Chief Peguis Trail - P3 Construction

Submitted by:
Bruce Biglow, P.Eng. & Gwen Coolidge, P.Eng.
Morrison Hershfield Limited
Suite 1, 25 Scurfield Boulevard
Winnipeg, MB R3Y 1G4

Paper prepared for presentation
at the 2012 Conference of the
Transportation Association of Canada
Fredericton, New Brunswick

June 2012

Abstract

A case study of the Design and Construction of the Chief Peguis Trail Extension Project in Winnipeg, Manitoba. This project was designed and constructed as a Private-Public-Partnership (P3) and the Contractor is responsible for maintenance for the next 30 years. The total time from award of the P3 contract to commissioning and opening the roadway was 15 months, approximately one year ahead of schedule. This fast-track schedule led to numerous challenges in staging and construction methods, particularly with numerous activities occurring simultaneously.

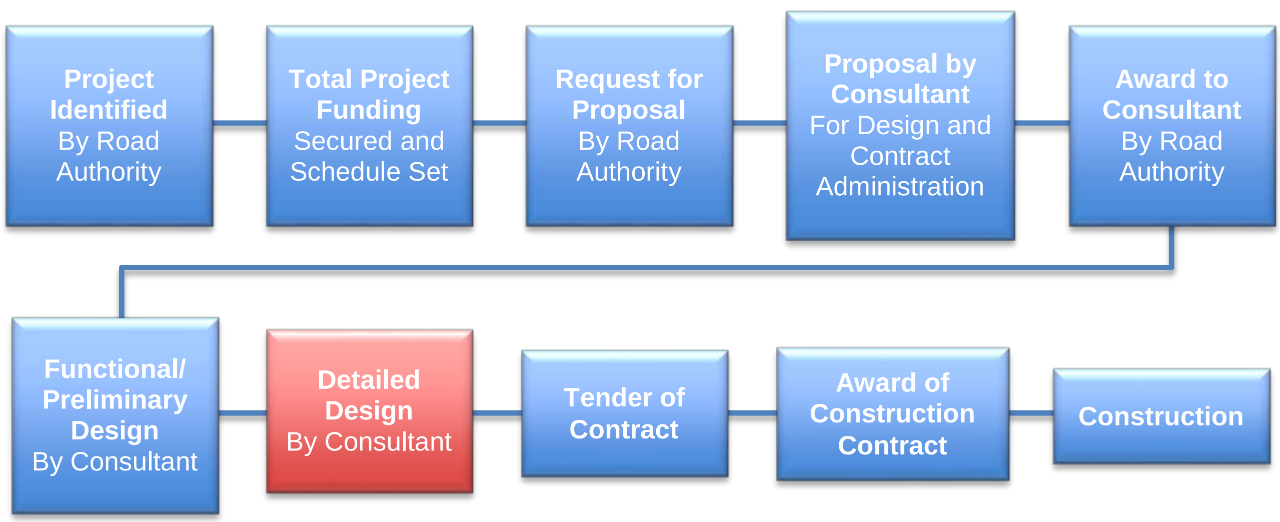
The project length of 3.7 km included a 4-lane arterial divided roadway with a fly-over roadway grade separation, sewer and water relocations, new land drainage piping, a pedestrian bridge, noise attenuation walls, multi-use paths, berms and three new intersections. Throughout the design and construction, decisions were made based on construction efficiency while also considering life cycle cost and maintenance costs. Because of the fast-track schedule and because the P3 Contractor will be maintaining the roadway, the design and construction process was very dynamic, compared to a traditional Design– Bid–Build project.

Background

Infrastructure in Canada and around the world begins to deteriorate and age as soon as it is installed, requiring continual maintenance and eventual replacement and reconstruction. With growing communities and changing economy, construction of new infrastructure is also necessary and Governments are always searching for ways to make infrastructure funds stretch further to try and get ahead of the growing infrastructure deficit.

In recent years, the Public sector has begun incorporating the Private sector to help fund and build infrastructure, to try and improve the conditions of the infrastructure and reduce the deficit. In the transportation sector, consultants are used to the conventional way of design and construction, Design-Bid-Build (DBB) Process where the road authority funds the project, retains the design consultant and tenders construction to the lowest bidder. The road authority also maintains the infrastructure after completion. Figure 1 depicts the linear flow of the conventional process to complete a typical transportation project. The process is very systematic, with all approvals completed before advancing to the next step.

