THE CORPORATION OF THE CITY OF COURTENAY

STAFF REPORT

To: Council **File No.:** 5335-20

From: Chief Administrative Officer (Interim) **Date:** December 07, 2020

Subject: 6th Street Multi-Use Active Transportation Bridge Update

PURPOSE:

The purpose of this report is to provide Council with an update on the 6th Street Multi-Use Active Transportation Bridge Project, and to seek direction from council to proceed into detailed design for the symmetrical cable-stayed bridge option, which is recommended in the recently completed Detailed Options Analysis.

EXECUTIVE SUMMARY

Council has previously directed staff to investigate options for a 6th Street Multi-Use Active Transportation Bridge. An options analysis for this was completed in January of 2020. Subsequently, a Detailed Options Analysis was initiated with the goal of developing the bridge options further, and refining the designs and cost estimates.

Through the use of an evaluation matrix, four bridge design options were narrowed down to two shortlisted alternatives: the network arch and cable-stayed options. The cable stayed bridge is the recommended option. It has the benefit of requiring a much smaller staging area during construction, which would have a lesser impact on businesses and traffic, as well as less impact to the environment on the park side of the bridge.

The need to confirm a bridge design is required to facilitate potential construction in 2022. Without a confirmed design, critical path items such as procurement and permitting cannot proceed. Archaeology permits for example, require a minimum nine months of lead time before gaining approval. Additionally, the borrowing process if utilized will also require a long lead time of approximately 8 months and should be started as soon as possible after detailed design and grant funding is secured.

Public engagement has been a priority throughout the development of the project. The project team has met with multiple stakeholders throughout the year to solicit feedback about what is important to consider as the City developed design options for the project. Much of the feedback has been incorporated into the design recommendation.

The project team has been reviewing current grant options throughout 2020. Many of the currently available grant opportunities are for projects that are “shovel-ready” or will only cover portions of a project such as construction costs. However, the project team will continue to search for grant opportunities that meet both the desired level of funding as well as the timeframe of construction in late 2022.

CAO RECOMMENDATIONS:

THAT based on the December 7th, 2020 staff report "6th Street Multi-Use Active Transportation Bridge Update" Council approve OPTION 1, and direct:

1. Staff to include a line item in 2021 of the 2021-2025 Financial Plan to support design works with potential construction in 2022 subject to successful grant funding and borrowing in place.
2. Staff to proceed with detailed design of a 4 metre wide Symmetrical Cable Stayed Bridge, as per the project schedule presented;
3. Staff to commence public engagement to Inform the public of the project ;
4. Staff to further review potential grant opportunities in 2021, with the goal of supporting construction in late 2022.

Respectfully submitted,

Trevor Kushner, BA, DLGM, CLGA, PCAMP
Interim Chief Administrative Officer

BACKGROUND:

The January 27, 2020 presentation to Council detailed various options for the proposed 6th Street Multi-Use Bridge. The City of Courtenay has further developed and evaluated these options for improving active transportation connections across the Courtenay River adjacent to downtown.

On February 3, 2020, Council provided the following direction to staff:

> "That Council affirm the priority construction of the 6th Street multi-use pedestrian-bike bridge project and direct staff to include the 6th Street multi-use Pedestrian-bike Bridge project on the list of Council priorities."

A 6th Street Multi-Use Bridge is included in the recently completed Parks & Recreation Master Plan and referenced in the Transportation Master Plan for the City of Courtenay. The bridge is listed as a long-term improvement in the Parks and Trails Master Plan. In addition, the Downtown Courtenay Playbook also notes an additional crossing at 6th Street should be explored further.

A 6th Street Multi-Use Bridge would provide a dedicated cycling and pedestrian connection between downtown and Simms Millennium Park as well as enhance an east-west connector connection to the future cycling network along 6th Street and Anderton Avenue, the Courtenay Riverway Trail, and the Lewis Park pathway connection to the Lewis Centre.

DISCUSSION:

Detailed Options Analysis

Appended to this staff report as Attachment #1 is the 6th Street Bridge Detailed Options Analysis report. This report takes a detailed look into the background information and existing site conditions around the 6th Street crossing, with the goal of identifying and evaluating options for the bridge structure. Available bridge options are explored and compared using an evaluation matrix. For the two preferred options, an Opinion of Probable Cost and 10% design drawings are prepared.

6TH STREET ACTIVE TRANSPORTATION BRIDGE - EVALUATION MATRIX

Item	Evaluation Criteria	Qualitative Criteria/Measurement	Weighting	Score			
				Prefabricated Bowstring Bridge	Prefabricated Bailey Bridge	Network Tied Arch Bridge	Cable-Stayed Bridge
1	Structural Design	- minimized engineering complexity - high redundancy	10%	10%	9%	7%	6%
2	Geotechnical Design	- lighter superstructure minimizes weight on foundations - straight-forward foundation construction	10%	8%	8%	9%	7%
3	Environmental Considerations	- minimized tree impacts - efficient use of materials	10%	3%	3%	6%	8%
4	Life Cycle Cost	- low upfront cost - low maintenance cost - ease of inspection/repainting	20%	15%	16%	13%	13%
5	Constructibility	- minimized lay-down area and staging reqiurements - can be built incrementally	20%	5%	7%	8%	17%
6	Pathway Grading & User Experience	- approach grades below 5% - enjoyable, open feel that connects users with the river	15%	2%	0%	15%	15%
7	Aesthetics	- attractive structure - high transparency - viewpoint opportunity over river	15%	5%	0%	14%	15%
		TOTAL SCORE	**100%**	**48%**	**43%**	**72%**	**81%**

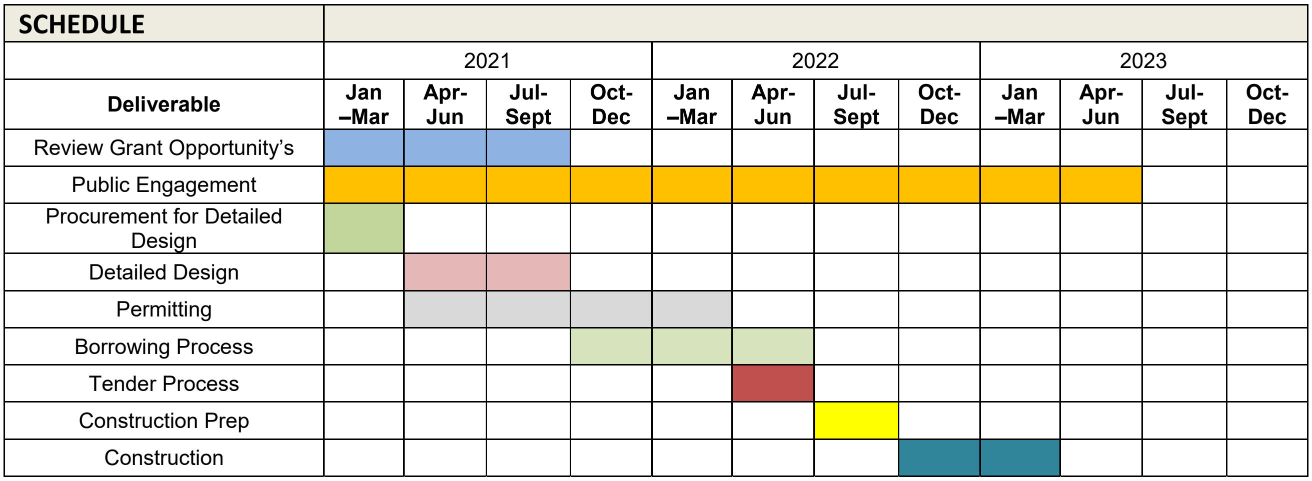
Through the use of the Evaluation Matrix, the four bridge options are narrowed down to two shortlisted alternatives: the network arch and cable-stayed options. These two options were comparable in their final scoring, however the cable-stayed bridge has both a higher score and the opinion of probable cost shows it to be less cost than the network arch option.

The cable stayed bridge option has the benefit of being constructible with less environmental impact, due to the ability to build incrementally. If the network arch option were chosen, the impacts on the park would be greater as more tree clearing would need to occur due to the temporary bridge supports. Construction access through the park would also be more challenging as the access to bridge site will require moving larger construction equipment across the culvert and through narrow paths.

Given this evaluation, the cable-stayed option is recommended as the preferred option to proceed to detailed design.

Schedule

The schedule presented below is the recommended timeframe for this project to proceed.



The need to confirm a bridge design is required, to facilitate construction in 2022. Without a confirmed design direction, critical path items such as procurement and subsequently permitting cannot proceed. Many of the permits required have a long lead time. The table below outlines some of the major permits required as well as their lead times.

Permit Required	Estimated Approval Duration
1. Heritage Inspection Permit - Province of BC Archaeology Branch	9 months
2. Site Alteration Permit – Province of BC Archaeology Branch	9 months
3. Changes in and about a stream - Ministry of Forests, Lands, Natural Resource Operations & Rural Development	6 months
4. Request for Review – Department of Fisheries and Oceans	6 months
5. Notice of Work on Non-Schedule Waterways- Transportation Canada	3 months

The archaeology permits currently require minimum nine months of lead time before gaining approval. There is no guarantee that approval will come in 9 months. Due to the extensive earth work expected on this project, a greater level of detail may be required by the archaeology branch and the approval time could extend up to 12 months. Archaeology permits also require time to prepare before they can be submitted for review by the branch.

An environmental management plan will also need to be prepared and submitted to the Province as part of the Changes in and about a stream notification, as well as to the Department of Fisheries and Oceans. The environmental management plan requires a site investigation to be completed as part of the plan. The lead time for approvals for each of these permits are estimated at 6 months. Environmental management plans require preparation time before they can be submitted for review.

The borrowing process also requires a long lead time and should be started as soon as possible, after detailed design is completed with a Class A cost estimate and grant funding secured.

Construction is currently planned to take place in late 2022. Through preliminary environmental reviews, an eagle's nest has been identified in Simms Millennium Park that is within 150m of the construction site. As per migratory bird nesting regulations, construction may be limited to a non-nesting window of October to December. Given that the construction phase is estimated to take 6 months, there is a risk that construction may be broken into two phases (Q4 2022, and Q4 2023). The project team will continue to investigate options to mitigate this risk, with the hope of executing construction in one single phase.

Funding Opportunities

The City of Courtenay previously received grant funding from the Federation of Canadian Municipalities (FCM) Green Municipal Fund for the completed 6th Street Bridge Options Analysis/Feasibility Study. The grant funded 50% of the study and the total amount received was $29,300.

Many of the currently available grant opportunities are for projects that are "shovel-ready" or will only cover smaller portions of a projects costs. The project team will continue to search for grant opportunities that meet both the desired level of funding as well as the timeframe of construction in late 2022.

Shovel-ready projects require minimum levels of progress and documentation to have been completed prior to application. Typically this means a completed detailed design, secured funding for the works, a detailed cost estimate, and all supporting permitting.

The project team will also continue to explore opportunities for fundraising, and donations from community groups.

FINANCIAL IMPLICATIONS:

A detailed Class C (+35%/-25%) cost estimate for a 4 metre wide cable stayed bridge is included in the attached Detailed Options Analysis report. It estimates the base cost for the base scope of the project at $4.4M in 2020 dollars. Included in this scope is connectivity improvements on both sides of the bridge as well as luminaire lighting in the park and bridge lights on one side. This cost also includes estimates for detailed design and contract administration during construction, as well as 25% contingency.

Optional Scope Items

Additional optional scope items have also been identified as per the below table. These items are not included in the base cost noted above.

Scope	Item	Estimated Cost
Original Scope	**4m Symmetrical Cable Stayed Bridge**	**$4,424,000**
Optional Scope	High Quality Railing Premium	$152,100
Optional Scope	Bridge Lighting (2nd side)	$137,500
Optional Scope	Aesthetic Lighting of Bridge Features	$75,000
Optional Scope	Public Art Installation	$200,000
Optional Scope	**Sub-total**	**$564,600**
	Grand Total	**$4,988,600**

The report has also provided cost estimates associated with increasing the width of the bridge from the recommended design width of 4 metres. The tables shown below estimate the cost to increase the deck width from the base recommendation of 4 metres.

5m Deck Width

Scope	Item	Estimated Nominal Cost
Original Scope	4m Symmetrical Cable Stayed Bridge	$4,424,000
Optional	Optional Scope Items	$564,600
Optional	Increase Bridge to 5m Deck width	$843,000
	Grand Total	**$5,831,600**

6m Deck Width

Scope	Item	Estimated Nominal Cost
Original Scope	4m Symmetrical Cable Stayed Bridge	$4,424,000
Optional	Optional Scope Items	$564,600
Optional	Increase Bridge to 6m Deck width	$1,685,000
	Grand Total	**$6,673,600**

The Grand Total estimated project costs would have to be approved to be included in the 2021-2025 Financial Plan. Currently, there are no approved funds for the 6th Street Bridge in the 2021 project budget, and there is $4,000,000 identified in the 2022 project budget with 50% potential grant funding and 50% debt funding.

ADMINISTRATIVE IMPLICATIONS:

The 6th Street Bridge Rehabilitation Project will be led by Engineering Services, with support from most other City Departments. Consultants with technical knowledge specific to this work will be utilized to develop and implement detailed designs and processes. Estimated costs associated with external consultants are included in the project capital budget.

ASSET MANAGEMENT IMPLICATIONS:

Courtenay practices advanced asset management principles and is recognised as a leader in the field. Within this context, the 6th Street Bridge would become one of the City’s most valuable assets providing a critical service of connecting the east and west parts of the community for active transportation users.

On-going maintenance would be periodically required to maintain the asset at its intended level of service thereby avoiding pre-mature failure, and increased costs resulting from reactive rather than planned maintenance. The bridge would likely be inspected under contract, and routine maintenance and repairs would be undertaken as part of PWS’ operational budget. The annual operating costs will be quantified with the approved design and will be submitted for Council consideration for the 2023 general operating Financial Plan.

STRATEGIC PRIORITIES REFERENCE:

As part of the 2019 Strategic Priorities Chart a list of Council's NOW/NEXT priorities were adopted.

Strategic Priorities 2019 - 2022

As part of the Strategic Priorities for 2019 – 2022 the following are relevant to the 6th Street Bridge Project:

We proactively plan and invest in our natural and built environment

- ● Focus on asset management for sustainable service delivery
- ▲ Look for regional infrastructure solutions for shared services
- ● ▲ Advocate, collaborate and act to reduce air quality contaminants
- ● ▲ Support social, economic and environmental sustainability solutions

We plan and invest in methods of multi-modal transportation

- ● Move forward with implementing the City's Transportation Master Plan
- ▲ ■ Collaborate with regional and senior government partners to provide cost-effective transportation solutions

OFFICIAL COMMUNITY PLAN REFERENCE:

The OCP sets out the following policies in Part 4 Land Use Designations and Part 5 Transportation:

4.6.6.3 Policies

1. Wherever possible, the walkway portion of the Riverway system will be adjacent to the foreshore of the Courtenay River, slough and estuary. Where necessary or desirable, land acquisitions or easements will be sought to accomplish this objective while considering the integrity of these areas.

2. Council will investigate the feasibility of a pedestrian/bicycle bridge crossing of the Courtenay River, to link the west bank downtown with Lewis Park and/or Simms Millennium Park (for example, a suggested pedestrian/bicycle bridge from 6th Street to the east bank).

5.3 Policies

7. The City will continue to pursue the development of a continuous, integrated bicycle network in order to promote and encourage cycling as a commuting alternative to the automobile and as a means of active recreation. The Bicycle Planning Strategy adopted in 1995 will be reviewed and updated.

REGIONAL GROWTH STRATEGY REFERENCE:

The 6th Street Bridge Project is aligned with "Goal 4: TRANSPORTATION" of the RGS:

Supporting Policies:

- 4B-1 Promote and encourage cycling plans and programs through ongoing local and regional initiatives and actions.
- 4B-4 OCPs should identify regionally important, priority street connections for pedestrian and cycling improvements and require that connections be established as a condition of redevelopment.

CITIZEN/PUBLIC ENGAGEMENT:

Public engagement has been a priority throughout the development of the detailed options analysis. In the fall of 2020, the City reached out to community stakeholders to offer a meeting to review the potential options for the 6th Street Active Transportation Bridge as well as to solicit feedback about what is important to consider as the City further develops the design for the project.

Letters were sent out to the below 6 external stakeholders inviting them to a one-on-one meeting with City staff. To date, meetings with three of these stakeholder groups have occurred while the others either provided a written response or declined the offer.

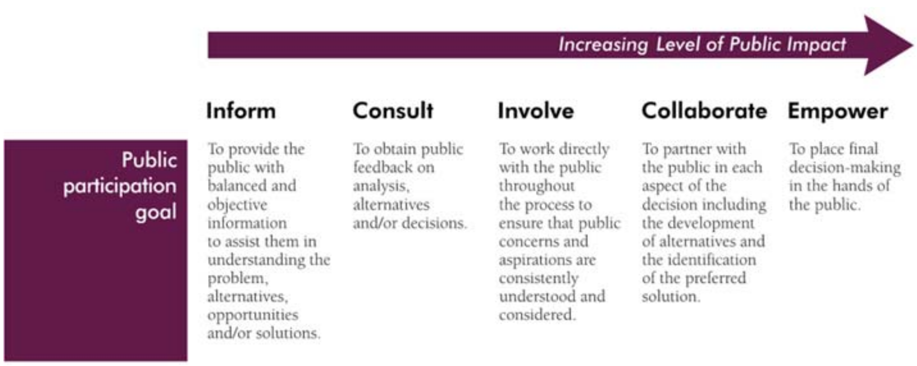
1. Comox Valley Cycling Coalition
2. Accessibility Advisory Committee (Working Group)
3. Central Builders Home Hardware
4. Comox Valley Conservation Partnership
5. Downtown Courtenay Business Improvement Association (DCBIA)
6. Sixth Street Pedestrian/Cycling Bridge Steering Committee

Outreach to the K'ómoks First Nation is currently in progress.

