Demolition Orchestra: The removal of a bridge in a weekend

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Abstract

Demolishing a major piece of infrastructure can be as significant as constructing it. Reverse engineering each stage of the unbuilding of a major piece of infrastructure is required to have a controlled demolition process. Effective traffic management and work zone coordination is critical to ensure safety for all involved workers and roadway users.

As part of Metrolinx's Scarborough Subway Extension project, the Scarborough Centre Station (SCS) will be built adjacent to Scarborough Town Centre in Toronto. A post-tensioned bridge at the project site infrastructure needed to be demolished to create sufficient space for the new station. The removal of this bridge carrying a 6-lane arterial roadway was executed over 72 hours.

The Progress Avenue Bridge, constructed in 1984, was evaluated at each phase of the demolition to ensure each section, including the longitudinal and transverse post-tensioned cables, could be contained and removed safely. Traffic diversions and transit detours were coordinated with the municipal and provincial roadway authorities due to its proximity to a major highway, multiple bus operators due to its proximity to a major bus terminal, and adjacent property owners due to its proximity to the Town Centre commercial properties. Clear demarcation and separation of work zones were implemented to safeguard the public and prevent spectators from trespassing. Utility coordination took place with municipal and third party utility owners to protect services.

The result was a coordinated choreography of twelve excavators and 960 work hours to demolish and remove 3000 cubic metres of concrete, all implemented safely and with minimized environmental impact. The rubble was removed and recycled within this period and the roadway below was open to traffic once more at the end of the 72-hour closure.

1 Structural Demolition

As part of Metrolinx's Scarborough Subway Extension project, the Scarborough Centre Station (SCS) will be built adjacent to Scarborough Town Centre in Toronto. The construction of the SCS required the demolition of several existing civil structures, including Progress Avenue Bridge.

The Progress Avenue Bridge, constructed in 1984, was evaluated at each phase of the demolition to ensure each section, including the longitudinal and transverse post-tensioned cables, could be contained and removed safely. Traffic diversions and transit detours were coordinated with the municipal and provincial roadway authorities due to its proximity to a major highway, multiple bus operators due to its proximity to a major bus terminal, and adjacent property owners due to its proximity to the Town Centre commercial properties. Clear demarcation and separation of work zones were implemented to safeguard the public and prevent spectators from trespassing. Utility coordination took place with municipal and third party utility owners to protect services.

The demolition of civil structures in the Scarborough Centre Station area is broken up into several demolition stages, as follows:

1.1 Demolition Stage 1 – Superstructure Demolition Pre-Work

This Demolition Stage included the full closure of Progress Ave. in both directions from Grangeway Ave. to the McCowan Rd. Off-Ramp, but with existing traffic patterns maintained on McCowan Road. The purpose of this demolition stage was to perform all possible work related to the Progress Ave. Bridge superstructure demolition that can be done prior to the full closure of McCowan Rd. during the long weekend closure. Tasks included in this stage are:

- Remove Progress Ave. street lighting on/near bridge.
- De-energize lighting on underside of Progress Ave. bridge
- Remove signage on Progress Ave. on/near bridge.
- Sample conduit in south sidewalk wall for asbestos.
- Provide for noise and dust control in accordance with Project Agreement and City ordinances.
- Set up lighting for nighttime operations.
- Stage materials in preparation for full closure of McCowan Rd. and sidewalks (e.g. detour signage, barricades, fencing, cones, concrete barriers, variable message signs, etc.)

1.2 Demolition Stage 2 – Superstructure and Center Pier Demolition

This stage included the full closure of Progress Ave. in both directions from Grangeway Ave. to the McCowan Rd. Off-Ramp (as with the previous demolition stage), along with the full closure of McCowan Rd. in both direction from Triton Rd. to Corporate Drive. One southbound lane of McCowan Rd. remained open north of the bridge for access from the north to the McCowan Rd. Off Ramp to Progress Ave./Mall Access Road. The duration of the closure was kept to one long weekend, with McCowan Rd. reopened to full traffic at the end of the closure. The purpose of this demolition stage was to fully remove the bridge superstructure and the center pier columns.

The largest and most complex of the structure demolitions in this package was removal of the Progress Avenue bridge superstructure over McCowan Road. This bridge was a two-span, post-tensioned concrete superstructure, with separate superstructures for eastbound and westbound Progress Avenue. The substructures were reinforced concrete abutments on piles and a center pier comprised of six 1.2m diameter circular concrete columns (made integral with the superstructure) on spread footings (one

footing for each superstructure). The bridge length was 59m (29.5m each span) and the total bridge width was 30.1m. The bridge was on a curve, with a radius of 260m.

There were grouted longitudinal and transverse post-tensioning cables in the superstructure. Cutting of the longitudinal or transverse tendons embedded in the deck could damage portions of the structure that are not being worked on. Uneven removal of one portion of the structure changes the internal forces in the remaining structure, which have been designed for the completed structure. However, concerns about the post-tensioning were alleviated by the fact that:

- no portion of the structure was in service while other portions are being demolished
- the entire structure was being demolished
- sequential demolition of the superstructure by conventional methods (excavators equipped with hydraulic breakers, typically) in narrow strips on all spans of the bridge was a safe and viable method for superstructure demolition within the available work window.

