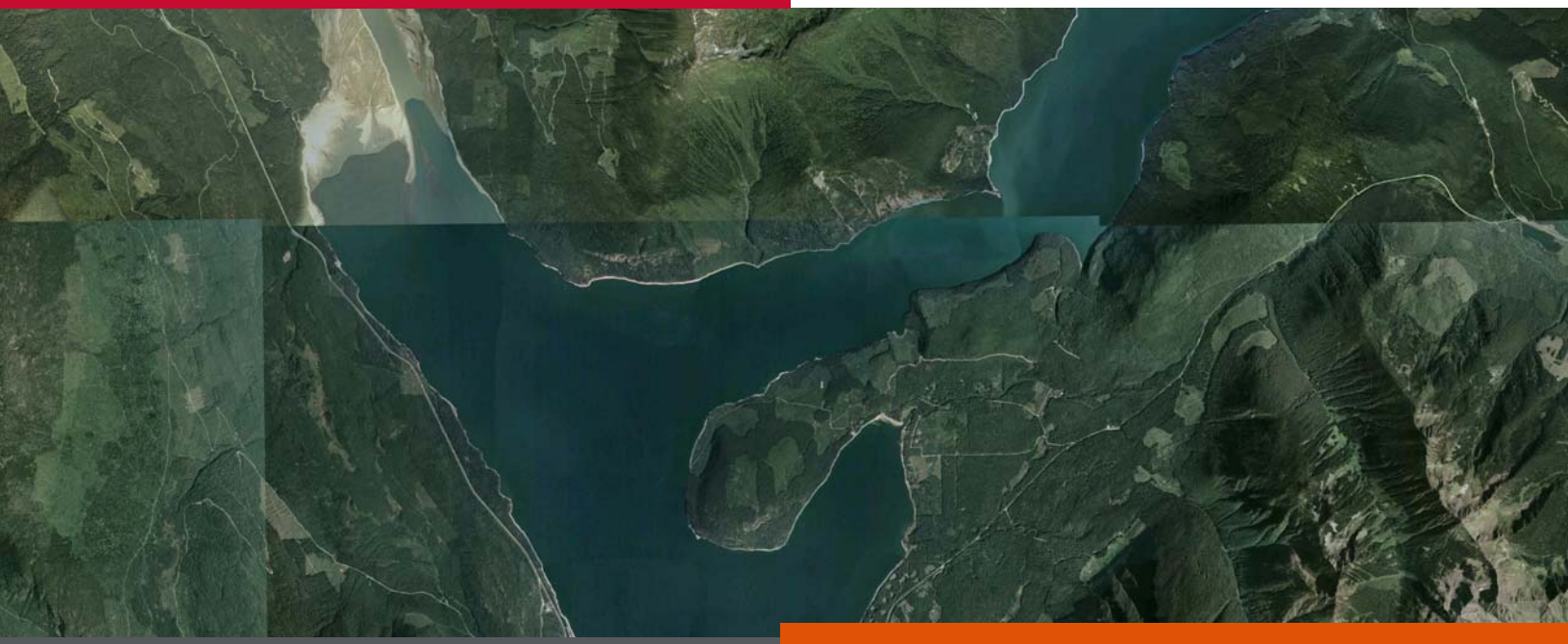
REPORT PREPARED FOR THE MINISTRY OF TRANSPORTATION & INFRASTRUCTURE

Upper Arrow Lake Fixed Crossing



Highway 23, Upper Arrow Lake Crossing:

Cost Estimate Review and Update

July 2014

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1.0 INTRODUCTION

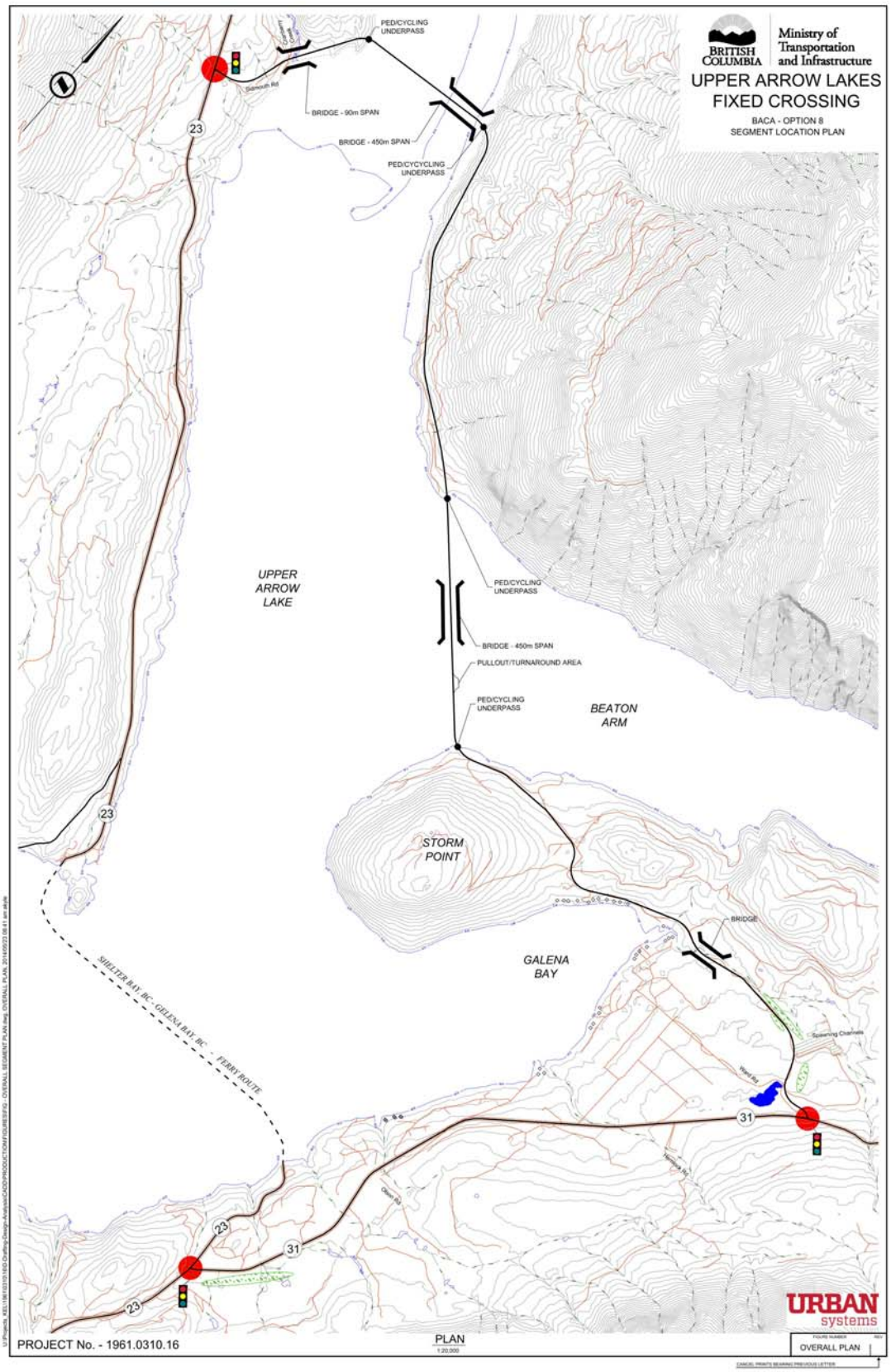
Arrow Lake is located within BC's southern interior and stretches for approximately 230 km from Castlegar to south of Revelstoke. Fed by the Columbia River and restricted by the Hugh Keenleyside Dam, Upper Arrow Lake has formed a nature obstacle for Highway 23 that connects Revelstoke in the north with Nakusp in the south. Highway 23 crossing Upper Arrow Lake at the Beaton Arm crossing, approximately 50 km south of Revelstoke, between Shelter and Galena Bay. The highway is fully dependant on the ferry service, as no alternative route exists in the vicinity.

Highway 23 currently services an Annual Average Daily Traffic (AADT) of just under 650 vehicles per day, of which roughly 28% are heavy vehicles. Daily traffic volumes vary from one month to the next and demonstrate significant seasonal fluctuations, with the daily traffic volumes varying by approximately 800 vehicles. Peak average daily volumes occur during the months of July and August, where an AADT of approximately 1,200 vehicles per day are currently observed. As the highway is directly dependent on the ferry crossing, the daily volumes are limited by the capacity and frequency of the service. As of late June 2014, a new vessel is in operation on the Upper Arrow Lake crossing between Galena and Shelter Bay. The M.V. Columbia can accommodate up to 80 vehicles and 250 passengers; it replaces to smaller 40 year old vessels.

