Plessis Road Twinning and Grade Separation at CN Redditt Subdivision: Design Challenges and Innovative Solutions

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ABSTRACT

The Plessis Road Widening and Grade Separation (Underpass) at CN Redditt Subdivision was considered a Short Term City of Winnipeg (COW) project. Short Term projects have the highest priority for funding and a key driver for this project was the funding contribution by the Building Canada Fund, which was established under the 2007 Federal budget for projects from 2007 to 2014.

The COW awarded the preliminary and detailed design for the Plessis Road widening and grade separation at CN Redditt Subdivision in July 2012 to AECOM Canada Ltd. (AECOM) Construction on the first of five contracts began in summer 2013 and the project was substantially complete on October 3, 2016. Two lanes were opened to traffic in October of 2015 and all remaining lanes were open by September 2016.

The final project upgraded Plessis Road from a two lane undivided, road at-grade crossing, to a four lane divided grade separated facility. The roadway services an industrial area, including truck traffic from CN's intermodal facility located south of the project along Plessis Road.

The many challenges for the project included dealing with multiple stakeholders, maintaining rail traffic throughout the duration of the project and meeting a very short design and construction schedule. Major stakeholders in the area consisted of an oil pipeline valve station located on the northeast corner of the project, oil pipelines north of the CN mainline, CN double mainline track, the CN Transcona Maintenance Shops/Yard lead, the Malteurop Plant lead, Manitoba Hydro, MTS and Shaw.

Design challenges included providing clearance between the roadway surface and the underside of the rail bridge, which utilized through-plate-girders to achieve the minimal profile required, given that Dugald Road was located 300 m south of the tracks. A major land drainage channel for the COW, located on the south side of Dugald Road, could not be relocated without major cost implications and could not flow into the underpass area. The existing land drainage system was at capacity and the underpass runoff required storage prior to discharging into the existing system.

The end result was the successful completion of the project using alternative solutions from numerous engineering disciplines, with minimal disruption to the stakeholders involved. The increased road and rail traffic experienced the day the first two lanes opened, has proven that the project was required to meet travel demand forecasts.

Introduction

The Plessis Road Widening and Grade Separation (Underpass) at CN Redditt Subdivision was considered a Short Term City of Winnipeg (COW) project. Short Term projects have the highest priority for funding and a key driver for this project was the funding contribution by the Building Canada Fund, which was established under the 2007 Federal budget for projects from 2007 to 2014. Funding for this project was split three ways between the Federal, Provincial Governments and the COW, CN funded a portion of a basic grade separation, with the City responsible for remainder of the funding above the initial commitment.

On July 11, 2012, AECOM Canada Ltd. (AECOM) was retained by the City of Winnipeg to conduct conceptual and preliminary design studies for the Plessis Road widening and grade separation at the CN Redditt Subdivision. Work on preliminary design and design optimization continued into 2013, when AECOM was awarded detailed design and contract administration for the construction of the Plessis Road Twinning and Grade Separation at CN Redditt Subdivision. The main objective of the project was the replacement of the existing at-grade crossing of Plessis Road and the CN Redditt Subdivision with an underpass grade separation structure, including retaining structures. The additional objectives of the project included:

- enhancing vehicle and pedestrian safety;
- reducing traffic congestion related to the substantial train crossing delays;
- improving pedestrian accessibility;
- providing a connection to the COW active transportation network
- minimizing environmental impacts (improve transit, reduce greenhouse gas emissions, etc.)

The final project upgraded Plessis Road from a two lane undivided, road at-grade crossing, to a four lane divided grade separated facility. The roadway services an industrial area, including truck traffic from CN's intermodal facility located south of the project along Plessis Road. The existing sidewalk was upgraded from the standard 1.5 m to a 2.1 m cross section on the west side of the underpass and a 3.5 m active transportation pathway on the east side.

Technical information contained within this paper was provided from various documents written as part of the project including: the preliminary design report, the traffic report, the tender documents and the construction report. Traffic counts were provided by the COW. Dillon Consulting Ltd., the roadworks and utility coordination sub-consultant to AECOM for this project, provided information contained within the documents listed above.

Figure 1: CN Redditt Subdivision Looking West (east of Plessis Road)

Figure 2: CN Redditt Subdivision Looking East (at the existing Plessis Road crossing)

Figure 3: Plessis Road Looking North from the CN crossing

Figure 4: Plessis Road Looking South from the CN crossing

The project was separated into 5 contracts as follows and construction on the first of five contracts began in summer 2013 and the project was substantially complete on October 3, 2016. Two lanes were opened to traffic in October of 2015 and all remaining lanes were open by September 2016.