Figure 1. Progress Ave. Superstructure Demolition Plan

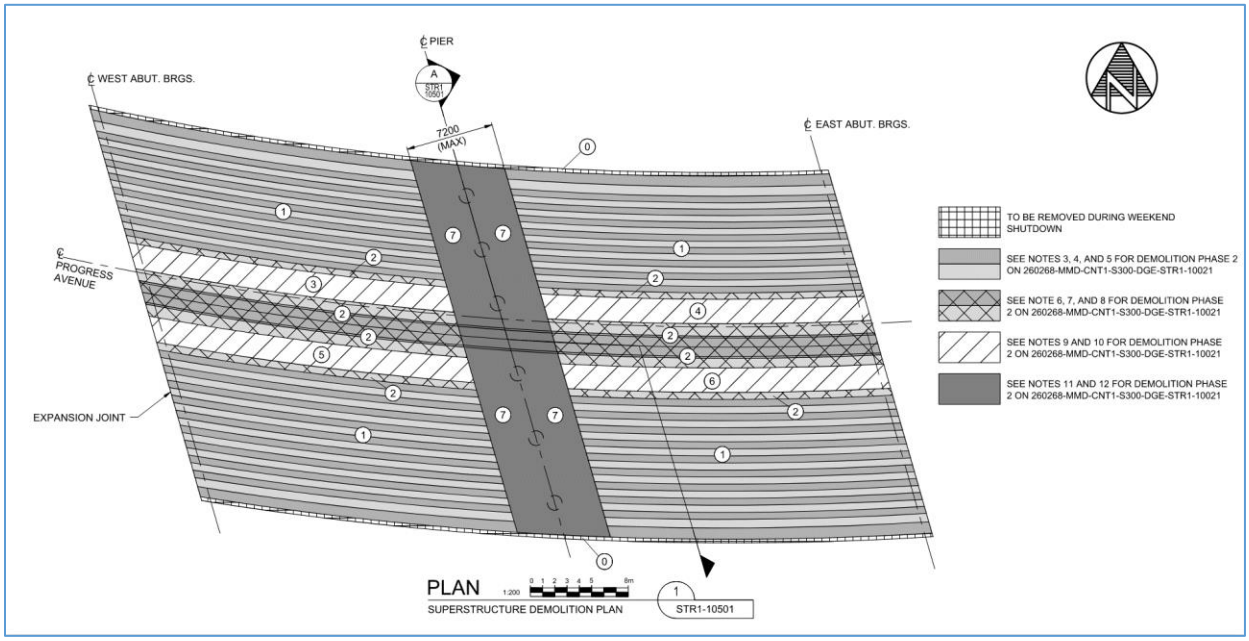
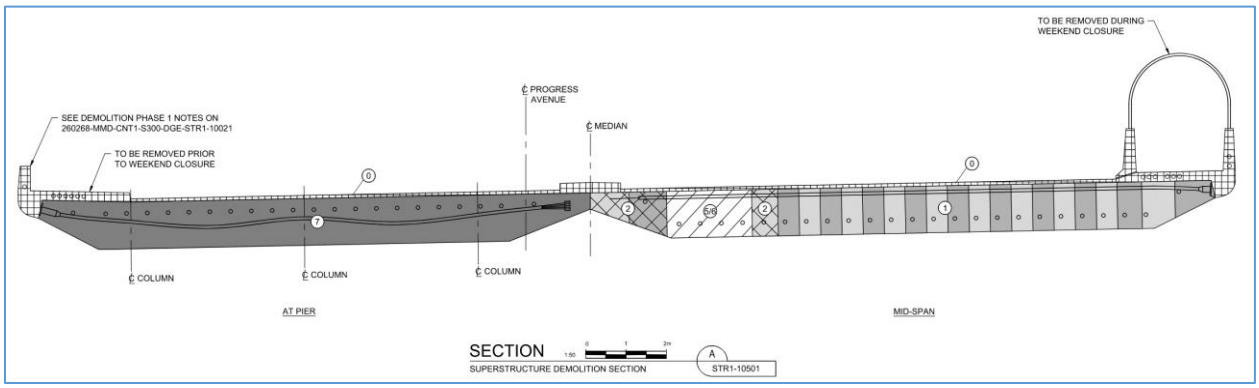


Figure 2. Progress Ave. Superstructure Demolition Section



The basis of demolition presented in this paper was an assumed demolition sequence. At each of the assumed stages of demolition shown, the remaining structure was checked for stability and capacity.

1.2.1 Demolition Sequence:

- Place layer of fill on McCowan Rd. for protection of pavement. Fill layer was estimated to be 600mm thickness of sand material. Demolition contractor determined the exact requirements based on means and methods that were employed.
- Provided for noise, dust, and vibration control in accordance with Project Agreement and City ordinances.
- Provided two excavators per span, per side (8 total), on McCowan Rd. at each fascia of the bridges. Excavators were equipped with hydraulic breaker attachments, to demolish the eastbound and westbound Progress Ave. bridges, working from the fascias, moved toward the center joint between bridges.

- Excavators were also equipped with grapple, pulverizer, crusher, shear, or grabber attachments, as needed.
- Demolition proceeded evenly and simultaneously along the length of each span (to the existing expansion joints at the west and east abutments) and across the width of each span. One-metre wide increments were marked out in spray paint on the bottom and top of the superstructure to aid in even demolition progress. Portions of the superstructure to remain in place until a later stage of demolition were clearly marked out as well.
- When the excavator was able to safely reach the median from reaching over the superstructure, it began removing the median overhang on each span of each bridge. The excavator removed the overhang and the two strands closest to the median.
- Once the median overhang was completely removed, the excavator continued demolishing the span from the point it left off.
- The final portion of the deck was removed was approximately 1050mm wide and was bounded by the two strands approximately 2182mm and 3212mm from the median joint. Temporary shoring, or support by crane, of the remaining span was used to prevent large sections of the span from dropping in an uncontrolled manner, in order to prevent unsafe dropping of the slab. Personnel, equipment, and the roadway surface remained protected at all times. (Typical, each span, each bridge.)
- Once the first span was removed, remove the final deck section in the second span of each bridge.
- When the only remaining portion of the superstructure was left over the pier, it was demolish along the pier transversely with four excavators on the east side of the pier and four excavators on the west side of the pier, evenly and simultaneously removing concrete and transverse tendons over the pier. Temporary shoring of the remaining pier and superstructure was required, dependent on the contractor's means and methods.
- Removed the center pier columns to roadway elevation.
- Additional excavators, dump trucks, and other equipment were on site to cycle in and remove debris away from bridge.
- Continuous operations, using lighting for nighttime work, was conducted until bridges were removed.
- Removed all debris and protective layer on McCowan Road.
- Cleaned up of McCowan Rd., made repairs/replacement to concrete barriers and pavement surface.
- Removed road closure, reopened McCowan Road to pre-existing traffic conditions.