In 2004, ND Lea Consultants Ltd. and Buckland and Taylor Ltd. compiled preliminary evaluations of the engineering feasibility for a fixed crossing to replace the existing Arrow Lake ferries, connecting Highway 23 between Shelter and Galena Bay. The engineering assessment identified and evaluated three potential crossing options, investigating the feasibility and cost of each option. The assessment recommended the most feasible option would be a causeway/ bridge combined structure crossing from Highway 23, north of Shelter Bay, connecting to Storm Point on the eastern side of the lake. This option takes advantage of the relatively shallow water depth, enabling shorter bridge spans to be achieved, than compared to other alternative locations within the area. Although this option was evaluated as the most feasible, the report highlighted a number of uncertainties that were either not included within the fee estimate or required further investigation; including geotechnical conditions, environmental concerns, reservoir hydraulics, and First Nation consultation.

Following this preliminary options evaluation, the Beaton Arm Crossing Association (BACA) compiled a business case for a potential fixed crossing using a multiple account evaluation. The evaluation assessed a total of eight options at various locations within the vicinity of the Beaton Arm area of Upper Arrow Lake. The existing ferry service was incorporated within the assessment as one of the options under evaluation, in order to compare the current operations against potential fixed link options. Scoring of the options was based on a qualitative approach, evaluating criteria by a ranking system. Similar to the ND Lea report the assessment concluded a Beaton Arm fixed causeway/bridge combination crossing north from Storm Point, then re-crossing at Sidmouth back to the existing Highway 23 to the west to be the most viable, due to the shallow water depth. Within the report this option was referred to as Option 8. This preferred Option 8 is illustrated in the project study area in **Figure 1**, below.

Figure 1 - Project Study Area



According to the BACA studies, the Nakusp region has experienced stagnate growth in recent years, with many surrounding communities experiencing population loss. Population projections for the area are expected to be less than 1% per annum over the next 25 years.

Due to the restricted nature of the existing ferry service operating along Highway 23, a fixed crossing is sought, in order to improve the connectivity of the highway and access to communities located on the eastern side of the lake. A fixed crossing is expected to improve the reliability and efficiency of operations along Highway 23 and is expected to generate greater economic growth in the surrounding communities, particularly for the Nakusp region. The existing limitations of a ferry crossing have been identified as a possible contributing factor to the ongoing economic challenges in the area.

2.0 PROJECT SCOPE AND OBJECTIVES

Based on the previous studies completed for a potential fixed crossing at Upper Arrow Lake, Urban Systems Ltd. (USL) has been engaged by the BC Ministry of Transportation and Infrastructure (BC MoTI) to undertake a review and update of the cost estimates for the preferred Option 8 Alignment; fixed causeway/ bridge combination crossing option. The review and update is focused on the potential costs of this preferred option and compiling a logical cost estimate for the various components required for such a project. It should be noted that the review does not include any investigation of alternative alignments or an evaluation of the merits of the proposed option. The assessment has only focused on the Option 8 Alignment as the preferred route across Arrow Lake within the area. USL engaged ***E. Wolski Consulting Inc.*** to undertake the primary cost estimating tasks, in close collaboration with USL and BC MoTI staff.

As outlined in the BACA Business Case report; Option 8 has been selected as the most viable option for a fixed crossing in the vicinity of the Beaton Arm of Upper Arrow Lake. The option includes two bridges and causeway combinations; the first connecting the existing Highway 23 from Revelstoke to Sidmouth and the second spanning the Beaton Arm from Arrowhead to Storm Point, connecting to Highway 31 and ultimately tying back into Highway 23. This proposed alignment is illustrated in detailed within **Appendix A**.

Although, Option 8 was not identified in the 2004 ND Lea Report, some components are similar to that of the bridge/causeway option connecting Highway 23 to Storm Point that was evaluated within the 2004 report. The causeway/bridge combination option completed by ND Lea and Buckland and Taylor investigated the project costs of this option through the use of the Elemental Parametric Estimating Method (or Wolski Method). Given the similar components involved in this preferred Option 8 alignment, this update has adopted the methodology from this previous study, through the use of this Wolski Methodology.

