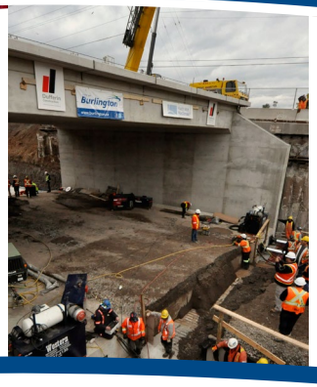
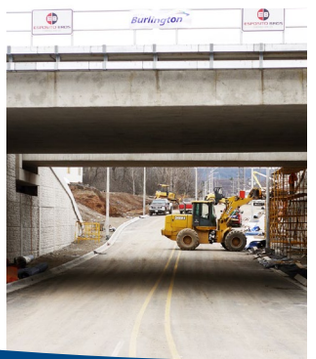
KING ROAD/CN GRADE SEPARATION





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2014 CANADIAN CONSULTING ENGINEERING AWARDS ENTRY SUBMISSION

Hatch Mott MacDonald

amec

King Road / CN Rail Grade Separation

Clients: City of Burlington and Canadian National Railway

Project Objectives & Challenges

The King Road level crossing is located in CN's Oakville subdivision in the City of Burlington. This section of the Oakville Sub, known as "The Throat", has five separate subdivisions feeding over 100 trains per day through the three mainline track gauntlet. The 129 km/hr rail corridor hosts Metrolinx commuter trains, VIA and Amtrak intercity passenger service, and CN's transcontinental and international gateway freight traffic. Further complicating the task was an environmentally protected stream parallel to the track and an adjacent CN freight yard entrance with its associated signal plant.

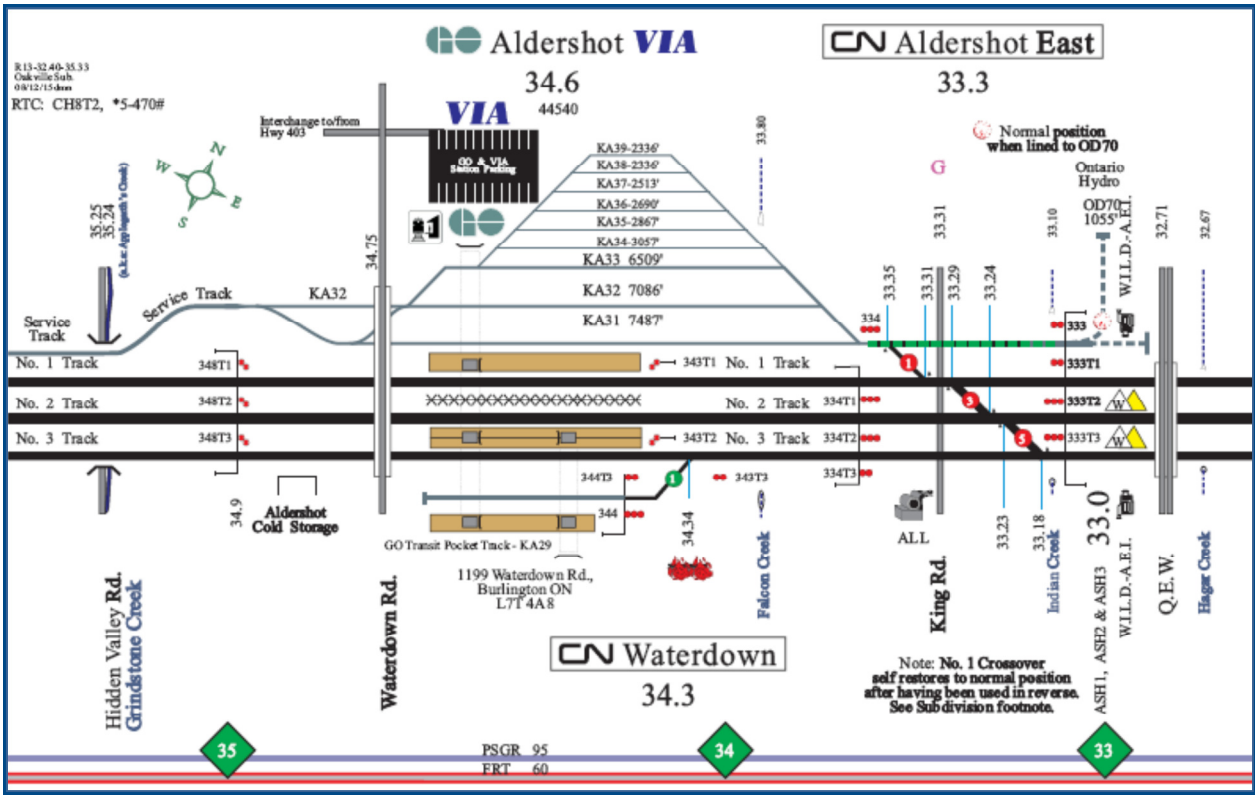
Although King Road is within an urban area, it still had a rural cross-section. The two-lane arterial road served as a primary connection between the community of Aldershot and Highway 403, which connects communities between Oakville and Hamilton. A key constraint to effective area development was the transportation bottleneck at the grade crossing caused by a high volume of trains, wait times and queues, resulting in long delays which would only deteriorate with more local development.