Additionally internal stakeholder meetings were held with the City of Courtenay Parks, and Operations and Asset Management groups.

Should staff be directed to proceed into detailed design, a public engagement program would be initiated including follow up meetings with key stakeholders as well as a public awareness campaign to highlight the project. The campaign could include social media advertising, updates to the project website as well as a Frequently Asked Questions brochure to be updated as the project progresses. A potential fundraising campaign could also be included in this task, but would have to be investigated further.

Based on the design recommendation from the report, staff recommend to **Inform** the public and key stakeholder groups based on the IAP2 Spectrum of Public Participation:



OPTIONS:

Option 1: THAT based on the December 7th, 2020 staff report "6th Street Multi-Use Active Transportation Bridge Update" Council approve OPTION 1, and direct:

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4. Staff to further review potential grant opportunities in 2021, with the goal of supporting construction in late 2022.

Option 2: Refer back to Staff for further review.

Prepared by:

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Engineering Technologist

Concurrence by,

Trevor Kushner, BA, DLGM, CLGA, PCAMP
Interim Chief Administrative Officer

ATTACHMENT(S):

1. *Attachment 1: 6th Street Bridge Detailed Options Analysis Report*

CITY OF COURTENAY

October 2020

6th Street Active Transportation Bridge

Detailed Bridge Options Analysis

100% Submission

Prepared for:

City Courtenay

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V+M STRUCTURAL DESIGN

Contract PO 11527
V+M Project No. 1173
Doc. No. 1173-REP-S-001
Revision 0

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1 Introduction

The City of Courtenay (the City) engaged V+M Structural Design, Inc. (V+M) to conduct a detailed options analysis for the proposed 6th Street Active Transportation Bridge across the Courtenay River. The goal of the project is to provide improved cycling and pedestrian connections through the City that is divided by the Courtenay River.

This report takes a more detailed look into the background information and existing site conditions around the 6th Street crossing, with the goal of identifying options for the bridge structure. Available bridge options are explored and compared using an evaluation matrix. For the two preferred options, an Opinion of Probable Cost and 10% design drawings are prepared.

Figure 1: *Project location*

2 Project Description and Background

2.1 Purpose and Need

The need for a pedestrian and cycling oriented crossing of the Courtenay River at the foot of 6th Street has been discussed since an initial study in 2012. A missing link was identified from the termination of the Courtenay Riverway Trail (Riverway Trail) on the west side to Millennium Simms Park and the east side of the City.

The need to improve connectivity for multi-modal transportation across the Courtenay River has been referenced in several community plans over the last several years:

- *Downtown Courtenay Playbook: A Partnership Action Plan* adopted by Council in 2016 recommends improving connectivity to, along, and across the river, as one of five strategic planning goals.
- *City of Courtenay Parks and Recreation Master Plan* adopted in September 2019 notes the challenge of current river crossings for pedestrians, identifying both 5th and 6th Streets as potential locations for new or improved connectivity.
- *Connecting Courtenay: Cycling Network Plan Cycling Network Plan* updated in September 2019 notes the current lack of comfortable river crossings for cyclists, and identifies both 5th and 6th Streets as options that have been explored.
- *City of Courtenay Transportation Master Plan* adopted in September 2019 highlights the opportunity for a new and improved river crossing at 5th and 6th Streets for pedestrians and cyclists.

Currently, the only crossing of the Courtenay River at this downtown vicinity is via the 5th Street Bridge, which has narrow sidewalks on each side of the roadway. Currently, cyclists are required to dismount when using the sidewalks to cross the bridge while sharing the space with pedestrians. Previous plans to widen the sidewalks on the existing 5th Street Bridge were abandoned, and the focus was shifted to the planning and development of a new crossing at 6th Street.

Figure 2: *View west of the existing 5th Street Bridge sidewalk*

The new pedestrian bridge would connect both sides of the City across the river and with the Riverway Trail. The trail is close to 6 km of recreational trail along the City's riverfront, with a planned eventual build-out to connect to the Royston Seaside Trail. The trail connects a series of green spaces and the bridge would connect it across the river to Lewis and Simms Millennium Parks. The new bridge would further enhance the City's network of trails and outdoor amenities.

2.2 Site and Location Description

The proposed location of the bridge is east of Anderton Avenue at the end of 6th Street, and south of the existing 5th Street Bridge. The bridge is envisioned to be a key link in the future cycling network.

This study focuses on the structural considerations for the new 6th St Bridge and immediate connections with existing trail infrastructure at each end. At this time, the designs for future trail and cycling network connections in east Courtenay are still being developed by the City. For the purposes of this study, bridge connectivity is developed as follows:

- Connection with the current terminus of the Riverway Trail at 6th Street; and
- Integration into the existing trails of Simms Millennium Park.

Figure 3: *View south toward the proposed 6th Street Bridge site*

Figure 4: *View east along 6th Street toward the proposed bridge location*

2.3 Background Information

The City's GIS system has information on utilities, property parcels, and contours that helped form the basis for evaluating site constraints. No additional site investigations were conducted for this study, but are anticipated to be conducted in the future detailed design phase.

2.3.1 Existing Utilities

For the west approach, one key consideration is to avoid conflict with an existing 600 mm diameter storm main that runs along the centreline of 6th Street and daylights at the existing retaining wall along the river. The bridge alignment is therefore shifted closer to the south edge of the City right-of-way to avoid impacting this storm main. It is noted there are two (2) observation wells, which are possibly from previous geotechnical investigations, and a 100mm diameter pipe that will be impacted by the bridge approach structure.

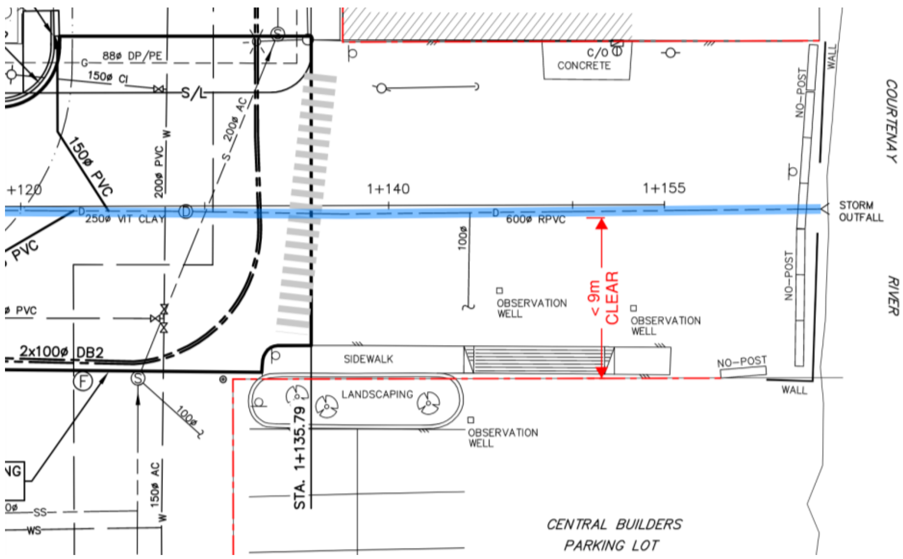

***Figure 5:** 6th Street road reconstruction works (2008) with storm sewer highlighted in blue*

On the east approach, there does not appear to be any utility conflicts in the area of the planned bridge approach. Consideration should be given to the existing culvert supporting the pathway trail within the park, as construction access would likely need to cross over this culvert. Protection during construction will likely be needed.

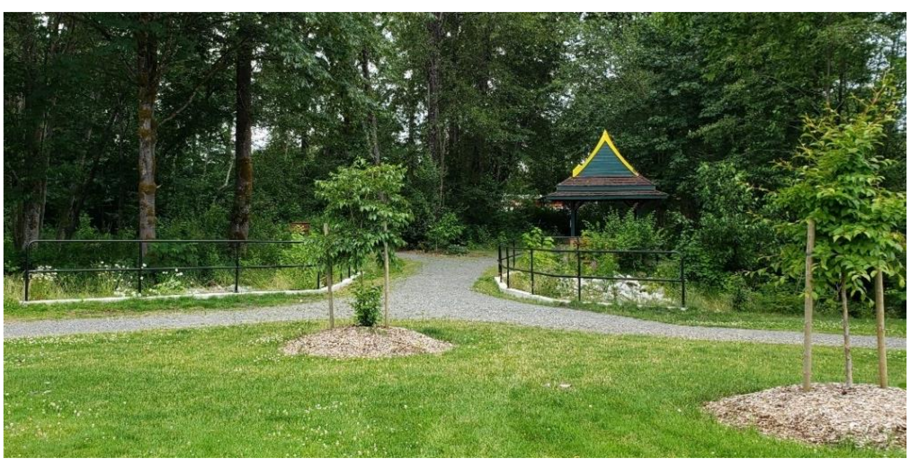

***Figure 6:** Looking west at location of existing culvert in Simms Millennium Park*

2.3.2 Right-of-Way and Property Parcels

Property boundaries of parcels and available public right-of-way (ROW) and setback considerations from each bank dictates the location of the bridge, along with the configuration of the bridge span and foundation locations. Staging areas during construction are limited due to space constraints.

The three adjacent properties on either side of 6th Street (590 Anderton Ave, 610 Anderton Ave, and 610B Anderton Ave) belong to the same owner. It is anticipated that during construction, access to the storage structure at 590 Anderton Ave will be temporarily impacted, as its doorways open directly onto 6th Street.

The south parcel, 610 Anderton Ave, contains a parking lot. The secondary entrance from 6th Street will be permanently impacted by the presence of the proposed bridge ramp. The primary access will be maintained throughout construction.

After the bridge is in use, access to 590 Anderton Ave will be slightly reduced, but still accessible from the public ROW along 6th St. The west driveway to 610B Anderton Ave would become the primary access to the 610/610B Anderton Ave parcels.

The footprint of the completed bridge and approach structures would be entirely within the public ROW and no property acquisition is anticipated at this time.

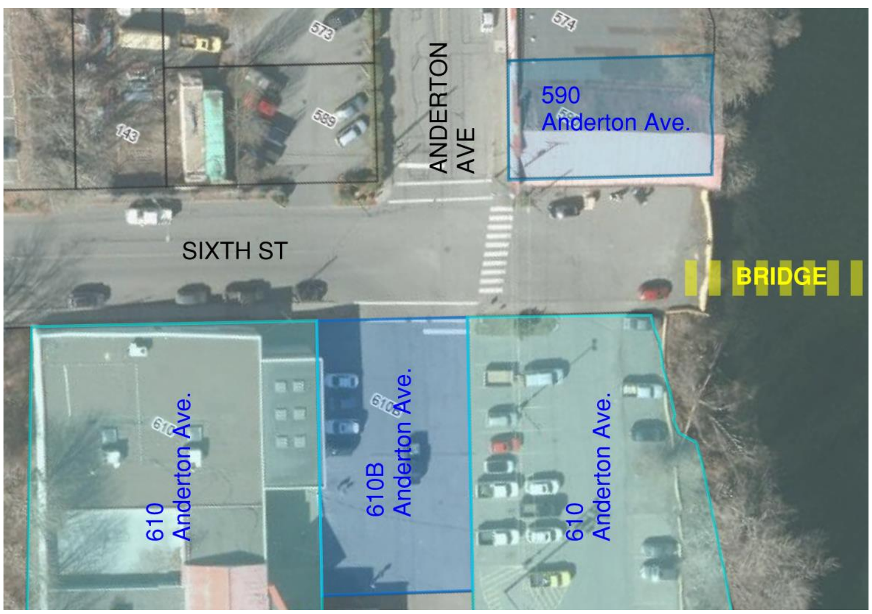

Figure 7: *Property parcels adjacent to proposed bridge location*

Figure 8: *Property parcels adjacent to proposed bridge location*

2.3.3 Flood Elevations

Another important consideration is the design flood level and ensuring adequate freeboard underneath the proposed bridge structure. From a review of the available floodplain maps and existing topography, the 1-in-200-year flood levels at the site are approximately at Elevation = 4.3m (reference datum from Geodetic Survey of Canada per the BC floodplain map). These flood elevations include an unspecified allowance for freeboard in the reported values.

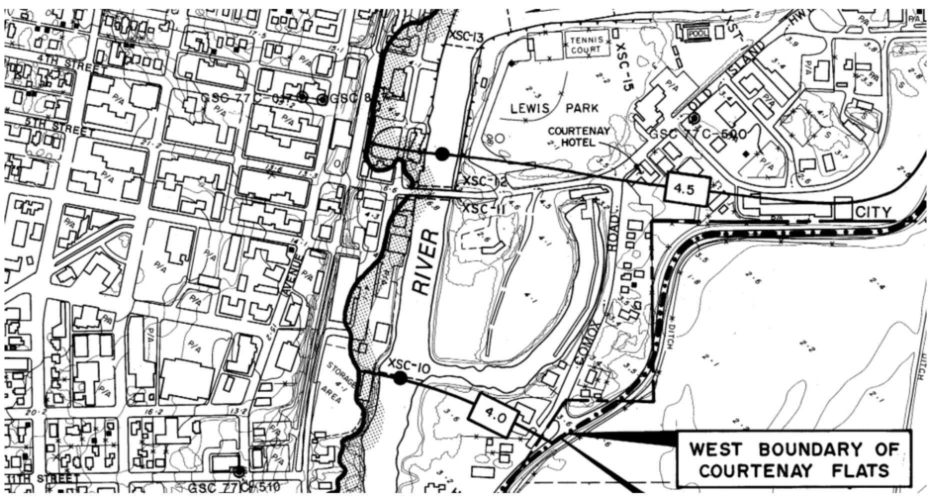

Figure 9: *BC Floodplain Maps for Courtenay area*

Source: *http://www.env.gov.bc.ca/wsd/data_searches/fpm/reports/bc-floodplain-maps/Courtnay_Puntledge_TsolumR/2-89-13-2.pdf*

The City's floodplain management bylaw (no. 1743) requires that all structures in areas of tidal influence, which includes the current project site, should be designed to provide an additional 0.8m of freeboard in addition to the 1-in-200 year flood construction level. This requirement results in the bridge soffit maintaining clearance above an elevation = 5.1m. This value forms the design basis of the conceptual bridge options developed in this study.

It should be noted that the floodplain map was issued in 1991 and the floodplain management bylaw was ratified in 1994. Given the age of these two documents, there is a potential that the requirements and expected elevations may be updated in the future. Future revisions could impact the required bridge soffit clearance and subsequently the grades of the approaches.

2.3.4 Environmental Considerations and Permitting

In-water piers were considered for an earlier 2012 iteration of a bridge design at this location. For this study, a clear span of the Courtenay River is used. To simplify the assessment, the City directed that in-water piers should not be used for any of the options evaluated in this study.

It is understood that in 2016-2017, channel improvements were carried out along the Simms Millennium Park side channel that feeds between the Courtenay Slough and Courtenay River. Proposed tie-ins will therefore avoid impact to the improved watercourse at this location. It is also noted that the construction access road that was built along the west side of the channel was converted into the current trail that exists in the park today.

Another consideration is the tree canopy on the east approach through Simms Millennium Park. To build the bridge, some site clearing will be required along the riverbank to facilitate the bridge main span and its supports. The impact of different bridge options on the extents of tree removal is an important consideration.

From discussions with the City's parks department, eagles are present within the park and other migratory birds are common. January to mid-September are understood to be nesting season for these species. City records indicate that an eagle's nest is located in a tree at the southern corner of the park. It is understood that provincial regulations require a construction buffer of 1.5 times the tree height (assumed for this study to be 50m without survey information) at all times, and an additional 100m during nesting season. The locations of the bridge and trail tie-ins are outside the 50m buffer, but largely within the 150m buffer zone.

The construction schedule may need to be coordinated to have work occur outside of the eagle nesting period. The proposed construction schedule shows construction beginning in the fall of 2021 and continuing through the winter. A more detailed study of the sensitivity of this eagle will be undertaken by a biologist to determine if construction during the nesting period is possible. If construction during nesting season is not possible, construction will need to be split into two phases, with the first phase occurring in October through December of 2021 and October through December of 2022. The details of the work schedule will need to be further evaluated in the future detailed design phase.