In order to update the cost estimate for the proposed alignment an initial review has been undertaken to establish the specific criteria and components adopted within the cost estimate using the given methodology. Given the quantity of materials required for such a project, an initial review of unit rates and availability of material has also been investigated to ensure accurate assumptions can be made for various components of the project.

In addition, consideration has been given to various other elements of the project that may have potential to significantly affect the project costs, these include;

- Geotechnical issues;
- Environmental concerns;
- Property acquisition and conflicts;
- First Nation issues;

3.0 METHODOLOGY

The cost estimate of the Option 8 alignment has been completed through the use of the Elemental Parametric Estimating Method. The method calculates the construction costs using a quantity take off system applied to a typical cross-section for the unique segments along the given alignment. The assessment is completed by sub-dividing the alignment into a number of common components and tabulating each component individual. The method then applies factors to the construction costs to develop soft cost items such as engineering, project/program management and contingencies. Standard MoT unit rates and factors are applied to the quantities to then generate estimates based on 2014 dollars.

In total the Option 8 alignment has been sub-divided into seventeen separate segments, with each segment detailing a unique component of the project. Within each segment a typical cross-section has been created that represents the average roadway for that given segment. Combined with the length of the given segment, specific quantities can be calculated independently for each component. **Figure 2** illustrates the breakdown of the Option 8 alignment and the various extents of each segment within the project.

In order to assemble common typical cross-sections for each segment that can be combined to create a consistent road alignment a number of global assumptions have been established. These assumptions have been developed to create a common design criterion for the whole project. The following design elements have been included within the design criteria for the project;

- Highway Design Elements:
    a. Design Speed – 90 km/h
    b. Lane width – 3.6 m
    c. Shoulders Width – 2.5 m (clear width assuming no Concrete Roadside Barrier; if CRB is required then add 0.6 meter width)
    d. Shoulder Rounding – 0.5 m
    e. Clear Zone – 9.0 m

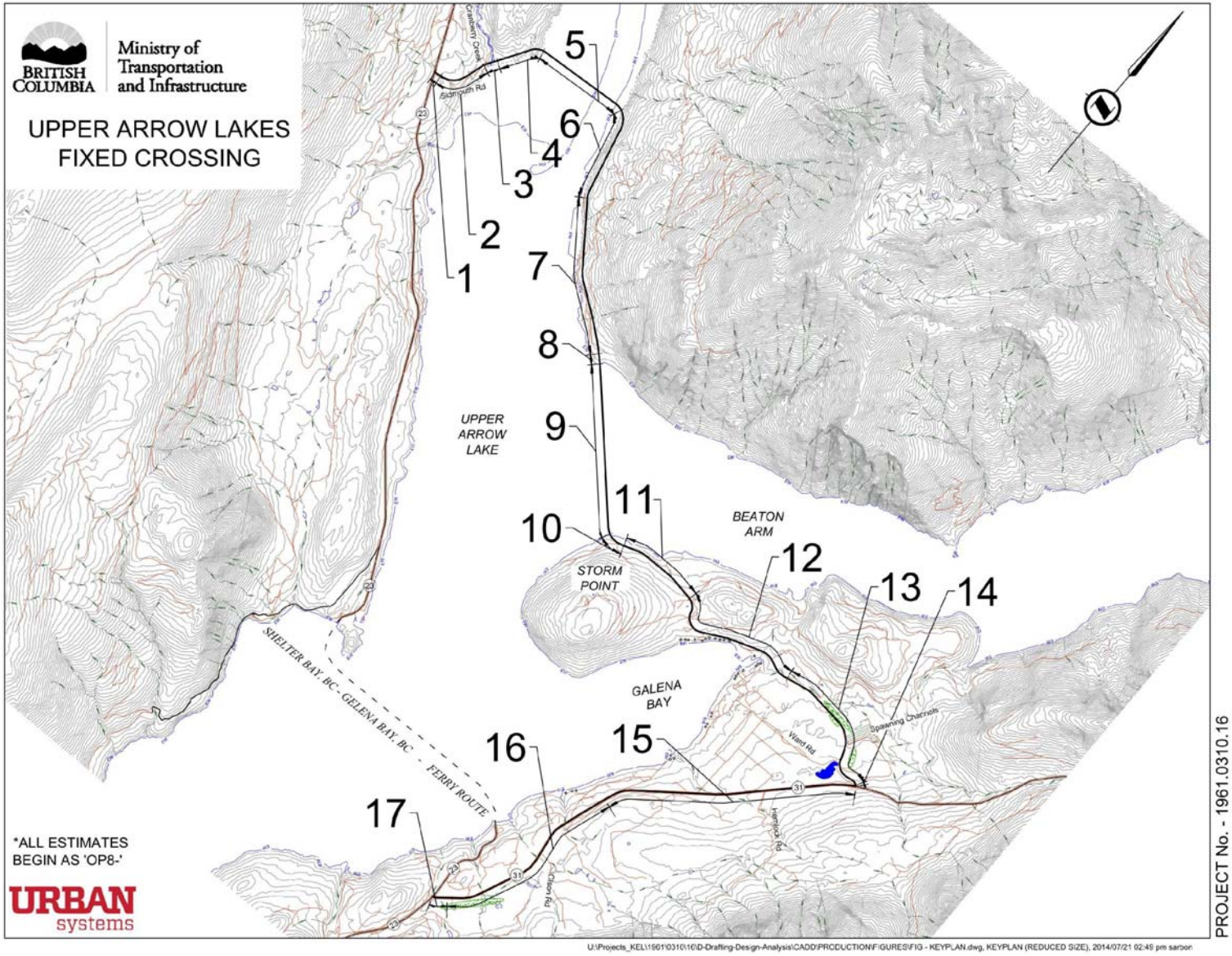
- Causeway and Bridge Structure:
    a. Design Speed – 90 km/h
    b. Lane width – 3.6 m
    c. Shoulders Width – 1.5 m plus barriers
    d. Pedestrian pathway - 3.0 m one side only
    e. Assumption base of Causeway - 2 meter Settlement

