Coxwell Sanitary Trunk Sewer Emergency Repair: By-pass Sewer Tunnel Construction Update

Date: February 25, 2013
To: Public Works and Infrastructure Committee
From: General Manager, Toronto Water
Wards: Ward 29
Reference Number: P:\2013\Cluster B\TW\pw13002

SUMMARY

This report provides an update on the progress made in the construction of a permanent by-pass tunnel around the damaged section of the Coxwell Sanitary Trunk Sewer (CSTS). The report also provides information on challenges experienced during construction that have delayed completion of the project, and the emergency measures which have been implemented to help mitigate the impacts in the event of a partial or complete failure of the CSTS prior to completion of the permanent by-pass construction.

RECOMMENDATIONS

The General Manager, Toronto Water recommends that:

1. Public Works and Infrastructure Committee receive this report for information.

Financial Impact

There are no financial implications resulting from receipt of this report.

DECISION HISTORY

City Council at its meeting of January 27 and 28, 2009, authorized the General Manager, Toronto Water, to retain the various professional and engineering consultants and to procure the various goods and/or services to undertake the engineering design and the construction of physical works to support the implementation of emergency works necessary to address the damaged section of the CSTS. The General Manager was also authorized, subject to certain conditions, to negotiate, and execute on behalf of the City
the terms of these agreements with such consultants. A copy of the Council Decision Document can be found at:

At the May 20, 2009, Public Works and Infrastructure Committee the General Manager, Toronto Water, presented an information report providing an update on the progress made in contingency planning, activities and various options being considered in advancing the work required to address the damaged section of the CSTS. A copy of the report can be found at:

At the October 6, 2009, Public Works and Infrastructure Committee the General Manager, Toronto Water, presented a follow up information report on the progress made on the various activities being undertaken to address the damaged section of the CSTS and the selection of a by-pass tunnel as the permanent solution. A copy of the report can be found at:

At the May 18, 2010, Public Works and Infrastructure Committee the General Manager, Toronto Water, presented a report on the progress made on the various activities being undertaken to address the damaged section of the CSTS, and the contract award for the by-pass sewer tunnel. A copy of the report can be found at:

At the May 16, 2012, Public Works and Infrastructure Committee the General Manager, Toronto Water, presented a report on: progress made in the construction of a permanent by-pass tunnel around the damaged section of the CSTS; challenges experienced during construction that have delayed completion of the project; and emergency measures implemented to mitigate the impacts in the event of a partial or complete failure of the CSTS prior to completion of the permanent by-pass construction. A copy of the report can be found at:

ISSUE BACKGROUND

During an inspection of the CSTS, significant damage was found to about 60 metres of pipe located beneath Barbara Crescent, north of the intersection of Coxwell Avenue and O’Connor Drive. While the initial inspection, as well as subsequent additional inspections, of the sewer shows that it is working as it should, with no backups or flow restrictions, the severity of the observed distress is such that the potential for blockage cannot be ruled out should there be further deterioration or a collapse of the sewer.

As reported to Public Works and Infrastructure Committee on October 6, 2009 staff explored and evaluated a number of temporary and permanent by-pass options while also continuing to monitor the status of the CSTS. Given the associated site constraints, high flow conditions, and timelines and costs, it was concluded that temporary measures or internal repairs were not feasible and that a permanent by-pass tunnel around the
damaged section of the CSTS, extending from about the confluence of the Don River and Taylor-Massey Creek to the intersection of Coxwell Avenue and O'Connor Drive, should be designed and constructed as expeditiously as possible. A design-build approach was selected to reduce the delivery schedule by overlapping the design and construction phases of the by-pass. The consulting engineering firm Hatch Mott MacDonald (HMM) was retained, through a competitive process, as the Owner’s Engineer, to act as an agent on behalf of the City, to prepare a preliminary design for the by-pass, and to administer the design-build contract.

In parallel, work also proceeded, on an emergency basis, on the implementation of monitoring programs to detect changes in the condition of the CSTS, and on measures to control the discharge of sewage and help mitigate the environmental impacts in the event the CSTS were to collapse.

