

# 12 Street SE Bridge Replacement Project

Calgary, Alberta

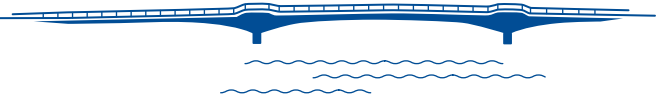
**Calgary**



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# Project Description



The City of Calgary (The City) recently opened the new 12 Street SE Bridge which spans an environmentally sensitive area of the Bow River. Located in SE Calgary, the new structure replaces the 108-year-old St. George's Island Bridge and connects St. George's Island with the historic community of Inglewood on the south side of the river. Although St. George's Island is now home of the Calgary Zoo, the old bridge was originally built in 1908 to replace a ferry service that ran to the Island, then just a community park. The first collection of animals was not brought to St. George's Island until 1917, and the Calgary Zoological Society was later established in 1929.

Shortly before its demolition, the old St. George's Island Bridge carried about 8,000 vehicles a day on two narrow lanes of roadway. This was a substantial change from the original horse-and-buggy traffic the bridge was originally designed for. It also included a very narrow sidewalk on the east side for pedestrians and cyclists. Due to the limited space, cyclists were requested to "dismount and walk their bicycle" for approximately 150 metres while crossing from one side of the river to the other. Because the lanes were so narrow, vehicles were often forced to drive very close to each other resulting in frequent collisions. There was often broken glass and other debris found on the sidewalk from cars' broken side mirrors.

Despite regular inspections and extensive rehabilitations throughout its lifespan, the bridge continued to deteriorate with age. The oldest part of the St. George's Island Bridge was never designed for modern roadway standards or volumes. To further complicate matters, the north end of the bridge had a "made to fit" roadway connection. The substandard horizontal curve conflicted with access to the adjacent Zoo Administration

Parking Lot, resulting in poor lines of sight for drivers and an increased risk of accident. Subsequent investigations conducted after the 2013 Calgary floods noted substantial damage to the bridge and a serious deterioration of the substructure. That, combined with the bridge's age, significant geometry challenges, height and weight restrictions for vehicles and the need for constant maintenance to ensure public safety led The City to determine a new structure was required.

In 2015, The City retained CH2M, now Jacobs, to develop a feasibility study, conceptual, preliminary, and detailed designs, and to provide tender and construction administration services, including on-site engineering. Some of the key objectives during the design phase included:

- Minimizing environmental risk through design.
- Increasing the flood resiliency of the area.



- Improving roadway geometrics and connectivity for all modes.

From concept development through to detailed design and construction oversight, CH2M drew on the expertise of its Structural Bridge Team in Alberta, as well as its industry-leading Construction Support and Project Management specialists. CH2M's innovative design used full-depth, full-width precast concrete deck panels and Ultra High-Performance Concrete (UHPC) instead of a fully cast-in-place bridge deck.

This approach reduced the potential for environmental impacts during construction, while the new haunched girder profile and the structure's vertical curve addressed The City's need for improved flood resiliency. Widened traffic lanes and a broad multi-use pathway have also improved traffic flow as well as safety for all users. To the project team's knowledge, this is the first time in Alberta that full-depth, full-width, precast deck panels with UHPC connections have been used in a multi-span, continuous vehicular bridge.

The City held a grand opening for the 12 Street SE Bridge on December 9th, 2017 where the community was invited to explore the newly completed bridge and take a stroll across the river before opening to traffic the following day. The new bridge has been very well received by The City, the residents of Inglewood and visitors to the Calgary Zoo.



Accelerated Bridge Construction (ABC) methods, such as using full-depth, full-width deck panels combined with Ultra High-Performance Concrete, are increasingly common tools for bridge designers. There are several benefits from using precast ABC techniques, including a higher level of quality control compared to traditional cast-in-place elements, less onsite formwork, shorter construction timelines, and lower risks corresponding to work over water or live heavy traffic.



# Rising to the Client's Needs



The success of every project is fundamentally measured by how the design accomplishes the client's goals. Before diving into the details, it is critical to identify the key drivers that will shape the project and select design elements that positively address them. Working in close collaboration with The City, CH2M's project team focused on three crucial drivers that guided our design choices:

1

Minimizing environmental risk through design

2

Increasing the flood resiliency of the area

3

Improving roadway geometrics and connectivity for all modes

These three guiding factors directed the innovations we made across the project, including the bridge form, alignment and composition.