1.3.1 Structural Checks

The bridge was checked for stability against collapse at various stages of demolition. As each strand was removed, it was assumed that the closest remaining strand would require to take the additional load. Therefore, individual strands were checked as demolition progresses across the spans. See Figures below for location and size of sections checked on both the north and south bridges.

Figure 3. North Bridge Checked Sections

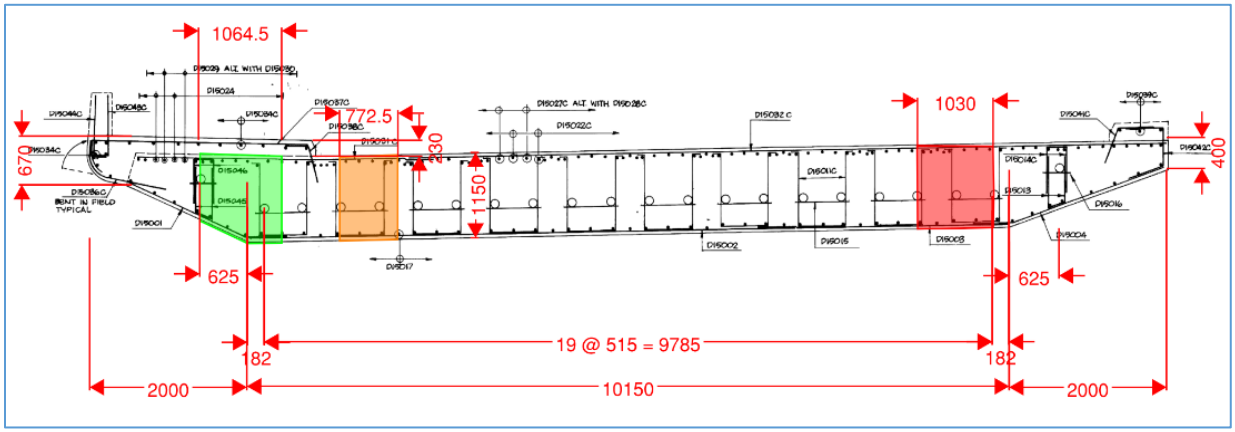
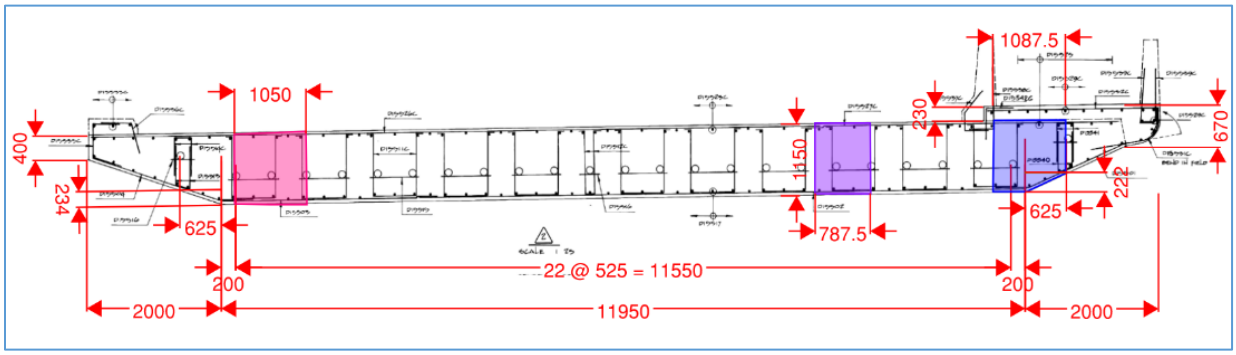


Figure 4. South Bridge Checked Sections



It was assumed that when the final section of each bridge remained, it was removed in Span 1 first, so Span 2 became a simple span. Under this condition, the following checks were completed:

- The final section as a simple span in both the north and south bridges.
- The moment connection between the deck and the pier column.
- The additional moment and shear created in the deck spanning across the pier columns.
- The additional moment and axial forces created in the pier columns.

The calculations showed that the remaining structure (including the remaining post-tensioning tendons) has sufficient strength to resist self-weight gravity loads during each stage of the demolition. Calculations are included as an appendix to this memo.

1.3 Demolition Stage 3 – Removal of Abutments and Stairs

1.3.1 Demolition Stage 3A – East Abutment and Southeast Stair Removal

This stage had three southbound and two northbound lanes open on McCowan Rd., however Progress Ave., Bushby Drive Off-Ramp to McCowan Rd., and Progress Ave. Off-Ramp to McCowan Rd. were all fully closed. In this stage, the entire east abutment, east abutment pile cap, southeast stairways, and southeast stairway pile caps were fully removed. Existing piles were cut off and buried, to be removed as part of the station box excavation. Demolition of the abutment could be conducted from Progress Ave. from behind the existing abutment, or from in front of the existing abutment. The far right northbound lane of McCowan Rd. (closest to the shoulder barrier and east abutment) was closed as part of this traffic control stage, and pedestrian traffic was closed on the east side of McCowan Rd. from

Bushby Drive to Progress Ave. Off-Ramp. A pedestrian detour during this stage used Bushby Dr. (east) and Grangeway Ave. (north) to Consilium Place.

1.3.2 Demolition Stage 3B – West Abutment and Southwest Stair Removal

This stage had three southbound and two northbound lanes open on McCowan Rd., however Progress Ave., Bushby Drive Off-Ramp to McCowan Rd., and Progress Ave. Off-Ramp to McCowan Rd. were all fully closed. In this stage, the entire west abutment, west abutment pile cap, southwest stairways, and southwest stairway pile caps were fully removed. Existing piles were cut off and buried 2.4m below finished grade. Demolition of the abutment could be conducted from Progress Ave. from behind the existing abutment, or from in front of the existing abutment. A protected pedestrian walkway was provided along the west side of McCowan Rd. for pedestrian traffic between Triton Rd. and Corporate Drive.

