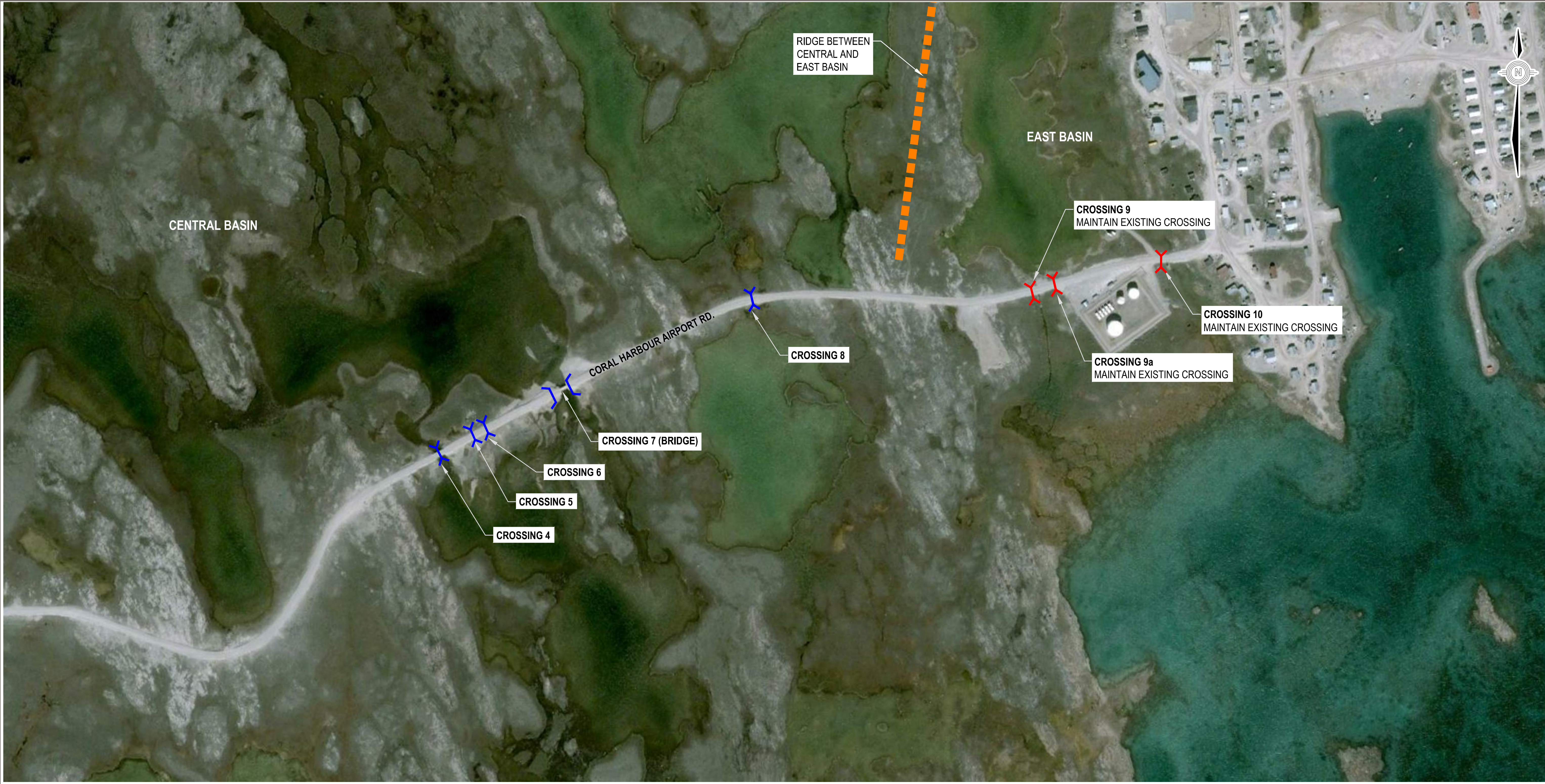


SITE PLAN

ISSUED FOR USE

LEGEND

- BRIDGE CROSSING
- EXISTING CULVERT CROSSING
- MAINTAIN EXISTING CROSSING

SCALE 1:5000

50 0 50 100 200m

NOTES

CLIENT

Nunavut

TETRA TECH EBA

AIRPORT ROAD DRAINAGE REHABILITATION
CORAL HARBOUR, NU

APPROACH 1 - MAINTAIN EXISTING SYSTEM

PROJECT NO.	DWN	CKD	REV
C31103153-01	JDM	DM	0
OFFICE	DATE		
VANC	October 06, 2014		

Figure 3.1

Q:\Vancouver\Transportation\C311\C31103153-01 - Coral Harbour Nunavut\Working\C33103153-01 - Coral Harbour Option Review_Fig 5.1 - 5.4.dwg [FIGURE 3.1] November 04, 2014 - 4:21:17 pm (BY: MANG, JUSTIN)