- Pavement Structure
    a. Asphalt – 100 mm. Crushed base course – 300 mm gravel
    b. S.G.S.B – 300 mm gravel

It has been proposed that pedestrian and cyclist can utilise the proposed shoulders of the roadway while travel along the new approach segments of the roadway. While a single 3.0 metre multi-use pathway is proposed along the causeway and bridge structure. Pedestrian underpasses have also been proposed at beginning and ending of each causeway segment to enable pedestrian and cyclists to access the single multi-use pathway without having to cross the highway.

In addition, in order to maintain the navigable waters on Upper Arrow Lake, both bridge structures are required to achieve minimum clearances for marine vessels to safely navigate under the future crossing. The navigable water clearance used in the estimates are 18**m** high above the high water level (HWL) and 44 m wide.

Figure 2 - Project Key Plan



4.0 SEGMENT DESCRIPTION

In order to assess each segment within the alignment independently summary project sheets have been compiled that summarize the typical cross-sections and notable construction items for each of the seventeen segment within the projects. These project sheets are provided within **Appendix B**.

4.1 Segment One – St. 100+00 – 101+25

Upgrades to the intersection at Highway 23 and Sidmouth Road, located approximately 15 kilometres north of Shelter Bay Ferry Terminal. The upgrades incorporate signalising the intersection with the inclusion of turning lanes and traffic islands

Length of Segment: 125m
Segment Total Cost: $1.08M
Refer to figure 1.1 in **Appendix B**

4.2 Segment Two – St. 101+25 – 109+75

New highway construction of Sidmouth Road from the east leg of the Highway 23 intersection to the approach of the Cranberry Creek bridge crossing. Construction includes extensive timber removal, clearing and grubbing with significant excavation for new highway grade construction.

Length of Segment: 850m
Segment Total Cost: $15.69M
Refer to figure 1.2 in **Appendix B**

4.3 Segment Three – St. 109+75 – 112+25

The crossing of Cranberry Creek requires an approx. 90 meter Bridge (3 spans of 30 meters). Significant earthwork is required for the bridge approach construction.

