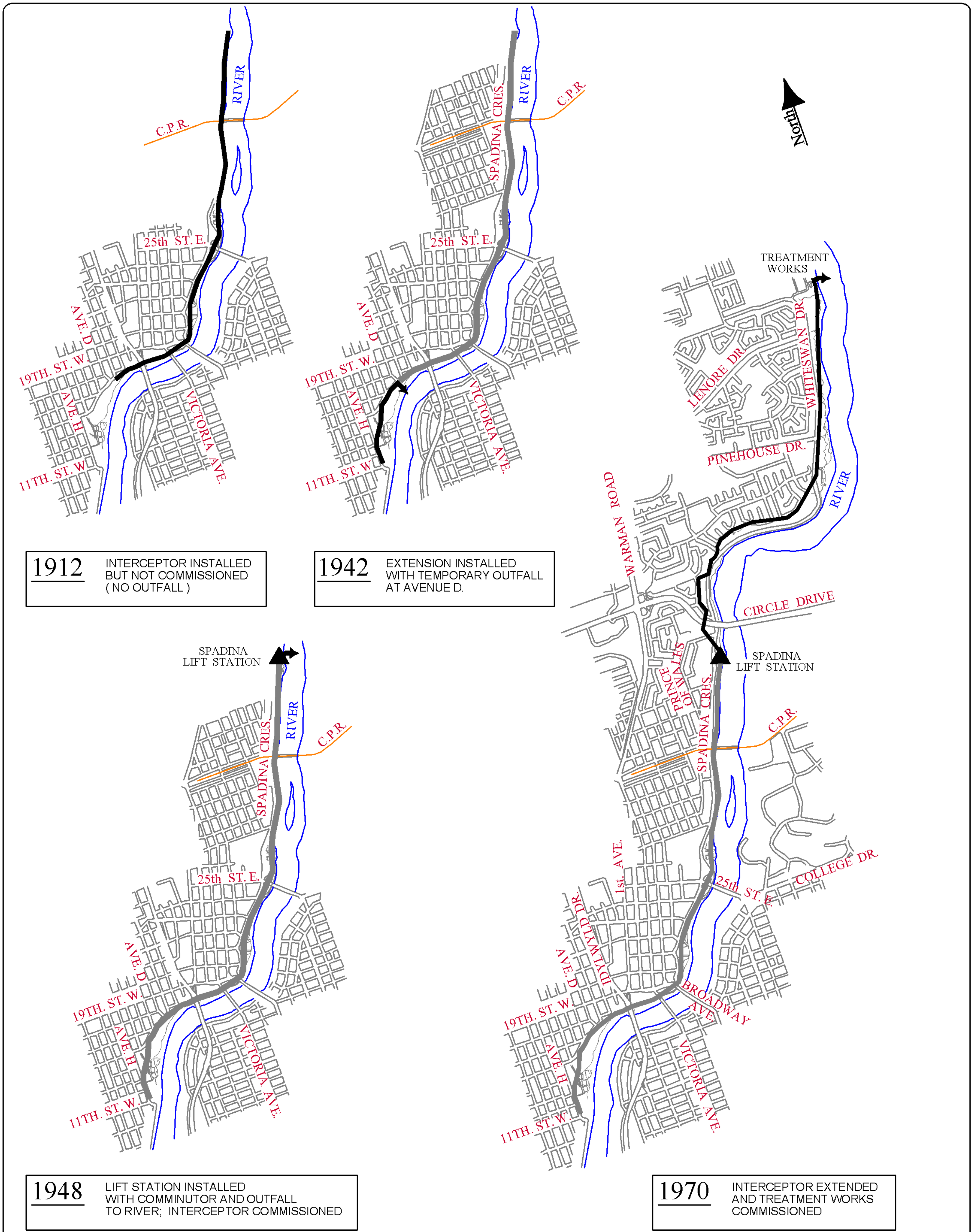


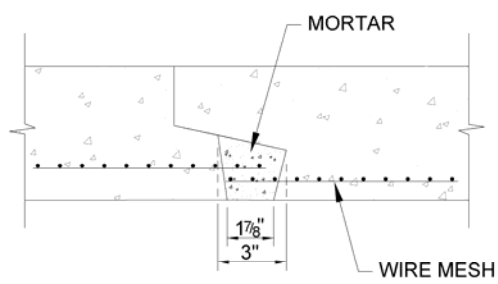
FIGURE 1
INTERCEPTOR
CONSTRUCTION STAGING

2005-S2

INTERCEPTOR DESIGN AND CONSTRUCTION

Pipe

The Interceptor comprises reinforced, pre-cast concrete pipe.[b] The pipe was fabricated on site in accordance with the specifications shown in Table 2 using aggregate crushed from boulders found locally. Pipe walls were reinforced using "triangular wire mesh" in the weights shown in the table. An ashpaltic coating was applied to the exterior of all pipes prior to installation (see Photograph 1). The Engineer's report indicates that this was done as protection against "alkali which appeared at several points along the sewer." The specifications indicate that the pipe was to be laid with the spigot end pointing toward the outfall (City Engineer's Report, 1912).