Figure 1: Conventional Design-Bid-Build Process



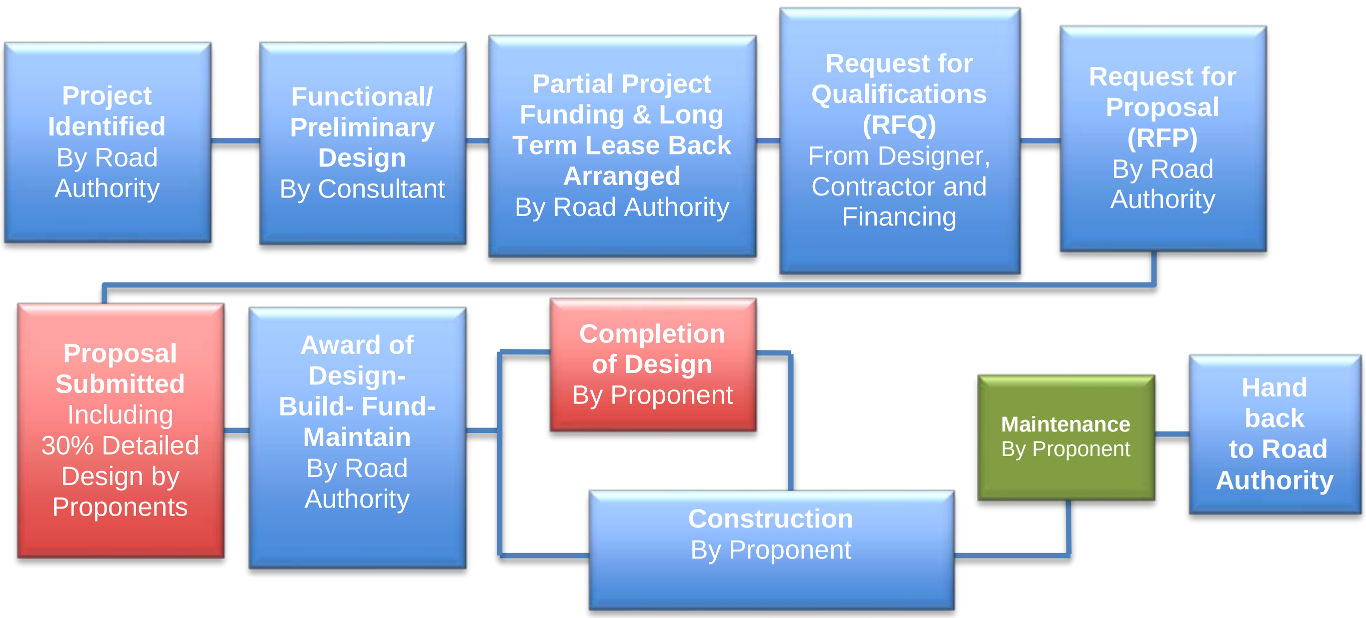
Alternative methods of completing projects include Design-Build-Maintain (DBM) as well as Design-Build-Finance-Maintain (DBFM), also known as a Public-Private-Partnership (P3). A DBM involves the private sector completing the design and construction, with the road authority funding the project, while the maintenance is performed by the private sector, based on a maintenance fee.

The P3 process is similar to the DBM process but integrates a private funder to finance the entire design and construction processes. Figure 2 shows the simplified process for a P3 project. The process is dynamic, with approvals from both the road authority and proponent being completed throughout the entire process. As the consultant is now part of the proponent's team, this process requires a different approach. Since a portion of the detailed design is completed by all bidders, the pricing and terms of reference from the road authority are completed based on the winning proponent's design.

The engineer that is part of the P3 team must ensure that this design is functional and no major costs will be added when proceeding to the next step. The final cost is established when the proposal is submitted and any changes, by either the road authority and or proponent, must be negotiated. As seen in the figure the completion of the detailed design overlaps with the beginning of construction.

Overlapping design and construction accelerates the schedule which allows the proponent to collect a portion of his investment earlier, once the project is commissioned.

Figure 2: Design-Build-Finance-Maintain/Public-Private Partnership Process



The design of a P3 is long-term performance-based compared to conventional methods that are usually based on standards and best practices.

As an incentive for the Public Sector to use the P3 process, *PPP Funding Canada* has been established to provide funding and expertise to the nation. This organization, created as a Crown Corporation reporting to the Minister of Finance to Parliament was established to improve the delivery of public infrastructure by achieving better value, timeliness and accountability to taxpayers (PPP Canada). The Chief Peguis Trail Extension Project and the City of Winnipeg was one of the first projects in the country to go through the PPP Funding Canada process and obtained funding for 25% of eligible costs up to a maximum of $25 Million

(Deloitte & Touche LLP and affiliated entities, 2011).

Introduction

Chief Peguis Trail (Chief Peguis Trail) is an important link on the City of Winnipeg's inner-ring road. It was originally identified in a 1968 study and the final route alignment was established in 1982. Eventually this inner-ring road will encircle the city, as a major arterial thoroughfare, as shown in Figure 3.