COMMENTS

The following presents an update on the construction of the permanent by-pass tunnel (the By-pass) on challenges experienced during construction that have delayed completion of the project.

As reported on May 3, 2010, a design-build contract was awarded to McNally Construction Inc. (McNally) on February 26, 2010, in the amount of $31,229,500.00 (net of GST/HST). McNally began detailed design immediately and began construction on April 9, 2010.

The permanent by-pass construction associated connections (around the distressed area of the existing CSTS) have now been completed. This consisted of three basic components (refer to Attachments 1 and 2):

i) Entry Shaft: 10 metres deep located in Taylor Creek Park and represents the site where a tunnel boring machine (TBM) was launched and where a permanent diversion connection was made to the existing CSTS (i.e., the upstream connection point);

ii) Tunnel: 510 metres of segmented concrete-lined 2.7 metre diameter tunnel which by-passes the damaged section of the CSTS; and

iii) Exit Shaft: 42 metres deep located at the northwest corner of the intersection of Coxwell Avenue and O'Connor Drive, and represents the site from which the TBM was retrieved and where the permanent connection was made to the existing CSTS (i.e., the downstream connection point). Photos of various phases of work undertaken at this location are presented in Attachments 3, 4 and 5 and include: a) the removal of the top half of the CSTS and the installation of a temporary flume (steel section of pipe); b) the construction of a tunnel extension section; and c) the removal of the temporary flume, and installation of a concrete encased, steel diversion elbow.

The schedule, contained in McNally’s design-build proposal, indicated that construction of the By-pass was to be completed by January, 2011. While the noted Tunnel component of the By-pass and virtually all the work that could be completed at the Entry
Shaft was completed in 2011, construction was hampered at the Exit Shaft. The entire project was delayed due to unforeseen construction difficulties and challenging ground conditions at the Exit Shaft location. Extra time and precautions have been taken during construction at this location due to its close proximity to the damaged section of the CSTS, and to existing homes and infrastructure.

Since the May 16, 2012, Public Works and Infrastructure Committee Meeting, a second element of By-pass construction was successfully completed at the Exit Shaft on October 24, 2012. As was the case for the Entry Shaft, this involved careful removal of the top half of the concrete-walled CSTS at the base of the 42 metre deep Exit Shaft, and installation of a temporary flume (steel pipe used to maintain continuous flow while allowing demolition and preparatory work for the permanent connection) within the existing CSTS using innovative techniques under live flow conditions. This then allowed demolition of the lower portion of the existing CSTS in order to construct an extension of the Tunnel up to a point where a prefabricated steel elbow was used to make the final diversion connection. The Tunnel extension was completed on February 1, 2013. The final two live connections, at the Entry Shaft and Exit Shaft respectively, to divert the sanitary flow into the newly constructed Tunnel and by-pass the damaged section of the existing CSTS were made essentially simultaneously on February 21, 2013. The temporary steel flumes were sequentially removed and replaced by the permanent diversion elbows during early morning hours of low flow, at which point the by-pass became operational and this aspect of the project substantially completed.

**Construction Delays**

The Exit Shaft was constructed directly over top of the existing CSTS and is 42 metres in depth. Unforeseen construction difficulties and challenging ground conditions have significantly delayed the Exit Shaft portion of the Project.

**Unforeseen Construction Difficulties**

There have been a number of unanticipated delays to the project schedule caused by site conditions, mechanical issues, and safety concerns which included the following.