## Mitigating Risk Through Design

A primary concern for The City was the potential impact of construction activities over the environmentally sensitive Bow River. To mitigate the risk of placing large volumes of concrete over the Bow River, the design team turned to growing field of Accelerated Bridge Construction (ABC) and utilized full-depth, full-width, precast concrete deck panels in place of a traditional cast-in-place concrete deck. While precast concrete deck panels have been used on bridges across North America, this project represents the first time full-depth, full-width panels were implemented for a multi-span continuous vehicular bridge project in Alberta. In addition, the large dimensions of the panels and need to provide negative moment continuity in the deck over large spans were

challenges that pushed the current boundaries for this type of construction. UHPC was used to provide panel-to-panel and panel-to-girder connections.

## Form Based on Function

The old St. George's Island Bridge survived a number of floods, though inspection photos in 2013 showed river levels within inches of the structure soffit. The new structure needed to, first and foremost, improve flood resiliency by reducing the risk of upstream flooding. It also needed to provide a robust connection across the river to facilitate evacuation in the event of a natural disaster. This meant the new bridge needed greater vertical clearances and a minimal in-stream footprint. At the same time, the bridge had to tie in with the existing roadway, which put constraints on how much the structure could be raised.

The preliminary design for the bridge looked at three structure options:

1. A 4-span NU-concrete girder bridge
2. A 3-span steel through truss bridge
3. A 3-span haunched steel box girder bridge with vertical curve

To achieve the desired clearance under the structure, it was recognized that a balance had to be struck between the cost of the structure and the cost of the roadway grading required at either end. The NU-girder option presented the cheapest capital bridge costs but added costly roadway fills and an additional in-river pier. The truss option best echoed the history of the existing structure but carried the highest structure cost and would require substantial maintenance over its lifespan.

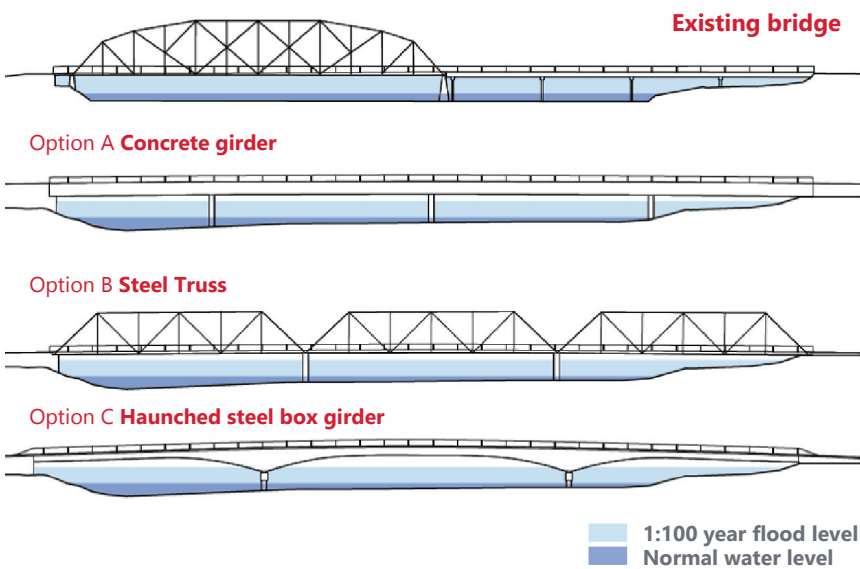
The solution chosen was a haunched steel box girder design with variable girder depth and a vertical curve. The combination of the haunched profile and the vertical curve allowed for small grade changes at the abutments, which reduced the need for earth fill while raising most of the bridge above the 1:100-year flood level. It also minimized the number of piers required and allowed for a more efficient use of steel material. The girder design used steel box girders, which are seldom used in Alberta but are more efficient for curved (in plan) and skewed bridges, and provide a higher span to depth ratio with less environmental exposure.