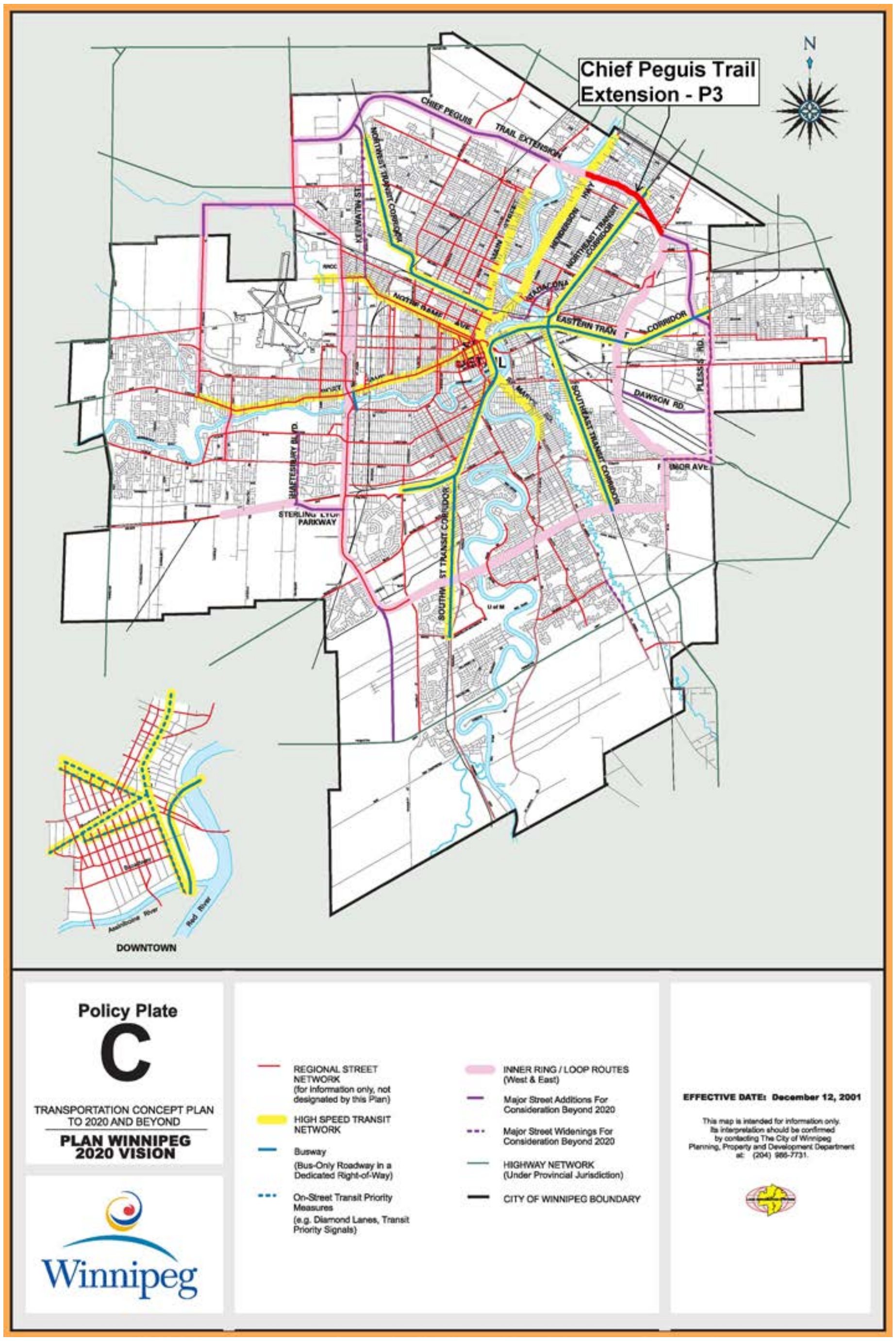


Figure 3: City of Winnipeg Inner Ring Road Plan (City of Winnipeg, 2011)

This new section of Chief Peguis Trail provides a limited-access alternative east-west route, allowing vehicles to avoid residential streets between two major north-south routes, Henderson Highway and Lagimodiere Boulevard as shown in Figure 4.

Figure 4: Chief Peguis Trial - Location Plan

Prior to 2011, Chief Peguis Trail was a short section of roadway crossing the Red River between Main Street and Henderson Highway opened in 1990. The City had been planning to extend Chief Peguis Trail by 3.7 km farther east to provide a continuous link between Main Street and Lagimodiere Boulevard and in 2009 the project was tendered as a Public Private Partnership (P3). Funding for the project included grants from:

- The Federal Government - through the P3 Canada Fund.
- The Province of Manitoba
- City of Winnipeg

DBF2 Limited Partnership (DBF2) was the private consortium selected to design-build-finance and maintain the roadway and structures, and they are financing the remainder of the project's construction and maintenance costs.

The project was awarded to DBF2 in July 2010 and Morrison Hershfield Limited (MHL) was retained by DBF2 in September 2010 to undertake the detailed design for the surface works and pedestrian bridge. In addition MHL provided overall construction management, field layout and inspection and developed and implemented the quality management plan.