Length of Segment: 250m
Segment Total Cost: $10.99M
Refer to figure 1.3 in **Appendix B**

4.4 Segment Four – St. 112+25 – 120+70

The new highway construction extends from the Cranberry Creek east approach to the tidal flats of Arrow Lake. This section requires extensive earthworks, with the majority in the form of Type ‘A’ rock excavation and the balance as Type ‘D’ soil excavation.

Length of Segment: 845m
Segment Total Cost: $8.99M
Refer to figure 1.4 in **Appendix B**

4.5 Segment Five – St. 120+70 - 137+90

Spanning from the west to the east tidal flat of Arrow Lake, this segment includes significant causeway embankments comprised of coarse angular material on either side of a 450 meter span bridge. Included in the bridge construction are approaches comprised of lightweight fill and precast wall panels with a profile that achieves minimum clearances for marine vessels to safely navigate.

Length of Segment: 1,720m
Segment Total Cost: $80.26M
Refer to figure 1.5 in **Appendix B**

4.6 Segment Six – St. 137+90 – 154+80

New highway construction from the east side approach crossing Arrow Lake heading south along Arrowhead Point. Construction includes extensive timber removal, clearing and grubbing with significant Type 'A' rock, Type 'D' soil excavation and retaining walls along a steep hillside paralleling the lake.

Length of Segment: 1,690m
Segment Total Cost: $23.20M
Refer to figure 1.6 in **Appendix B**

4.7 Segment Seven – St. 154+80 – 182+50

New highway construction along the east side of Arrow Lake heading south along Arrowhead Point. Construction includes extensive timber removal, clearing and grubbing with significant Type 'A' rock, Type 'D' soil excavation and retaining walls along a steep hillside paralleling the lake.

Length of Segment: 2,770m
Segment Total Cost: $37.22M
Refer to figure 1.7 in **Appendix B**

4.8 Segment Eight – St. 182+50 – 184+30

This short segment is comprised of timber removal, clearing and grubbing, excavation and embankment construction along with a pedestrian underpass, assumed to be a multi-plate arch culvert with headwalls.

Length of Segment: 180m
Segment Total Cost: $1.49M
Refer to figure 1.8 in **Appendix B**

4.9 Segment Nine – St. 184+30 – 214+20

The crossing of Beaton Arm includes the construction of causeways approaching the north and south side of a 450 meter long bridge. In order to maintain the navigable waters on Upper Arrow Lake, similar to the Sidmouth crossing bridge structure, the profile of this bridge and approaches are required to achieve minimum clearances for marine vessels to safely navigate. The 120 meter approach embankment made

of lightweight fill will progressively increase in height and will be retained by precast MSE walls. Also included in the causeway construction is a widened emergency turnaround/ pullout area for vehicle refuge.

Length of Segment: 2,990m
Segment Total Cost: $199.48M
Refer to figure 1.9 in **Appendix B**

4.10 Segment Ten – St. 214+20 – 217+50

This short segment is comprised of timber removal, clearing and grubbing, Type 'D', Type 'A' excavation and embankment construction along with a pedestrian underpass, assumed to be a multi-plate arch culvert with headwalls.

Length of Segment: 330m
Segment Total Cost: $6.31M
Refer to figure 1.10 in **Appendix B**

4.11 Segment Eleven – St. 217+50 – 232+50

New highway construction along an existing forest service road at Storm Point consists of timber removal, extensive clearing and grubbing, along with Type 'D' excavation and embankment.

Length of Segment: 1,500m
Segment Total Cost: $7.22M
Refer to figure 1.11 in **Appendix B**

4.12 Segment Twelve – St. 232+50 – 257+50

This segment of new highway construction takes place along the existing Hill Creek Road corridor. Timber removal, clearing and grubbing is required along the existing right of way. Impact to private property is likely with many freehold recreation properties in the vicinity. Two creek crossings require a large diameter or multi-plate culvert and a 35m long bridge.

Length of Segment: 2,500m
Segment Total Cost: $18.53M
Refer to figure 1.12 in **Appendix B**

4.13 Segment Thirteen – St. 257+50 – 282+10

Continuing along existing Hill Creek Road, new highway construction follows the existing gravel road corridor. Utility pole relocations, timber removal, clearing and grubbing is required along the segment. A combination of Type 'A' rock and Type 'D' soil excavation is required. The proximity of an adjacent creek and environmental sensitive area will complicate construction with potential for retaining walls and environment mitigation measures.