### Improving the User Experience

The original alignment suffered from a substandard, 90 degree turn at the north end of the bridge, narrow 2.6m lanes, poor sightlines to the Zoo Administration parking lot and a low vehicle height clearance due to the Through-Truss design. Through the project's Feasibility Study, the design team determined the best solution was to alter the bridge alignment. By rotating the alignment to the NW, the design softened the sharp north turn and

## Flood levels and bridge designs

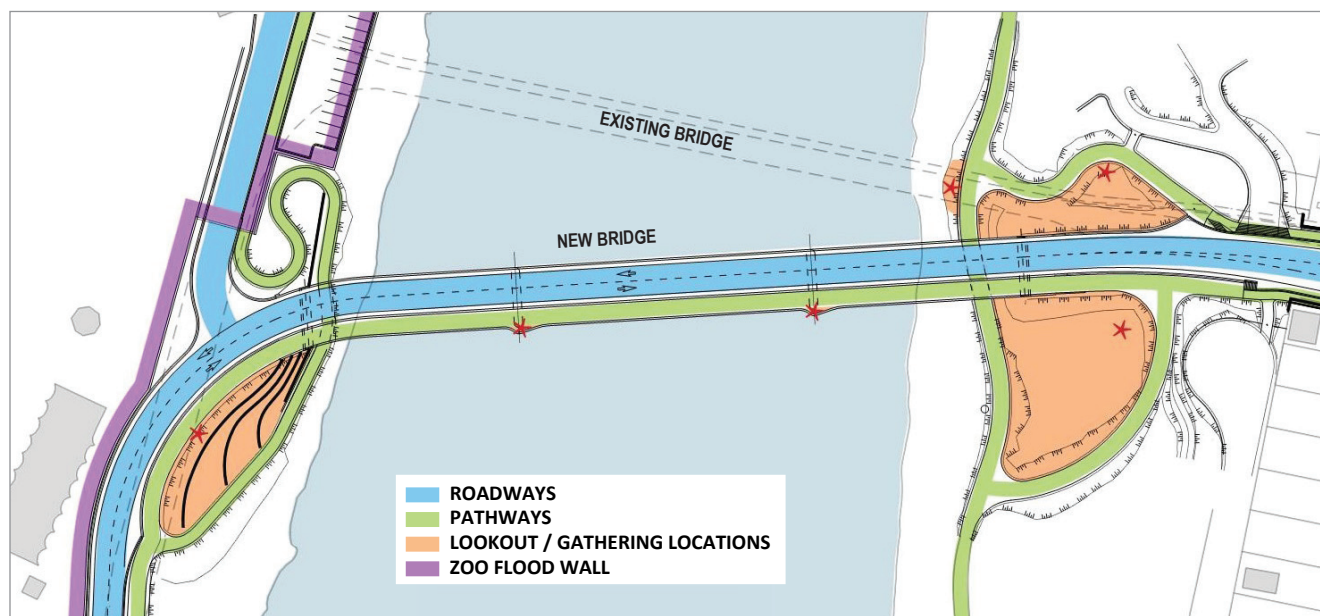
Compares 1:100 flood levels with normal river levels

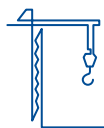


lengthened the driveway access. Combined with updated lane widths of 3.5 m, 1.0 m shoulders and the additional vertical clearance, the new 12 Street Bridge benefits from improved driver visibility, safety and comfort.

Improved vehicle flow wasn't the only aim of the project. Enhanced facilities for all modes of travel were vital to the project's success. The St. George's Island Bridge had a narrow sidewalk which could barely accommodate two

people abreast. The 4-metre-wide multi-use pathway on the new structure provides ample space for pedestrians and cyclists to safely cross the river and connect with Calgary's Regional Pathway system, the Inglewood Community and nearby recreational facilities. At the bridge piers, the path features teardrop-shape lookout platforms, offering Calgarians an opportunity to pause and enjoy the city skyline.





# Leading in Unfamiliar Territory



It can be challenging to adopt new technologies in the construction industry. A lack of design and construction familiarity, as well as financial, safety and quality risks, make it difficult to bring design innovations forward. To do so requires a strong relationship between client and designer, built on cooperation, respect, and trust. CH2M had a capable and willing partner in The City of Calgary, who not only provided financial support but also significant technical input on the development of the precast concrete deck panels. The result was a boundary pushing application of an emerging technology that provides guidance to future designs for the adoption of full-depth, full-width, precast concrete deck panels.



## Advancing New Technology

To our knowledge, this is the first time in Alberta that full-depth, full-width, precast deck panels with UHPC connections have been used in a multi-span, continuous vehicular bridge. Partial-depth, precast-concrete deck panels have been previously used on multi-span bridge projects in Alberta; however, these partial-depth panels typically rely on a concrete overlay to form a

continuous concrete deck. Full-depth, full-width, precast panels present an advantage over partial-depth panels in that they eliminate the overall volume of concrete required to be placed on site.