The original schedule for the project was to open the roadway in November 2012; however DBF2 challenged the design and construction team to accelerate the schedule and open one year early, in order to receive the 50% of the total capital costs on opening day. All team members accepted this challenge and the dedication and commitment was instrumental to the early opening of the roadway and bridges.

Team

Teamwork is essential when working on a P3 project. Unlike a conventional DBB process, the P3 contractor is involved throughout the entire design. Completing the design and construction within 15 months was a monumental task. It required experienced designers with strong organizational skills and a vision of how all the elements tie-in together for successful completion. The design and construction team consisted of roadway, municipal and structural designers, CADD technologists, quality management and audit staff, construction surveyors and inspectors and construction companies. Using the latest technology to complete the design and then transmit information electronically back and forth between the offices and the field as construction progressed was necessary. There was constant communication with all of the companies shown on Figure 5 as well as several city departments, the area City Councillor, utility companies, residents, business owners, CN Rail and others.

Since several members of the MHL team had participated in the functional and preliminary design of Chief Peguis Trail there was an advantage in understanding the project and its constraints and allowed design schedule to be accelerated. The design had to seamlessly integrate into the surrounding neighborhood, comprised mainly of residential properties abutting the narrow right of way. Context-sensitive design decisions were made, adjusting the project elements as required to fit the adjacent properties to minimize noise and visual impacts, while recognizing that DBF2 had a fixed budget.

Since the construction was started before the detailed design was complete, it was necessary to plan out the construction sequence in great detail and ensure that conflicts and constraints were resolved in advance. The extension of Chief Peguis Trail was constructed primarily on vacant land, and therefore the impact on existing traffic and pedestrians was minor, except where the new roadway intersected with the north-south routes including; Henderson Highway, Rothesay Street, Raleigh Street, Gateway Road, Springfield Road and Lagimodiere Boulevard.