Table 1: Contracts

Contract 1	Rail Shoofly Grade Preparation and Miscellaneous Wastewater Sewer, Watermain and Land Drainage Works	COW Bid Opportunity 342-2013
Contact 2	Shoofly Track Installation and Permanent Track Construction at Mileage 246.64	COW Bid Opportunity 539-2013B
Contract 3	Plessis Road Reconstruction, Underpass Structures, Pumping Station, Land Drainage Sewer and Miscellaneous Underground and Landscaping Works	COW Bid Opportunity 712-2013
Contract 4	Oil Pipelines Relocation Works	COW Bid Opportunity 1058-2013
Contract 5	Supply of Steel Pipe and Fittings	COW Bid Opportunity 346-2014

Contract 1

Contract 1 was tendered early in 2013, to facilitate the achievement of the critical stages by moving some key utilities out of the underpass excavation area and constructing the grade for the rail shoofly embankment. Contract 1 was prepared and issued for tender in spring 2013. The major components of work for Contract 1 were the construction of grade for CN rail shoofly and north track realignment, relocation of miscellaneous wastewater sewer, watermains and land drainage sewer works under CN rail shoofly and existing track.

Contract 2

Contract 2 was prepared and issued for tender in the summer of 2013. The major components of work for Contract 2 were the supply and install of the shoofly and permanent north track material including turnouts and

ballast for the track construction and the earth and base works for the track embankment including sub ballast placement and ditching. The permanent track supply and installation was added into Contract 3 for ease of construction.

Contract 3

Contract 3 was the main construction contract for the underpass project and was prepared and issued for tender in late fall 2013. The major components of work for Contract 3 were split into six phases. Phase I consisted of the Pumping Station construction, miscellaneous underground works, underpass land drainage sewer construction and construction of grade for the north track realignment. Phase II (commenced after Contract 2 was completed and the shoofly was in service) consisted of the underpass substructure and retaining walls, dry pond construction prior to rail shoofly decommissioning and out of service maintrack rail removal. Phase III consisted of Stages A1, A2, B1 and B2 for the Plessis Road Asphalt Reconstruction – Dugald Road to approx. 300 m south and the Plessis Road Concrete Reconstruction – 390 m south of Kernaghan Avenue to Pandora Avenue W. and Stage 3 – Dugald Road Rehabilitation and Plessis Road Concrete Reconstruction Dugald Road to 100 m north of Dugald Road. Phase IV consisted of the underpass superstructure and retaining walls, final track configuration and north and south maintrack cutovers. Phase V consisted of the shoofly rail removal, retaining walls and excavation and final dry pond construction. Phase VI consisted of the underpass road reconstruction, miscellaneous structural works, landscaping works, miscellaneous removals and site restoration.

Contract 4

Contract 4 was prepared and issued for tender in the fall of 2013. Contract 4 was originally prepared with three phases for the supply and installation of the oil pipelines. Phase I was the north pipeline relocation under the CN maintrack and shoofly, Phase II consisted of the oil pipeline relocation under Plessis Road and Phase III was the oil pipeline relocation north of the valve station. Work included in the 3 phases included; the supply of the steel carrier and casing pipe, coatings and steel pipe and the installation using horizontal directional drilling and open cut excavation for the relocation north of the valve station.

Contract 5

Contract 5 was prepared and issued for tender in the spring of 2014. Contract 5 was a pipe and related material supply only contract, for the oil pipelines.

Stakeholders

Major stakeholders in the area consisted of an oil pipeline valve station located on the northeast corner of the project, oil pipelines north of the CN mainline, CN double mainline track, the CN Transcona Maintenance Shops/Yard lead, the Malteurop Plant lead, Manitoba Hydro, MTS and Shaw as well as the City of Winnipeg Water and Waste Department. Each utility required an assessment of the condition of the existing infrastructure and a determination of whether it could be maintained or if it required relocation.

Oil lines south of the valve station were protected in place, north of the valve station a section was relocated to accommodate the underpass footprint and the oil pipelines parallel to the rail lines were relocated on a similar alignment under the underpass roadway structure.

Given the small footprint of available Right-Of-Way (ROW), Manitoba Hydro, Shaw and MTS infrastructure was relocated to the west of the underpass. The 200mm watermain and 450 wastewater sewer were also relocated to the west, as the existing infrastructure was within the excavation for the underpass. The overland drainage collection system was installed on the east side and the 500mm watermain was relocated around the dry pond holding area for the underpass runoff. The underpass land drainage system was installed under the new roadway. Figure 5 gives an overall view of the utility relocations within the underpass cross-section.