3.1.2 Approach 2: Augment Capacity of the Existing System

The second Approach is to remove the existing eight culverts at Crossing 4 and construct a new structure at the same location with sufficient hydraulic capacity to increase the overall system capacity to accommodate a 100-year peak flow of 94.2 m^3/s.

The culverts currently installed at Crossings 5 and 6 would be relocated to Crossings 9 and 10 where they would replace the existing smaller crossings. Currently, the invert elevations of the culverts at Crossing 5 and 6 are too high to provide any benefit to the overall performance of the system. The culverts at crossings 9 and 10 are smaller in diameter.

Remediation work to the existing bridge crossing (Crossing 7) would also occur. Specifically, the bridge abutments could be jet-grouted to protect the existing wire mesh forming the gabions. Approach 2 is illustrated in Figure 3-2.

Approach 2 would increase the overall hydraulic capacity of the system, reducing the risk of the road overtopping. The risk of piping failures is also reduced since impounded water levels will be lower. Although washouts occur in the east basin, we are recommending that the new crossing be positioned in the central basin at the site of Crossing 4 as we predict that the reduction of the water level in the central basin will reduce the lateral flow of water from the central to the eastern basin.

3.1.3 Approach 3: Replace Existing System with One Crossing

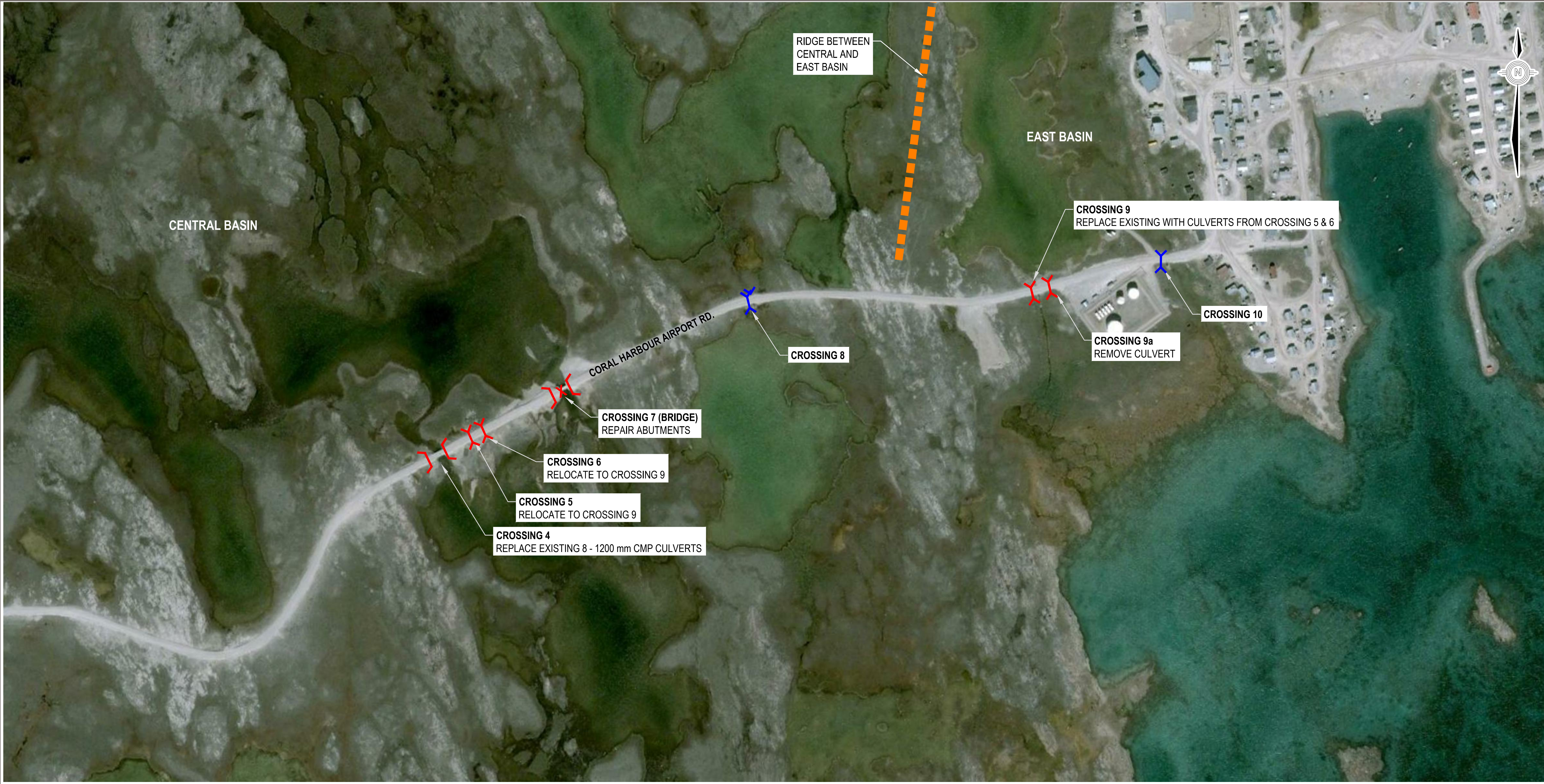
The third Approach involves removing the existing eight culverts at Crossing 4 and the existing bridge at Crossing 7. A new structure would then be constructed at Crossing 7 with sufficient capacity to accommodate the 100-year peak flow of 94.2 m^3/s. As with Approach 2, we predict that the reduction of the water level in the central basin will reduce the flow of water from the central basin to the eastern basin. The culverts currently installed at Crossings 5 and 6 would be relocated to Crossings 9 and 10 where they would replace the existing culverts. Approach 3 is illustrated in Figure 3-3.