1.4 Demolition Stage 4 – Progress Avenue Off-Ramp and Pedestrian Underpass Demolition

This stage had three southbound and two northbound lanes open on McCowan Rd., however Progress Ave., Bushby Drive Off-Ramp to McCowan Rd., and Progress Ave. Off-Ramp to McCowan Rd. were all fully closed. In this stage, asphalt was stripped from the ramp roadway structure, and the ramp area was excavated and re-graded. There was a reinforced concrete pedestrian underpass structure under the Progress Ave. Off-Ramp, which connected the east side of McCowan to Consilium Place. The underpass structure had a 4.0m clear span, approximately 4m rise, and was 8.2m long. The structure also included curved retaining walls and wingwalls on all four quadrants. This structure was excavated and demolished by conventional methods. The existing backfill behind the existing abutments was excavated down to the bridge footings prior to the deck removal since the abutment could not resist the backfill earth pressure without the deck in place.

2 Diversion and Detours

Traffic diversions and transit detours were coordinated with the municipal and provincial roadway authorities due to its proximity to a major highway, multiple bus operators due to its proximity to a major bus terminal, and adjacent property owners due to its proximity to the Town Centre commercial properties. Clear demarcation and separation of work zones were implemented to safeguard the public and prevent spectators from trespassing. Utility coordination took place with municipal and third party utility owners to protect services.

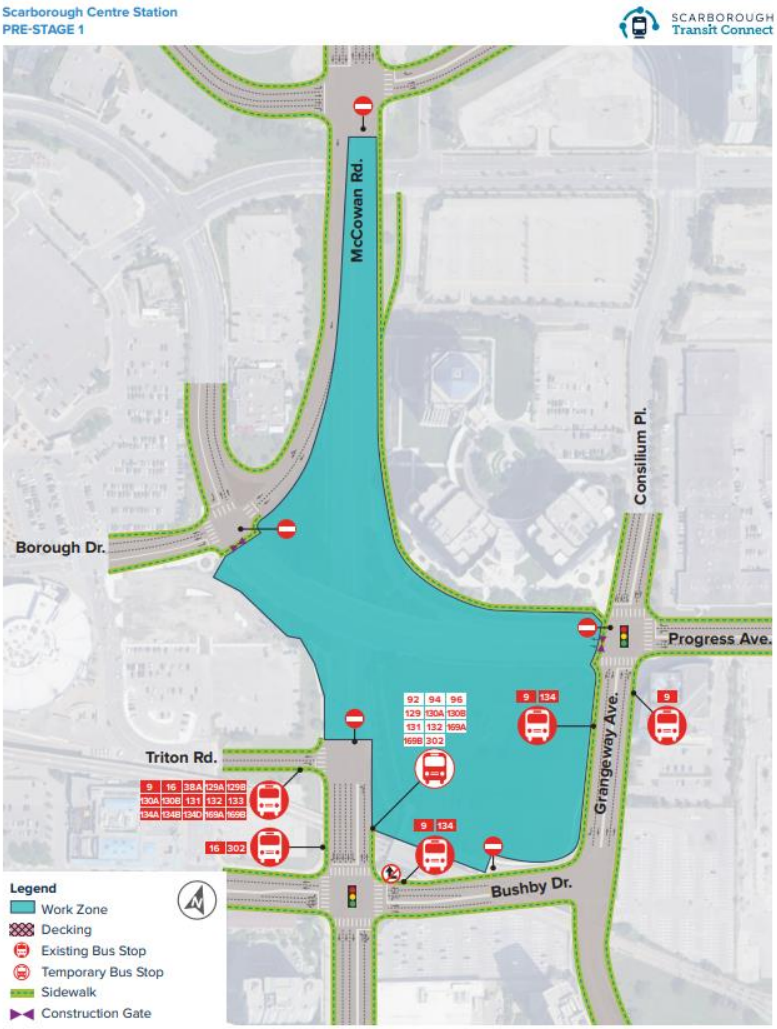
2.1 Traffic Staging

Pre-Stage 1 Traffic Staging is the traffic arrangement for the demolition and removal of the following structures:

- Progress Avenue Bridge over McCowan Road – deck, superstructure, and centre pier columns

This stage involved the long-term, full closure of Progress Ave. from Grangeway Ave. to the McCowan Rd. Off Ramp, and the short-term (one long weekend), full closure of McCowan Rd. from Triton Rd. to Consilium Place and is shown in Figure 5.

Figure 5. Traffic Pre-Stage 1



Pre-Stage 1 of SCS construction focused on the demolition of the Progress Avenue bridge deck, superstructure, and center pier. Due to the size, type, and complexity of the existing structure, full closure of McCowan Road was required during a long weekend to facilitate demolition of this bridge. Once the superstructure and pier was been demolished, traffic on McCowan Road was restored.

The demolition plan for the Progress Avenue Underpass superstructure and center pier was comprised of two main phases: a pre-work phase and then the full McCowan Rd. closure phase. In the pre-work phase, all bridge demo tasks that could be completed with the full closure of Progress Ave. (but with regular traffic on McCowan Rd.) was completed in advance of a weekend closure of McCowan Rd. The full McCowan Rd. closure phase was when traffic will be closed completely in both directions, from Triton Rd. to Consilium Place, for Labour Day long weekend. A protective layer of fill was placed on McCowan Rd. and the superstructure and center pier was demolished. McCowan Rd. was cleaned up and re-opened to normal traffic by the end of the long weekend. Erosion and sediment control measures applied.