To resolve this, the City of Burlington retained Hatch Mott MacDonald (HMM) and AMEC Environment & Infrastructure (AMEC E&I) to conduct a Class EA for developing a solution that would better serve the community. A key project objective was to fast-track the implementation, which would minimize rail and road traffic disruptions, limit property impacts to local businesses, and protect Indian Creek.

Preliminary design concepts revealed that conventional in-situ phased construction would require an undesirably long shutdown of individual mainline tracks. This was unacceptable due to the considerable adverse effect on the local economic and social environment. Another major challenge that the project team faced was that Indian Creek, the roadway and railway were situated in a tightly confined area.

Innovative Solutions

Rail Structure: The location of the grade separation, with its inherent physical constraints, and the fact that Oakville Subdivision is a major rail corridor that could not be shut down for long periods, required a new



Oakville Subdivision – System Map

"out-of-the-box" engineering solution. Led by Hatch Mott MacDonald, the design team called on its local and worldwide experts to develop a solution that involved constructing a reinforced concrete bridge structure 'off-line' and sliding it under the railway tracks over a 72-hour long Thanksgiving weekend – working round the clock!

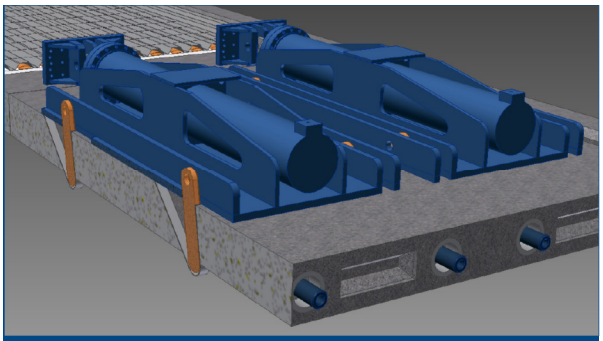
This method *accelerated construction*, *limited track shutdown* to one long weekend, and *significantly reduced economic and social impacts* of train disruptions during peak periods.

The jacking option also allowed the majority of the work to be performed outside the CN right-of-way. This resulted in a finished product of much higher quality because forming and reinforcing concrete was not compromised by short construction durations, typical in a track-block situation. Additionally, by limiting the installation to a low travel weekend and creating a diversion track, made scheduling freight traffic and busing more manageable.

HMM had considered the options of 'tunnel jacking' versus an 'open-cut' excavation. Since the costs associated with each technique were comparable, the open-cut installation method was chosen due to its lower risk; safety; and minimal impact on the businesses, neighbouring residents and train traffic.

The structure to be pushed and eventually serving as the underpass was essentially a 'box' - its cross-section width of 18.6m was dictated by the City's requirements established in the Class EA to achieve the desired urbanized roadway geometry. This included (in both directions) a 3.5m vehicular lane, a 1.2m dedicated bike lane delineated by curb, and a 3m gutter with a sidewalk and boulevard. The length of the box (16.6m, with additional 3.5m of wingwalls on the south side) was dictated by the diversion track required on the north side. The structure was designed to AREMA loading (Cooper E90) with reinforced concrete walls approximately one-meter thick weighing 2,313 metric tonnes.