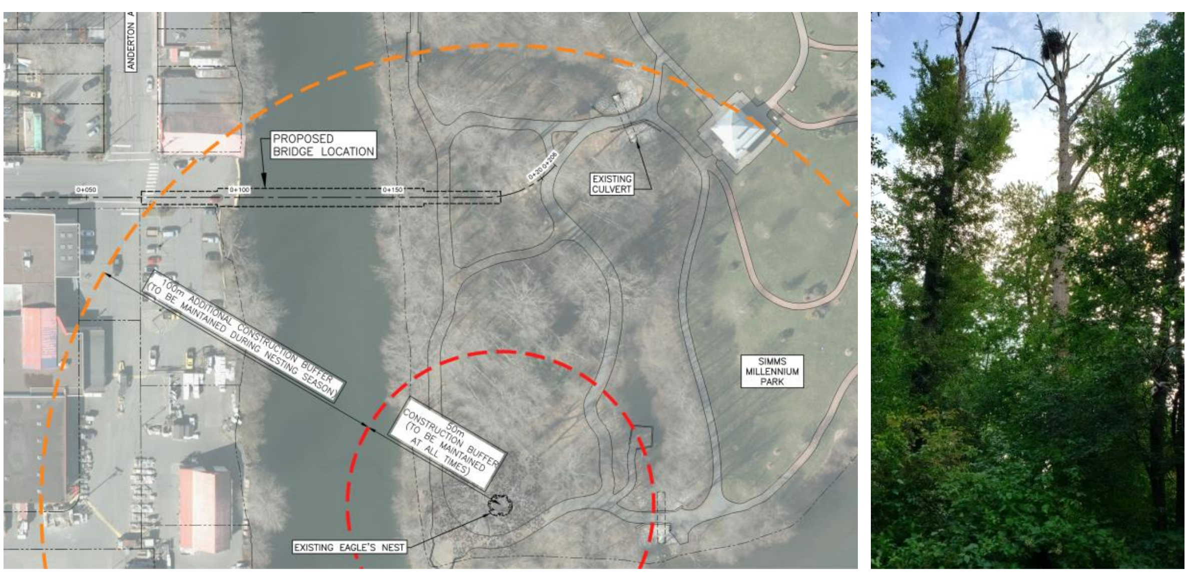

Figure 10: *Eagle's nest location at southern end of Simms Millennium Park*

2.3.5 Geotechnical Considerations

Preliminary site investigations were conducted by Levelton in 2012, with four boring locations sampled (two per side). The report noted that firm ground was encountered approximately 4.5m to 5.5m below grade on the west approach, and 8m to 10m below grade on the east approach.

The presence of liquefiable soils in the layers above firm ground, coupled with the initial structural arrangement with abutments supported on taller embankments, led to the recommendation of ground improvements for the project at that time. Given the significant cost premium associated with ground improvements, this current study attempts to utilize structural alternatives with less fill material to mitigate the need for ground improvements.

2.3.6 Drainage

The bridge will incorporate both a longitudinal grade and a deck crown to help direct water flow to the sides and ends of the bridge. The deck geometry may incorporate a curb along each edge to collect water, or could allow for dispersion along the length of deck. The latter is possible with non-pollution generating surfaces like a pedestrian bridge. Through discussions with the City, it is understood that maintenance crews would like an option to clear snow off the bridge with a snow blower, which would be made easier with a curb-less deck.

At the ends of the bridge, deck drains would likely be provided to collect and dispel water into the stormwater system. Details of the drainage system would be developed further in the future detailed design phase.

3 Design Criteria

The following criteria are used to determine the baseline for the options evaluated in this study.

3.1 Materials

The new bridge will most likely make use of structural steel and concrete for primary structural components. Consideration will be given to painted steel, which offers an opportunity to select a preferred colour and is in line with the City's goals for future maintenance. The coating will require periodic maintenance over the lifetime of the structure.

Figure 11: *Typical coated steel finish*

Other materials were not considered for the following reasons:

- Weathering steel is not considered to be a viable material choice given the wet climate and proximity to saltwater. The BC Supplement to the Canadian Highway Bridge Design Code (CHBDC) also requires the use of coated structural steel in marine environments, which would preclude uncoated weathering steel.
- Due to past concerns with user accessibility, vandalism, and durability, structural timber and timber decking are also not considered viable materials for the bridge.

A concrete deck is generally low maintenance over the lifetime of the structure while providing a high grip and smooth surface for riding, rolling, and walking. This type of deck addresses concerns with durability and user comfort. Fibre-reinforced polymer (FRP) decking could also be explored in the future detailed design phase.

For this study and the purposes of comparison, all bridge options are assumed to utilize a concrete deck surface.

For the approach trails beyond the bridge abutments, asphalt paving is intended to be used along improved sections of the trail. The *BC Active Transportation Guidelines* recommend the use of asphalt for multi-user pathways to enhance user accessibility.

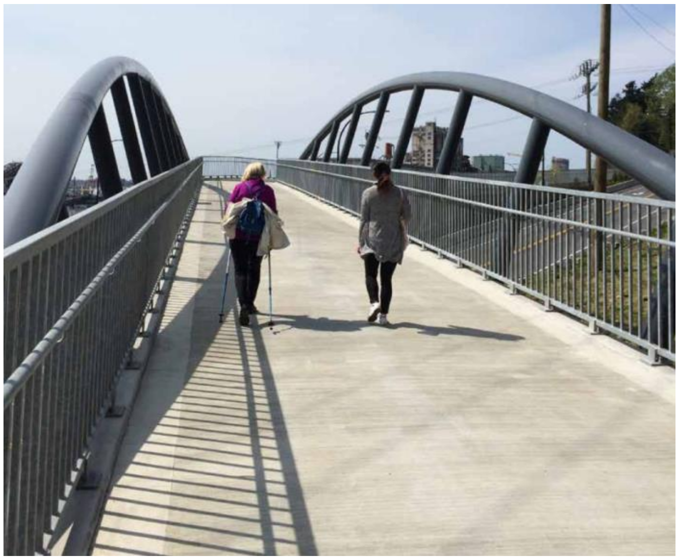

Figure 12: *Example of concrete deck surface on a Spirit Trail pedestrian bridge*

3.2 Deck Clear Width

The basis for a 4.0m deck width was concluded in the previous Bridge Options Analysis Report conducted by another consultant in January 2020. However, it was noted that user volumes measured for this bridge from a 2019 count indicate a minimum 3.5m pathway width based on the *BC Active Transportation Guidelines (BCATG)*. The 4m deck width was proposed on the assumption that user volume would grow in the future.

From discussions with the City, a clear deck width of 4m will be used as a baseline for this study. This width would provide comfortable passage for pedestrian and wheeled mobility users in both directions of travel. A number of multi-use trails in the Lower Mainland, including the Central Valley Greenway in Burnaby, BC, and the North Shore Spirit Trail in North Vancouver, BC, have 4m wide bridges along their routes.

Figure 13: *Four-metre wide deck on Central Valley Greenway pedestrian bridge*

3.3 Flood Considerations and Vertical Clearances

Per Section 2.3.3, the 1-in-200 year return period flood value with freeboard is Elevation = 5.1m. The bridge soffit needs to clear this elevation over the width of the river banks. The approaches will drop below this elevation as they connect back to grade at each bank.

3.4 Environmental Considerations

For this study, options that have less impact on the environment are viewed more favourably. The level of tree clearing at the east approach is an important consideration.

Other elements, such as efficient use of materials, minimized environmental footprint, and low visual impact are also considered.

3.5 Pathway Grades

The City desires that the approach grades of the bridge be kept to minimum to enhance accessibility, ease of use in all weather conditions, and to minimize pathway maintenance. From the *BC Active Transportation Design Guide*, a maximum longitudinal grade of 5% is recommended for multi-user pathways.

The effective depth of each structural system considered in this study influences the approach grade on the west side due to limited available length for the approach ramp. Bridges using low-profile deck solutions result in grades meeting the desired 5% maximum. Options with bridge systems requiring a larger distance from top of deck to underside of structure, require a grade of 8.33% with the 2% landings due to the constrained site.

3.6 Bridge Railing Considerations

Bridge railing geometries would conform to the Canadian Highway Bridge Design Code (CHBDC) and the BC Ministry of Transportation and Infrastructure Supplement to CHBDC. The requirements for a bridge carrying pedestrian and bicycle traffic are railings at least 1400mm high and handrails 1050mm above top of deck, where longitudinal grade exceeds 5%.

Figure 14: *Example of standard Ministry bicycle fence in pedestrian bridge application*

The BC MOTI standard steel railing is typically galvanized, but can be painted if desired. It is widely used on BC MOTI projects, but has a heavier appearance than custom designs.

More elegant bridge railings include longitudinal cable infill, stainless steel cable mesh infill, or welded wire infill. An inward sloping railing system can minimize climbing potential and help with aerodynamics.

Figure 15: *Examples of handrails with cable infill (left) and cable mesh infill (right)*

3.7 Geotechnical Assumptions

For this study, deep foundations are assumed to be feasible to support the main span and approach spans. Piles or drilled shafts would extend down into till, with a typical embedment length for development. Size and extents will need to be confirmed with a geotechnical engineer in the future detailed design phase.

A previous study that was done in 2012 considered the use of ground improvements to support the bridge abutments directly adjacent to the riverbanks. This current study considers alternatives to avoid ground improvement schemes, which can be extensive and costly.

Using a clear span to cross the river eliminates intermediate supports within the water. The bridge piers will likely utilize deep foundations set back from the riverbanks. From the previously conducted geotechnical investigation, there is sound material to bear on and anchor into at reasonable depth. The assumptions made for deep foundations for the site-specific ground conditions should be confirmed by a geotechnical engineer in a future stage of design.

On the west side of the river, the pier must be sufficiently set back from the existing lock block wall in case geogrid reinforcing is present. Record drawings for this existing wall are not available.

3.8 Seismic Considerations

The previous geotechnical investigation carried out in 2012 indicated the presence of liquefiable soils in the upper layers of the proposed approach locations. For liquefiable soils, the expected site classification should be Site Class D or lower.

For a preliminary look at the seismic considerations at this site, the 2015 NBCC Seismic Hazard Calculation yields a peak ground acceleration value for Site Class C of 0.321g for the 1/2475 year event (to compare to Site Class C values given in the 2012 geotechnical memo). An in-depth seismic analysis and site classification will be required for the selected structural configuration in the future detailed design phase.

3.9 Lighting

The main span and bridge approaches would likely utilize a low level lighting system to avoid light spilling onto the river below. This could be comprised of horizontal linear LED lighting fixtures installed in the top railing element and shining down on the deck. Vertical linear fixtures installed within the stanchions could also be utilized. LED lighting technology is energy efficient and has become reliable and affordable. Luminaire lighting along the main span would have a negative visual impact and would have more light spillover onto the river.

At the west end of the bridge, the area is generally well lit by existing street lighting. It is assumed the main deck lighting will continue along the west approach span to provide aesthetic consistency across the length of the bridge.

At the east end tying into the park, it is anticipated that new pedestrian level lighting will be installed to illuminate the pathway for user safety. It is understood that some stakeholders have raised concerns about adequate lighting on the existing pathways at nighttime. Luminaire lighting spaced at regular intervals along the edge of the pathway could provide ample lighting levels in a cost-effective manner.

A provisional sum is carried in the cost estimates for functional lighting and a modest amount of aesthetic lighting to highlight key elements of the bridge. Lighting will be refined in the future detailed design phase.

3.10 Connectivity to Existing Pathways and Trails

On the west approach, the bridge is anticipated to provide an extension of the Riverway Trail that currently terminates at 6th Street, mid-block between Cliffe Avenue and Anderton Avenue. It is understood that one of the objectives of this project is to provide this missing connection between the Riverway Trail and the east side of the City and the amenities around Simms Millennium Park and Lewis Park.

A cycling connection along 6th Street to Anderton Ave was identified in the 2019 Cycling Network Plan as a part of the City's cycling network. A bidirectional bike lane can be added along the south edge of the roadway from the Riverway Trail up to the bridge approach without affecting the existing paint lines on the street. The bike lane would include a painted buffer along the edge of the vehicular lane. The details and benefits of this tie-in are further discussed in Section 4.2.4.

Figure 16: *Terminus of Riverway Trail looking south (left) and looking east along 6th Street (right)*

Figure 17: *Buffered bike lane examples*

On the east approach, the bridge alignment would tie into the existing pathways within Simms Millennium Park. For this study, the bridge approach trail follows an arcing alignment, which integrates with the two park entrance trails using a new roundabout.

An objective of the pathway alignments is to minimize tree impacts. A future topographic survey, along with tree survey, will help to inform the pathway alignment, but from the existing orthophoto it appears that this route for the east approach trail minimizes the tree impacts. The existing trail following parallel with the riverbank will become blocked by the bridge approach, which would have a large elevation difference. The section of that trail affected by the bridge approach would be re-routed to connect back with the existing trail (further discussed in Section 4.2.4), and the portions decommissioned could be part of a restoration area that is replanted with trees.

Evaluation of future connections with other pedestrian and cycling routes beyond the park space is considered beyond the scope of this work and will be a part of a separate study.

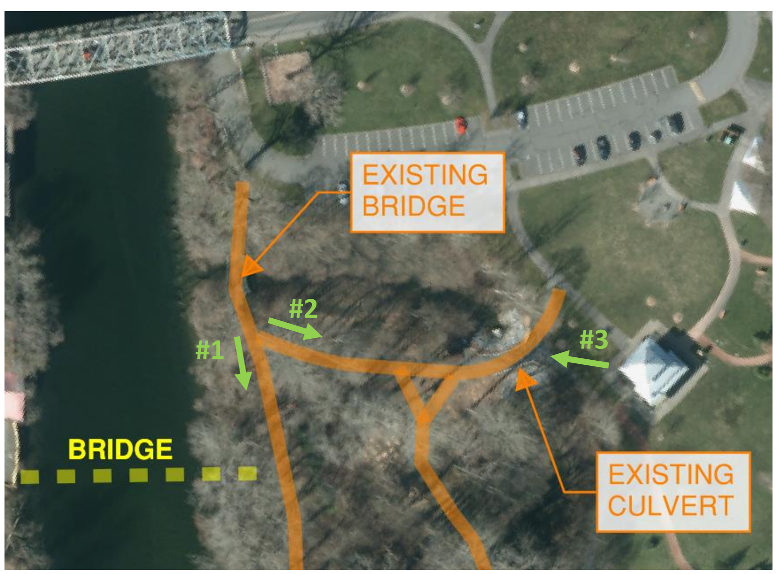

Figure 18: *Simms Millennium Park existing conditions (see following photos)*

Figure 19: *Arrow #1 looking south at pathway fork*

Figure 20: *Arrow #2 looking east from riverside pathway fork*

Figure 21: *Arrow #3 looking west near existing culvert*

3.11 User Safety and Comfort

The proposed bridge would serve a mix of pedestrian and cyclist traffic. Maintaining a safe, accessible pathway for users of all ages and abilities is an important consideration. Methods to limit user travel speeds could include posting a speed limit, signage that indicates the bridge is a multi-use pathway where cyclists yield to pedestrians, adding other cues like textured pavement, or introducing chicanes into the pathway.

For this study, the ability to include a local widening at the mid-span of the bridge is also considered. From initial stakeholder consultations and discussions with the City, there is a desire for this bridge to become a destination and feature that will be well-used by the local community and visitors alike. Providing a location within the main span would enable users to linger and observe the views both upstream and downstream of the river, while preserving the clear width for other users.

3.12 Construction Staging and Access

3.12.1 Off-Site Staging Areas

It is understood that the option of barging a full 50-m span to site was considered during an earlier design study that used in-water piers. In that study, an initial site located to the south of the 17th Street roadway bridge was identified as a possible staging area to build the span and transport to the bridge site. Although, it has been noted by the City that this site may no longer be available.

Use of an off-site staging area for clear span options considered in this current study, would require that the span be assembled at an off-site location south of the bridge site, placed on a barge and transported to site. A longer 65m main span is required to clear the riverbanks. If a staging site is located south of the 17th Street roadway bridge, then the span would need to fit through the lift span opening, which is understood to have a clear opening of approximately 13m wide and 15m height at high tide. The logistics of using the lift span would have to be coordinated with the BC Ministry of Transportation and Infrastructure. Once at the 6th Street bridge site, the 65m span would be very restricted in being able to be rotated on the river and would require cranes on both sides of the river to lift it into position. The cranes would need to have a long reach to then be able to swivel it into its final perpendicular alignment across the river.

3.12.2 Staging Areas at 6th Street

Access to the site on the west side of the bridge is via paved municipal streets that lead up to the bridge site. There are some restrictions: 6th Street climbs a steep hill just west of the bridge site; Anderton Avenue heading north of the site does not have a way to cross 5th Street; and Anderton Avenue does not continue south of 6th Street, as this is private property.

Staging areas on this side of the river for storing materials and equipment potentially include:

- 6th Street ROW,
- Private parking lot at the NW corner of the intersection of Anderton and 6th Street (same owner as 590 Anderton Ave), and
- A portion of the private parking lot SE corner of the intersection of Anderton and 6th Street (same owner as 590 Anderton Ave).

Figure 22: *Staging areas.*

There is a lack of large open spaces adjacent to the bridge site for staging and construction activities. Crane placement is one such challenge. It is noted that any work in the 6th Street ROW next to the river will obstruct or affect the access to the Central Builders (Home Hardware) storage building doors.

Assembling the full span, or even larger segments of the bridge, in the private parking lot SE of the intersection will have a large impact on the parking and would require approval by the owner.

The presence of overhead power lines at the site also limits available crane reach, and extra care will need to be taken to ensure that utilities are not affected.