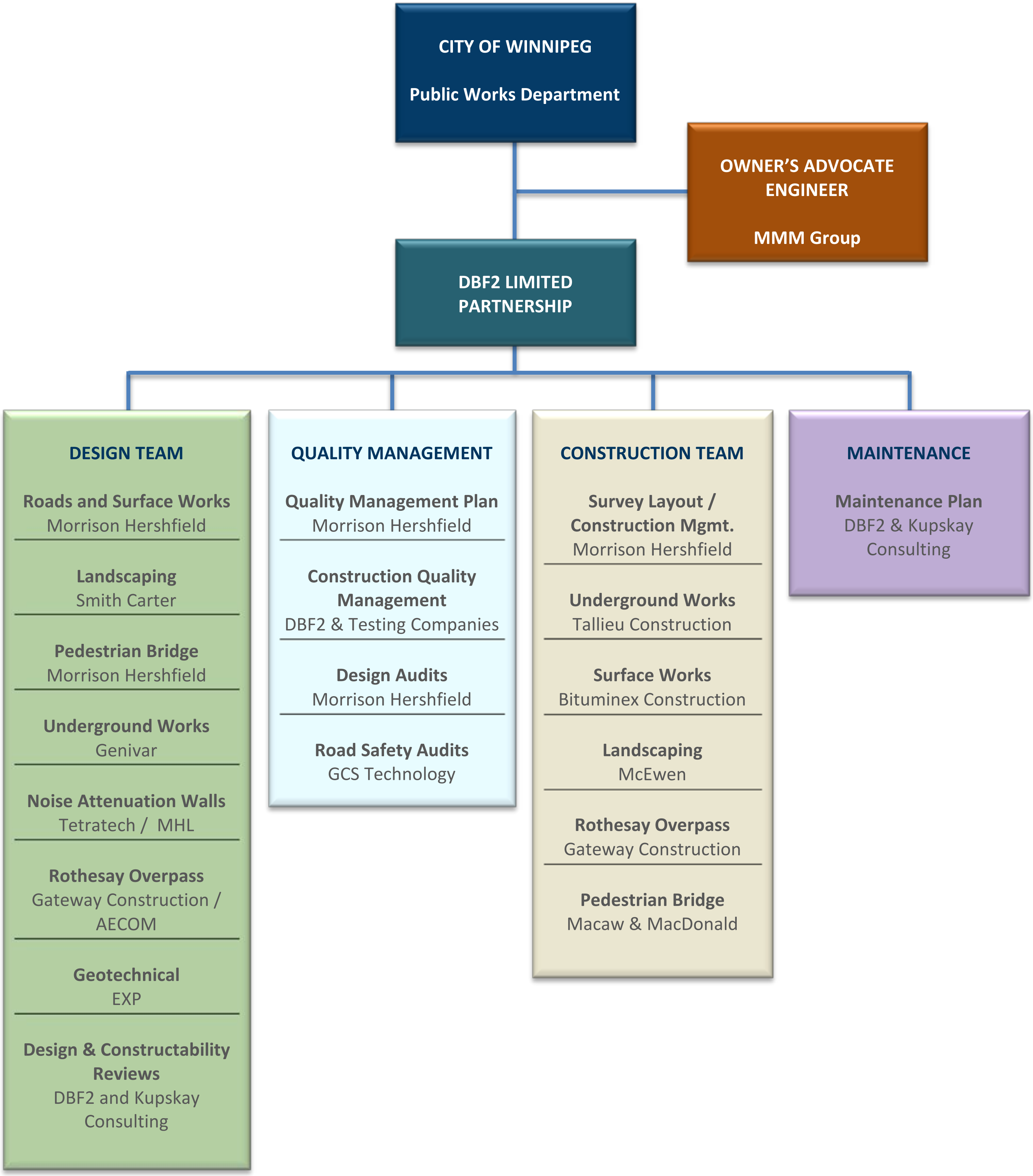


Figure 5: Team Organizational Chart

Design

The design process under a P3 model is completely different from a conventional DBB project. A typical DBB project would proceed in a very linear manner, all design decisions are made, specifications and tender documents are prepared before interested contractors see the project. With this P3 project, DBF2 prepared their bid and completed about 30% of the design work and this was used as a basis for their final fixed price. Once DBF2 was awarded the project, the design and construction moved ahead very quickly in numerous parallel, but inter-related streams. This was a very dynamic environment and decisions were made very quickly.

One of the keys to the success of this project was to have one team member become the "clearing house" for all elements of the design. All drawings (by all consultants) were to be produced in a common coordinate system and sent electronically to MHL and inserted into the master base plan. Every design element was checked for conflicts, both horizontally and vertically to ensure everything would fit together. Inserting every design element into a master base plan allowed conflicts to be identified immediately with existing infrastructure, so that either the design could be revised, or arrangements could be made to relocate the conflicting infrastructure (e.g. hydro poles, buried cables, buried gas mains, etc.).

The Chief Peguis Trail Extension Project was a complex undertaking that required all team members to communicate constantly in order to successfully expedite the design and construction. The preliminary design report provided the starting point, including the basic geometry as well as certain features, such as multi-use paths, noise attenuation walls and lane requirements. Along with the preliminary design report, a *Terms of Reference* was developed by the City of Winnipeg and provided to DBF2 with all aspects required for opening day and the 30-year maintenance period. These documents outlined the City's requirements and aided in the decision making with DBF2.

A critical task was establishing the road alignment and profile as this provided the foundation for all other design work, such as land drainage piping, structures, multi-use paths and noise attenuation walls. The right-of-way was narrow and could not be widened, as well established housing and commercial developments were immediately adjacent to the entire corridor. As the cross section shows (Figure 6), there was barely enough room for four lanes of pavement with shoulders, median swale, ditches, multi-use path and noise attenuation walls. The design also had to allow for a future widening to 6-lanes (addition of two lanes in the median). The road profiles had to be optimized very quickly to allow the rest of the team to begin their designs, especially the land drainage piping. Unlike conventional methods, the P3 process allowed the contractor to begin building, at their own risk, before all drawings were approved and issued for construction. Because of this fast tracking, it was essential to keep in contact at all times with approving authorities to ensure the submissions were detailed and no major changes would affect the ongoing construction of the project. Adjustments to the profile had to be carefully considered to minimize excavation but provide proper drainage.

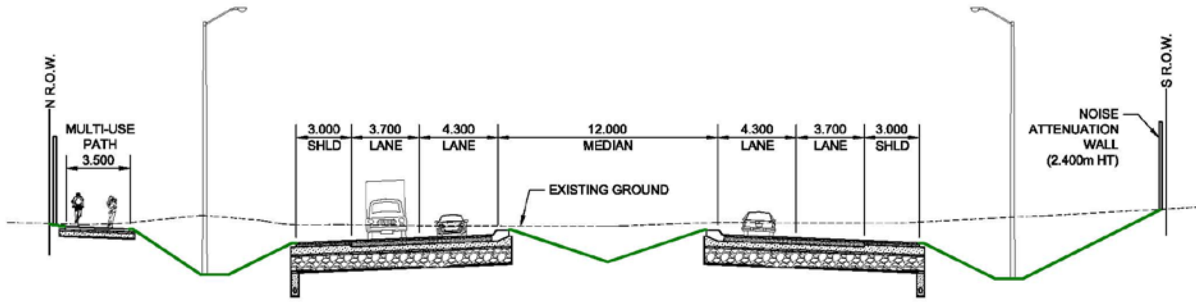


Figure 6: Typical Cross Section

With the funding provided from the PPP Canada Fund, this allowed the City of Winnipeg to include a grade separation at Rothesay Street. Chief Peguis Trail and Rothesay Street was a controversial intersection as the public expressed concerns about safety of school children crossing Chief Peguis Trail with an at-grade intersection complete with traffic lights. In the preliminary design report, the grade separation option included expropriating a home to allow for a pumping station to be constructed. Through the RFP stage of the P3 process, the pumping station was eliminated by DBF2 and gravity sewers from the underpass were proposed to reduce costs. This meant raising Rothesay Street about 3 meters above natural ground, and lowering Chief Peguis Trail approximately 3 meters below grade.