The principle behind the jacking of a structure of this size was to push it into place with hydraulic jacks on an engineered surface designed to mitigate the effects of friction. To accomplish



Jacking Panel Assembly

this, the structure was built on a 'sandwich layer' installed between the box structure and the jacking pad, comprised of corrugated galvanized steel, industrial ultra-high molecular weight polyethylene sheeting, and industrial grease. To further reduce frictional loss, a system of air hoses was introduced within the corrugated cavities that transferred some of the structure's weight from the middle to the ends positioned on the jacking slab. This allowed the structure to be pushed under a fraction of its own weight using a set of four relatively small and mobile 150-ton hydraulic jacks.

Creating a road underpass using this unique jacking technique is the first application of its kind in Canada and the largest such undertaking by CN on its mainline tracks.

Indian Creek: Another notable innovation on this project was the method of protecting the environmentally sensitive Indian Creek, which runs alongside the railway tracks. The AMEC E&I design team developed a multi-stage realignment of the creek, which comprised the design of a "Creek Bridge" built over King Road and later integrated into the CN retaining wall.

However, for effective implementation of this solution, numerous physical and technical challenges had to be overcome through design and analysis. The most fundamental of these related to raising Indian Creek gradually so that its longitudinal gradient could be established for it to be conveyed over the roadway effectively and sustainably. This involved a creek realignment of 480m, negotiation with upstream property owners, and the application of Natural Channel Design principles.

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New design standards were developed for the first operating creek bridge to be built in Canada in over a century.

Other complementary investigative and design tasks were undertaken, all of which required regulatory permitting by Conservation Halton.

Frazil Ice Assessment: This investigation determined that the potential of ice build-up resulting in blockages and possible flooding was low, and mitigating elements (insulation) were added to the creek bridge structure accordingly.

Natural Substrate: The objective was to allow fisheries and aquatic organisms to use and to migrate the structure effectively. The design team developed a unique cellular bottom for the creek bridge to hold natural stone and vegetation in-place during storm events and also provided a mild meander, which again promotes a more natural character to the structure.

Regulatory Event Capacity: In this location, the Regulatory Event is a Regional Storm, based on Hurricane Hazel transposed to the Indian Creek watershed. The geometry of a creek structure was developed which could transition flows from the open waterway across the roadway and safely convey the Regulatory Event. The resultant creek bridge is a post-tensioned concrete U-shaped channel 4.5m wide and 1.95m high. It can convey upwards of 17m^3/s of water, which exceeds the Regulatory Event.

Leak Prevention: A fundamental concern was the potential for creek water to leak into the underpass causing functional and maintenance concerns. The Study Team addressed this issue by specifying a unique clay liner which covers the apron area and approaches. The liner is on the upstream side of the structure and attached to the vertical face of the creek structure using a concrete cap, sandwiching the liner between two layers of concrete.

Erosion Protection: Given that the creek has been raised from its in-situ condition, regulators had concerns about the potential for the system to downcut and thereby render the creek bridge ineffective, or worse, ponding could result on

Realigned west/east creek reach adjacent to the CN tracks

the upstream and downstream sides. The Study Team worked to implement a high standard of erosion protection at both approaches of the creek bridge. The downstream protection consists of a layer of impermeable material with clay soil placed in the embankments to minimize the effects of erosion. The upstream protection was provided by a 4.5m wide, 20m long concrete block system under the creek. This will protect the integrity of the creek and the structure during significant storm events. Over 1500m^3 of impermeable clay liner and 3000m^3 of clay soil were placed to protect the creek structure from this erosion.

Flood Warning: Since the creek is "over" the road, Conservation Halton had concerns regarding the potential for water to suddenly discharge from the creek onto motorists and then flood the underpass. To mitigate this, the team designed a monitoring station consisting of a water depth sensor and associated recording equipment which communicates directly with City maintenance staff, who can take appropriate action to protect the community.

Realigned north/ south creek reach online after grading

Subway Drainage: To avoid the need for a costly mechanical pumping station, AMEC designed over 700m of gravity storm sewer through the

residential community to the south, ultimately discharging to the main branch of Indian Creek.

Project Complexity

The Design Team dealt with significant physical constraints, e.g., inadequate space for construction staging, protection of an environmentally sensitive watercourse, and the large volume of rail traffic while maintaining road traffic during construction. This made the grade separation project one of the most complex initiatives ever undertaken by the City of Burlington. The fast-track schedule required the monolithic structure to be jacked into place over a 72-hour long weekend. This narrow window for completing this mammoth bridge jacking operation necessitated round-the-clock work. The crew shifts were planned and coordinated in minute detail to maintain schedule.