Approach 3 will reduce the risk of road overtopping, lower water levels upstream of the road, and reduce the risk of piping failure through the road.

3.1.4 Approach 4: Replace Existing System with Two Crossings

Approach 4 specifies removing the eight culverts at Crossing 4 and the existing bridge at Crossing 7. Two new structures would then be constructed at each crossing to take advantage of the established flow paths of the river. The combined capacity of the two new crossings would be sufficient to accommodate the 100-year peak flow of 94.2 m^3/s. As with Approaches 2 and 3, the location of the proposed new crossings in the central basin serve to attenuate high water levels throughout the basin and prevent water from flowing laterally into the eastern basin. As part of this Approach, the culverts currently installed at Crossings 5 and 6 would be relocated to Crossings 9 and 10 where they will replace the existing culverts. Approach 4 is illustrated in Figure 3-4.

Approach 4 will reduce the risk of road overtopping, lower water levels upstream of the road, and reduce the risk of piping failure through the road.



SITE PLAN

ISSUED FOR USE

LEGEND

AUGMENT THE CAPACITY OF THE EXISTING SYSTEM

EXISTING CULVERT CROSSING

RELOCATE THE EXISTING CULVERT STRUCTURES

UPGRADE ABUTMENTS OF EXISTING CROSSING

SCALE 1:5000

50 0 50 100 200m

NOTES

CLIENT

Nunavut

TETRA TECH EBA

AIRPORT ROAD DRAINAGE REHABILITATION
CORAL HARBOUR, NU

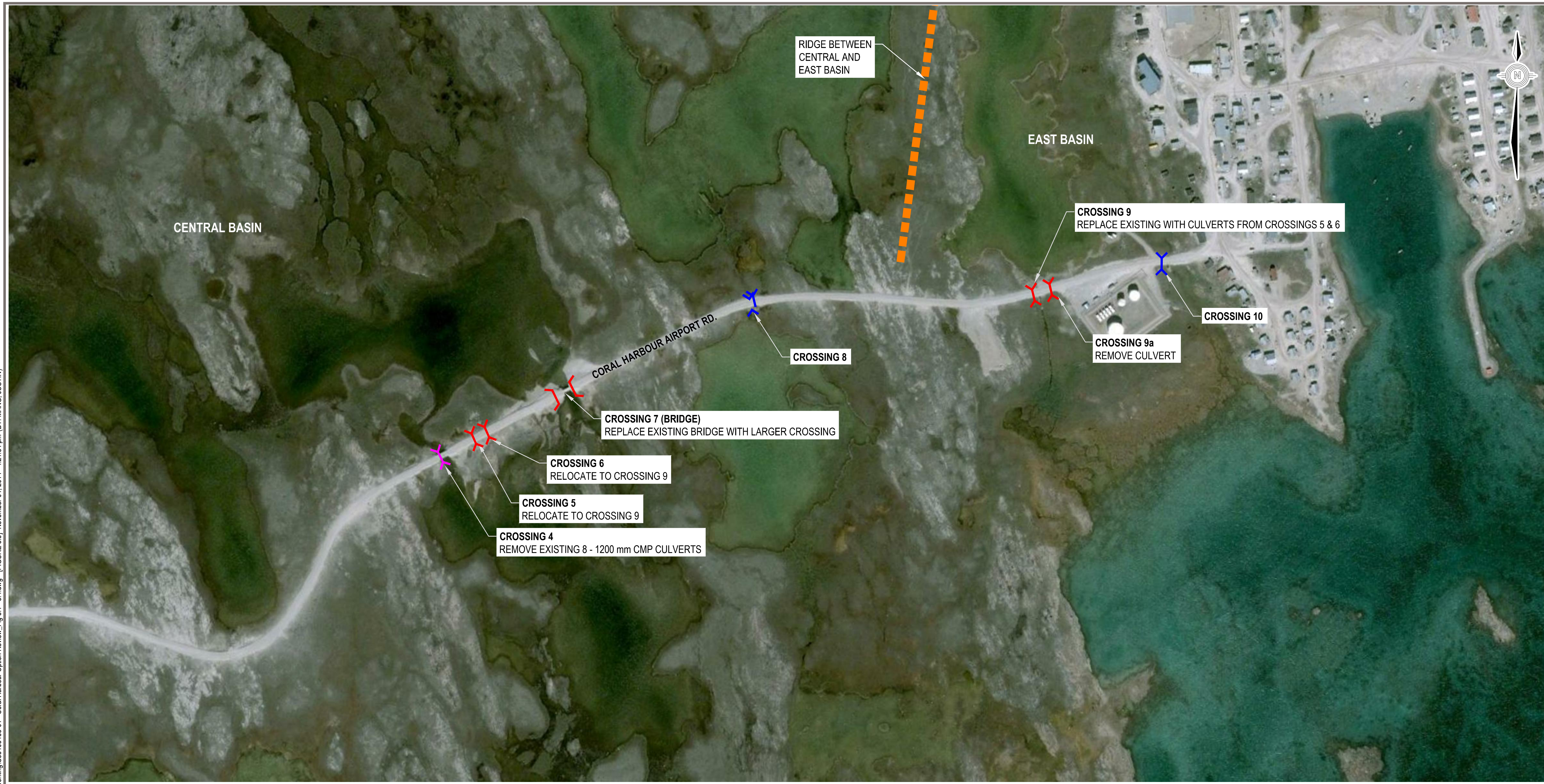
APPROACH 2 - AUGMENT THE CAPACITY OF THE EXISTING SYSTEM

PROJECT NO.	DWN	CKD	REV
C31103153-01	JDM	DM	0

OFFICE	DATE
VANC	October 06, 2014

Figure 3.2

Q:\Vancouver\Transportation\C311\C31103153-01 - Coral Harbour Nunavut\Working\C31103153-01 - Coral Harbour Option Review_Fig 5.1 - 5.4.dwg [FIGURE 3.2] November 04, 2014 - 4:21:35 pm (BY: MANG, JUSTIN)