3.12.3 Staging Areas at Simms Millennium Park

On the Simms Millennium Park side, it will be more challenging to mobilize large construction equipment without impacting trees. By using a sweeping arc for the east approach span between the bridge alignment and culvert crossing, tree impacts look to be minimized as this alignment crosses through some more open zones within the wooded parkland. Given the final bridge deck width will be at least 4m, clearing along the east alignment can create temporary construction access on the same alignment as the final trail. This could then accommodate larger equipment for foundation construction. However, deploying a large hydraulic crane to provide for a tandem lift of a clear span truss or arch solution could lead to major disturbance of the tree canopy along the riverbank.

The park side access is also limited by the loads that can be taken by the existing culvert and adjacent Rotary Club timber pedestrian bridge. There will most likely be a need for temporary widening of the culvert crossing to provide sufficient construction equipment access.

Figure 23: *Significant canopy along waterfront trail*

Figure 24: *Existing timber bridge north of site (left) and existing culvert east of site (right)*

Previous reports indicated the presence of poor compressible soils at the bridge location. Use of heavy construction equipment with highly concentrated footprints to lift larger structural elements may not be feasible without ground improvements. It would appear to be advantageous to keep equipment size as small as possible with these considerations in mind.

A portion of the Simms Millennium Park parking lot and adjacent lawn could serve as a stockpile location for construction equipment, materials, and temporary site office.

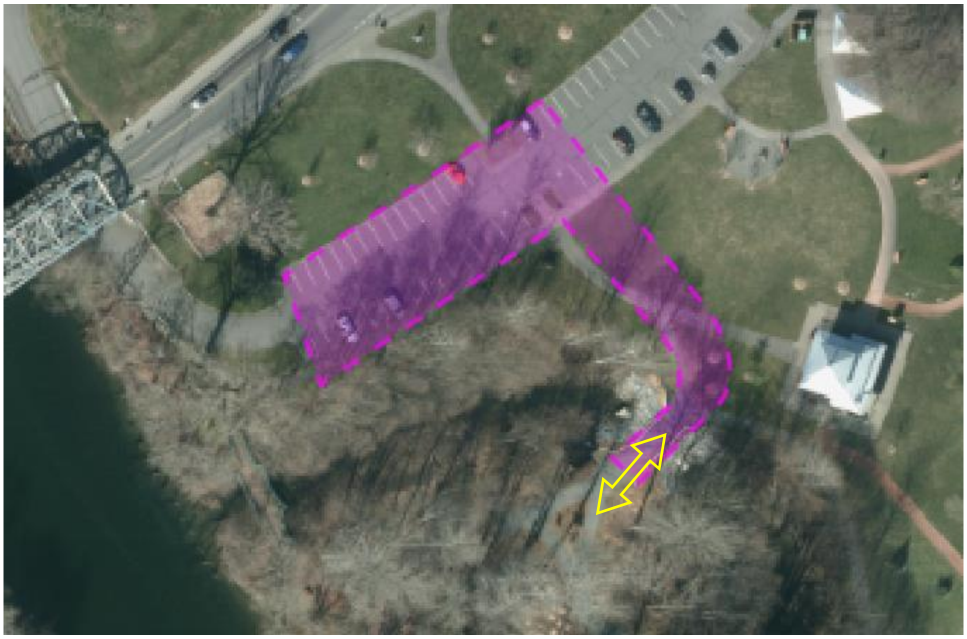

Figure 25: *Potential staging area within Simms Millennium Park*

4 Design Considerations

4.1 Bridge Alternatives

Four (4) bridge alternatives are considered in this detailed options analysis. The work in this study is meant to assess the options considered in the previous study and to take a deeper look at the feasibility, constructability, geometry, and aesthetics of each option at the project site.

These updated options are compared using an evaluation matrix to arrive at two preferred alternatives. These two options are then developed in more detail with 10% design drawings and an updated opinion of probable cost.

4.1.1 Pre-Engineered Truss (Bowstring) Bridge

Pre-engineered truss bridges are commonly used in pedestrian applications, as they are typically fabricated off-site and installed as a single span on-site. The primary advantage is the ability to fabricate the majority of the bridge in the shop and reduce time required on site.

The pre-engineered truss that was considered previously was a bowstring truss bridge, which requires lateral bracing of the two truss planes below the deck. This requires substantial structural depth beneath the deck to eliminate overhead bracing. The structural section is similar to an H-type truss, with the deck level raised above the bottom chords to stabilize the truss planes and top chords against lateral buckling.

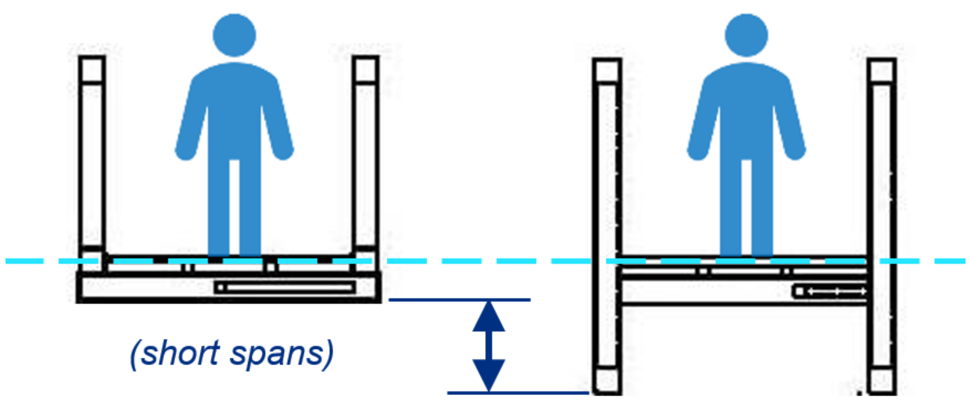

Figure 26: *Illustration of pony truss (left) and H-truss (right)*

A consequence of raising the deck means the approach grades must be steepened to 8.33% with intermediate landings, due to limited space on the 6^{th} Street side.

Another consideration for this type of bridge is that a significant steel tonnage will be required to achieve the span length and deck width for this site. In a bowstring truss, the top chord is unbraced laterally. This requires stocky steel chords in addition to thick vertical members to provide stiffness against lateral buckling.

Visualizations of the bowstring truss for the proposed crossing are presented below.

Figure 27: *Renderings of pre-engineered bowstring truss option at proposed project location*

Figure 28: *Johnson St Pedestrian Bridge in Victoria, BC with 35m span x 5m wide deck (left) and Cousineau Pedestrian Bridge in Windsor, ON with 60m span x 4m wide deck that uses overhead bracing (right)*

4.1.1.1 Constructability

Pre-engineered bridges are typically assembled as a full span in a staging area adjacent to the site and then lifted into the final position. However, given the limited staging areas near the site to accommodate a full span, this becomes challenging. Without viable staging areas adjacent to the site, this option would likely require the truss be assembled away from site and then barged down the river. The practicality of barging this long of a span along the Courtenay River and lifting it into place would require additional studies to verify feasibility. The barges would need to pass through the 17th Street Bridge, giving consideration to tidal influences on the river.

The steel tonnage for a clear span bridge of this size is significant, and multiple large cranes would be required for the bridge pick. A tandem crane lift with both cranes situated at the end of 6th Street would be needed to lift the steelwork from the barges and then rotate it into position.

Examples of pre-engineered bridge picks with similar span ranges are shown below.

Figure 29: *Construction of pre-engineered truss pedestrian bridges – Walter Bean Trail Bridge in Kitchener, ON (left) and Cousineau Pedestrian Bridge in Windsor, ON (right)*

In some instances, a pre-engineered truss bridge can be erected using smaller segments connected together over the waterway. However, for this site, the park side forested condition precludes crane access to the riverbank and delivery of steel sections. Without cranes on both sides of the waterway, it is not practical to connect smaller segments together over the water.

4.1.1.2 Benefits and Drawbacks

Benefits of the pre-engineered truss bridge:

- Potentially quick fabrication and installation

Drawbacks of the pre-engineered truss bridge:

- Most likely limited to 4m-wide deck with a pre-engineered solution at this span length
- Requires the bridge profile to be raised, resulting in steeper approach grades up to 8.33%
- Requires significant staging area for assembly
- Low transparency of structure due to heavy, deep structural elements
- High steel tonnage required
- Heavy lift requires very large cranes within limited available area at the end of 6th Street
- May potentially require a partner crane on park side of river, leading to more tree impacts
- Larger painted surface area will attract more graffiti and will have higher maintenance
- Cannot easily accommodate wider lookouts at discrete locations along span

Figure 30: *Bird's eye view of pre-engineered bowstring truss option at proposed project location*

4.1.2 Modular Panel (Bailey) Bridge

The previous study looked at a modular panel structural system consisting of a Bailey-style bridge with pinned panels to achieve a clear span. This type of bridge is typically used as a temporary solution and is often built using hot-dipped galvanized structural steel members.

This system has similar considerations to the pre-engineered bowstring truss in terms of deck geometry, as the deck elevation must be raised up significantly above the bottom chord to achieve stability of the unbraced top chords of the trusses. This leads to increased approach grades to touch down within the limited space available on the 6th Street side.

This structural system uses multiple planes of trussed members that is visually busy with a lack of transparency across the river.

There is a need for long-term regular inspection of the pins connecting the panels of this bridge system. Bailey bridges are typically galvanized; however, it may be more appropriate to paint the system in this marine application.

Figure 31: *Renderings of modular panel bridge option at proposed project location*

Figure 32: *Example of modular panel bridge*

4.1.2.1 Constructability

One key advantage of the modular panel bridge is the ability to push-launch from one side to erect the bridge across a waterway. This would be ideal for the 6th Street Bridge site, as access on the east side is challenging for large equipment, given the tree canopy and narrow trails. If the bridge could be launched from the roadway over the river, that would minimize access needs on the park side.

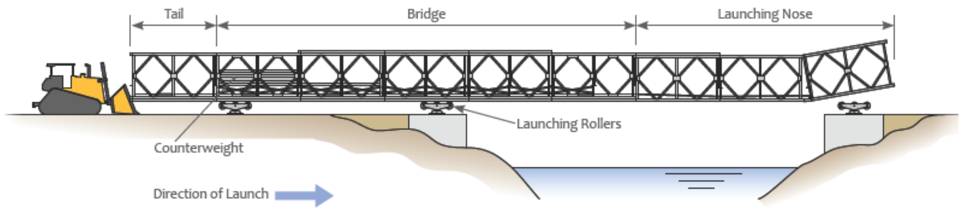

Figure 33: *Typical construction of modular panel bridge*

However, push-launching is typically done with a relatively flat approach grade to allow for a level launch. There are challenges in maintaining the required bridge geometry and angles to land the bridge on the receiving side. Given the sloped topography of 6th Street, this erection method may not be feasible.

Figure 34: *Intersection of 6th St and Anderton Ave, roadway sloping up to the west*

Additionally, to preassemble the span, complete with a launching nose, would obstruct the Anderton intersection and access to the Central Builders property.

Figure 35: *Assembly area required for launching operations*

Figure 36: *Truss being push-launched with launching nose attached*

Without an option to push-launch the span, this option does not present a clear advantage. It would most likely need to be constructed off-site and barged into place. Construction considerations would be very similar to those of the pre-engineered bowstring truss bridge discussed in the previous section.

4.1.2.2 Benefits and Drawbacks

Benefits of the modular panel (Bailey) bridge:

- Potentially quick installation
- Could be push-launched from one end (but may not be feasible at this site)
- Could likely accommodate wider deck widths of 5m to 6m

Drawbacks of the modular panel (Bailey) bridge:

- This type of bridge is most typically a temporary solution
- Requires that the bridge profile be raised to accommodate under-deck bracing of the trusses, resulting in steeper approach grades up to 8.33%
- Requires significant staging area for assembly
- Poor aesthetic quality and sagging appearance
- Low transparency due to multiple truss planes rising high above bridge deck
- Pins at panel joints require regular inspection
- Cannot easily accommodate wider lookouts at discrete locations along span

Figure 37: *Bird's eye view of modular panel (Bailey) bridge option at proposed project location*

4.1.3 Network Arch Bridge

The previous study looked at the network arch system to achieve a clear span. This type of bridge is typically comprised of steel arch rib and tie-chord members with a network of thin, crisscrossing steel hangers connecting the ribs and tie-chords. This results in an efficient and very stiff structural system.

Network arch bridges have a slender profile and a high level of transparency, affording users open, unobstructed views along the bridge span. The network arch has a strong aesthetic quality.

With the use of overhead bracing, a low deck profile can be utilized to help minimize the approach grades. This is a key advantage over the bowstring and modular truss options.

Figure 38: *Renderings of network arch option at proposed project location*

Figure 39: *Happy Hollow Bridge in San Jose, CA (left) and Shaganappi Trail Bridge in Calgary, AB (right)*

Figure 40: *Harbourside West Pedestrian Bridge in North Vancouver, BC*

4.1.3.1 Constructability

Like the pre-engineered bridge option, one method of building the network arch system is to assemble the steel framing in a staging area near the site and then lift it into place using cranes. However, given the constraints of the current site, it may not be the preferred method due to limitation on available staging area. Barging required to get the bridge to the site poses challenges for how cranes could lift the arch from the west riverbank. The size of cranes required to lift the main span could pose an issue in being able to practically set up such cranes at the project location, but it's noted the weight of a network arch span would be almost half that of the Bowstring truss

Some examples of arch bridge lifts are presented below.

Figure 41: *Examples of arch pedestrian bridge lifts*

Another method to build the network arch bridge is to use temporary works to incrementally build out the arch and tie chord in their final position. One method could use temporary towers with stay cables to create a cantilevered falsework system over the river. This method would not require temporary in-water works within the span. Because the individual elements of the arch are relatively lightweight and easy to maneuver, the equipment required to build out the structure could be a single crane positioned at the end of 6th Street. With this fashion of construction, the arch is built out incrementally from both sides, connecting at mid-span prior to removing the temporary elements. This method was used to construct the Happy Hollow Zoo Pedestrian Bridge in San Jose, CA.

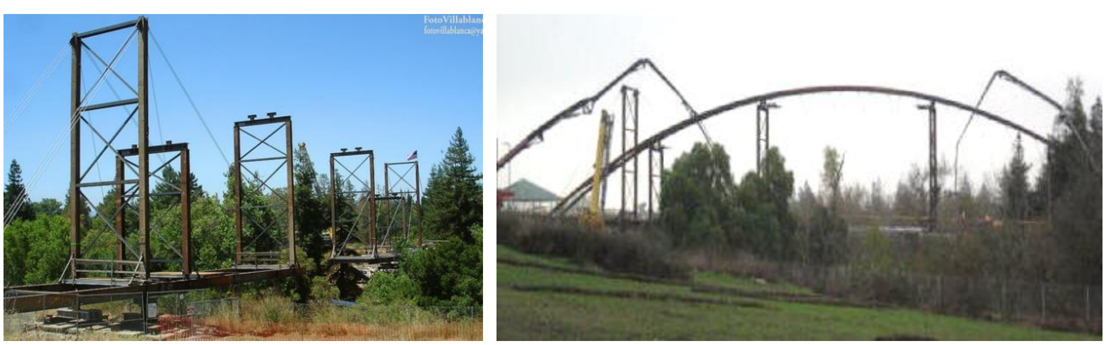

Figure 42: *Construction of Happy Hollow Zoo pedestrian bridge*

The incremental construction method could enable the span to be constructed in its final location. Possible areas for a supplemental stockpile area during construction include portions of the two parking lots next to the site, if access could be obtained from the owner of these lots. Off-site assembly and barging to the site would not be required in this case.

The incremental construction would progress as follows.

- Install foundations at each end of main span, including temporary foundations for temporary backstays.
- Erect temporary towers to support stick building method of construction.
- The main span would then be constructed on the cantilevered falsework with steel segments flown into position using a crane located at the end of 6th Street.
- Once the structural steel and hangers are in place and the concrete deck is cast, the temporary supports could be removed.

4.1.3.2 Benefits and Drawbacks

Benefits of the network arch bridge:

- Low deck profile results in flatter approach grades below 5%
- Efficient structural system results in lighter structure
- High aesthetic quality
- High transparency along span through network of hangers
- Stiff structural response to address user comfort and bridge vibrations
- Could accommodate wider deck widths of 5m to 6m
- Could incorporate small discrete lookouts at mid-span as a feature for users
- Minimal area for graffiti

Drawbacks of the network arch bridge:

- Pre-assembled and full span lift option requires significant staging area for assembly (although possibility to build incrementally to reduce staging area)
- Periodic inspection of steel hangers required over lifespan

Figure 43: *Bird's eye view of network arch bridge option at proposed project location*

4.1.4 Cable-Stayed Bridge

The fourth option considered in this study is the cable-stayed bridge system. Like the network arch bridge, a key advantage is the low deck profile of the bridge, enabling the approaches to use lower grades. Transparency and aesthetic quality are considered high for this option. The back spans on either end of the main span would be engaged as a part of the full system response to resolve longitudinal load components from the backstays and allow for vertical loads to be transferred from the system into the foundations. There is more complexity in the design of this type of structure than the others.

An asymmetric cable-stayed bridge was conceptualized as a part of a previous study. This asymmetric geometry positioned the tall tower on the park side of the river. This leads to several disadvantages, including:

- Major impacts to trees within the park, as all foundation work and erection would be carried out on the park side;
- Inferred bedrock is found to be dropping deeper from the west to the east, meaning the anchorage of the asymmetric configuration would likely require deeply embedded rock anchors;
- The height of the tower would make inspections of the cable anchorages challenging; and
- The long-term behaviour of this type of asymmetric bridge can pose challenges at the opposite end of the tower due to long-term effects like cable relaxation and concrete creep.