Protecting the environmentally sensitive Indian Creek was a major challenge due to its proximity to the railway tracks and the adjacent signal plant. The team prepared a complex staging plan to convey this watercourse over the roadway while minimizing traffic disruption during construction. AMEC E&I developed a nine-stage construction implementation plan that served as a basis for approvals and ensured the merging of the roadway and creek system design.

Subway drainage also added to the project complexity, as the team had to address the amount and location of the existing infrastructure and the substantial depth of the system. The outlet point at Indian Creek was only 4m below the low point of the grade separation, hence the longitudinal gradient only reached 0.3%.

Construction of a 975mm diameter concrete sewer was a challenge due to high local groundwater elevations and soil conditions, consisting mainly of sand. The storm sewer was constructed through a mature residential area which required jack-and-bore operation under pedestrian pathways in some areas, with homes in close proximity.

Social/Economic/Environmental Benefits

The grade separation has created a much safer environment for the local community. In addition to track safety, the road users are no longer hampered by rail traffic. Travelling through the area has become much easier, faster and safer even as the employment lands in Aldershot have become fully developed. As a result, the travelling public is spending far less time waiting in traffic; resulting in reduced gas emissions; improving the environment and quality of life; and promoting economic vitality. As part of this project, King Road was also upgraded to an urban status with the addition of sidewalks and bicycle lanes, as well as being reinstated as the City's emergency route. These efforts have provided many positive benefits in improving the residents' quality of life.

The social, economic and environmental considerations during construction were instrumental in significantly reducing adverse impacts on the travelling public as well as the surrounding community. Community relations, a collaborative effort among the City of Burlington, CN and Metrolinx, ensured public outreach. They engaged the public and local businesses in numerous ways, including: a project website; quarterly community bulletins to property owners and businesses; and an email 'blast' to a broad list of interested parties. In December 2013, the public was invited to participate in the opening of King Road.

Advanced planning was required specific to Metrolinx and VIA Rail to accommodate commuter traffic during the weekend of the jacking operation. Both agencies supported the project by allowing commuter rail operations to cease during the three-day weekend. The project team worked with Metrolinx and VIA Rail to achieve this, providing them with regular updates and bulletins, allowing them the opportunity to give sufficient notice to their respective ridership of the planned closure. During the closure itself, commuters of both services were transported between stations, bypassing the construction area.

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The nonconventional and innovative Creek Bridge concept proved to be environmentally superior and cost effective. In total, the Creek Bridge and creek reconstruction cost the City and CN approximately $2.2 million. The alternative would have cost approximately $9.4 million, as it would have had to include four long culvert crossings, along with the purchase of existing commercial properties in the area.

Meeting Client's Needs

The project achieved all the needs of the City of Burlington and CN, as well as those of the key stakeholders. Following analyses of several concepts based on cost, constructability, schedule, and impact on operations and the local community, it was evident that the client's need to maintain rail and road traffic operational would require something other than the traditional in-situ construction of the bridge. The solution of constructing the bridge box offline and jacking it in place over a long weekend when the commuter traffic would be low met the client's objectives. The result was a much better quality structure and minimal impact on rail operations.

Not only was this the first time that the innovative jacking/sliding technique had been used in this type of scenario, but, compared to conventional in-situ construction, the finished structure was of *higher quality,* and the project team was able to *meet all scheduled milestones* for a fast-tracked project. This was achieved with negligible railway disruption, while *saving millions of dollars* in plant relocation and lost business, as well as *minimizing inconvenience to the travelling public*.

The grade separation improved traffic flow and economic vitality in the area and set the stage for employment development in the area. King Road has been upgraded with sidewalks and bicycle lanes for the enjoyment of the residents. The Project goals were to fast-track the implementation with minimum disruption to rail and road traffic, while protecting the environmentally sensitive Indian Creek and minimizing property impacts to local businesses.

Protecting Indian Creek required conveying it over the roadway in a nine-stage construction plan. This plan served as a basis for approvals, given the complex environmental regulations along with the detailed structural elements, merging roadway and creek system design.

Conclusion

This project serves as a model for overcoming significant physical and timeline constraints with creative engineering, combined with effective planning and cooperation by all key stakeholders.