Length of Segment: 2,460m
Segment Total Cost: $21.66M
Refer to figure 1.13 in **Appendix B**

4.14 Segment Fourteen – St. 282+10 – 283+35

Upgrades to the intersection at Highway 31 and Hill Creek Road, located approximately 8 kilometres northeast of Galena Bay Ferry Terminal. The upgrades incorporate signalising the intersection with the inclusion of turning lanes and traffic islands.

Length of Segment: 125m
Segment Total Cost: $1.08M
Refer to figure 1.14 in **Appendix B**

4.15 Segment Fifteen – St. 300+00 – 344+50

Symmetrical widening of Highway 31 to construct paved shoulders and ditching along with wildlife fencing will require utility pole relocation and Type 'D' soil excavation. Drainage improvements for the most part concentrate on replacing or upgrading existing culverts and installing one large diameter or multi-plate arch culvert.

Length of Segment: 4,450m
Segment Total Cost: $15.76M
Refer to figure 1.15 in **Appendix B**

4.16 Segment Sixteen – St. 344+50 – 378+50

Symmetrical widening of Highway 31 to construct paved shoulders and ditching along with wildlife fencing will require utility pole relocation and Type 'D' soil excavation. Drainage improvements for the most part concentrate on replacing or upgrading existing culverts and installing two large diameter or multi-plate arch culverts. The proximity of an adjacent environmental sensitive wetland area will complicate construction with potential for retaining walls and environment mitigation measures.

Length of Segment: 3,400m
Segment Total Cost: $11.97M
Refer to figure 1.16 in **Appendix B**

4.17 Segment Seventeen – St. 378+50 – 381+63

Upgrades to the intersection at Highway 31 and Highway 23, located approximately 2 kilometres south of Galena Bay Ferry Terminal. The upgrades incorporate signalising the intersection with the inclusion of turning lanes and traffic islands.

Length of Segment: 313m
Segment Total Cost: $1.74M
Refer to figure 1.17 in **Appendix B**

5.0 COST ESTIMATE SUMMARY

Using the Elemental Parametric Estimating Method the cost estimate for the Option 8 crossing option alignment has been completed. The cost estimate has incorporated the design, management and construction cost of the potential project, including contingencies and management reserves. These project and construction costs have been presented in present (2014) dollars and have been summarized per segment in **Table 1**.

Table 1: Option 8: Elementary Parametric Cost Estimate per Segment

Segment	Station Length	Description	TOTAL (Millions) (2014 Dollars)	TOTAL Cost per meter
1	St. 100+00- St. 101+25	Intersection	$ 1.080	$ 8,644
2	St. 101+25- St. 109+75	Highway construction	$ 15.688	$ 18,456
3	St. 109+75- St. 112+25	Bridge construction	$ 10.990	$ 43,960
4	St. 112+25- St. 120+70	Highway construction	$ 8.990	$ 10,641
5	St. 120+70- St. 137+90	Bridge construction	$ 80.256	$ 46,660
6	St. 137+90 - St. 154+80	Highway construction	$ 23.199	$ 13,727
7	St. 154+80 - St. 182+50	Highway construction	$ 37.221	$ 13,437
8	St. 182+50- St. 184+30	Highway construction	$ 1.491	$ 8,283
9	St. 184+30- St. 214+20	Bridge construction	$ 199.479	$ 66,715
10	St. 214+20- St. 217+50	Highway construction	$ 6.309	$ 19,119
11	St. 217+50- St. 232+50	Highway construction	$ 7.221	$ 4,813
12	St. 232+50- St. 257+50	Highway construction	$ 18.527	$ 7,411
13	St. 257+50- St. 282+10	Highway construction	$ 21.658	$ 8,804
14	St. 282+10 - St. 283+35	Intersection	$ 1.080	$ 8,644
15	St.300+00- St. 344+50	Existing highway widening	$ 15.761	$ 3,542
16	St.344+50- St. 378+50	Existing highway widening	$ 11.965	$ 3,519
17	St. 378+50 - St. 381+63	Intersection	$ 1.743	$ 5,570
Total	**St.100+00 – St.381+63**		**$ 462.658**	**$ 17,460**

The total project cost of alignment Option 8 has been estimated at **$462,658,000**. The cost estimate per segment demonstrates that the bridge structural segments account for the majority of the total cost of the project. In addition the average cost per linear meter throughout the alignment has been estimated at **$17,460** for the 26.5 km alignment.