SITE PLAN

ISSUED FOR USE

LEGEND

REPLACE EXISTING CROSSING WITH LARGER STRUCTURE

EXISTING CULVERT CROSSING

RELOCATE THE EXISTING CULVERT STRUCTURES

REMOVE EXISTING CROSSING

SCALE 1:5000

50 0 50 100 200m

NOTES

CLIENT

Nunavut

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AIRPORT ROAD DRAINAGE REHABILITATION
CORAL HARBOUR, NU

APPROACH 3 - REPLACE EXISTING SYSTEM WITH ONE CROSSING

PROJECT NO.	DWN	CKD	REV
C31103153-01	JDM	DM	0

OFFICE	DATE
VANC	October 06, 2014

Figure 3.3

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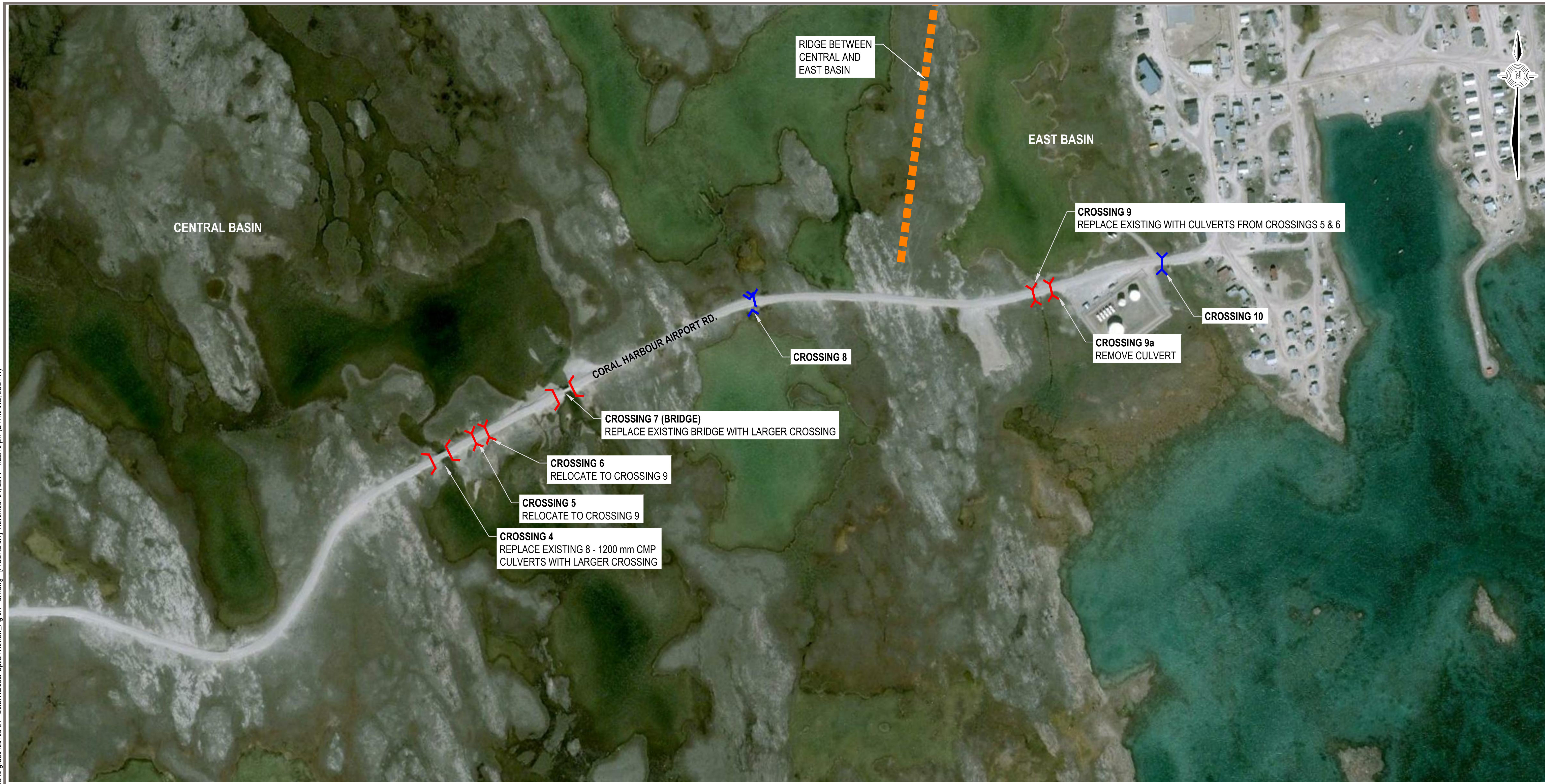