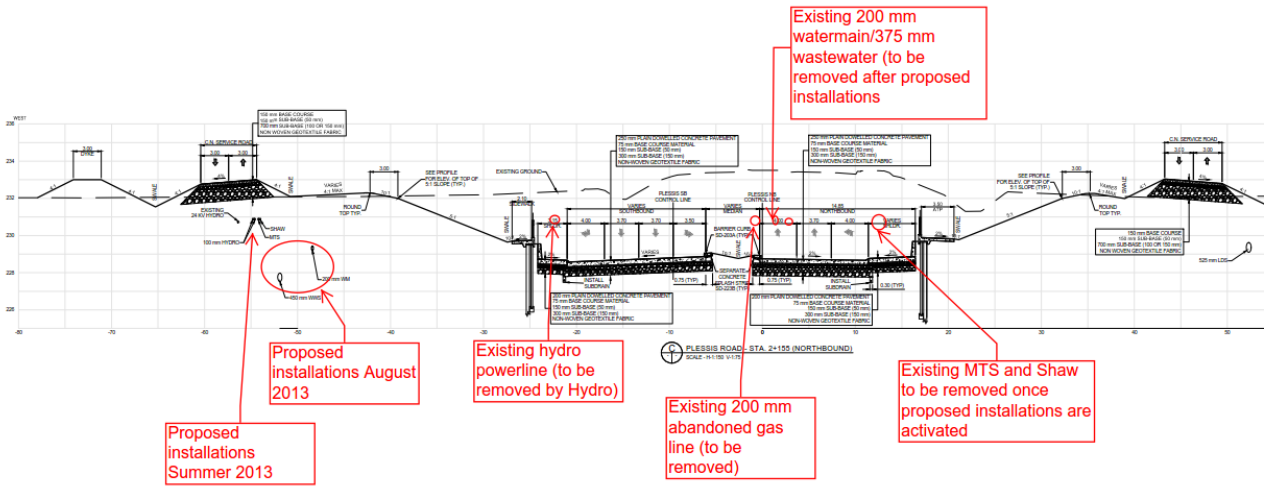

Figure 5: Utility Relocations

The double mainline CN track was temporarily relocated to the south of the bridge structure to accommodate construction and maintained both the Malteurop Plant lead (approx. 180 m east of the structure, off the south track) and the CN Transcona Maintenance Shops/Yard lead (located just east of the structure, off the north track). Once the bridge was in service, the north mainline was relocated north of its original position to accommodate the bridge design. As well both the north and south tracks were raised 280 mm (11 inches), to accommodate the clearance required for the roadway. Figure 6 below shows the mainline relocations with red as the temporary shoofly and the green as the final configuration.

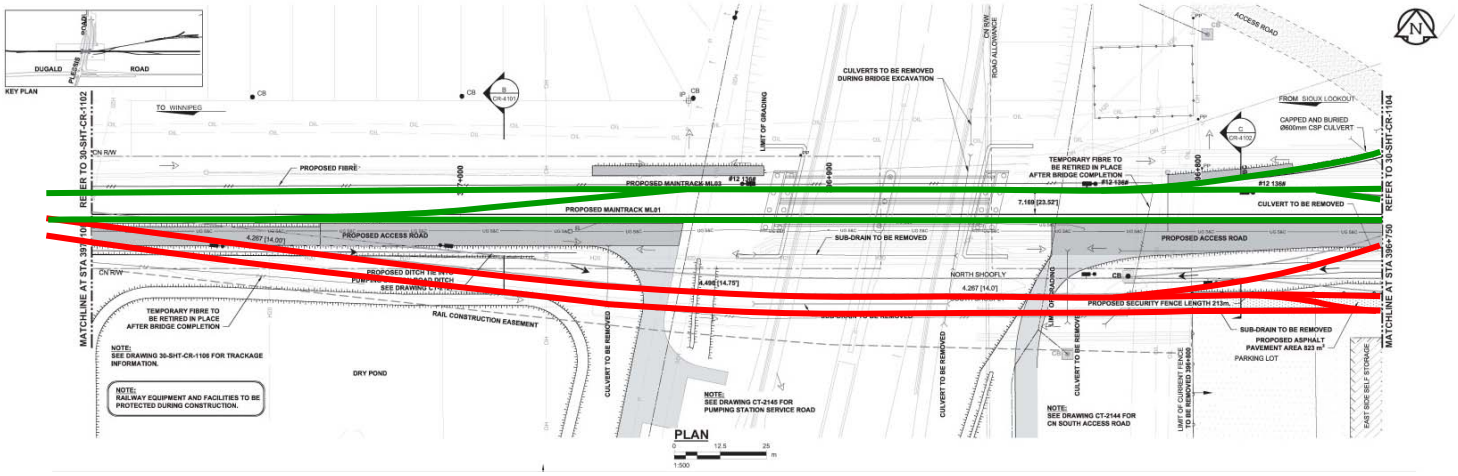

Figure 6: Mainline Track Relocations

CN had existing fibre optic cable (north side of the tracks) and CN signal and communication works (majority on the south side), which required temporary relocation to accommodate the shoofly and a second relocation for the final configuration.