This method of grade separation should be under consideration as an alternative to traditional diversion-staged project execution.

Similarly, the non-conventional but innovative Creek Bridge concept proved to be environmentally superior and also cost effective. While unusual to have a creek flow above a roadway, this innovation may lead others to adopt this approach in similar settings. The standards and techniques applied to analyze and permit the structure to be built provide a precedent for the industry.

Finished Grade Separation

Project Photographs

King Road / CN Grade Separation

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Monolithic bridge structure built offline then launched under the tracks

Photo by: Rocco Cacchiotti; Authorized by: CN

Railway track sections being reinstalled after the jacking operation

Photo by: Rocco Cacchiotti; Authorized by: CN

Project Photographs

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Photo by: Hatch Mott MacDonald

Bridge structure jacking panel assembly

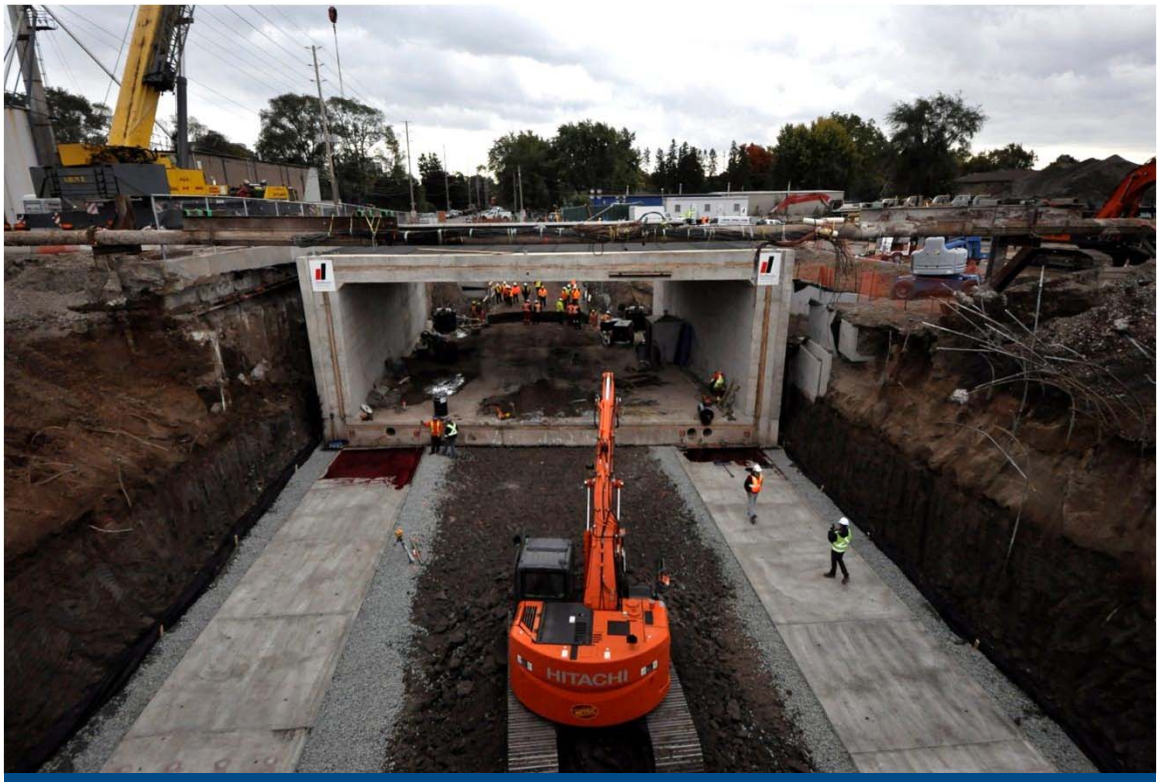

Photo by: Hatch Mott MacDonald

Open cut within tracks prepared for jacking to commence

Project Photographs

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Finished rail/road grade separation - King Road below completed in December 2013

Photo by: Hatch Mott MacDonald

Indian Creek bridge substructure

Photo by: AMEC Environment & Infrastructure

Project Photographs

King Road / CN Grade Separation

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Indian Creek bridge under construction

Photo by: AMEC Environment & Infrastructure

Temporary connection of Indian Creek to creek bridge

Photo by: AMEC Environment & Infrastructure

KING ROAD/CN GRADE SEPARATION