The Pre-Stage 1 plan also included establishing work zones and laydown areas to support future construction stages. Detour routes were designated to ensure continued functionality of traffic during

the demolition process. Bushby Drive Channelized Right Turn Lane & Progress Avenue Channelized Right Turn Lane were both permanently closed in Pre-Stage 1 and scheduled to be removed in Stage 1. Progress Avenue was closed between Grangeway Avenue and McCowan Road Off-Ramp/Mall Access Road. Temporary construction signage was installed along Progress Avenue, Bushby Drive, Grangeway Avenue and McCowan Road as per the Ontario Traffic Manual (OTM) Book 7. At the intersection of Bushby Drive/Town Centre Road and McCowan Road, the northbound lanes at the south side of the intersection was rearranged and follow layout UI-16 and Table 3.6 from (OTM) Book 7. This was required as the previous design did not allow compliant turning movements for control vehicles (WB-20) in the NBL and SBL direction.

Toronto Transit Commission (TTC) bus stops and platforms were relocated to maintain existing bus service to the vicinity. Sidewalks and pedestrian crosswalks were maintained on all four quadrants of the intersection of Bushby Drive/Town Centre Road and McCowan Rd., as well as the southwestern quadrant of McCowan Road and Triton Road. The sidewalk at the northwestern quadrant of this intersection was closed to mitigate pedestrian incidents with the ongoing work zone. Signage were proposed at the northwest quadrant at the intersection of Bushby Drive/Town Centre Road and McCowan Rd. notifying pedestrians of the sidewalk closure to the north. The bus stop located on the south side of Triton Rd. remained fully functional and accessible. During the demolition of existing structures and excavation of the station box, there was no pedestrian access allowed on the existing sidewalk on the east side of McCowan Rd. from Bushby Drive to Progress Ave Off-Ramp exiting to McCowan Road. To ensure pedestrian safety and convenience, a temporary detour route has been established on the east side of McCowan Road. Pedestrians traveling from the intersection of Bushby Drive/Town Centre Road and McCowan Road to Consilium Place are directed to follow this designated detour.

Modifications to existing traffic signals and new temporary traffic signal equipment were proposed for the following intersections during Pre-Stage 1 and Stage 1, to accommodate the modified lanes and allowed turning movements:

- McCowan Rd. and Bushby Dr./Town Centre Crt.
- McCowan Rd. and Triton Rd.
- Progress Ave. and Mall Access Rd./McCowan Rd. Off Ramp
- Progress Ave. and Grangeway Ave./Consilium Place

2.1.1 Roadway Detour

Roadway vehicle and bus detours were established to maintain traffic flow and functionality throughout Pre-Stage 1. Vehicles traveling northbound on McCowan were detoured west on Ellesmere Rd., then north on Brimley Rd., and then east on Sheppard Ave. to tie back into McCowan Rd. For vehicles traveling southbound on McCowan this process was reversed. Vehicles affected by the Progress Ave. closure utilized Corporate Dr. in both eastbound and westbound directions. Progress Ave., between the Mall Access Rd./McCowan Rd. Off-Ramp and Corporate Dr., remained open to avoid restricting access and negative impacts to Jack Astors and businesses of Scarborough Town Centre.

2.2 Stage 1

Stage 1 Traffic Staging was the traffic arrangement for the demolition and removal of the following structures and roadway surfaces:

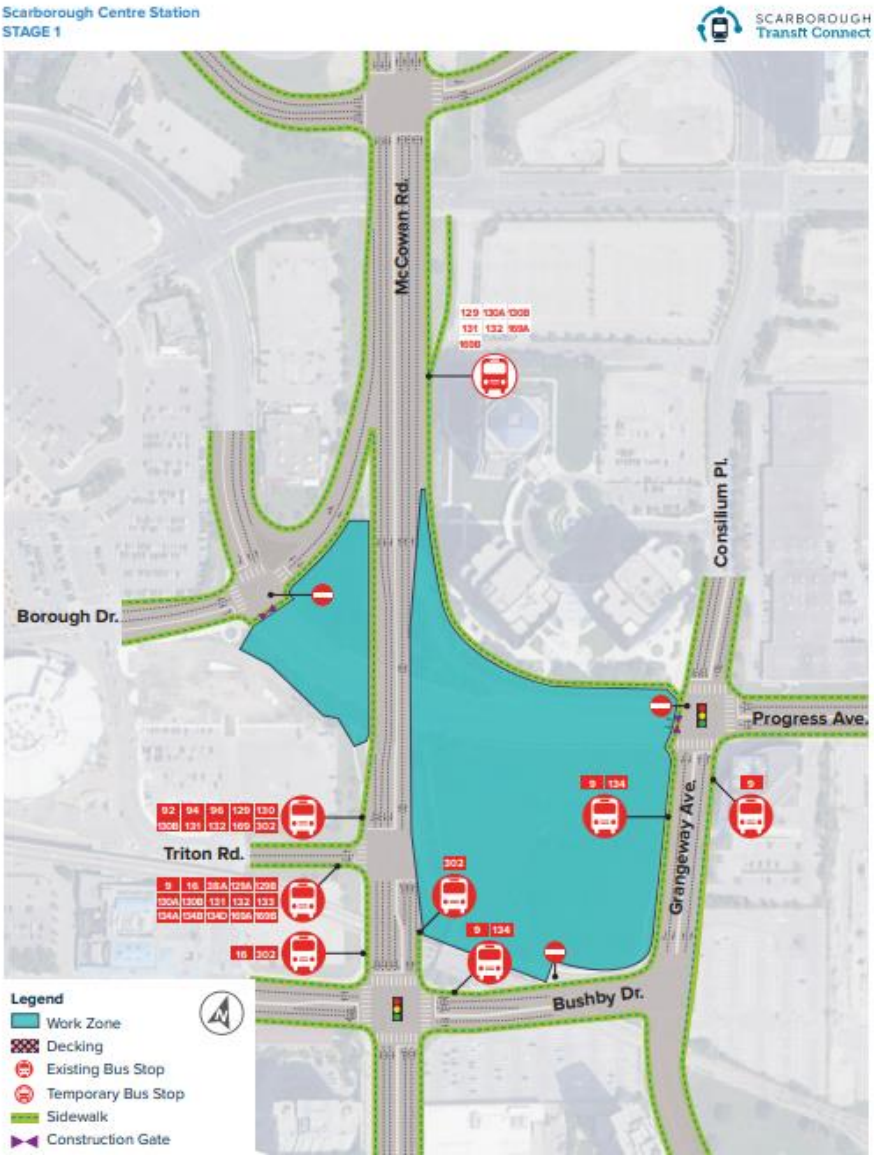
- Progress Avenue Bridge – Abutments and adjacent stair structures
- Progress Avenue Ramp Channelized Right Turn Lane to McCowan Rd.