Design Challenges

Design challenges included providing clearance between the roadway surface and the underside of the rail bridge, which utilized through-plate-girders (TPG) to achieve the minimal profile required, given that Dugald Road was located 300 m south of the tracks. A major land drainage channel for the COW (Dugald Drain), located on the south side of Dugald Road, could not be relocated without major cost implications and could not flow into the underpass area. The existing land drainage system was at capacity and the underpass runoff required storage prior to discharging into the existing system.

The road design required a design speed reduction to 70 km/h, allowance of up to 6% roadway grades on Plessis and minimal K values to ensure the reduction or elimination of an elevation change at Dugald Road intersection. The City mandated that no clearance restrictions be required at the bridge structure, to eliminate conflicts and the result was the lower profile TPG structure design. The double track steel TPG has an efficient strength to depth ratio, but based on loading and fatigue issues was modified to twin single track TPG structures. The north track was realigned approximately 2.74 m (9 ft) to accommodate CN inspections and the ability to perform repairs.

The existing soils in the area, based on the drilling program were primarily clay material that typically exhibits a reduction in bearing capacity with depth and therefore shallow foundations were not considered suitable to support the proposed structures. Deep foundations bearing on or within competent bedrock were required to support the structures. The foundations for both the bridge and the pump station were designed as rock socketed caissons, bearing on competent bedrock, approximately 18 m below existing grade.

Figure 7 highlights some of the challenges of inserting a new wastewater sewer, new land drainage sewer, and new watermains into the project while maintaining existing servicing. The depressed underpass section would affect property on the west side of Plessis Road. Three homes (1164, 1168, 1172 Plessis Road) were purchased as part of the project and demolished to as access couldn't be maintained and to accommodate the new wastewater and land drainage sewers.

As with many major projects property is required to upgrade the facilities. A temporary construction easement within two properties was required on the south side of the existing tracks to accommodate the temporary shoofly. Plessis Road was widened up to Pandora Avenue and the widening was completed to the east of the existing roadway. Property was required from five owners on the east side to accommodate the twinning. Access to three properties, who had previous accesses located in the proposed depressed roadway section, had one shared access road constructed just north of the underpass section.