The previous study looked at using weathering steel members for main structural elements and a pressured treated timber deck for the traveling surface.

To address the various drawbacks associated with this earlier concept, the cable-stayed concept is evolved to utilize a symmetric configuration with a tower on each side of the river. This reduces the tower height, while retaining a striking appearance. Having lower towers that are more easily accessible for inspection with readily available mobile lifts facilitates the periodic inspections required during the life of the bridge. A concrete deck surface would provide durability and accessibility with a high friction, all-weather riding/walking surface.

Using two towers reduces the individual stay cable lengths, which opens up various material options to be used for the stays. The shorter length is also beneficial from a wind dynamics perspective.

The height of the towers could be varied to suit aesthetic desires. The geometry of the towers and back spans would fall within a range between the following visual comparison of shorter versus taller towers, while maintaining structural efficiency.

Figure 44: *Renderings of cable-stayed bridge option with shorter (left) and taller towers (right)*

Figure 45: *Renderings of cable-stayed bridge option with shorter (left) and taller towers (right)*

Figure 46: *Delta Ponds Bridge in Eugene, OR (left) and Mary Ave Pedestrian Bridge in Cupertino, CA (right)*

Cable-stayed bridge towers are an opportunity for creating a sculpted form. The tower masts can take on a variety of configurations, including outward leaning masts or diamond shaped portals as seen in the examples above.

Figure 47: *Examples of sculptural steel pylons*

4.1.4.1 Constructability

The required construction footprint for the cable-stayed bridge option is significantly smaller than that required for preassembly of a full-span option. The construction considerations would be very similar to the incrementally built method for the network arch discussed in the previous section, which would likely use temporary shoring towers supported from one another using cables. Instead of creating a temporary bridge to support the permanent arch bridge, this fourth option simply incrementally constructs the final cable-stayed bridge without the need for temporary shoring.

The construction would progress as follows:

- The back span anchorages would be constructed on each end using micropiles and counterweights.
- The main towers would be flown into position using a crane onto the deep foundations.
- The back spans would be erected from the tower to anchorages on falsework, with tie-downs installed at anchorages.
- The main span would then be constructed using cantilevered construction where steel frames are flown into position using a crane and supported from progressive sets of forestays.

To maximize efficiency of the structure and to keep pick weights down, it is envisioned that the main span will be comprised of steel framing that is installed with stay-in-place metal forms attached. The metal forms would be made composite with the cast-in-place concrete deck. The back spans can be made using a thicker concrete deck than the main span to increase the counterweight to help reduce the uplift force on the back span anchorages.

4.1.4.2 Benefits and Drawbacks

Benefits of the cable-stayed bridge:

- Low deck profile resulting in flatter approach grades below 5%
- Modular construction method possible, avoiding need for large staging area
- Efficient structural system results in lighter structure
- Higher aesthetic quality
- Higher transparency along span
- Back spans are a part of the structural system (rather than discrete approach spans)
- Could accommodate wider deck widths of 5m to 6m
- Could incorporate discrete lookouts at mid-span as a feature for users
- Minimal area for graffiti

Drawbacks of the cable-stayed bridge:

- More complex bridge system to design and construct
- More flexible system requires assessment for user comfort and wind stability
- Requires more specialized contractor to complete the construction
- Requires periodic inspection of the cable anchorages over the lifetime of the structure
- Backstay anchorages requires uplift resistant foundations

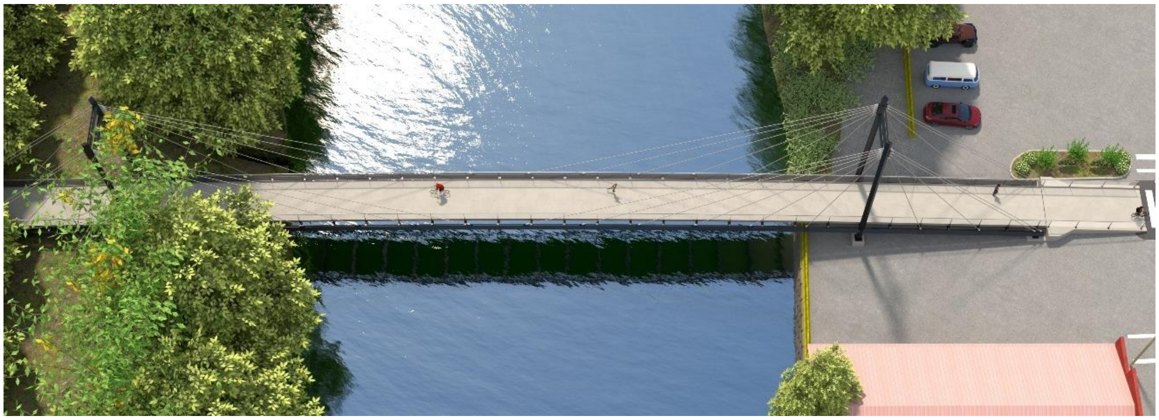

Figure 48: *Bird's eye view of cable-stayed bridge option at proposed project location*

4.1.5 Other Bridge Alternatives

Girder bridge options would require significant depth and would affect the approach grades too significantly. A central raised box section was explored as a variation to a through girder system, which preserves river views out from the bridge deck. The back spans can have active tie-downs to add stiffness to the center span and help reduce the vertical vibrations. However, this solution divides the pathway in two, effectively creating narrower passages on either side of the central spine. Fabrication costs are higher with the spine girder, which must have enough torsional stiffness to ensure vibrational comfort for users.

Figure 49: *Mary Elmes Pedestrian Bridge in Cork, IR is an example of a raised torsion girder span*

A suspension bridge system with stiffened deck was also evaluated. In this solution, the main line cables are connected to anchorage blocks and the deck segments installed from the hangers. The geometry of the suspension bridge option is similar to the cable-stayed option, which uses side spans, forestays, backstays, and anchorages. Advantages of both suspension and cable-stayed systems are a low deck profile, minimal structure at mid-span, and transparency of the superstructure.

Figure 50: *Elbow River Suspension Pedestrian Bridge in Calgary, AB.*

After discussion with the City and due to the similarities between the suspension and cable-stayed bridge systems, it was determined that the original four options would be retained.

4.2 Bridge Deck Widths, Approaches and Trail Considerations

4.2.1 Bridge Deck Widths and Cost

It is understood that a wider bridge deck, ranging up to 6m, has been expressed as a desire by some stakeholders from outreach discussions (summarized in Section 5). A wider deck would have different implications for different options, as discussed in the options analysis. Deck width is generally proportional to construction cost. For example, a bridge with a 5.0m deck would cost approximately 25% more than a 4.0m wide deck, and a 6.0m wide deck would cost approximately 50% more. Note that these cost increases would be applicable to the bridge structure construction costs; secondary costs, such as railings and lighting, would not be unchanged.

Wider deck options may have implications on the existing storm pipe running down 6th Street, which might need to be relocated if installation of the bridge foundations gets too close.

Figure 51: *mixed-use 4.26m wide pathway on SR 520 floating bridge in Seattle*

Figure 52: *painted delineation examples on 5.4m wide deck over I-80 (left) and 5.5m deck over the Rhine River (right)*

4.2.2 Delineation Considerations

The previous study included discussions regarding user delineation of the new pathway and onto the bridge. The *BC Active Transportation Guidelines* (the Guidelines) provides the following recommendations:

- Section E.2 of the Guidelines (Multi-Use Pathways) states that “the decision to separate bicycle users from other users is based on a number of factors including: right-of-way width available, the total volume of current and anticipated pathway users, and the ratio of pedestrians to all daily pathway users. If the required space is available, it is recommended to provide separation between bicycle users and other pathway users."

- Section E.3 of the Guidelines (Separated Bicycle + Pedestrian Pathways) recommends minimum constrained travel widths for two-way bicycle traffic of 3.0m and for pedestrian traffic of 1.8m. This would equate to a total delineated use pathway width of 4.8m, at a minimum.

It should be noted that the Guidelines do not specifically address pathway requirements for pedestrian and cyclist bridges. With the above considerations feeding into this study, the formal delineation of users by mode is not recommended at the design deck width of 4.0m. Directional delineation could be implemented at this width, but the Guidelines discourage striped centerlines on multi-use pathways:

- Page E23 of the Guidelines states: "Centreline striping is generally not recommended along multi-use pathways. Although the use of a centreline can reduce the possibility of a conflict between users travelling in different directions, it can contribute to conflicts that arise when faster moving pathway users cross the centreline to pass slower moving users. Many pathway users also disregard centrelines, which can create conflicts. In addition, a centerline implies a 'rule' that is likely to generate complaints but not be enforced."

To satisfy the minimum recommended widths of a single pedestrian zone and two-way cycling zone, the deck would need to be at least 4.8m wide. However, as this is a tranquil river crossing, pedestrians would tend to want to linger along the edges of the deck to take in the upstream and downstream views. Adding an additional walkway to meet this desire would add another 1.8m of width, bringing the total delineated width to 6.6m. This pathway width becomes rather substantial for the supporting bridge structure.

As mentioned by the Guidelines, one of the challenges with contiguous delineation zones across the width of a bridge deck is that users do not always stay within their designated zone. Calgary's Peace Bridge uses slightly raised sidewalks along each edge with for pedestrians with a central two-way cycleway. Pedestrians notoriously walk within the central zone. One of the issues for this comes from the fact that the sidewalks are rather narrow; a couple walking side-by-side cannot pass another couple walking side-by-side in the opposite direction. The other challenge is the consideration for peak times of pedestrian use and peak times for cyclist use. The sidewalks may not handle the pedestrian demand at peak use.

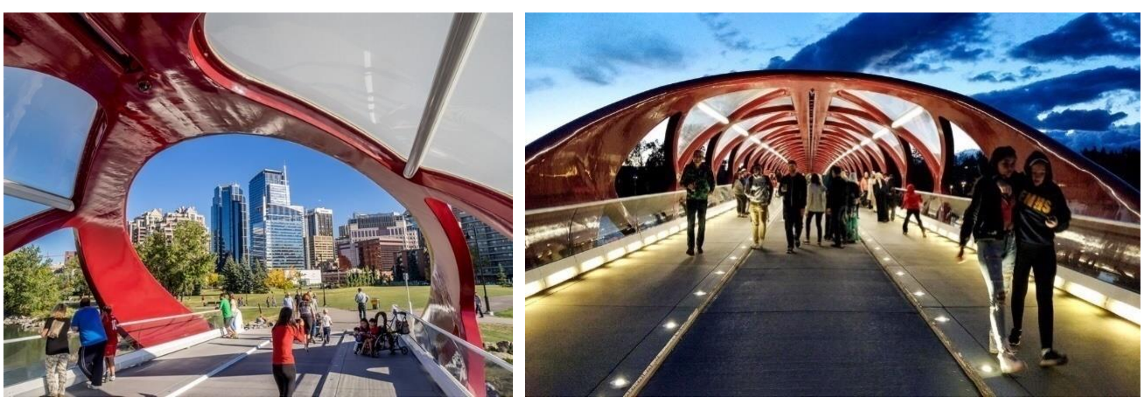

Figure 53: *Separated pathways along Peace Bridge (6.2m-wide deck) in Calgary*

The last point is an important one, as multi-use trails typically see a shift in the peak hour of use for cyclists and peak hour of use pedestrians. Commuters that are cycling to work typically use a pathway early in the morning or during the 16:00-18:00 hours. Pedestrians tend to use the pathway slightly later in the morning, at noon, in the summer evenings, and on weekends.

Delineated User Experience and Function

A second challenge arises about delineation of user type on pathways and bridges. Users become very frustrated with other types of users operating in their designated space, which is often the case with pedestrians walking in designated zones for bikes. A sense of entitlement arises that can lead to increased conflicts when user types move outside of their designated zones, as noted in the excerpt from page E23 of the Guidelines.

For narrower deck widths, delineation would not preferable, as it is difficult to satisfy the minimum functional widths for each user type. Dividing the space into too small of zones inevitably leads to users needing to move outside their designated zones to maneuver when high traffic is present on the bridge. Having a shared use pathway without any form of delineation on narrower bridge decks tends to help with moderating cyclist speeds. Cyclists are expected to follow the rules of the road and must also yield to pedestrians. When heavy pedestrian crowds are present it creates a visual cue for cyclists to slow down on the shared space of the bridge.

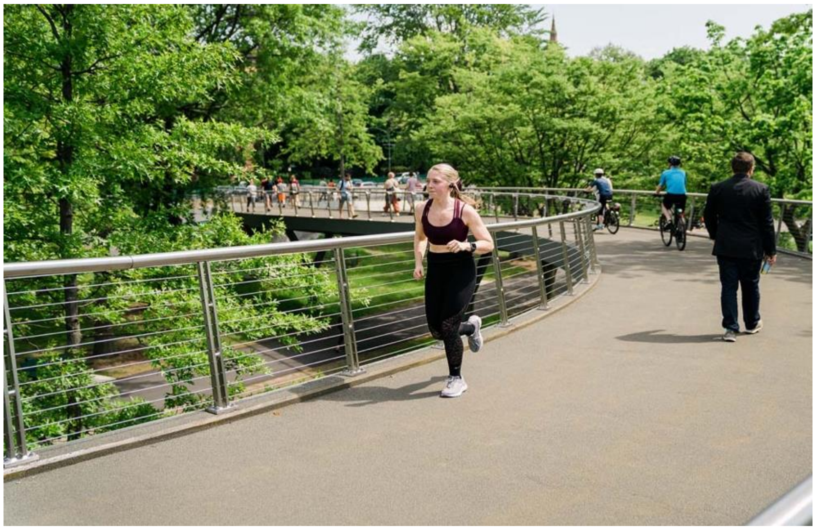

Figure 54: *Multi-use bridge deck of the new Fanny Appleton Bridge (4.3m-wide deck) in Boston*

It is important to note that most multi-use pathways are 3m in width; the Riverway Trail is also 3m in width along significant stretches of its pathway. The baseline deck width considered in this study is 4m wide, which provides additional room over the minimum width required by the Guidelines.

Impacts to Cost

When considering the pathway network within a city or region, cost is an important consideration. Bridges are very expensive to construct relative to their at-grade counterparts. The recommendations of the Guidelines do not address considerations for multi-use pathways with bridge crossings, which need to balance cost with function. To add significant width to a bridge for a future ability to delineate could result in a cost-prohibitive project that ultimately reduces the funds available to continue building trail connections. In this case, there is a significant need for investment on the east side of the Courtenay River to develop an all ages and abilities pathway system capable of conveying users safely to and from the bridge.

Delineation Conclusions

To summarize the topic of delineation, new bridges serving multi-use trails do not typically include mode delineation. If, in the future, the bridge user counts become significant to justify delineation, the base width of 4m could be marked with a dashed yellow centerline and separated by travel direction. This width is challenging to separate modes.

If it is desired to have the option to potentially delineate user modes at a future date, a minimum deck width of 4.8m would allow modal separation, although the pedestrian zone would be rather tight. Wider deck widths can be used, but will add cost to construct the project. Decks wider than 5.5m will also likely have an impact on the existing storm sewer and require its relocation.

4.2.3 Bridge Approaches

Approach/back spans are proposed for the various options to reduce the amount of embankment required and to eliminate the need for ground improvements, which were considered in previous studies. This also helps to avoid placing fill near the Q200 flood zone.

There would be an open space underneath each approach span leading down to the approach embankments. Screening this area beneath the deck off from access by the public would be desirable from a safety perspective. Welded wire mesh, or similar, could be used, which could act as a trellis for native climbing plants.

4.2.4 Trail Tie-In Along 6th Street

On the west approach, it is anticipated that the sidewalk to the west of the intersection at 6th Street and Anderton Avenue will be supplemented with a minimum 3-metre wide separated bike lane by displacing on-street parking to connect the proposed bridge with Riverway Trail. This arrangement provides an all ages and abilities connection between the existing multi-use trail and proposed bridge.

The bike lane and sidewalk would provide ample usable width. The new bike lane would also satisfy the minimum "constrained" width requirement of 3.0m set out by the Guidelines for bidirectional protected bike lanes. Types of buffers can vary from painted lines to physical barriers like flexible posts, planters, and concrete barriers.

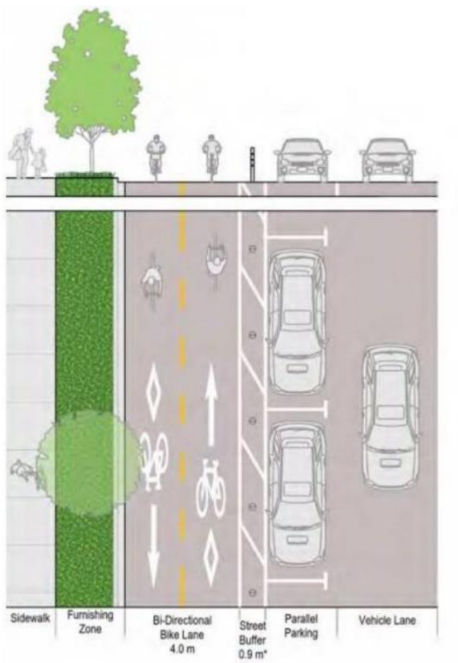

Figure D-41 // Bi-Directional Protected Bicycle Lane Cross-Section with On-street Parking (Desired Width)

Table D-11 // Protected Bicycle Lane Width Guidance

FACILITY	DESIRABLE (M)	CONSTRAINED LIMIT (M)
Bicycle Through Zone (Uni-Directional)	2.5*	1.8
Bicycle Through Zone (Bi-Directional)	4.0	3.0
Street Buffer Zone	0.9*	0.6
Furnishing Zone**	2.0	0.25

* If Street Buffer Zone is not adjacent to on-street motor vehicle parking, the desirable width is ≥0.9 metres, with a wider buffer creating additional cycling comfort.