The Rothesay Street grade separation added complexity to the design, with the road and multi-use path going underneath the structure. In order to fit the desired cross-section, mechanically stabilized earth (MSE) walls were required, along with concrete barriers and drainage swales. The design optimized the length of wall and minimized excavation to reduce cost as much as possible, as required by DBF2.

The depth of the Rothesay underpass was designed so that gravity flow sewers could be used to drain the underpass and discharge into a storage pond, approximately 500 meters away. With this in mind, the Chief Peguis Trail profile under Rothesay Bridge had a fixed bottom elevation, and it was essential the roadway could be built to this elevation with minimal conflicts. The multi-use path was also designed to go under Rothesay Street, constrained to a maximum path grade of 5%, to ensure that the path would not compromise safety and usability. The Rothesay Bridge was contracted out by DBF2 as a Design-Build within the P3. They awarded the structure to Gateway Construction who in-turn retained AECOM for the structural design. This added complexity as another schedule was incorporated, with another group of workers, and designers to collaborate with.

Many other features were introduced into the design in order to reduce cost for the project. For example, berms were added where there was room, to attenuate noise, improve aesthetics and to minimize hauling excavated clay off-site. DBF2 was required to haul some excavated material off site, but staging the on-site hauling was also required. As many of the north-south routes were still open while excavation began, deciding how to haul fill to locations along the 3.7km right-of-way, as well as determining what fill stayed on site was discussed at great length to ensure efficiency and cost savings.

Focusing on excavation and the staged placement of fill was necessary to optimize the cost. This differed from a conventional DBB project, where the designer would typically quantify overall amounts of excavation and suitable site fill, but not necessary detail, how and what fill material was moving to what location on the site.

A pedestrian overpass structure was included in the project and constructed approximately half way along the corridor. As part of the proposal, DBF2 provided specifications for the pedestrian bridge. This included a two-span bridge with a center pier. Once structural design began, it was identified that a center pier was not feasible, since the pier would not fit into the median if the roadway was ever expanded to 6-lanes. Therefore the structure was designed as a clear-span with MSE walls and lightweight fill embankments connecting on each side to multi-use pathways and landscaped areas.

Figure 7: Looking East at Gateway Pedestrian Bridge

Since the bridge design differed from the accepted proposal, approvals from both DBF2 and City of Winnipeg were necessary, prior to construction of this structure. It took several iterations to design the path to connect to the bridge, ensuring longitudinal grades below 5%, and maximum cross fall of 4%. The additional loading of fill over an existing feedermain also caused great concern. It was necessary to minimize the amount of fill placed on the feedermain without exceeding maximum side slopes on the berm. After several iterations the optimum solution was found, however, monitoring for any potential movement of the feedermain was also planned to ensure this critical infrastructure remains safe.

Since this space had been a green field for many years, numerous City sewer lines and utility lines had been installed throughout the entire corridor. Countless meetings, discussions and designs were completed with Manitoba Hydro Power and Gas, Shaw, Manitoba Telephone System, City Traffic Signals and Telus. Lowering of gas mains, relocations of services to homes, removal of power poles and underground services and adjustments to numerous telephone lines all had to be accommodated and scheduled. In order to minimize conflict working closely with Manitoba Hydro to locate the new street lights and path lighting along the whole corridor was necessary.

Ensuring all 200 street and path lights would not interfere with any of the underground infrastructure was necessary before finalizing the locations. All costs incurred by the utilities were paid for through DBF2. This differs from conventional methods where the road authority pays for these items directly and they are not part of the DBB process. DBF2 scrutinized each of the planned utilities relocations, in order to reduce costs, and also to ensure that the utilities were placed such that they would not affect maintenance along the corridor.

Existing utilities also created many constraints for the design and installation of the noise attenuation walls. Along the Chief Peguis Trail corridor, approximately 3.5 km of noise attenuation wall was designed. A noise study identified where walls were required to mitigate vehicle noise to meet the City Bylaw. DBF2 choose a Simtek Fencing System. The fence is made from proprietary Linear Low Density Polyethylene Plastic and reinforced with galvanized steel. With this system, the pile spacing was pre-determined to be 2.4 m (8ft), center to center.

Figure 8: Noise Attenuation Wall

Locating each pile for the noise wall was not an easy task, as there were many buried utilities parallel to and crossing the noise wall alignment. A soft dig program was carried out to identified conflicts with all buried utilities, to determine the exact location and depth. The survey crew located and documented all the utilities lines and their coordinates and elevations were transmitted electronically to the office and added to the master base plan.