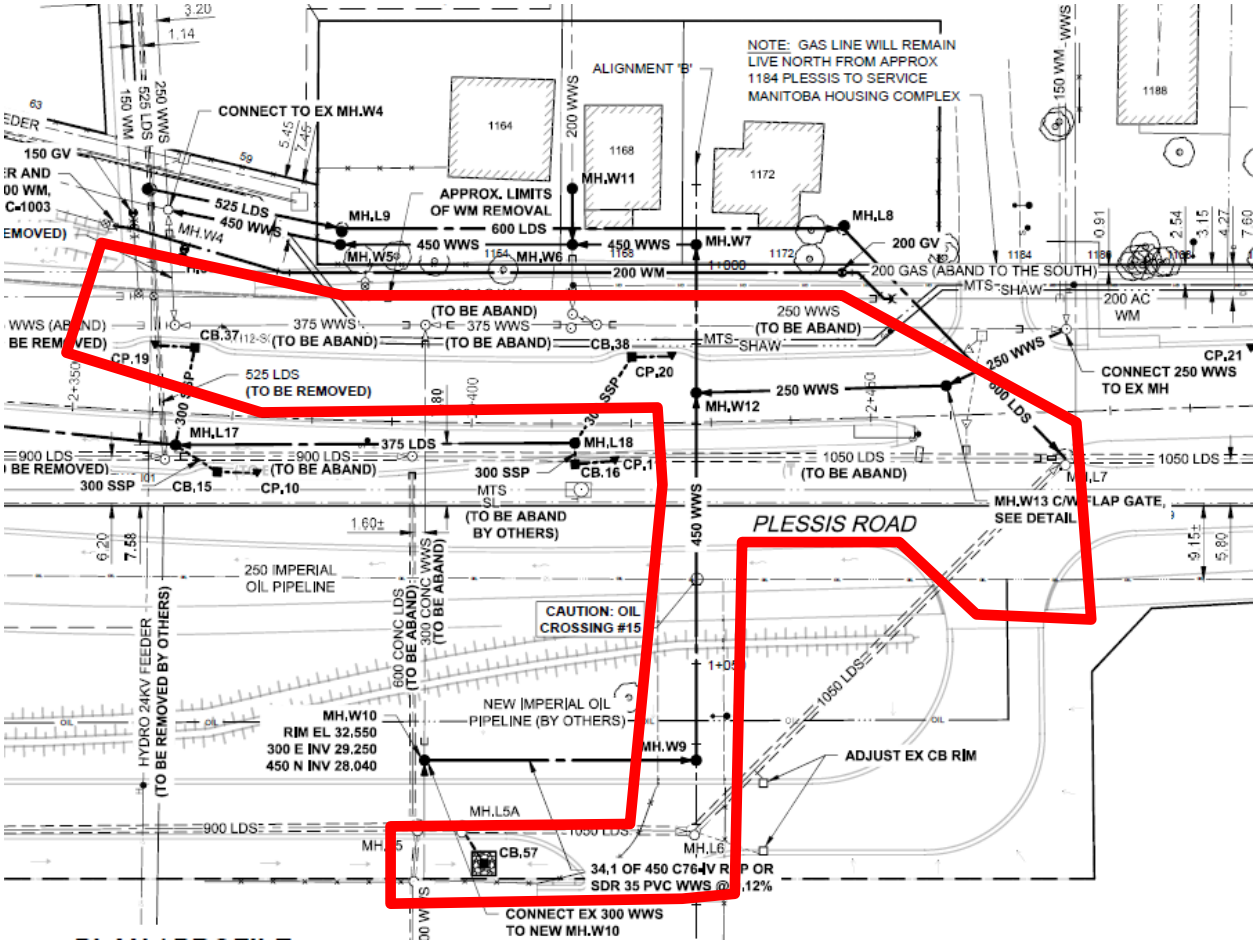

Figure 7: Underground Works

The Dugald Drain flows from east to west along the south side of Dugald Road to Dawson Road. At Dawson Road it turns south and runs behind a number of industries, before discharging to the Seine River near the Marion Street Bridge. Development in the area has used the stormwater retention basin storage for stormwater control. Existing stormwater retention basins are dewatered using small pumps, although it should be noted these pumps cannot be discharged to the Dugald Drain until levels in the Dugald Drain have subsided. It was apparent during design that the runoff generated from the underpass would need storage retention during major rain events to prevent flooding in the area. Figure 8 highlights the overland land drainage piping and the control structure needed to regulate flows from the Dugald Drain. Figure 9 shows the 0.8 Ha storage pond that was constructed to accommodate the underpass runoff, prior to discharge to the Dugald Drain.

The corresponding pump station was required to accept the underpass runoff and the discharge was located south of the underpass structure. The pump station is unique to the area and required multi discipline teams to coordinate the design. The high capacity pump station would pump the stormwater from the underpass land drainage into the storage pond and the pond would be dewatered using smaller pumps to the Dugald Drain.