Figure 55: *Typical layout of bidirectional bike lanes and dimensions per BCATG*

With the separated bike lane adjacent to the existing sidewalk, cost to implement the widened multi-user path is kept to a minimum. It also provides sufficient sightlines for users negotiating the 90-degree turn to and from the Riverway Trail. This block of 6th Street have steep grades, so keeping the cyclists adjacent to the sidewalk allows safe space for those needing to walk their bike to the hill. This two-way bike lane eliminates the need for westbound cyclists to cross traffic at the intersection and then again mid-block to connect with the trail. This approach is in line with the Section G1 of the Guidelines:

Minimize conflicts between users

Conflicts can be minimized by separating different users in space and/or time. Providing dedicated spaces and/or protected phasing for active modes through intersections and crossing points increases the predictability of movements and supports more compliant behaviour. Minimizing exposure between active transportation users and motor vehicle traffic can also help to reduce conflicts.

A raised crosswalk is proposed across the access into the private parcel 610B to keep vehicle speeds low as they enter and leave the parking lot. The table width of the raised crosswalk would match the width of the bridge and/or the combined sidewalk and bikelane. Elephant feet could line the edges of the crosswalk to indicate the mult-use nature of the crossing.

Figure 56: *Example of raised crosswalk*

East of the Riverway Trail access, the 6th Street southern curb line does not follow a straight line, but causes the roadway to neck down uphill from the Riverway Trail. A concrete roadside barrier (CRB) is proposed to be installed to create a protected taper for the eastbound traffic lane along 6th Street as the bike lane starts at midblock. The CRB would also block vehicular access into the bike lane. Future options for extending cycling infrastructure along 6th Street beyond this connection to the Riverway Trail could be explored in the future detailed design phase.

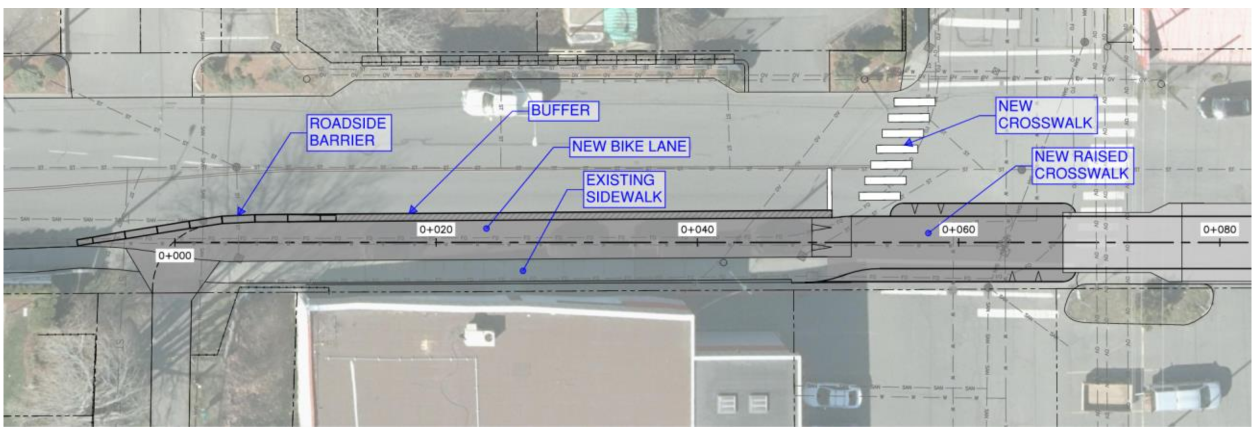

Figure 57: *Proposed tie-in to Riverway Trail*

4.2.5 Trail Tie-In at Simms Millennium Park

On the east side, the bridge approach span will link into existing trails within the park. It is anticipated that a portion of the waterfront trail will be interrupted by the new bridge and abutment location. To address this break in connectivity, trail traffic will be redirected to existing trails on either side of the new bridge. A portion of the existing waterfront trail would be decommissioned and replanted as mitigation areas.

The existing intersection point of the trails could be modified to incorporate a roundabout for cyclists and other users to navigate to other portions of the trails. The curves will help to serve as a speed control for cyclists leading up to the bridge.

Figure 58: *Examples of non-motorized trail roundabouts*

If a wider pathway and bridge are considered, there would be larger impacts on the existing trees and there would be limits on the size of the roundabout. The baseline 4m width is shown below and integrates well with the existing trails.

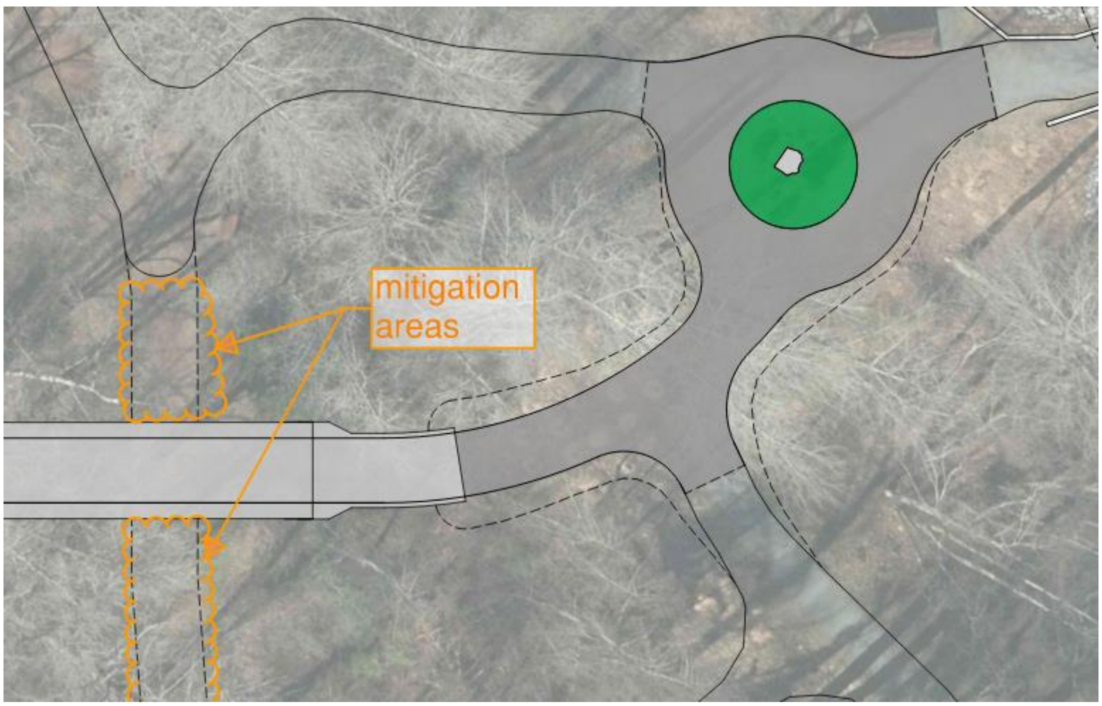

Figure 59: *Proposed tie-in with Simms Millennium Park trails*

4.3 Public Art Opportunities

There may be a desire to integrate public art into this project; the theme, style and location of the artwork would be coordinated through a future detailed design phase. Opportunities could include the placement of public artwork at the centre of the proposed roundabout at the east approach. Below are some Indigenous artwork installations, including a roundabout in Chillawack and in Stanley Park.

Figure 60: *Examples of artwork at roundabouts*

Lighting feature could also become art installations along the new trail through Simms Millenium Park. The examples below showcase a Coast Salish pattern in stainless steel wrapping around a tighting tube, while the righthand example showcases light tubes helping to illuminate the space around benches.

Figure 61: *Examples of illuminated art installations*

The roundabout could include pavement patterns or change in material to bring awareness that it is a trail node that requires caution by users as they navigate through the shared space. Thermoplastic patterns can be applied to asphalt or concrete surfaces such as the example below left in Steveston. Pavers or embeds can add a tactile experience in addition to being a visual cue.

Figure 62: *Examples of pavement markings*

5 Stakeholder Consultations

A separate consultation process was carried out by the City in September and October 2020 to engage affected stakeholders of this project. These stakeholders included:

- Comox Valley Cycling Coalition
- Accessibility Advisory Committee
- Central Builders (Home Hardware) (owner of several properties adjacent to project site)
- Comox Valley Conservation Partnership
- Downtown Courtenay Business Improvement Association
- Members of 6th Street Pedestrian/Cycling Bridge Steering Committee
- City of Courtenay Parks Department (internal)
- City of Courtenay Asset Management Department (internal)

Additionally, it is understood that a separate process is planned for formal engagement of the K'ómoks First Nation.

Discussions were held with the City to review feedback from the stakeholder consultations that have been held so far. Key elements of the feedback received include:

- Desire by user groups to have a wider bridge, up to 6m, with grades limited to 5% or less.
- Pathway separation of cyclists from pedestrians.
- Timber decking is not preferred by user groups due to accessibility concerns.
- The idea of compensating for tree removal at the bridge approach by replanting and mitigating the decommissioned trail areas was well-received. Consideration should be given to migratory birds and eagles' nests in the park.
- Balance of pathway paving for user accessibility and maintenance considerations for asphalt over tree roots on the east approach.
- User safety, especially at crosswalks, and adequate lighting are important considerations.

6 Alternatives Evaluation

6.1 Evaluation Criteria

Weighting of each criterion has been assigned in consultation with City staff on order of importance.

6.1.1 Structural

The structural design complexity of each option is considered from the perspectives of engineering and construction effort. Seismic performance is another consideration in this category. Options requiring more effort are rated lower than those with perceived simpler efforts.

6.1.2 Geotechnical

Ground conditions and geotechnical risk is categorized with this item. Options requiring less onerous geotechnical solutions (lighter structures, no uplift, mitigates liquefaction) are rated more favourably.

6.1.3 Environmental Impact

Impact to the tree canopy, particularly on the park side, is considered for each option. Options with a larger footprint, both in the temporary construction access and permanent condition, are rated less favourably.

6.1.4 Life Cycle Cost

Cost is an essential aspect of this project, as procuring sufficient funding and support for the new bridge is a large part of the evaluation process. The City desires a structure that can deliver on its goals while maintaining reasonable costs for construction and future maintenance.

The evaluation of cost for each of the four options will be based on a relative scale between each other, as refined estimates will not be developed for the pre-engineered truss and modular panel bridge options. Elements that feed into the cost include materials, erection, staging, and accessibility. Consideration should also be given to maintenance requirements over the lifetime of the structure after the project is completed and handed over the City. Scoring will be based on the relative costs developed in the previous report with additional consideration of staging and transportation costs.

6.1.5 Long-Term Maintenance

Long-term maintenance of the completed structure is factored into the assessment of bridge options. Durable features should be favoured over elements that may require more frequent intervention.

6.1.6 Constructability

Constructability relating to each option is an important factor, as there is a trickle through impact to the design, construction cost and environmental considerations.

6.1.7 Pathway Grading

Grading and accessibility are important considerations to the design. Some of the options require steeper grading to achieve the necessary tie-ins to existing connections. Those options would be rated less favourably in the evaluation.

6.1.8 User Experience

Options providing a positive user experience are rated highest. This includes an openness with the river, opportunities for lookouts at midspan, and a less imposing structural mass.

6.1.9 Aesthetics

Through discussions with City Council and staff, the evaluation should consider the aesthetics of the new bridge. It is understood that the City is looking for a balance of form and function for this bridge. There is also potential for this new structure to become a future landmark and destination as the City grows over the long term. Options with perceived aesthetic merit will be rated higher in this category.

6.2 Evaluation Comparison

Using the evaluation criteria discussed in the previous section as a basis, an evaluation matrix with weighted scores is used to assess the merits of each bridge option.

Table 1: *Evaluation matrix for bridge options.*

6TH STREET ACTIVE TRANSPORTATION BRIDGE - EVALUATION MATRIX							
				Score			
Item	Evaluation Criteria	Qualitative Criteria/Measurement	Weighting	Prefabricated Bowstring Bridge	Prefabricated Bailey Bridge	Network Tied Arch Bridge	Cable-Stayed Bridge
1	Structural Design	- minimized engineering complexity - high redundancy	10%	10%	9%	7%	6%
2	Geotechnical Design	- lighter superstructure minimizes weight on foundations - straight-forward foundation construction	10%	8%	8%	9%	7%
3	Environmental Considerations	- minimized tree impacts - efficient use of materials	10%	3%	3%	6%	8%
4	Life Cycle Cost	- low upfront cost - low maintenance cost - ease of inspection/repainting	20%	15%	16%	13%	13%
5	Constructibility	- minimized lay-down area and staging reqiurements - can be built incrementally	20%	5%	7%	8%	17%
6	Pathway Grading & User Experience	- approach grades below 5% - enjoyable, open feel that connects users with the river	15%	2%	0%	15%	15%
7	Aesthetics	- attractive structure - high transparency - viewpoint opportunity over river	15%	5%	0%	14%	15%
		TOTAL SCORE	**100%**	**48%**	**43%**	**72%**	**81%**

From the evaluation and discussions with Council and City staff, the network arch and cable stayed options emerge as the shortlisted alternatives. The opinion of probable cost for these options is discussed in the following section and 10% general arrangement drawings for these options are included in **Appendix A** of this report.

7 Cost Comparison

7.1 Opinion of Probable Cost

Estimates for the two top scoring options (network arch and cable-stayed bridges) have been prepared with limited site information and are based on probable conditions affecting the project. The costs have been developed with consideration for details of the bridge design. These costs represent the identifiable elements of the project available at this preliminary design stage, and are anticipated to be used for planning purposes, to establish a more specific definition of needs, and to obtain preliminary project approval.

The values presented below represent the nominal costs associated with each option. For Class C estimates, a range of -25% to +35% from these nominal values should be considered to capture the potential variations and uncertainties at this preliminary phase of the project. Details of the cost estimate are provided in **Appendix B** of this report.

Table 2: *Summary of opinions of probable cost for construction of shortlisted options.*

Option	Nominal
Network Arch	$4.682M
Cable-Stayed	$4.424M

Trail improvements beyond the bridge footprint, features intended to enhance user experience and aesthetics, and wider bridge decks are considered as optional add-on items to be considered as the design progresses to the next phase of work.

Rough maintenance costs are estimated over an assumed service life of 75 years, without consideration for escalation. Typical items are listed below, but other items could also arise over the lifetime of the bridge. Cost will be highly dependent on exposure, use, regular maintenance and upkeep over the lifetime of the bridge, but are provided to give a relative comparison for life cycle cost considerations. Further discussions and design development are required to better inform the maintenance costs for the final bridge configuration. Off-bridge items related to trail and landscaping maintenance are not included in this table below.

Table 3: *Estimated maintenance costs for shortlisted options.*

		Cost per Occurrence	
Item	**Frequency**	**Network Arch**	**Cable-Stayed**
Annual Maintenance (snow clearing, washing, etc.)	1 year	\$3000	\$3000
Visual Inspections	2 years	\$4000	\$4000
Detailed Inspections	5 years	\$8000	\$8000
Bridge Re-Coating	25-30 years	\$50,000	\$40,000
Bearing Replacement	25-30 years	\$75,000	\$25,000
Deck Joint Repairs	15-25 years	\$25,000	\$20,000
Miscellaneous Structural Repairs	25-50 years	\$150,000	\$150,000
Annualized cost (assuming higher frequency)		**\$19,300/year**	**\$17,500/year**

8 Recommendations and Next Steps

This report set out to make a recommendation for a preferred option to move forward with in the future detailed design phase. Through the use of the Evaluation Matrix, the four bridge options are narrowed down to two shortlisted alternatives: the network arch and cable-stayed options. These two options were comparable in their final scoring, with the cable-stayed bridge having a slightly higher score and the opinion of probable cost shows it to be less cost than the network arch. This bridge type has the benefit of being highly constructable within the constraints of the site, while the others require more complex means of falsework systems or barging from an off-site location. The cable-stayed bridge can also accommodate wider deck widths if so desired.

Given this discussion, the cable-stayed option is recommended as preferred option to proceed with to the detailed design phase. Additional site investigations, including survey and geotechnical investigations, will be required to obtain a fuller picture of the design requirements.

Input collected from the stakeholder consultations will be considered in the detailed design phase for this project. Further public consultation and outreach could be conducted in the future detailed design phase to inform the details of the selected option.

9 Closure

This document has been prepared by V+M Structural Design, Inc. (V+M) for the exclusive use of the City of Courtenay. V+M accepts no responsibility or liability for the consequence of this document being used for a purpose other than the purposes for which it was commissioned.

We trust that the information presented in this report provides the City with a thorough understanding of the design considerations for the 6th Street Active Transportation Bridge and assists with planning the next steps of this important project.

Please do not hesitate to contact us should you have any questions about the discussions presented in this report.