Using this data optimum pile locations were determined to avoid the buried utilities where possible.

In cases where buried utilities could not be avoided, grade beams and custom posts were installed to span over the conflict area. The grade beams varied from 4.8 m to 7.3 m and allowed the noise wall to be continuous over utilities such as the feedermain, land drainage sewers, waste water sewers and primary hydro cables. There were also 21 custom corner posts designed, to accommodate deflections and corners as the noise attenuation wall followed the property lines. These posts were custom fabricated for a specific angle and specific location along the corridor.

A public open house was scheduled early in the project. The noise attenuation wall, public use areas and traffic concerns were the major topics of the evening. Since the detailed design was well underway at the time of the open house, it was an opportunity for DBF2 to show the public what was being proposed. Fortunately DBF2 was able to accommodate many of the public's concerns into the final design. Relationships were built with two churches that fronted onto the corridor to work together to create new, aesthetically pleasing entrances to their facilities. In addition detours and construction staging was designed to accommodate traffic to the churches during construction.

Construction staging and traffic requirements were stated in the City's *Terms of Reference*, and were followed by DBF2. As traffic patterns and lane closures changed during the project the public was kept informed through signage and notices posted on the City's website.

For each intersection along the corridor, detailed construction staging plans were prepared to minimize the impact on traffic, pedestrians and cyclists. The two major north-south routes at each end of the project, Henderson Highway and Lagimodiere Boulevard each received pavement rehabilitation and overlays, one lane at a time to accommodate traffic. Rothesay Street across Chief Peguis was a well-travelled pedestrian route and walkway for school children. However, it had to be closed for several months while the overpass was constructed, so a fenced-in walkway was created away from the bridge site to allow pedestrians to safely walk through the worksite.

Figure 9: Gateway Road Construction Staging

At Gateway, pedestrians were accommodated on one side of the roadway at a time while the widening of Gateway was being constructed. The staging plan was very detailed in order to figure out what lanes could be constructed while traffic was still using the roadway. The Gateway design profile was approximately 1.2 meters above the existing road, in order to tie into Chief Peguis Trail, so ensuring slopes were stable with enough room to construct each lane was necessary. With the staging plan the contractor was able to maintain through traffic in both directions for four of the five stages. In the last stage, the pavement widths did not allow traffic to flow in both directions, so flag persons were on-site to temporarily allow buses through, against the flow of other vehicles. To minimize impact on traffic, this last stage was done during the weekend, when reduced bus service and less commuter traffic was present.

Construction of Chief Peguis Trail across Springfield Road was also a challenge, as this residential collector was heavily used as the east-west route between Henderson Highway and Lagimodiere Boulevard. The City's *Terms of Reference* indicated that it could only be closed for 40 days. Therefore, the design team along with DBF2, decided to build Chief Peguis Trail as close to Springfield as possible, without affecting the flow of traffic or drainage. Then, 40 days before Chief Peguis Trail was ready to open, Springfield Road was closed permanently and new pavement was constructed on Chief Peguis Trail to fill in the gap. This made it easy for the public to understand, as Springfield Road was never re-opened and Chief Peguis Trail became their new route.

Figure 10: Springfield Road and Chief Peguis Trail

One of the design features of this corridor was to minimize hazards within the clear zone and ensure all roadside slopes were recoverable. This was not only for safety, but also to reduce costs for DBF2. All hazards on the boulevards/ditches were located outside the clear zone, including street lighting, overhead sign structures (OHSS) and abutment walls. However, at several locations OHSS had to be placed within the median. As well, the center pier for the Rothesay Bridge was in the median. At these locations, roadside hazard protection was required. The design team reviewed all hazards and locations to determine the available options for protection to meet the NCHRP 350 TL-3 requirements. There were two feasible options; the Midwest Guardrail System (MGS) or QuadGuard Crash Cushions. Both protection methods were acceptable, and following DBF2 discussions with the City of Winnipeg, it was agreed to use the QuadGuard Crash Cushions for majority of the OHSS protection because of maintenance and snow clearing issues with the Midwest Guardrail System. The QuadGuards also allow for a future widening to six lanes, which the Midwest Guardrail system did not. The protection for the OHSS on Lagimodiere Blvd. was designed with a Midwest Guardrail System because of a wide median and guardrail was installed along back of curb, eliminating the snow clearing concern.

After the protection type was chosen, curb height, median slopes and grading was designed to provide recoverable slopes and minimize the risk of vaulting. Pier protection for the underpass at Rothesay Street was also designed with the QuadGuard system for both directions to protect traffic from the blunt ends of the barrier.