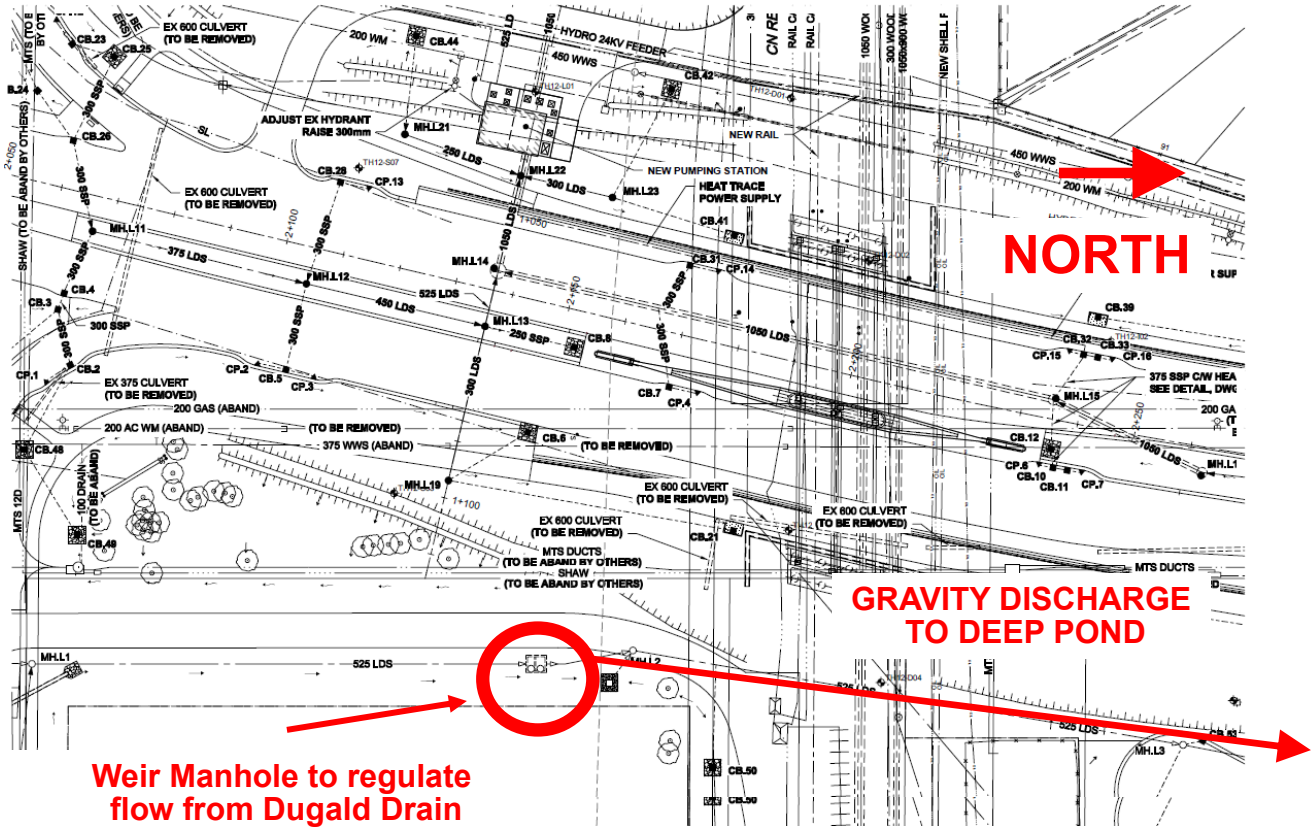

Figure 8: Underground Works

The pump station with a firm capacity of 1.2 m3/s and a total capacity of 1.8 m3/s, was configured with three duty pumps, each with a capacity of 600 L/s. The resulting pump station has two sump pumps for minor rain events, three duty pumps for large events and two pumps to dewater the pond.

During the design phase a test caisson was drilled to determine bedrock depths in the area, as well pump tests were performed to determine dewatering plans for the pump station construction. The pump tests confirmed that the upper carbonate aquifer could not be drawn down to accommodate the construction, given the existing limitations of the land drainage in the area as well as the potential effects on the nearby groundwater users. The base of the pump station would be within 5 m of the aquifer and a factor of safety against basal heave was less than adequate. The Contractor designed a unique shoring system utilizing secant piles drilled into competent bedrock to cut off the flow of water around the pump station excavation. This system mitigated the piezometric forces acting on the base of the pump station excavation to acceptable levels and resisted the soil loads for the excavation. See Figure 10.