- Progress Avenue Ramp Pedestrian Underpass

Stage 1 of SCS construction focused on the demolition of the Progress Avenue Bridge abutments including adjacent stair structures. The roadways and associated structures of Progress Avenue Channelized Right Turn Lane and Bushby Drive Channelized Right Turn Lane were also removed in this stage.

In this stage, McCowan Road was reopened for both northbound and southbound traffic, while Progress Avenue will remain closed in accordance with the previous stage. Temporary construction signage continued to be placed along Progress Avenue, Bushby Drive, Grangeway Avenue, and McCowan Road, following the guidelines outlined in the OTM Book 7. Stage 1 is shown in Figure 6.

Figure 6. Traffic Stage 1



To ensure uninterrupted bus service in the area, TTC bus stops were relocated and platform areas provided. Sidewalks and pedestrian crosswalks maintained on all four quadrants of the intersection of Bushby Drive/Town Centre Road and McCowan Road, as well as the western quadrants of McCowan Road and Triton Road. Temporary sidewalk detours along the west side of McCowan Road were enclosed, providing protection from the demolition activities. Pedestrian access is still not allowed on the sidewalk located on the east side of McCowan Rd. Pedestrians are still to follow the detour from the previous stage to reach Consilium Place from the intersection of Bushby Dr./Town Centre Rd and McCowan Rd.

The work conducted during this stage included the removal of the Progress Avenue Bridge abutments and pile caps. Additionally, the southeast and southwest pedestrian covered stairways between McCowan Road and Progress Ave. were removed. Following these tasks, the demolition of the Progress

Ave. ramp and pedestrian underpass structure took place, along with the removal of the Bushby Drive channelized right-turn ramp and associated structures.

2.2.1 Roadway Detour

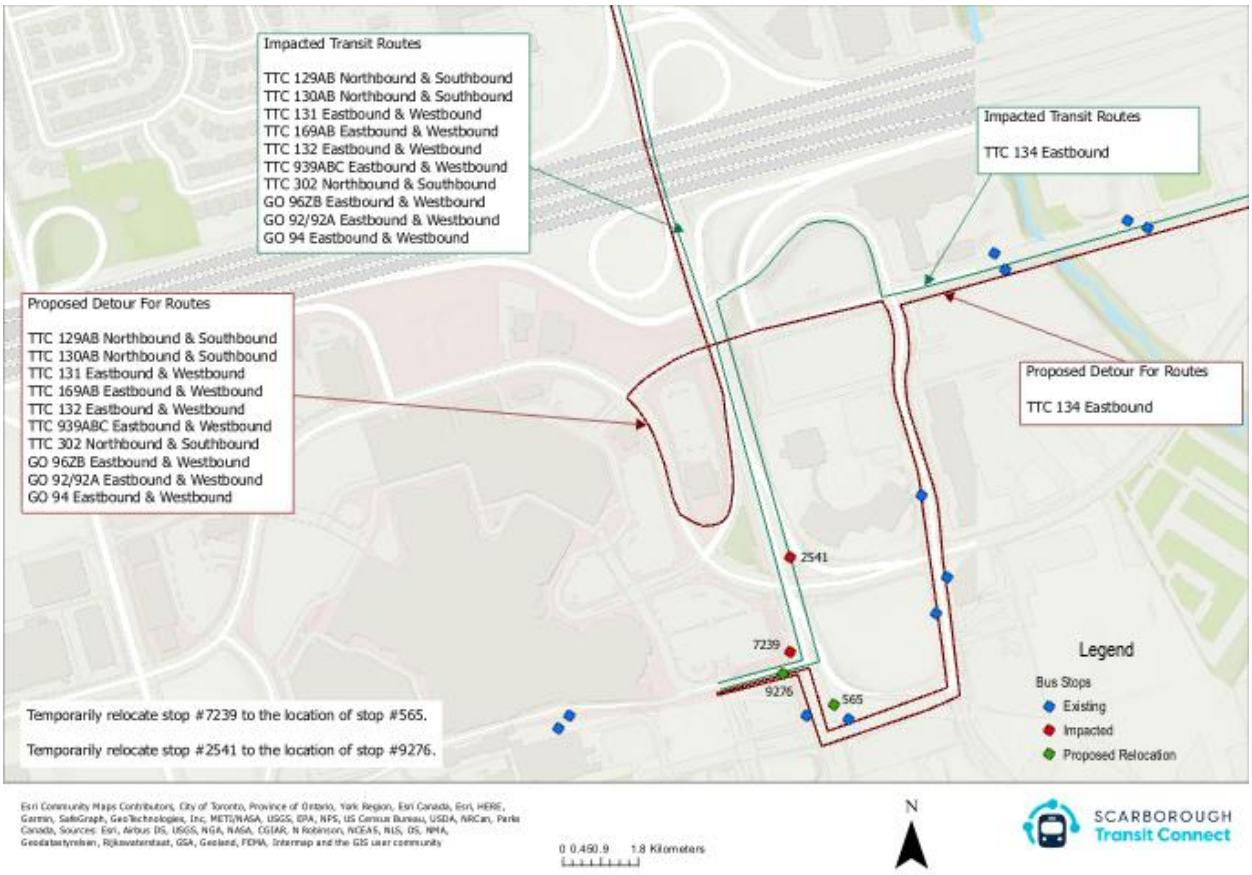
For Stage 1, McCowan Rd. was reopened, however Progress Ave. remained closed within the same limits of Pre-Stage 1. Vehicles travelling east and west on Progress Ave., that would previously use the Progress Avenue Bridge, followed the same detour from the previous stage.