1912 JOINT DETAIL

Joints were formed using a bell and spigot arrangement. The spigot was nominally 1 7/8" shorter than the bell; the reinforcing mesh was allowed to protrude out of the pipe walls into the resulting gap at the joint. The mesh was meant to be wired together within the gap, before mortar was placed, to "lock" the joint (Agreement, 1912).

Mortar was trowelled into the joints in the lower half of the pipe (up to the springline level). According to the project specifications a steel band was to be placed around the entire interior perimeter of the joint to act as a form to hold grout in the upper "arch" portion. The mortar was to be placed through an opening in the crown of the pipe. The 1912 Engineer's report indicates that the contractor had considerable difficulty in making good joints, however. The wire mesh in the joints wasn't always tied together, mortar was often placed the upper portion by trowel (rather than using the steel bands) and it was difficult to thoroughly clean mud and debris out of the lower portion of the joint (due to the wire mesh). During cold weather, the contractor installed temporary bulkheads and stoves in the sewer in order to allow the joints to set-up more quickly.

Photograph 1-1

Lowering 1800 mm (72”) pipe into trench, bituminous coating clearly visible

Photograph 1-2

Trench with 1200 mm (48”) pipe in place; native bedding around pipe; backfill being placed

Photograph 1-3

Typical manhole installation with native bedding (on1500 mm pipe)

Table 2 1912 Pipe Specifications

Nominal Diameter	Wall Thickness	Pipe Length	Minimum Weight of Steel (lbs per square foot)
36"	4"	3' or 4'	0.6
48"	5"	3' or 4'	0.6
60"	6"	3' or 4'	n.a.
66"	6 ½"	3' or 4'	0.9
72"	7"	3' or 4'	1

Installation

The sewer was installed completely in open trench with little need for trench bracing or sheeting. Sheeting was left in place at the downstream end of the pipe to form a bulkhead (City Engineer's Report, 1912). The pipe was bedded using native backfill material which was placed in thin, well compacted layers to a level at least 12" above the crown of the pipe. Above that, backfill material was allowed to be thrown into the trench with less control (see Photograph 2).

The Engineer's Report notes that during the initial stage of construction of the interceptor, the invert was laid with a slight longitudinal unevenness. This was apparently due to the contractor not shimming the pipe to compensate for the tolerance in the bell and spigot. The contractor corrected this problem by temporarily inserting a plank under each pipe during installation.

Three pieces of pipe were damaged by boulders dropped on them while backfilling the trench. The contractor repaired these pipes by casting a concrete cradle between the pipe and native trench walls and by placing a 6" thick concrete cap over the fractured pipe. The engineer's report does not indicate the precise location of these pipes.

Manholes

Manholes were installed at changes in alignment and at locations of incoming sewers. The manholes were made using standard 42" diameter pipe sections turned on end (see Photograph 3). At changes in sewer size, a reinforced, cast-in-place manhole base was constructed to form a transition.

1970 Segment - Design and Construction

The 1970 Interceptor comprises 1800 and 2100 mm diameter reinforced, precast concrete pipe installed in open cut with the exception of one tunnelled section. The 447 m long tunnelled section comprises a 1800 mm diameter, un-reinforced, cast-in-place concrete liner. The precast pipes correspond to conventional CSA standards (Class III, IV and V pipe in accordance with then current Standards). Conventional bell and spigot joints with asphaltic sealant was applied throughout.

PREVIOUS INVESTIGATIONS

Two earlier reports commented on the condition of the Interceptor. The following information was taken into consideration:

1944 City Engineer's Report

Repairs were carried out on the Interceptor in 1943 and 1944. The City Engineer reports that once the Interceptor was pumped out and,

> *"cleared of large deposits of mud which had accumulated in it over many years it was found that its condition was much better than anticipated. All joints and other bad places in the pipe have been repaired......."* (City Engineer's Report, 1944).

Unfortunately the City Engineer didn't document what condition was originally anticipated.