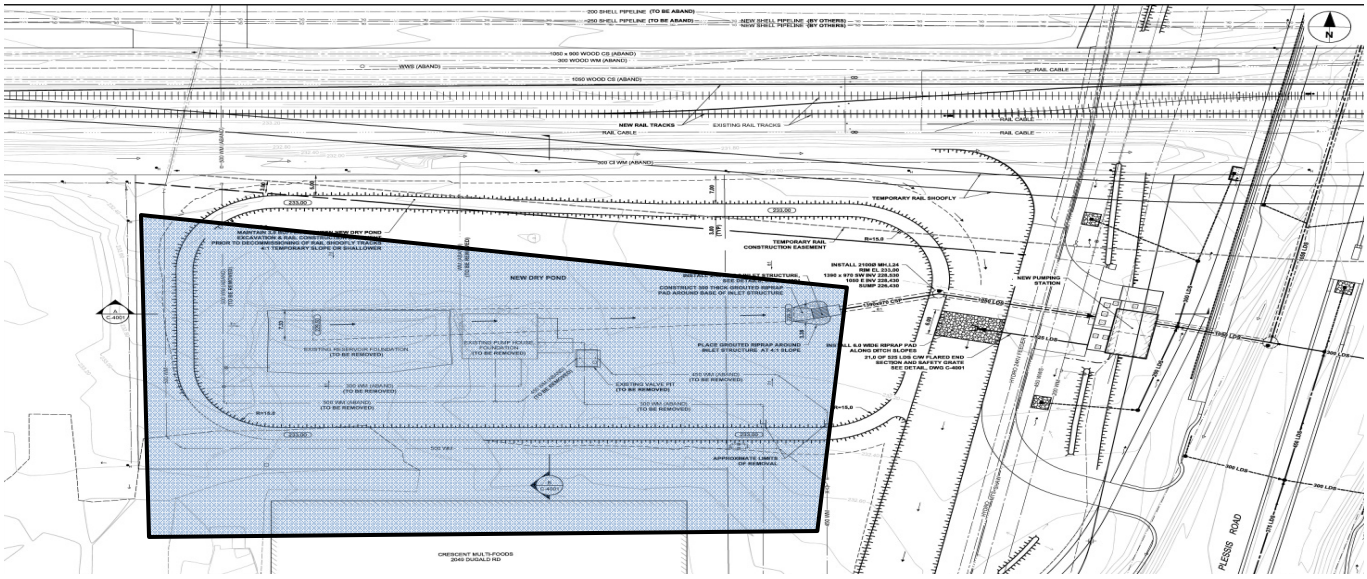

Figure 9: Dry Pond Storage

Figure 10: Secant Pile Shoring for the Pump Station

Figure 11: Caissons Installed from Grade for the Pump Station

The Dugald Drain was previously a 900 x 1400 arch culvert (crossing Plessis Road) and was replaced with two 1050 mm reinforced concrete pipe culverts in the same location. The Dugald drain is typically full of water during spring and summer conditions and work needed to be completed during late fall or winter. A small pumping station would have been required, if work was completed during summer so as not to flood residents to the east. Work was completed across Plessis Road by open cut methods in winter while maintaining two lanes of traffic.

Given the soft soils and the excavation required for the underpass, a minimum slope of 5:1 was required for the side slopes. This could only be achieved with the use of a retaining wall on both the east and west sides of the bridge. Steel sheet piles were designed and installed with a concrete cladding to make this more aesthetically pleasing. The retaining wall and underpass structure construction required multiple stages due to the oil pipelines located to the north of the structure and the requirement to maintain rail traffic. See Figure 12 for a typical section showing the staged construction.

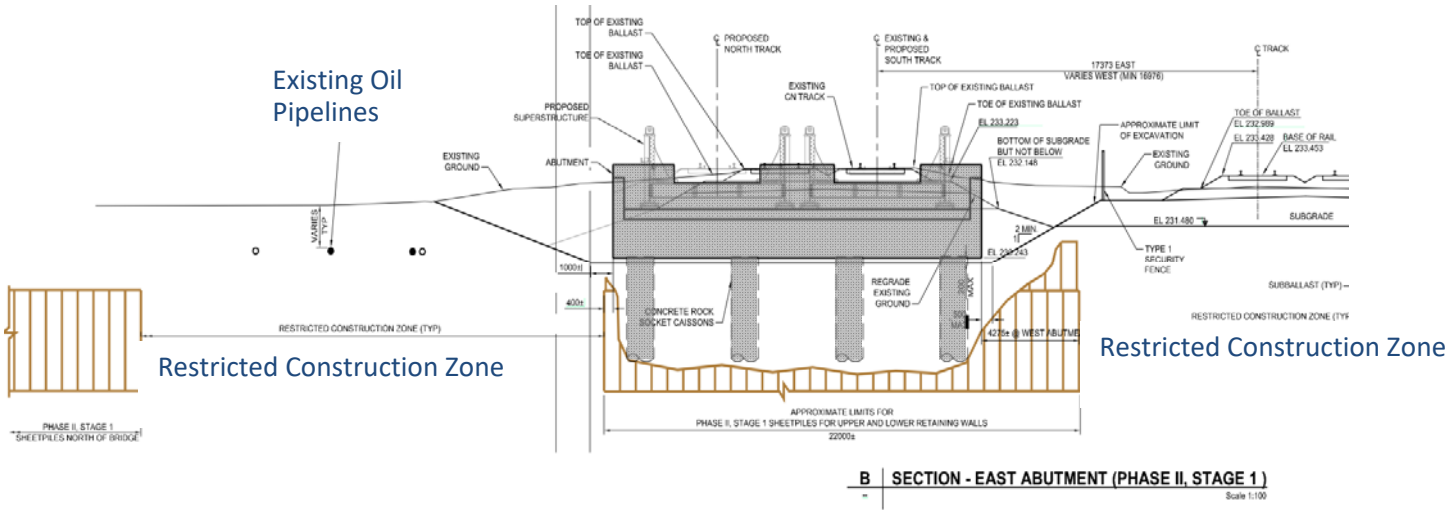

Figure 12: Staged Construction

As part of the project close to 100,000 m3 of material was excavated to accommodate the road structure, given that the roadway was lowered 8.1 m at the rail crossing. This required the reconstruction of Plessis Road from Dugald Road to approximately 200 m north of the low point to accommodate the grades. A maximum grade of 5.04% was required south of the structure to avoid lowering Dugald Road.