SITE PLAN

ISSUED FOR USE

LEGEND

- REPLACE EXISTING SYSTEM WITH LARGER STRUCTURE
- EXISTING CULVERT CROSSING
- RELOCATE THE EXISTING CULVERT STRUCTURES

SCALE 1:5000

50 0 50 100 200m

NOTES

CLIENT: Nunavut

TETRA TECH EBA

AIRPORT ROAD DRAINAGE REHABILITATION
CORAL HARBOUR, NU

APPROACH 4 - REPLACE EXISTING SYSTEM WITH TWO CROSSINGS

PROJECT NO.	DWN	CKD	REV
C31103153-01	JDM	DM	0

OFFICE	DATE
VANC	October 06, 2014

Figure 3.4

Q:\Vancouver\Transportation\C311\C31103153-01 - Coral Harbour Nunavut\Working\C31103153-01 - Coral Harbour Option Review_Fig 5.1 - 5.4.dwg [FIGURE 3.4] November 04, 2014 - 4:22:13 pm (BY: MANG, JUSTIN)

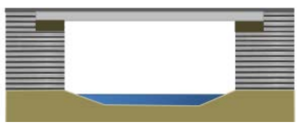
3.2 Description of Alternatives

As Approaches 2, 3, and 4 involve the construction of new hydraulic structures, several types of bridges and culverts were reviewed. An overview of each Alternative is presented in each of the following sections.

3.2.1 Bridge Design Alternatives

These Alternatives include the erection of a bridge complete with various abutment options. For all the Alternatives, a modular superstructure was reviewed. The superstructure modules can be barged to Coral Harbour, assembled and then placed on the substructure. The bridge assembly could be completed prior to the actual instream works. Barge delivery dates may be the governing factor controlling the construction start dates. Various substructure designs were considered in this report and a summary of each type is provided in the sections below.

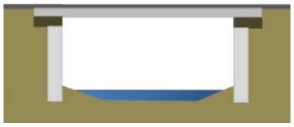
3.2.1.1 Binwall Abutment



Binwall components could be barged to Coral Harbour and assembled onsite. The binwalls would be backfilled with course native material to mitigate against loss of backfill material through piping. A polymer coating is recommended for the binwall to increase its lifespan in marine environments like Coral Harbour. The expected lifespan of this abutment is 50 years, assuming that each component of the binwall is coated with polymer paint. An example is provided for reference in Figure 3-5.

Figure 3-5: Binwall Abutments Example (Baffin Island)

3.2.1.2 Concrete Pile Abutment



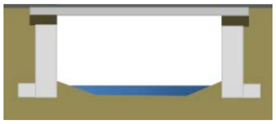
Concrete pile abutments would include anchoring and casting in place multiple concrete piles. Each row of piles would be capped with a horizontal concrete reinforced beam to transfer the load from the superstructure evenly across the piles. This design may be very difficult to construct in Coral Harbour due in part to construction duration and temperature considerations as well as equipment limitations.

The piles would have to be cast in place, forcing the contractor to use formworks and other temporary structures to support the construction activities.

3.2.2 Lock-Block Abutment

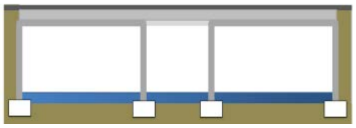
This abutment configuration would consist of the stacked concrete Lock-Blocks, backfilled with the same material used to construct the current road embankment. The Lock-Blocks would be precast and barged to site from either Churchill, MB or Ste-Catherines, QB. Once onsite, the Lock-Blocks would be placed with an excavator, then backfilled with the local gravel. The expected lifespan of this abutment is in excess of 75 years. The simplicity and speed of construction makes this type of abutment very simple to erect.

3.2.2.1 Concrete Cast-in-Place Abutment



Concrete cast-in-place abutments would include anchoring and casting in place concrete bridge abutments with steel rebar. Sills behind the concrete cast-in-place abutments would be used to transfer loading from the bridge deck to the embankment material protected by the abutments. Similarly to the concrete pile alternative, this abutment design could be very difficult to construct in Coral Harbour due in part to construction duration and temperature considerations as well as equipment limitations. The contractor would be forced to use formworks and other temporary structures to support the construction activities.

3.2.2.2 Concrete C-Span Abutment



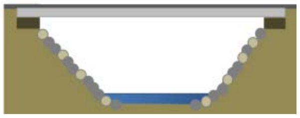
This abutment design would involve pre-cast concrete C-Span sections acting as abutments and as supports to the bridge deck. This Alternative allows for a shorter overall bridge deck length as the abutments themselves provide some hydraulic conveyance capacity. The precast concrete spans would be barged to Coral Harbour and positioned onsite by an excavator. The expected lifespan of this abutment is in excess of 75 years. The weight of each concrete section increases the overall cost of this Alternative. An example is provided for reference in Figure 3-6.