In order to evaluate the various engineering and construction costs of the proposed crossing a breakdown of the core elements is presented in **Table 2**.

Table 2: Option 8: Elementary Parametric Cost Estimate per Project Item

Item #	Description of Work	TOTAL (2014 Dollars)	TOTAL Cost per meter
2000	PROJECT MANAGEMENT	$ 21,280,496	$ 803.00
3000	PRELIMINARY DESIGN	$ 6,874,961	$ 259.00
3500	DETAILED DESIGN	$ 22,012,048	$ 831.00
	Total Engineering	$ 28,887,009	$ 1,090.00
4000	LAND ACQUISITION	$ 9,194,250	$ 347.00
5000	GRADE CONSTRUCTION	$ 168,095,281	$ 6,344.00
5300	OTHER CONSTRUCTION	$ 10,878,000	$ 411.00
5500	STRUCTURAL CONSTRUCTION	$ 107,635,753	$ 4,062.00
6000	PAVING CONSTRUCTION	$ 11,211,294	$ 423.00
6500	OPERATIONAL CONSTRUCTION	$ 3,955,089	$ 149.00
6700	UTILITY CONSTRUCTION	$ 6,254,400	$ 236.00
6800	RESIDENT ENGINEERING	$ 15,761,691	$ 595.00
	Total Construction	$ 323,791,508	$ 12,219.00
9700	CONTINGENCY	$ 57,472,989	$ 2,169.00
	Sub-Total	$ 440,626,252	$ 16,629.00
9800	MANAGEMENT RESERVE	$ 22,031,313	$ 831.00
	TOTAL COST	**$ 462,657,565**	**$ 17,460.00**

The breakdown of project items demonstrates that the highest construction costs are anticipated to be the earthworks and grading materials; with a total estimated cost of **$168,100,000** for the project. Various breakdowns of this Option 8: Elementary Parametric Cost Estimate have been detailed in **Appendices C - F**. A Key Plan Cost Summary of project items per segment has been compiled in **Appendix C**.

In addition, profile sheets and worksheets, detailing the rationale and assumptions within the cost estimate have been compiled in **Appendix D**.

A detailed breakdown of the costs per segment has also been assembled, as well as the breakdown of the structural cost components for each of the bridges and retaining wall structures within **Appendix E** and **Appendix F**, respectively.

Numerous elements have been compiled within the cost estimate, however some of the primary drivers, including the earthworks and structural components have been assumed with the following unit rates adopted;

Grade Construction:

- Site Prep (Clearing and Grubbing) - $12,000 per hectare;
- Fill Material:
  - Rock Material - $20 per cubic meter;
  - Ordinary Material (O.M.) - $15 per cubic meter;
  - Strip Material - $12 per cubic meter;
- Selected Granular Sub-Base (SGSB) - $40 per cubic meter;
- Crushed Based Course (CBC) - $50 per cubic meter.

Structural & Paving Construction:

- Average Costs of Bridge per square meter of deck area.:
  - Segment #3 - Gross $ 5,340.38 per square meter; Net - $4643.80 /$m^2$
  - Segment #5 - Gross $ 6791.86 per square meter; Net $5,905.96 /$m^2$
  - Segment #9 - Gross $8,017.93 per square meter, Net $6,972.12 /$m^2$
- Machine Paving Asphalt - $125 per tonne;

In addition to the construction costs, soft cost elements including the planning, detailed design, project management and contingencies have also been formulated within the project costs. The detailed design of the project has been estimated between 4.75% and 10% of the construction costs, based on the level of complexity of the various components being evaluated. First Nations consultation and approval costs have not been included within the estimate. Typical estimates for environmental and geotechnical approvals and investigations have been included, however, due to the size and complexity of this project these estimates should be reviewed. A 15% contingency has also been applied to all construction and engineering components within the project.

A digital copy of the complete workings of the estimate is also provided. Detailing the alignment and profiles, for each of the seventeen individual estimates, as well as the bridge calculations and assumptions used in the estimates for this project.