1968 Pollution Control Study

The operation of the Interceptor upstream of the Spadina Lift Station was investigated during preparation of the 1968 Report on Pollution Control (Report on Pollution Control, 1968). At that time (that is, prior to expansion of the station and extension of the Interceptor to the new treatment plant) it was found that the Interceptor usually operated in a surcharge condition due, in part, to the then inadequate capacity of the pumping station. This resulted in regular overflow of daily peak flows to the river and significant sustained overflows during wet weather. A profile of the Interceptor showing hydraulic gradients corresponding to minimum and peak daily flows was prepared which also noted sites of observed sediment deposits.

It was found that solids were depositing in the Interceptor due to continuous high water levels in the sewer and regular surcharging. It was recommended that the sewer be cleaned when the station's capacity was increased and the new Interceptor extension built.

INSPECTION FINDINGS AND CONCLUSIONS

The investigations addressed 9,800 m of pipeline and 52 chambers; 6,357 m was inspected using combined CCTV and Sonar equipment and 2,385 m using Sonar alone. All inspection data was compiled and reviewed using standard WRC practices. In addition 24 concrete cores were extracted at selected locations from the interior of the sewer.

Inspection and evaluation revealed that the Interceptor is generally in fair condition, but that there are sections in poor or bad condition that require near-term attention. Those sections found to be in fair condition were rated that way primarily due to light to moderate corrosion effects or heavy sediment deposits. Upstream of the Lift Station (1912 segments) four sections were rated in poor condition due to structural deficiencies and a portion of one section in bad condition due to constraints created by a storm sewer crossing. Downstream of the lift station (1970 segment) two sections were rated in poor condition due to moderate to heavy hydrogen sulphide related corrosion.

The sewer was generally found to be operating well and was typically 50% full except upstream of Avenue D and between Queen Street and the lift station. Upstream of Avenue D the sewer was found to contain heavy sediment deposits, has sluggish flow and was flowing near full. Between Queen Street and the lift station significant sediment deposits were observed and the depth of flow was found to progressively increase due to a surcharge condition at the lift station.

Evaluation of the extracted cores indicate that the concrete and reinforcing steel is generally in good condition with little surface damage, except in areas of corrosion. In these areas up to 25 mm of concrete deterioration, or loss, was observed. Reinforcing steel has also been corroded and de-bonded in areas of deepest penetration. Preliminary structural evaluation shows that notwithstanding the corrosion damage, the sewer retains structural capacity sufficient to resist current loading with adequate factors of safety. However, structural robustness is substantially reduced in the one area where there is exposed reinforcing steel and hence rehabilitation in this area is warranted in the very near term.

Recommendations were grouped into three categories. The first category included matters of high importance for which urgent, or higher priority attention, is required. These include the rehabilitation of a large junction chamber and a 208 m length of 1800 mm pipe and the development of a comprehensive corrosion management strategy. The second category included items of lesser urgency but for which planning should begin in the short term. These include isolated structural repairs, improvements to some crossings and improvements at the lift station in order to address the observed surcharging. Finally, the third category addressed items of a generally routine nature including various maintenance and operations issues.

REFERENCES

Agreement (between City and Lock Joint Pipe Company). 1912, pg. 12.

Board of Works Report (February 1906, file D500.I.12), and from personnel communication with Jeff O’Brien, City Archivist, memo dated February 6, 2006.

City Engineer’s Reports. 1912, 1944

Engineer’s Report (to the City Engineer), Dept. of Main Drainage, 26 Dec 1912, pg. 1.

Kerr, Don, and Stan Hanson, “Saskatoon: The First Half-century,” NeWest Press, Edmonton, 1982. Pg 118.

O’Brien, Jeff, Ruth Millar and William Delainey, "Saskatoon: A History in Photographs," Coteau Books, Regina, publication pending.

Report on Pollution Control, 1968, pg. 42.

ENDNOTES

[a] Through the late 1800's significant advances were made in Canada in the way of improved sanitary conditions; by 1910 sewers had become rather popular. Larger eastern cities were starting to service better neighbourhoods and real estate developers pushed for servicing of new lands in order to entice their potential homebuyers. But even the largest cities had difficulty financing such projects. For example, after decades of failed attempts due to lack of funds, the City of Toronto finally proceeded with construction of a Main Drainage system and treatment facility in 1910. In spite of its small population base, Saskatoon proceeded with construction of a comprehensive separate sewer system in advance of many larger, established cities. Perhaps such a sophisticated system was perceived as essential to attracting new homesteaders to the new city.

[b] Information regarding design and construction of the interceptor is from the Dec 1912 City Engineer’s Report and from the Agreement between the Corporation of the City of Saskatoon and Lock Joint Pipe Company dated 24 October 1912.