The pedestrian sidewalk on the west side of McCowan Rd. was reopened as well. This pedestrian sidewalk was enclosed from all sides to be protected from the demolition during this stage, specifically the Progress Avenue Bridge West Abutment. The sidewalk on the east side of McCowan Rd. remains closed.

2.3 Transit Detour Plan

Transit was affected by the closure of McCowan Rd. during Progress Ave. superstructure demolition. The closure was in close proximity to Scarborough Town Centre bus terminal. A transit detour plan was presented to the TTC and other stakeholders as part of the Traffic Impact Assessment.

Figure 7. Transit Detour Plan



This plan assumed that northbound buses would reroute via Bushby Drive and Grangeway Avenue. Southbound buses accessed Triton Road via McCowan off ramp, eastbound Corporate Drive, southbound Consilium Place, southbound Grangeway Avenue, westbound Bushby Drive, and finally

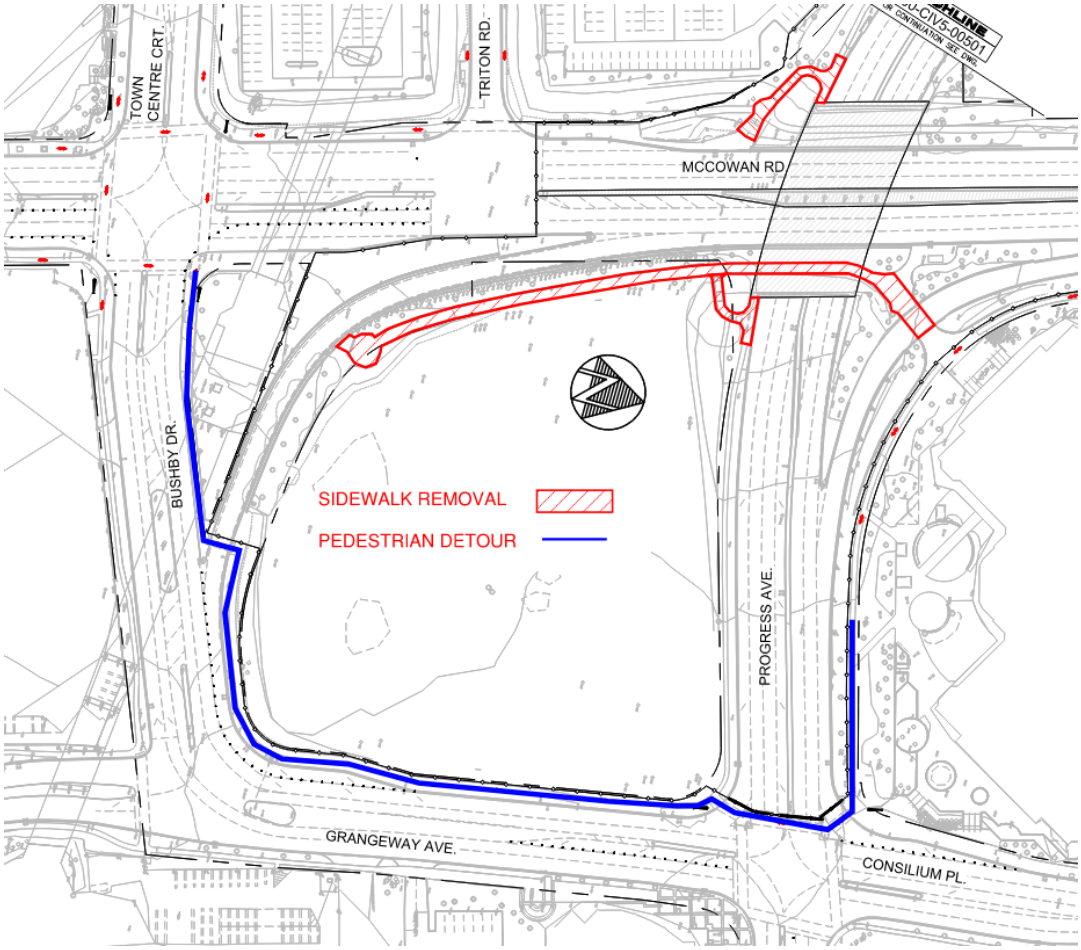
northbound McCowan Road. They were not able to turn left at McCowan Road and Consilium Place as the movement was not permitted.

2.4 Pedestrian Impacts

2.4.1 Pre-Stage 1

The pedestrian sidewalk situated to the east of McCowan Road was removed to make way for the construction of the station box. Pedestrians were directed to take a detour by heading east along Bushby Drive and then north along Grangeway Avenue in order to reach Consilium Place from the intersection of McCowan Road and Bushby Drive, and vice versa. This detour remains in effect to accommodate subsequent construction activities and ensure the safety of pedestrians.