## Pushing the Boundaries

While precast concrete deck panels are starting to see wider use, no local standards or guidelines currently exist regarding the design and detailing

of full-depth panels. The design team invested significant effort to source, review and apply the available literature from international references and authorities. During the design process, it was discovered that the dimensions of the full-depth panels used for the bridge deck pushed the boundaries of existing references from other locations.



## ADVANTAGES OF UHPC

The high compressive strength (160-200 megapascals) and ductility of UHPC, used for panel-to-panel and panel-to-girder connections, simplified the detailing, fabrication, and installation process. The high tensile strength and short splice length reduced the design complexity and increased the strength of the connection joints. This was especially important over the piers where high negative moments existed due to bridge continuity with the large spans. UHPC also had the added benefit of being batched on-site with a small mixing footprint and quick set up time.

This application used full-depth, full-width panels on a multi-span continuous bridge with long spans while most of the current global experience was in short, simply supported spans. The width of the bridge exceeded the maximum length recommended for full-depth panels in the existing references. Lateral pretensioning was used to reduce the risk of cracking during shipping and erection and keep the panel stresses in compression during service.

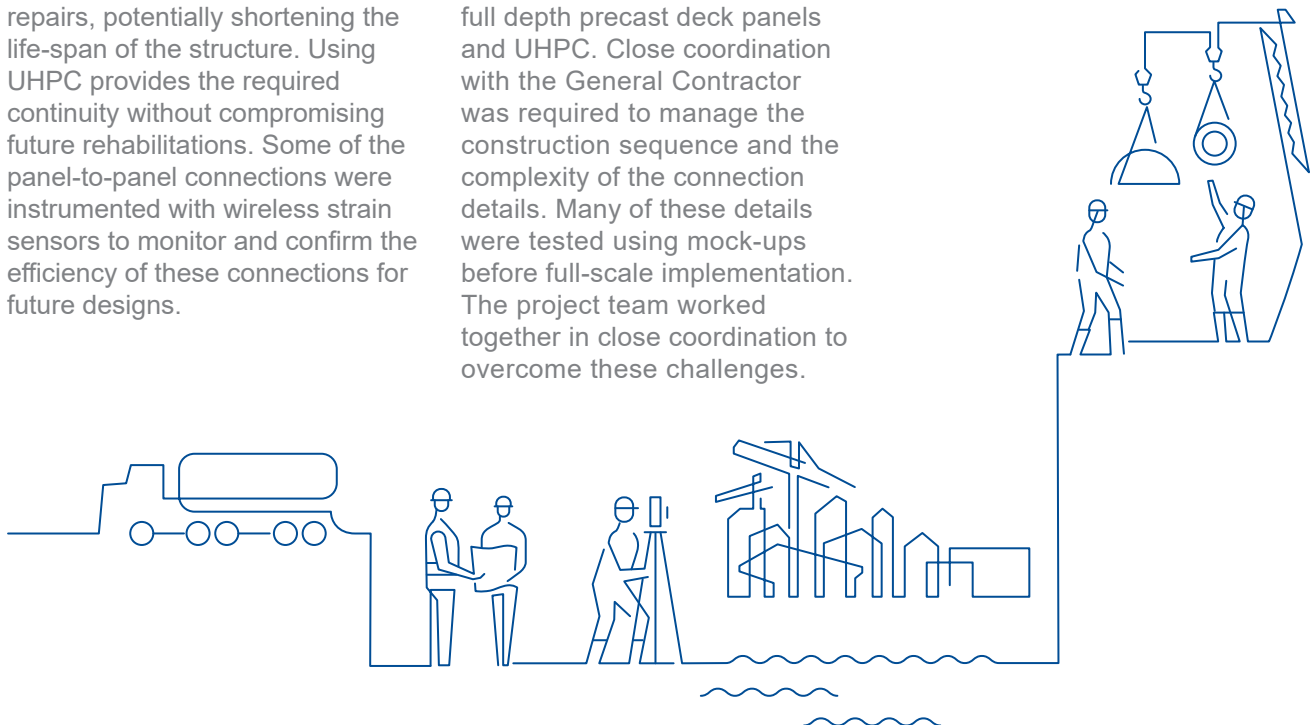
### Tying Everything Together

One of the primary challenges in the project design was providing longitudinal continuity in negative moment areas where the panels and their connections are subjected to high tensile forces. The current recommendation of the Canadian Highway Bridge Design Code CSA S6-14 is to use longitudinal post-tensioning to provide panel-to-panel continuity. While effective at transferring forces between individual elements, pre-stressed steel cables or rods present a potential risk to future bridge deck rehabilitation efforts. The presence of these cables adds risk to typical partial depth repairs, potentially shortening the life-span of the structure. Using UHPC provides the required continuity without compromising future rehabilitations. Some of the panel-to-panel connections were instrumented with wireless strain sensors to monitor and confirm the efficiency of these connections for future designs.

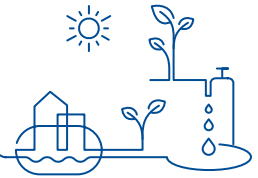


### Working Out the Kinks

Another main challenge with the panels was the lack of past construction experience with full depth precast deck panels and UHPC. Close coordination with the General Contractor was required to manage the construction sequence and the complexity of the connection details. Many of these details were tested using mock-ups before full-scale implementation. The project team worked together in close coordination to overcome these challenges.