- An abandoned, buried, pumping station at the Exit Shaft was deeper than assumed, as there were no as-built drawings on record. A complex shoring system was utilized to demolish and remove the pump station. This required additional time and effort and also pushed shaft construction into the winter season, further impacting the construction schedule.
- The specialized excavator used to construct the concrete slurry walls of the Exit Shaft experienced numerous mechanical breakdowns.
- To reduce the risk of collapse of the CSTS, the Exit Shaft walls extended close to, but did not connect with, the CSTS - leaving a gap between the two structures. An initial attempt to seal this gap via jet grouting was made, but unfortunately a solid seal was not possible as originally planned, possibly due to unanticipated timbers and debris left in place when the original sewer was constructed. A second round of jet grouting was needed to successfully seal the gap above the springline (centreline) of the sewer.
- A defect in one of the concrete wall panels of the Exit Shaft was discovered immediately above the CSTS, which allowed the passage of water and sand into the...
shaft once the defect was exposed by excavation. Work had to be stopped on two occasions, for safety reasons, and additional time was required to develop solutions to this problem.

- Excavation within the Exit Shaft took longer than expected because of the dense soil and soilcrete left by the jet grouting process for ground control purposes, at the base of the Exit Shaft.
- The Exit Shaft is located in close proximity to the damaged section of CSTS and excavation techniques had to be limited to medium-to-light duty to minimize the risk of damage to the existing sewer.
- Once the excavation of the Exit Shaft proceeded and exposed the CSTS below the springline it became apparent that a solid seal had not been achieved on the underside of the sewer with the jet grouting. Additional measures were implemented – these are discussed in the next subsection.
- Since the Exit Shaft was not ready in time to receive the TBM, the schedule had to be reworked in order to extract the TBM and mitigate risk of damage to, or loss of, this expensive equipment, in advance of completing construction of the Exit Shaft.
- As a consequence of issues at other tunnelling projects within the Province of Ontario, the Ministry of Labour (MOL) re-examined practices it had previously accepted as safe and no longer accepted such practices. Through no fault of its own, McNally had to implement additional safety measures on this project in order to comply with this change in MOL enforcement practices. This included the construction of a manway (ladder) to permit emergency egress of workers from the bottom of the exit shaft, and required nine weeks during which no work could be performed.

**Challenging Ground Conditions**

The ground at the base of the Exit Shaft where the existing CSTS is placed consists of fine-grained sand/silty-sand in a pressurized aquifer. Excavation in this layer without any ground control measures could result in an uncontrolled flow of these sands, which could trigger ground subsidence above.

Unfortunately, a solid seal between the CSTS and the Exit Shaft concrete walls, to prevent ground intrusion into the Exit Shaft, took much longer than anyone had expected and required measures in excess of those originally planned, due to the challenging and sometimes unpredictable nature of the ground, and potentially due to remnant construction materials/methods from the original construction of the sewer. Given the risk ground subsidence represented to workers, and infrastructure and structures on the surface, every precaution was taken in excavating near the existing CSTS, within the Exit Shaft.

After the failure of the jet grouting to provide a solid seal, a number of ground control options were examined by McNally and it’s engineering consultants and geotechnical engineering specialists, and by the City’s Owner’s Engineer. Given the available geotechnical information, it was decided that dewatering of the aquifer in combination with permeation grouting of the ground surrounding the CSTS within the Exit Shaft would be implemented. Other options for ground control were available, but they were discounted due to the length of time required to implement (none offered a guarantee of
ground control). Upon installation of the dewatering system, an extensive sodium silicate grouting program was begun, where the sodium silicate, a low-viscosity chemical grout, was used for control of water inflow and ground stabilization in fine sands. The sodium silicate solution penetrates into fine pores within the sands, and reacts with a catalyst to harden and block passage of water. Over a period of three months, roughly 20,000 litres of sodium silicate was systematically injected at various pressures into the ground surrounding the CSTS via 30 injection ports. Dewatering assisted in reducing the pressure resisting the inflow of the sodium silicate grout. Once a solid seal was created between the CSTS and the Exit Shaft, remaining excavation of the exit shaft could proceed without the risk of ground loss.