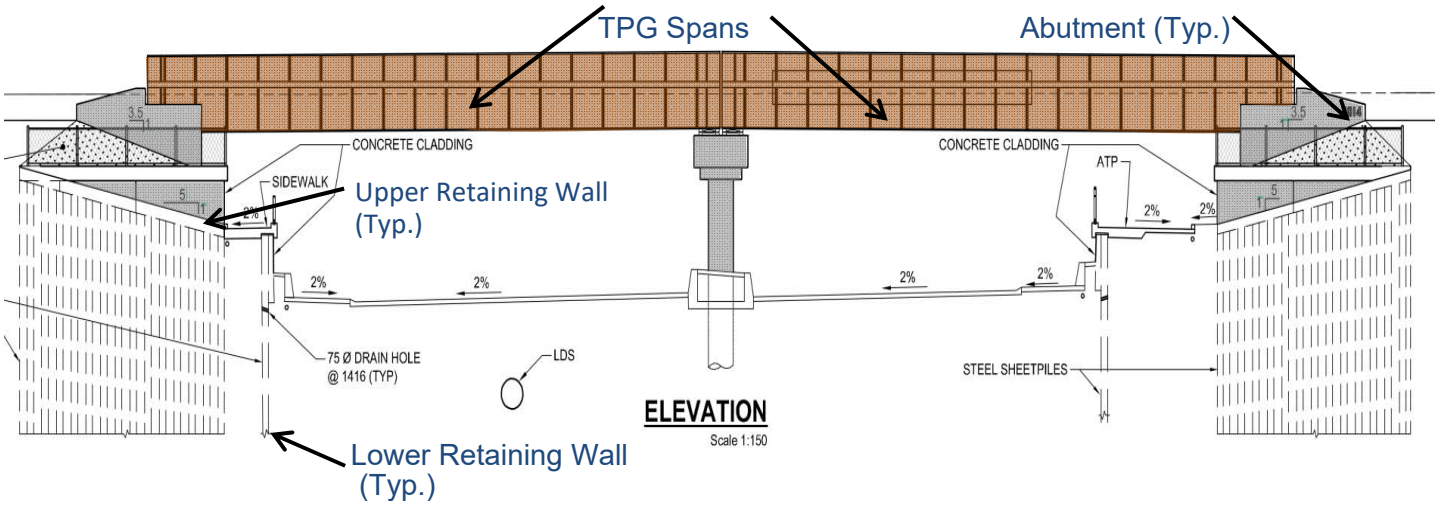

Figure 13: Underpass Cross Section

Figure 14: Sheet Pile Construction north of the bridge structure (east side)

Figure 15: Excavation looking north from the bridge structure

The oil pipelines parallel to the rail lines, were relocated to go under the roadway structure, but stayed above the underpass land drainage pipe due to the close proximity of the bedrock. The lines were protected from traffic loading with a 250mm reinforced concrete slab. Significant effort was required to ensure the safety of the lines and the workers during construction.

Prior to construction an estimate of 12 to 20 trains traveled through the area in a 24 hour period. During construction once the at-grade crossing was closed CN was able to stage longer trains coming out of the Transcona Shops. After construction train traffic increased with upwards of 30 trains going through the area in a 24 hour period.

A traffic review of the project intersection volumes was undertaken as part of the project by Dillon Consulting. A look at the Plessis Road – Dugald Road intersection is provided. The existing traffic volumes in the AM Peak Hour southbound on Plessis Road were 740 with 625 vehicles northbound. At Dugald Road 360 vehicles went right, 350 went south and 30 turned left. The existing PM Peak Hour southbound on Plessis Road was 760 with 805 vehicles northbound. At Dugald Road 235 vehicles went right, 370 went south and 155 turned left. Based on the traffic volumes the final lane southbound configuration was a dedicated right turn, two through lanes and a dedicated left turn. Northbound there were two through lanes and one yield lane to accommodate the right turns off Dugald to the northbound lanes. The traffic volumes presented have been balanced across the network and represent 2012 volumes.

Counts taken in November 2016 once the road was fully open to traffic show the increase in traffic. The southbound AM peak shows 843 vehicles with 445 going right at Dugald and 51 going left. The northbound AM peak shows 725 vehicles heading north. The southbound PM peak shows 929 vehicles heading south with 289 going right onto WB Dugald and 200 going left onto EB Dugald. The northbound PM peak has jumped to 1020 vehicles. The PM peak shows a more significant increase, but it is clear from the volumes that traffic has increased as the train delay has been removed.

The end result was the successful completion of the project using alternative solutions from numerous engineering disciplines with minimal disruption to the stakeholders involved. Road and rail traffic from the day the first two lanes opened has proven that the project was required to meet travel demand forecasts.

Figure 16: Road Fully Open to Traffic (Looking North)

Figure 17: Road Fully Open to Traffic (Looking South)