Sincerely,

V+M Structural Design, Inc.

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — S. L. VALDOVINOS # 34439

16-Oct-2020

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16-Oct-2020

Chelene Wong, M.Eng., P.Eng.
Project Engineer

Figure References

Figure 12: Example of concrete deck surface on a Spirit Trail pedestrian bridge

- https://www.canadianconsultingengineer.com/cce/awards/2016/B9_Stantec_LowLevelRoad.pdf

Figure 13: Four-metre wide deck on Central Valley Greenway pedestrian bridge

- https://www.flickr.com/photos/stchou/3666186103/

Figure 17: Buffered bike lane examples

- https://sitkacycling.wordpress.com/tag/pro-walkpro-bikepro-place-conference/
- https://images.app.goo.gl/e9M27dbu4wqMES5u9

Figure 28: Johnson St Pedestrian Bridge in Victoria, BC with 35m span x 5m wide deck (left) and Cousineau Pedestrian Bridge in Windsor, ON with 60m span x 4m wide deck that uses overhead bracing (right)

- https://www.youtube.com/watch?v=i5VbjSaDk7w&feature=youtu.be
- https://windsorstar.com/opinion/columnists/jarvis-were-lucky-to-have-this

Figure 29: Construction of pre-engineered truss pedestrian bridges – Walter Bean Trail Bridge in Kitchener, ON (left) and Cousineau Pedestrian Bridge in Windsor, ON (right)

- http://www.gatemanmilloy.com/portfolio/walter-bean-trail/
- https://www.ironbridgefab.com/work

Figure 32: Example of modular panel bridge

- https://algonquinbridge.com/product/modular-panel-bridge-systems/
- https://images.app.goo.gl/5y7BbAQLhnFJdPKo6

Figure 33: Typical construction of modular panel bridge

- https://images.app.goo.gl/qxxipFNk3Eq2RaJB6

Figure 36: Truss being push-launched with launching nose attached

- https://images.app.goo.gl/Bwo1k77dfsyNT5ei7

Figure 39: Happy Hollow Bridge in San Jose, CA (left)

- https://images.app.goo.gl/wJUNULoxQDbaDnE48

Figure 41: Examples of arch pedestrian bridge lifts

- https://lmnarchitects.com/project/tukwila-pedestrian-bridge
- https://hrcconstruction.com/bridges/40-tynehead-pedestrian-bridge

Figure 42: Construction of Happy Hollow Zoo pedestrian bridge

- https://www.flickr.com/photos/fotovillablanca/4991593978

Figure 46: Delta Ponds Bridge in Eugene, OR (left) and Mary Ave Pedestrian Bridge in Cupertino, CA (right)

- https://www.eugene-or.gov/3260/Bike-Repair-Rentals
- https://images.app.goo.gl/tYmfv8QG9qn72eaE9

Figure 47: Examples of sculptural steel pylons

- https://images.app.goo.gl/WfjfM85Sj9pjNt2s5
- https://moxonarchitects.com/project/477-greenwich-reach-2/

Figure 49: Mary Elmes Pedestrian Bridge in Cork, IR is an example of a raised torsion girder span

- https://images.app.goo.gl/yqA6Jbo89gkEcrVD9
- https://images.app.goo.gl/mGKAB55YNP7BZNNv8

Figure 51: mixed-use 4.26m wide pathway on SR 520 floating bridge in Seattle

- https://images.app.goo.gl/1qgZEqA4CFDfRNLg9
- https://images.app.goo.gl/q5Kj1ahvBEhNfSwL7

Figure 52: painted delineation examples on 5.4m wide deck over I-80 (left) and 5.5m deck over the Rhine River (right)

- https://www.cityofberkeley.info/contentdisplay.aspx?id=19818
- https://archinect.com/firms/project/68182948/three-country-bridge/99630356

Figure 53: Separated pathways along Peace Bridge (6.2m-wide deck) in Calgary

- https://twitter.com/cityofcalgary/status/1043137799099179008/photo/1
- https://crackmacs.ca/tourism/calgary-peace-bridge/

Figure 54: Multi-use bridge deck of the new Fanny Appleton Bridge (4.3m-wide deck) in Boston

- https://www.solomonfoundation.org/projects/frances-appleton-bridge/

Figure 58: Examples of non-motorized trail roundabouts

- https://www.albertnet.us/2017/12/
- https://www.fhwa.dot.gov/publications/publicroads/09janfeb/01.cfm

Figure 60: Examples of artwork at roundabouts

- https://images.app.goo.gl/wNDacV4Xvr5QsWZ67
- https://www.theprogress.com/news/canoe-themed-artwork-complete-at-the-vedder-bridge-roundabout/

Figure 61: Examples of illuminated art installations

- http://www.authenticindigenous.com/artists/james-harry

Figure 62: Examples of pavement markings

- http://www.vancouversun.com/health/Vancouver+puts+brakes+scramble+intersection/7863096/story.html

Appendix A – Schematic General Arrangement Drawings

PRELIMINARY
NOT ISSUED FOR CONSTRUCTION

REVISIONS

REV	DATE	DESCRIPTION	BY
A	2020/10/08	ISSUED FOR REPORT	SV

PREPARED UNDER THE DIRECTION OF

SCHAUN VALDOVINOS
ENGINEER OF RECORD

2020/10/08
DATE

VM STRUCTURAL DESIGN

DESIGNED: C. WONG — DATE: 2020/10/08
DRAWN: S. VARNEY — DATE: 2020/10/08
CHECKED: S. VALDOVINOS — DATE: 2020/10/08

CITY OF COURTENAY

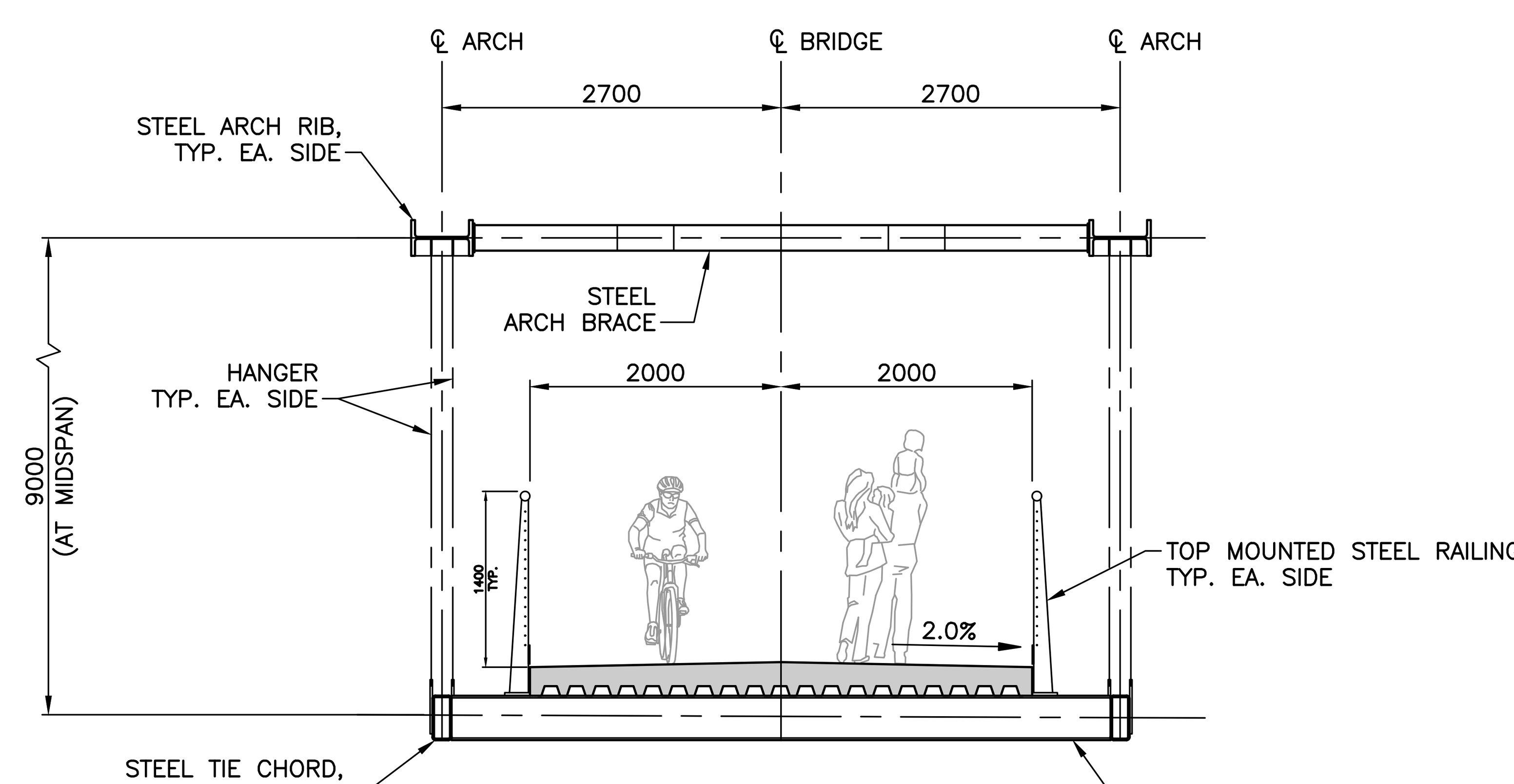
CITY OF COURTENAY
6TH STREET ACTIVE TRANSPORTATION BRIDGE
DETAILED BRIDGE OPTIONS ANALYSIS

SITE PLAN

SCALE: 1:500
FILENAME: 1173-S-01
PROJECT No: PO 11527
SHEET: S-01
REV: A

PLAN
SCALE: 1:200

PROFILE ALONG PROPOSED BRIDGE CENTERLINE
SCALE: 1:200



TYPICAL SUPERSTRUCTURE

SECTION (A)
SCALE 1:50

PRELIMINARY
NOT ISSUED FOR CONSTRUCTION

REVISIONS

REV	DATE	DESCRIPTION	BY
A	2020/10/08	ISSUED FOR REPORT	SV

PREPARED UNDER THE DIRECTION OF

SCHAUN VALDOVINOS
ENGINEER OF RECORD

2020/10/08
DATE

VM STRUCTURAL DESIGN

DESIGNED: C. WONG — DATE: 2020/10/08
DRAWN: S. VARNEY — DATE: 2020/10/08
CHECKED: S. VALDOVINOS — DATE: 2020/10/08

CITY OF COURTENAY

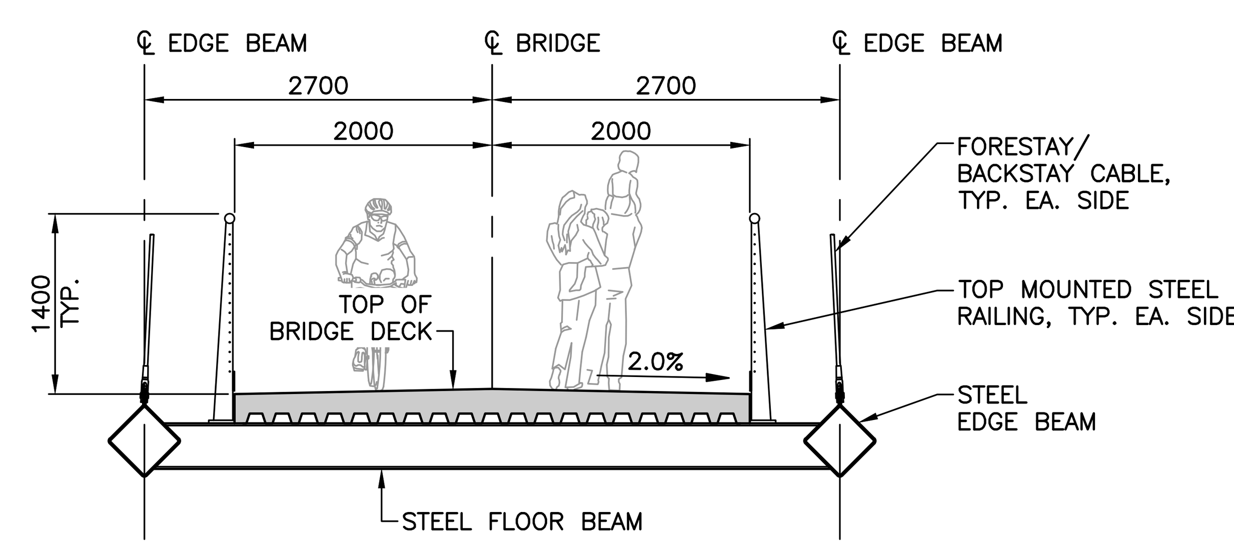
CITY OF COURTENAY
6TH STREET ACTIVE TRANSPORTATION BRIDGE
DETAILED BRIDGE OPTIONS ANALYSIS

ARCH OPTION
GENERAL ARRANGEMENT

SCALE: AS SHOWN
FILENAME: 1173-S-02
PROJECT No: PO 11527
SHEET: S-02
REV: A

PLAN
SCALE: 1:200

PROFILE ALONG PROPOSED BRIDGE CENTERLINE
SCALE: 1:200



TYPICAL SUPERSTRUCTURE

SECTION A
SCALE 1:50

PRELIMINARY
NOT ISSUED FOR CONSTRUCTION

REVISIONS

REV	DATE	DESCRIPTION	BY
A	2020/10/08	ISSUED FOR REPORT	SV

PREPARED UNDER THE DIRECTION OF

SCHAUN VALDOVINOS
ENGINEER OF RECORD

2020/10/08
DATE

STRUCTURAL DESIGN

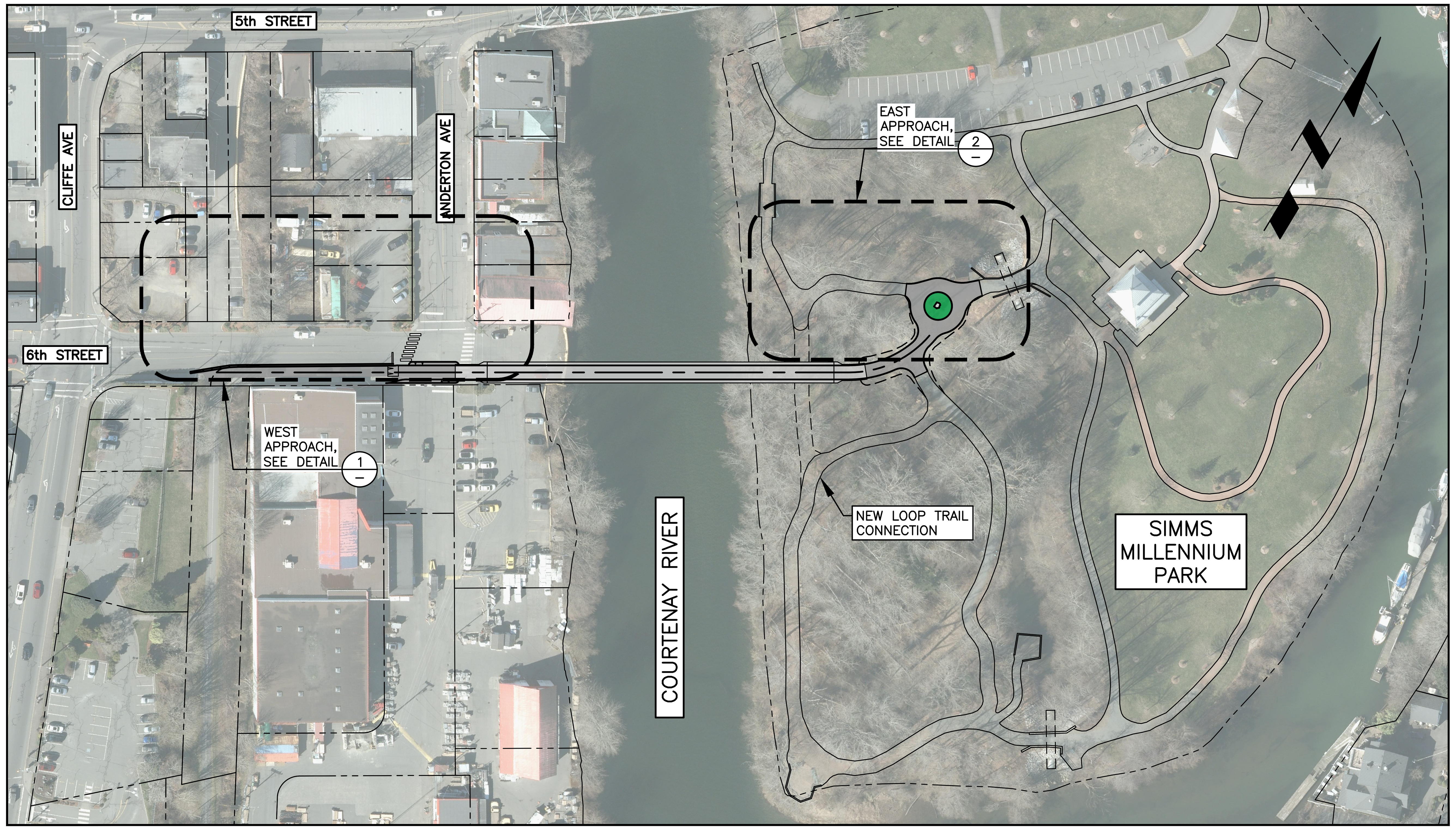
DESIGNED: C. WONG DATE: 2020/10/08
DRAWN: S. VARNEY DATE: 2020/10/08
CHECKED: S. VALDOVINOS DATE: 2020/10/08