Figure 11: Chief Peguis Trail looking east from Rothesay Overpass

Material selection and construction methods were also a large part of the design of Chief Peguis Trail and the P3 process. Since this project had an accelerated schedule; underground utilities were installed in the winter followed by road excavation and material placement in the late winter and early spring months. Geotechnical investigation and pavement design was primarily done by EXP, and their recommendations were incorporated into the design as needed to ensure constructability. Standard materials, such as limestone sub-base and base course and asphalt pavement were chosen as the main structure for the roadway.

Since DBF2 was responsible for 30 years of maintenance, consideration of easy maintenance and life cycle cost were incorporated into the design.

Silt areas were identified in the geotechnical study, so the design team worked together with DBF2 to determine procedures when silt was encountered in the road excavation. This included over-excavating to remove poor soils where necessary.

Another advantage of the P3 project was that there were opportunities to make changes very quickly as site conditions changed.

For example, as construction progressed the team became concerned about the future roadway under the Rothesay underpass. Because of poor soil conditions and extensive underground utilities, concrete pavement was recommended to minimize the life-cycle cost in this area. This recommendation was discussed with DBF2 to ensure the life cycle cost benefits of installing concrete versus asphalt pavement was justified and the change was approved. The option of installing concrete for the Gateway Road and Chief Peguis Trail intersection was also discussed, but later determined that the higher initial cost of installing concrete was not justified.

Other non-standard materials employed on this project included Cematrix (Cellular Concrete Solutions). This was used for light weight fill behind the MSE walls for both the Pedestrian Bridge and Rothesay Bridge to reduce potential settlement. Although materials were chosen during the detailed design process, many design changes and constructability decisions were made as construction progressed.

Contract Administration

MHL was responsible for contract administration, which included field layout for the entire Chief Peguis Trail corridor, except for the Rothesay Bridge, which was a design-build by Gateway Construction. The field staff was required to be efficient and knowledgeable of the design and features of the site. The team used AutoCAD with LDD, Survey GPS, Robotic Total Station as well as conventional rod and level. Each survey tool had a purpose and role in the layout and construction of the corridor. With fast paced construction, the Robotic Total Station was very efficient for construction layout of the noise attenuation wall, multi-use path and roadway elements.

The advantage of the Robotic Total Station, compared to the conventional total station is it can be used with only one person. This was greatly beneficial during this project as survey man power was very demanding. By importing the alignments and vertical profiles into the electronic field book, it made it possible for one experienced person to layout and grade the 6.8 km of multi-use path and 3.5 km of noise attenuation walls. Survey GPS was used for horizontal layout of every feature of the corridor, however it was not used for setting final grades. Survey GPS was used extensively to provide coordinates back to the office staff with locations of utilities and features. This allowed fine-tuning to adjust designs and solve field problems. Precise grades for road construction were set with conventional rod and level; this was also used to check grades after materials were placed. This advanced equipment allowed the project to be completed with accuracy and efficiency.

Quality Management Plan

As part of the P3 process and incorporated into the Terms of Reference was the requirement for a comprehensive quality management plan. This included a design quality management process, which was implemented for all of the consultants to follow, and this process was subject to audit. In addition, construction quality assurance / quality control processes were implemented. Materials testing frequencies and documented procedures for record keeping were established. The quality management plan was well received by the team and resulted in documented assurance that the design and construction met and/or exceeded the City's specifications.

Conclusion

The Chief Peguis Trail Extension Project was opened to traffic one year ahead of schedule on December 2, 2011 with a ribbon cutting ceremony attended by all three levels of Government, a representative from the PPP Canada and many stakeholders. To date there has been an overwhelming positive response from stakeholders. Remaining work for the summer of 2012 includes paving of the multi-use pathway and installing the landscaping. The project will be remembered by the entire team as a very demanding, fast paced but enjoyable experience.

Figure 12: Chief Peguis Trail Ribbon Cutting on Opening Day, Dec 2, 2011

The P3 process was a great learning experience that took some getting used to. The design team needed to understand their roles and responsibilities and how they differed from working in the conventional DBB environment. After a short time, the entire project team "gelled" and got used to working for the Contractor and gained an appreciation for the other side of the business.

Works Cited

City of Winnipeg. (2011, July 5). *Reports - Plan Winnipeg - 2020 Vision.* Retrieved March 2012, from Plan Winnipeg: http://www.winnipeg.ca/cao/reports/plan_winnipeg.stm

City of Winnipeg. (n.d.). *City of Winnipeg Major Projects*. Retrieved March 2012, from Chief Peguis Trail: http://winnipeg.ca/publicworks/MajorProjects/ChiefPeguisTrail/

Deloitte & Touche LLP and affiliated entities. (2011). *Cheif Peguis Trail Extension Project - Value for Money Report.* Winnipeg.

PPP Canada. (n.d.). *Corporate Information: PPP Canada*. Retrieved March 12, 2012, from PPP Canada Web site: http://www.p3canada.ca/about-ppp-canada-overview.php