# An Environmental Focus



An environment focus for a project can mean getting the right permits, conducting the proper field surveys, minimizing disruptions to habitats and restoring disturbed areas. It can also mean looking at the bigger picture and considering how your project interacts with the environment long-term. The project team looked at caring for the environment as not just being about our environmental impacts today but also about how we can mitigate the impacts of our work for future generations.

## Limiting Our Footprint

A guiding design principle was limiting the project's environmental footprint from concept to opening. It started in design by focusing on a span arrangement that called for two piers in the river instead of three. It continued with the choice of precast deck panels to significantly reduce wet concrete volumes placed over the river. It carried into construction by restricting the space cleared for work and minimizing the footprints of the in-stream berms. It extended to the removal process for the St. George's Island Bridge, where a diaper slung under the structure limited debris, such as lead paint, from entering the river and where the existing piers were removed to below the riverbed. It concluded with the partial salvage of the old truss structure, with sections stored to be used as future commemorative artwork in the area.

## Addressing Flood Resiliency

Flood mitigation was one of the main considerations in the bridge design. Not only does the structure need to withstand the floodwaters itself, it must achieve hydraulic efficiency for flood water flow. The challenge was to raise the bridge above the new 1:100-year flood levels with minimum changes in the existing approach elevations. This was achieved by using haunched girders with



variable depth and a curved vertical profile. With this design, most of the bridge will remain out of water in a 1:100-year event. The structure's shape also improved overall hydraulic capacity of the rivers' cross section, ensuring the structure will not impact water throughput under higher seasonal and flood conditions brought on by climate change.

## Designed for 100 Years More!

The City has a mandate that all new bridges are designed for a 100-year service life. How well a structure performs over that lifespan largely depends on its materials and detailing. Structural materials for the new 12 Street Bridge were selected with a focus on durability and low life cycle cost as guided by The City's guidelines. Atmospheric corrosion-resistant steel was chosen for the girders to eliminate the need for protective coatings, a costly maintenance expense.

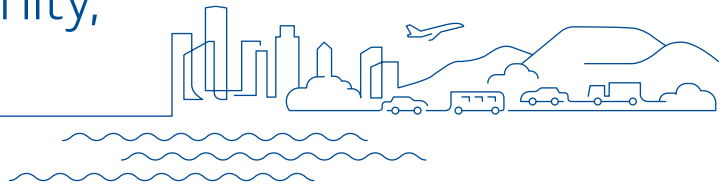
Stainless steel reinforcement and high-performance concrete were used for the precast deck panels and concrete elements within splash zones to reduce the long-term risk of corrosion. Disc bearings with galvanized steel hardware were selected that could tolerate submergence in a flood and require minimal servicing. A durable methyl methacrylate wearing surface was used in place of asphalt to cover and protect the multi-use pathway.



### MONEY IN THE BANK

The existing structure had experienced significant deterioration over its lifetime. Near the end of its life, the average cost of maintaining the structure was estimated at \$200,000/year. With a focus on durable, low maintenance materials, the new structure affords The City significant savings in annual maintenance costs.