**Remaining Work**

Now that the By-pass is operational, a thorough manual inspection of the damaged section of the CSTS will be undertaken, to determine the extent of and method of stabilizing the damaged section, to prevent a collapse of the old sewer, which could result in ground subsidence and risk of damage to infrastructure and structures on the surface. Once the damaged section is deemed safe, probing for and grouting of any voids in the soil surrounding the sewer will be undertaken. Finally, the entire length of the by-passed sewer will be completely filled with concrete to stabilize the sewer and surrounding ground. It is anticipated that this work will be completed by the fall of 2013.

Work has begun on building the permanent structures above the by-pass connections to the surface at the Entry Shaft and Exit Shaft. Work will then begin to restore the Entry and Exit Shaft sites, followed by landscaping of the two areas. The landscaping will follow the landscape plans which have been developed for both sites, in conjunction with staff from Parks, Forestry and Recreation and a group of local residents. The landscaping is expected to be completed in the summer of 2013, as seasonal planting conditions permit.

**Update on Additional Activities and Expenditures**

The following provides an update on additional activities and expenditures identified in the previous Staff Reports.

**Easements**

The proposed alignment is located within property owned by the Toronto and Region Conservation Authority (TRCA) Hydro One Networks Inc., and two private property owners. Staff carried out the necessary negotiations to secure these necessary easements.

**Emergency Contingency Measures**

All the emergency modifications to the Don Sanitary Trunk Sewer system to help mitigate the impacts in the event of a partial or full collapse of the CSTS have been implemented. An Emergency Response Plan was developed by Toronto Water in consultation with the City’s Office of Emergency Management and the Ontario Ministry of the Environment, to address various scenarios. Staff responsible for the implementation of the Plan have been trained and briefed on roles and responsibilities,
have participated in mock scenarios; and have been mobilized on site during key events, including the installation of the temporary flumes and the permanent diversion elbows in the Entry and Exit Shafts.

The design of emergency treatment works within the Keating Channel consisting of: disinfection equipment; spill containment booms to capture floatables; a submerged curtain wall to contain settled sludge; dredging to remove settled sludge; and skimmers to remove floating debris has been completed. Provisions have been made for the implementation and operation of these works, should they be necessary.

**Monitoring Program**

A comprehensive monitoring program was implemented when the damage to the CSTS was discovered, consisting of flow level, ground subsidence, and sewer condition monitoring, to track any changes associated with the damaged CSTS, and to help provide early warning should conditions deteriorate. The flow level monitoring program has shown conditions to be stable with no deterioration in system hydraulics. The data obtained from the ground monitoring has not indicated any large scale movement, however, slight, gradual settlement at the surface above the damaged section of the CSTS has been observed since the monitoring program began. Periodic re-inspection of the damaged section of the CSTS indicates that the condition of the CSTS is stable despite two seismic events (earthquakes) however, further deterioration is occurring.

Settlement and vibration monitoring have been carried out adjacent to the By-pass construction sites since this work began. Records of this monitoring demonstrate that both settlement and vibration levels have been well within acceptable limits and that construction of the By-pass is not the source of the observed settlement mentioned above. The records also validate that the measures taken to control the difficult soil and groundwater conditions have proven effective and the delays were justifiable.

**Communications with Local Residents, Regulatory Agencies and City Divisions**

Regular contact has been maintained with local residents, Councillors and other impacted City Divisions to inform them of the situation and ongoing activities. The City’s Office of Emergency Management – Emergency Management Working Group Meetings continue to include the CSTS as an agenda item.

Also, ongoing dialogue is being maintained with the Ontario Ministry of the Environment and the Toronto and Region Conservation Authority.

**Procurement of Services**

To date, Purchase Orders, including amendments, to a total amount of $39,060,518.16 (net of GST/HST) have been issued to obtain professional engineering, legal, and construction services to perform necessary emergency work required as a direct result of the damaged CSTS. Federal Infrastructure Stimulus Funding of $9,659,072 has been provided to support the construction of the By-pass. The following summarizes the procurement of goods and services, supporting the construction of the By-pass and the implementation of emergency contingency measures, to date (net of GST/HST):

b) Screening analysis of available options - $156,912.27 (MMM Group Ltd.).