CITY OF COURTENAY

CITY OF COURTENAY
6TH STREET ACTIVE TRANSPORTATION BRIDGE
DETAILED BRIDGE OPTIONS ANALYSIS

CABLE–STAYED OPTION
GENERAL ARRANGEMENT

SCALE: AS SHOWN
FILENAME: 1173–S–03
PROJECT No: PO 11527
SHEET: S–03
REV: A



TRAIL KEYPLAN
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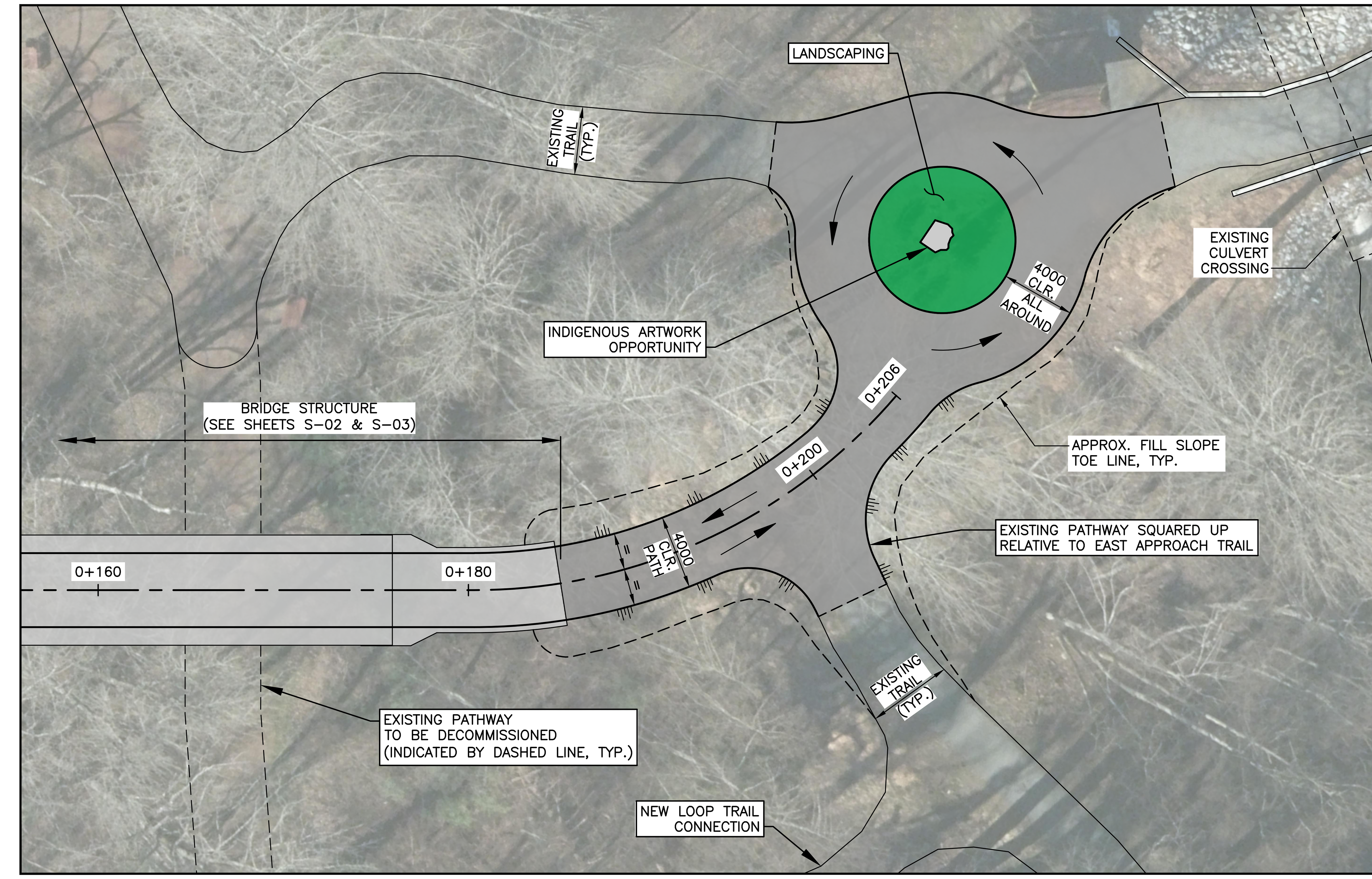
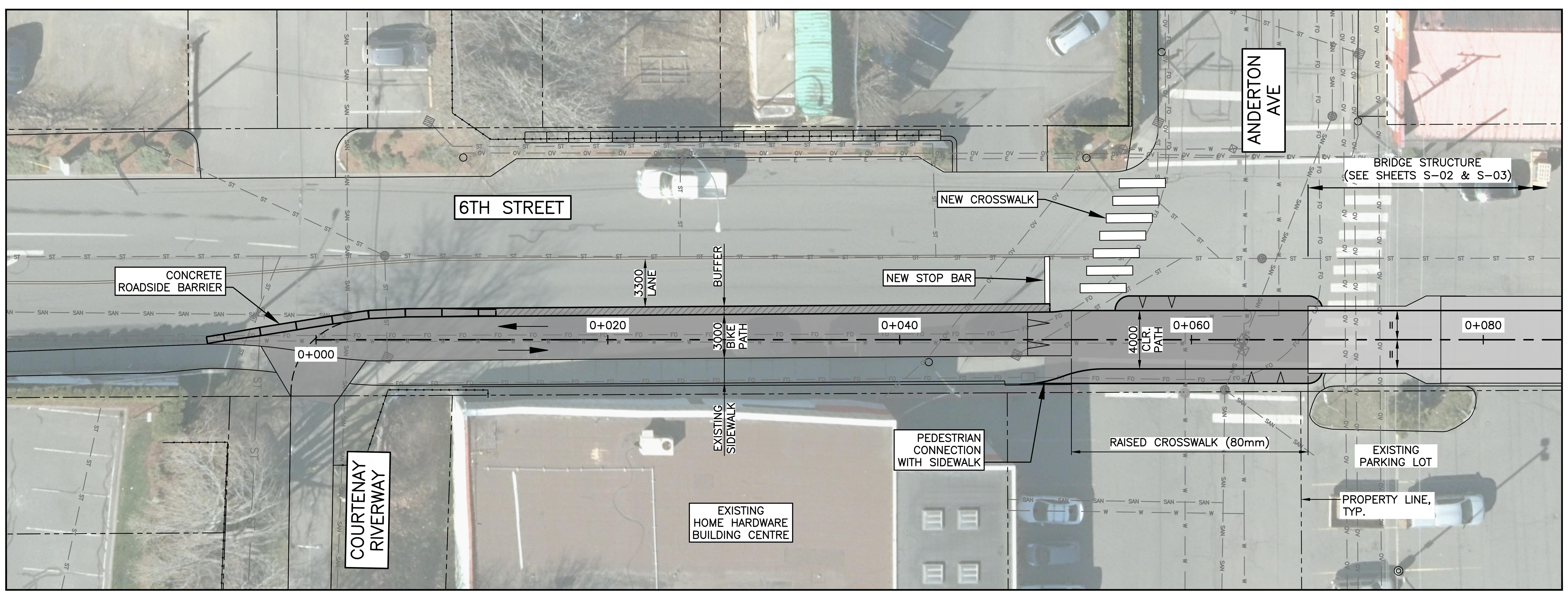


EAST APPROACH PLAN 2
SCALE 1:200



WEST APPROACH PLAN 1
SCALE 1:200

PRELIMINARY
NOT ISSUED FOR CONSTRUCTION

REVISIONS

REV	DATE	DESCRIPTION	BY
A	2020/10/08	ISSUED FOR REPORT	SV

PREPARED UNDER THE DIRECTION OF

SCHAUN VALDOVINOS
ENGINEER OF RECORD

2020/10/08
DATE

VM STRUCTURAL DESIGN

DESIGNED:	C. WONG	DATE:	2020/10/08
DRAWN:	S. VARNEY	DATE:	2020/10/08
CHECKED:	S. VALDOVINOS	DATE:	2020/10/08

CITY OF COURTENAY

CITY OF COURTENAY
6TH STREET ACTIVE TRANSPORTATION BRIDGE
DETAILED BRIDGE OPTIONS ANALYSIS

PATHWAY CONNECTIVITY

SCALE: AS SHOWN
FILENAME: 1173-S-04
PROJECT No: PO 11527
SHEET: S-04
REV: A

Appendix B – Opinion of Probable Cost

Planning Level Opinion of Probable Costs - Bridge Options

Disclaimer

This document has been prepared for the titled project. V+M accepts no responsibility or liability for the consequence of this document being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on the document for such other purpose agrees to indemnify V+M for all loss or damage resulting therefrom.

To the extent that this report is based on information supplied by other parties, V+M accepts no liability for any loss or damage suffered by the client, whether through stemming from any conclusions based on data supplied by parties other than V+M and used by V+M in preparing this document.

Basis of Estimate

This is a planning level cost estimate to provide a high level opinion of probable cost for the bridge types considered in the options analysis study and approaches for the City's planning purposes. These estimates are developed based on a clear deck travel width of 4.0m and include trail improvements beyond the footprint of the bridge. The estimates are calculated in 2020 dollars and do not include any escalation.

The cost estimate is for a planning level design corresponding to the Class C level estimate of the EGBC cost classification system and the planning design development level of the BC MOTI estimate classification system. The estimate is built up using basic unit costs applied to major elements. Unit prices are based on published costs and previous experience with costs for relevant completed pedestrian bridge structures.

Assumptions:

- The estimate costs are based on 2020 dollars.
- The project will be procured and awarded based upon a single bid-build contract for the procurement and construction within the contract limits.
- This estimate is based upon the assumption that there will be an adequate level of competition.
- The general contractor will be required to have coverage for General Liability and other applicable insurance requirements.

Exclusions:

- Costs associated with right-of-way acquisition, if required
- Financing costs
- Escalation to time of construction
- Applicable taxes
- Permit fees
- Owner's management reserve
- Costs associated with replacement of existing block wall at west approach

Opinion of Probable Cost
Network Arch Bridge Option, built incrementally

Bridge Length	117	m	along longitudinal axis
Deck Travel Width	4.0	m	

Description	Unit	$/Unit	Quantity	Item Cost**	
General Provisions and Site Work					
Mobilization	LS	$ 160,000	1	$ 160,000	*approx. 5%*
Temporary Works/Falsework	LS	$ 250,000	1	$ 250,000	*for cantilevered construction*
Site Preparation/Access	LS	$ 50,000	1	$ 50,000	
			Subtotal A: General =	**$ 460,000**	
Foundations and Substructure					
Drilled Shafts	m	$ 5,250	48	$ 252,000	*assumed 12m lg, 4 count*
Crossbeam Concrete	m3	$ 3,000	28.8	$ 86,400	*assumed 1.2m x 2m x 6m*
Abutment Micropiles	EA	$ 8,000	8	$ 64,000	*4 each abutment*
Abutment Footing Concrete	m3	$ 1,500	25.2	$ 37,800	*assumed 6m wide ftg*
			Subtotal B: Foundations and Substructure =	**$ 440,200**	
Approaches					
CIP Concrete Approach Slab	m3	$ 1,500	9.0	$ 13,500	*5m wide x 4m lg., 225 thk avg.*
Structural Steel	LS	$ 305,200	1	$ 305,200	
Composite CIP Deck	m2	$ 650	144	$ 93,600	
Approach Walls	m2	$ 800	80	$ 64,000	*type TBD*
			Subtotal C: Approaches =	**$ 476,300**	
Superstructure					
Structural Steel	LS	$ 1,260,400	1	$ 1,260,400	*For main arch*
Hangers	LS	$ 100,000	1	$ 100,000	
Composite CIP Deck	m2	$ 650	293	$ 190,200	
			Subtotal D: Superstructure =	**$ 1,550,600**	
Miscellaneous					
Baseline railing	m	$ 400	234	$ 93,600	
			Subtotal E: Superstructure =	**$ 93,600**	
			Subtotal F: Subtotals A+B+C+D+E =	**$ 3,021,000**	
Allowances					
Contingency	EA	25.0%	1	$ 756,000	
Engineering/Design/Constr Support	EA	15.0%	1	$ 567,000	
Pathway Lighting/Electrical	LS	$ 187,500	1	$ 187,500	*luminaires + 1 side linear lighting*
East Pathways Improvements	LS	$ 85,000	1	$ 85,000	*allowance, TBD*
West Pathway Improvements	LS	$ 65,000	1	$ 65,000	*allowance, TBD*
			Subtotal G: Allowances =	**$ 1,660,500**	
			Total Cost: Subtotals F+G (nominal) =	**$ 4,682,000**	*excluding taxes*

NOTES:
1) The expected variation for the Class C Cost Estimate is -25% below and +35% above the nominal estimated cost above.
2) Values rounded to nearest $100.
3) See cover page for list of exclusions.

	Optional Add-On Items	Unit	$/Unit	Quantity	Item Cost	
i	High Quality Railing Premium	m	$ 650	234	$ 152,100	*increase in cost over base case*
ii	Bridge Lighting	LS	$ 137,500	1	$ 137,500	*2nd side linear bridge lighting*
iii	Aesthetic Lighting of Bridge Features	LS	$ 75,000	1	$ 75,000	*allowance, TBD*
iv	Public Artwork	LS	$ 200,000	1	$ 200,000	*allowance, TBD*
v	Additional Cost for 5m Wide Bridge	LS	$ 915,000	1	$ 915,000	*increase in cost over base case*
vi	Additional Cost for 6m Wide Bridge	LS	$ 1,830,000	1	$ 1,830,000	*increase in cost over base case*

Opinion of Probable Cost

Cable-Stayed Bridge Option

Bridge Length	117	m	along longitudinal axis
Deck Travel Width	4.0	m	

Description	Unit	$/Unit	Quantity	Item Cost**	
General Provisions and Site Work					
Mobilization	LS	$ 150,000	1	$ 150,000	*approx. 5%*
Temporary Works/Falsework	LS	$ 50,000	1	$ 50,000	*allowance*
Site Preparation/Access	LS	$ 50,000	1	$ 50,000	
			Subtotal A: General =	**$ 250,000**	
Foundations and Substructure					
Drilled Shafts	m	$ 5,250	48	$ 252,000	*assumed 12m lg, 4 count*
Crossbeam Concrete	m3	$ 3,000	28.8	$ 86,400	*assumed 1.2m x 2m x 6m*
Abutment Rock Anchors	EA	$ 8,000	16	$ 128,000	*8 each abutment*
Abutment Footing Concrete	m3	$ 1,500	25.2	$ 37,800	*assumed 6m wide ftg*
			Subtotal B: Foundations and Substructure =	**$ 504,200**	
Approaches					
CIP Concrete Approach Slab	m3	$ 1,500	9.0	$ 13,500	*5m wide x 4m lg., 225 thk avg.*
Approach Walls	m2	$ 800	80	$ 64,000	*type TBD*
			Subtotal C: Approaches =	**$ 77,500**	
Superstructure (Main Span and Back Span)					
Structural Steel	LS	$ 1,354,600	1	$ 1,354,600	*towers and framing*
Cables	LS	$ 225,000	1	$ 225,000	
Composite CIP Deck	m2	$ 650	437	$ 283,800	
			Subtotal D: Superstructure =	**$ 1,863,400**	
Miscellaneous					
Baseline railing	m	$ 400	234	$ 93,600	
			Subtotal E: Superstructure =	**$ 93,600**	
			Subtotal F: Subtotals A+B+C+D+E =	**$ 2,789,000**	
Allowances					
Contingency	EA	25.0%	1	$ 698,000	
Wind Engineering	LS	$ 75,000	1	$ 75,000	
Engineering/Design/Constr Support	EA	15.0%	1	$ 524,000	
Pathway Lighting/Electrical	LS	$ 187,500	1	$ 187,500	*luminaires + 1 side linear lighting*
East Pathways Improvements	LS	$ 85,000	1	$ 85,000	*allowance, TBD*
West Pathway Improvements	LS	$ 65,000	1	$ 65,000	*allowance, TBD*
			Subtotal G: Allowances =	**$ 1,634,500**	
			Total Cost: Subtotals F+G (nominal) =	**$ 4,424,000**	*excluding taxes*

NOTES:

1) The expected variation for the Class C Cost Estimate is -25% below and +35% above the nominal estimated cost above.

2) Values rounded to nearest $100.

3) See cover page for list of exclusions.

	Optional Add-On Items	Unit	$/Unit	Quantity	Item Cost	
i	High Quality Railing Premium	m	$ 650	234	$ 152,100	*increase in cost over base case*
ii	Bridge Lighting	LS	$ 137,500	1	$ 137,500	*2nd side linear bridge lighting*
iii	Aesthetic Lighting of Bridge Features	LS	$ 75,000	1	$ 75,000	*allowance, TBD*
iv	Public Artwork	LS	$ 200,000	1	$ 200,000	*allowance, TBD*
v	Additional Cost for 5m Wide Bridge	LS	$ 843,000	1	$ 843,000	*increase in cost over base case*
vi	Additional Cost for 6m Wide Bridge	LS	$ 1,685,000	1	$ 1,685,000	*increase in cost over base case*