# Benefits for the Community, the City and Beyond



Bridges play a vital role in our civic infrastructure. As an instrument of travel, they allow us to traverse rivers, valleys and freeways to get from Point A to Point B. But bridges can be so much more than a simple crossing. Bridges can link communities and cultures together, helping to shape how a city grows. They can augment and enrich the natural environment, giving character to the landscape. And in times of trouble, they can be a lifeline for families to safely escape danger.

## A Secure Route for the Future

Large vehicles could not travel on the old structure due to a combination of a 4.5 tonne load restriction, vertical clearance restrictions and the tight horizontal geometry. The improvement in the road geometrics and load capacity of the new structure opens the route to be used by buses, trucks and emergency vehicles providing an alternate commercial route, additional service options for Calgary Transit and redundancy in the EMS network. Most importantly, the increased clearance from the river secures the road as an alternate evacuation route for the residents of Inglewood in a future flood.

## A Structure That Fits Within its Surroundings

The bridge is situated in a river valley and connects to park land on either side. It was important to have the structure blends with the natural environment, rather than clashes with it. The weathering steel girders provide a natural

earthy tone to tie in with this context. The arched shape of the girders gave the structure softer, flowing lines. This idea of softer edges was also applied to the pier caps and abutments, and gently flowing lines were shaped into the tear-drop pedestrian look outs. The bridge's character, lines and colour palette echo other structures nearby, contributing to a common design language in the community.

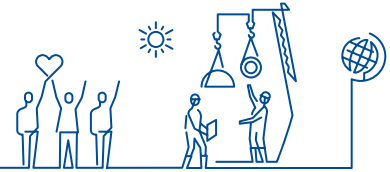
## A New Tool in the Toolkit

Accelerated Bridge Construction (ABC) methods, such as full-depth, full-width deck panels, are increasingly becoming common tools for bridge designers. These methods can provide substantial public value, reducing road closure times, shortening project schedules and limiting environmental impact. However, confidence and familiarity with new techniques must be earned through experience.

The experience gained from this project provides long term public and industry value as lessons learned can be applied for future designs, leading the way for more widespread use of full-depth, full-width precast deck panels. The wireless strain instrumentation installed in some of the panels and joints will allow the design team to monitor the structure's behaviour, further contributing to the collective design knowledge for this type of construction.



# A Winning Team



A successful project is only as good as the team that brings it all together. Under the guidance of CH2M's leadership, the team adopted a multidisciplinary approach that involved building constructability into the design from the beginning. The project benefited from the involvement of the team's accomplished senior project managers, engineers, and technical specialists who brought expertise in key areas and specific experience in the fast-track delivery of challenging assignments. CH2M and our team could not have achieved our project goals without the strong support of The City of Calgary's Bridges and Structures Division and The City's senior leadership.



The 12 Street SE Bridge Replacement project was designed by CH2M's (now Jacobs') Structural Bridge Team in Alberta. CH2M was supported by a strong group of subconsultants including Thurber Engineering (Materials and Geotechnical), Matrix Solutions (Hydrotechnical, Environmental Permitting), Carson McCulloch (Landscape), Marshall Tittlemore Architects (Architectural Support), ADP Engineering (Roadway Lighting), AECOM (Accent Lighting), Parsons (Independent Design Review),

International Quality Consultants (Steel Inspections) and Goal Engineering (Instrumentation).

The project was championed, supported and funded by The City of Calgary's Bridges and Structures Division within the Transportation Department.

The project was constructed by General Contractor Westpro – A division of Pomerleau, with assistance from key subcontractors Rapid Span (Girder Fabrication), Dakota Reclamators (Existing Structure Removal),

Lafarge Precast (Concrete Deck Panels), Lafarge Ductal (Concrete Supply/UHPC), RJ Watson (Disc Bearings), Watson Bowman Acme (Expansion Joints), AGF C&T Rebar (Reinforcement), WestCo Drilling & Piles (Piling), The Welder (Steel Erection), All-Span Engineering (Construction Engineering), PlaceCrete (Waterproofing), ALSA Road Construction (Paving), Kang Construction (Deep Utilities) and Highline Electrical Constructors (Streetlighting, Shallow Utilities).



*Photos and graphics for this submission were graciously provided by The City of Calgary, Westpro – A division of Pomerleau, Marshall Tittlemore Architects and Peak Aerials (PeakAerials.com).*

**JACOBS®** **ch2m.**

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