Figure 8. Pedestrian Detour



2.4.2 Stage 1

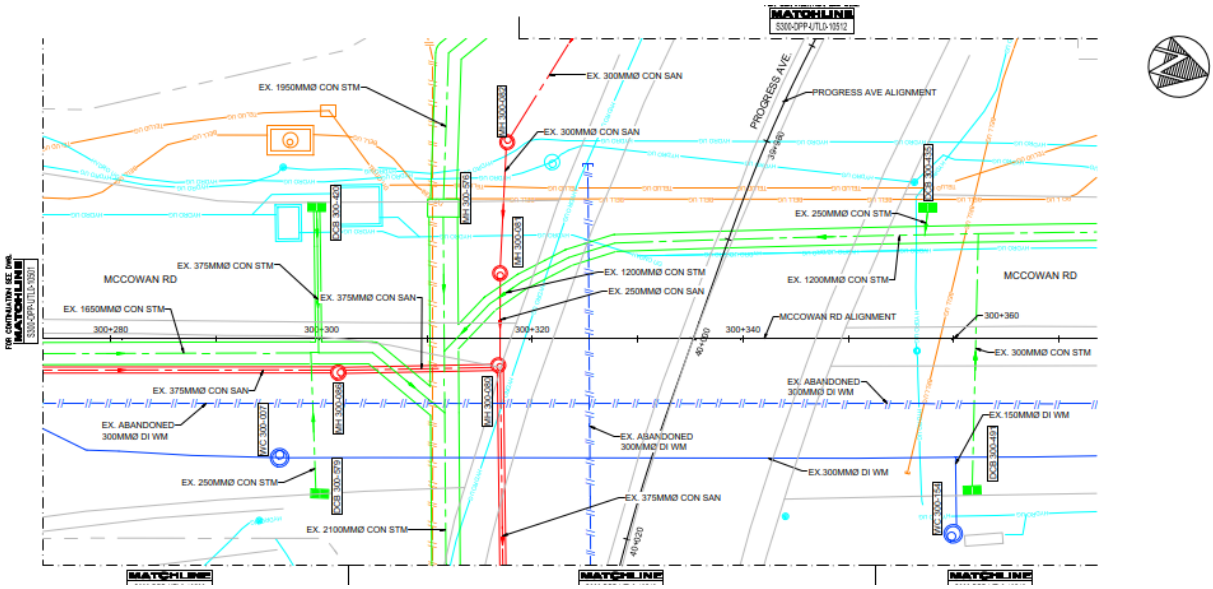
The east sidewalk on McCowan Road from Triton Road to Progress Avenue continues to be closed. Pedestrians will need to use the same detour as in Pre-Stage 1. The west sidewalk remains open.

3 Utility Protection

At the McCowan Road/Progress Avenue bridge/overpass location, see Figure 9 below for dry and wet utilities located in close proximity to the bridge.

All existing buried utilities located within the excavation zone and any other facilities adjacent to the excavation were carefully supported and protected from damage as a result of the Contractor's operations.

Figure 9. Wet and Dry Utilities at Progress Ave. Bridge over McCowan Rd.



During excavation for abutment, stair, Progress Ave. ramp underpass, and Bushby Ramp retaining wall removals, any wet or dry utilities were protected in place and removal work proceeded carefully around them.

Construction Demolition works in and around the City of Toronto Wet were protected from damage as follows:

- Utility locates was undertaken to identify Utilities within the work area
- Completed work in accordance with City of Toronto clearances to Wet and Dry Utilities in City of Toronto Sewer and Watermain Design Criteria Manual 2nd Ed Jan 2021- Appendix D – Clearances
- Completed work in accordance with TS 815 Removals
- Followed City Standard TS 4.60 Construction Specification for Utility Cut and Restoration - Utility Cut Repair Guidelines Sep 2021 for any Utility removals and reinstatement
- Completed work in accordance with City of Toronto clearances to Wet and Dry Utilities in City of Toronto Sewer and Watermain Design Criteria Manual 2nd Ed Jan 2021 – Vibration (Piling and Shoring)
- Followed Construction Specification for General Excavation TS 2.10 September 2018

3.1 Toronto Hydro Assets

Toronto Hydro owns several cable chambers and splice vaults in the vicinity of the Progress Bridge Demolition works. These assets are below grade structures housing electrical cables. As a result, one existing splice vault located in the boulevard (not vehicular traffic rated) needed to be upgraded to a cable chamber (vehicular traffic rated) in the same location. Another existing cable chamber located in the boulevard was broken and re-built with a new cable chamber at a deeper elevation to accommodate the grade cut. Some existing conduits located in the boulevard were exposed and protected with steel plates due to the grade cuts.

Street lighting removals:

- Street lighting poles on Progress Ave. approaches to the bridge, and four poles mounted on corbels on the bridge, were disconnected and removed. Disconnection of these lights occurred once Progress Ave. was shutdown. Cables connecting the lights were pulled, and conduits abandoned in place.
- Lighting in the Progress Ave. bridge sidewalk enclosure and stairway structures were disconnected and removed prior to bridge demolition, with cables removed and conduits left in place.
- Street lighting along the Progress Ave. Ramp were disconnected and removed. Cables in conduits were removed, and conduits abandoned in place.
- Street lighting along McCowan Rd. in the vicinity of the bridge were disconnected and removed at the beginning of bridge superstructure demolition. Cables in conduits were removed, and conduits abandoned in place.
- Wall-mounted and soffit-mounted HPS lights on the underside of the Progress Ave. bridge were disconnected at the beginning of bridge superstructure demolition, and removed along with bridge demolition.
- Temporary lighting replacement on McCowan Rd. was provided at the end of bridge demolition.

4 Results

The Progress Ave. superstructure demolition was demolished over Labour Day long weekend in 2024, with pre-work occurring with a fully closed Progress Ave. during the several weeks before the full closure of McCowan Road and superstructure demolition. The demolitions of the abutments, stair structures, Progress Ave. Ramp, and Bushby Dr. Ramp areas were conducted in the three-to-four months following the Progress Ave. Bridge superstructure demolition.

The works included twelve excavators and 960 work hours to demolish and remove 3000 cubic metres of concrete, all implemented safely and with minimized environmental impact. The rubble was removed and recycled within this period and the roadway below was open to traffic once more at the end of the 72-hour closure.

A video of the timelapse for the demolition works over the long weekend is found here: https://www.youtube.com/watch?time_continue=1&v=zSQYmBB04vg&embeds_referring_euri=https%3A%2F%2Fhubblecontent.osi.office.net%2F&source_ve_path=Mjg2NjY

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