c) Property condition assessments and settlement monitoring above the damaged CSTS - $400,000 (MMM Group Ltd. using Golder Associates as the geotechnical sub-consultant); amended for an additional $300,000 in 2010 to extend the assignment during construction; and amended for an additional $200,000 in 2012 to account for the delays in completing construction.

d) Geotechnical investigation and assessment of permanent relief sewer constructability - $184,239.45 (MMM Group Ltd. using Golder Associates as the geotechnical sub-consultant).

e) Preliminary design of temporary sewage by-pass pumping system - $127,331.64 (R.V. Anderson Associates Ltd.).

f) Inspection of other priority/critical trunk sewers in the City's system and screening of unsolicited repair offers - $290,000 (Andrews Infrastructure); amended for an additional $280,632.42 for additional inspections of the CSTS during construction. A further $21,485 was spent on inspections of the CSTS during construction after the original Purchase Order to Andrews Infrastructure was exhausted due to construction delays.

g) Review of alternative by-pass/treatment options - $497,700 (CH2M Hill Canada Limited); amended for an additional $40,000 for pilot testing of trash nets; and amended for an additional $46,668.82 for refinement of conceptual designs.

h) External legal services - $313,663 (Borden Ladner Gervais LLP).

i) Flow level monitoring upstream and downstream of damaged section of CSTS - $351,100.00 (Clarifica Inc.).

j) Expenditures for emergency measures associated with within the Keating Channel $1,022,665.40.

k) Construction of Massey Creek Sanitary Trunk Sewer Emergency Overflow - $240,171.43 (Utility Force Inc.).

l) Supply of galvanized 70 ft. span portable panel bridge - $97,038.88 (Acrow Bridges).

m) Competitively-bid consultant assignment for preliminary design of the CSTS By-pass Tunnel, and contract administration services during detailed design and construction of the By-pass Tunnel - $1,324,648.00 (Hatch Mott MacDonald).

n) Design-Build of the permanent By-pass Sewer Tunnel around the damaged section of the CSTS - $31,229,500.00 (McNally Construction Inc.).

o) Subsurface location of CSTS - $10,185.73 (TSH/TBE Subsurface Utility Engineers).

p) An Owner Controlled Insurance Program, implemented by the City to reduce the perceived risks of the By-pass construction, through our broker - $1,303,500.88 in premiums paid up to December 14, 2012 (Marsh Canada Limited).

q) Abandonment of the damaged CSTS can likely be accommodated within the contingency allowances in the Owner's Engineer assignment to Hatch Mott MacDonald and the Design-Build assignment to McNally (see items m) and n) above).

r) Services for easement negotiation and registration related to By-pass Sewer Tunnel - $25,395.24 (Facilities & Real Estate Division).
s) Miscellaneous costs including permits, payments to property owners for construction access, archaeological review, etc. - $440,000

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SIGNATURE

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Lou Di Gironimo
General Manager, Toronto Water
Attachment 1 - Schematic Diagram of CSTS Permanent By-pass Tunnel
Attachment 2 – Three-Dimensional Rendering of the CSTS Permanent By-pass Tunnel
Attachment 3 – Photos Taken at the Exit Shaft During Temporary Flume Installation

Photo a) Removing the third segment (27,000± pounds) from the top half of the CSTS

Photo b) Inserting the temporary flume into the CSTS at the Exit Shaft
Attachment 4 – Preparatory Work for Casting of the By-pass Tunnel Extension to Permit Connection with the CSTS with a Concrete Encased Steel Diversion Elbow

Photo c) Forming the Tunnel Extension
Photo d) Preparing to Cast the Tunnel Extension

Coxwell Sanitary Trunk Sewer Emergency Repair:
By-pass Sewer Tunnel Construction Update
Attachment 4 – Installation of Diversion Elbows at the Entry Shaft and Exit Shaft to Complete the Permanent By-pass

Photo e) Installation of the Permanent Diversion Elbow at the Entry Shaft
Photo f) Installation of the Permanent Diversion Elbow at the Exit Shaft