Figure 3-6: Concrete C-Span Section Example

3.2.2.3 Gabion Abutment

Gabion basket abutments could be assembled onsite and filled with local rock material. Expected lifespan of gabions in Coral Harbour is between 20 and 30 years due to the corrosive effects of the marine environment on the thin metal basket strands. The existing bridge along the Airport Road has gabion basket abutments which are showing signs of wear and should be replaced within the next few years. These types of abutments are easy to construct, but lack the durability offered by some of the other Alternatives. An example is shown in Figure 2-5.

3.2.2.4 Sill on Ground - Sloped Embankment



This design involves sloping each roadway embankment face and protecting the slopes with riprap of sufficient size and thickness to prevent the flowing river from eroding the banks. Protecting the embankment would protect the sills on which the proposed bridges are intended to rest. The riprap would be sourced on the island. Sloping the embankment and protecting it with riprap is likely the simplest solution, allowing the local contractor to quickly erect the bridge. The expected lifespan of this abutment is in excess of 75 years.

3.2.3 Culvert Design Alternatives

This Alternative includes the installation of various culvert types as a means of increasing overall system capacity. Four major culvert types were evaluated including: concrete box culverts, multi-plate corrugated steel culverts, bridge-plate corrugated aluminium culverts, and 40’ shipping containers (C-Cans). In all cases, it is assumed that the installation will be completed by anchoring the culverts directly onto bedrock. The multi-plate and bridge-plate culverts will require significant time to assemble. Based on the limited capacity of each culvert, a number of culverts would have to be placed and installed to match the capacity of a single span bridge. Depending on the material used, the lifespan of the culvert crossings could be extended to be 75 years, if covered with a polymer coat.

3.3 Approaches/Alternatives Rating Criteria

Tetra Tech has used the following criteria to evaluate each Approach/Alternative and provide a recommended option: constructability, material and construction cost, construction duration, service life, lifecycle costs, and environmental impacts. Minor consideration was given towards aesthetics, but presented to allow the community of Coral Harbour to provide input into the selection process. A discussion of each criteria is summarized in Sections 3.3.1 through 3.3.7 below.

3.3.1 Constructability

Constructability considers the following aspects:

- Ability to source materials from the island.
- Ease of transportation of the materials.
- Ease of installation.
- Speed and complexity of assembly.
- Dependence on heavy equipment.
- Need to erect temporary formwork.
- Flexibility to meet local site conditions including site topography and local soil/rock conditions.
- Susceptibility to variations in temperature.

Tetra Tech contacted the Hamlet to inquire about equipment availability on the island. The Hamlet owns a grader, a bulldozer, two loaders, and two dump trucks. A local contractor (Sudliq Developments) owns and operates an excavator, a rock truck, a grader, a loader, and a fork-lift. Alternatives which can be constructed with equipment already available in Coral Harbour were given a higher constructability ranking/rating than Alternatives which required additional equipment to be shipped in from Churchill or Ste-Catherines. Approaches/Alternatives requiring complex forming works, or susceptible to variations in temperature, or complex to construct were also downgraded to promote the Approaches/Alternatives which can be quickly erected without the need for complex systems or specialty equipment.

3.3.2 Material and Construction Cost

Material and Construction Costs (including mobilization, demobilization, shipping, materials and construction) were estimated to a Class D level for each Approach and Alternative. Quotes for material costs were obtained from various suppliers and the additional cost of barging materials from either Churchill, M.B. or Ste. Catharines Q.B. were incorporated into the price. Cost of construction was estimated based on rates provided by Sudliq and other similar projects constructed through Canada. Construction costs assume that the equipment available on the island can be contracted to move and place the materials. It is assumed that no extra equipment will need to be barged in.

For all the Alternatives, the cost includes the construction of a temporary road which will bypass the construction zone and allow residents of the Hamlet access to the Airport. Construction costs also include the engineering and the construction management services.

3.3.3 Construction Duration / Risk

Given the nature of the site, and the short construction window, the comparison between different Alternatives based on the length of time needed to complete the construction is critical in addressing risk. Alternatives which can be constructed in a very short time are viewed favourably compared to some of the Alternatives requiring a long construction window. Based on the local hydrology, water levels in the Post River recede by the end of June. This essentially leaves a construction window which is only 12 weeks long. Construction past this deadline could impact the quality of the finished product by interfering with the compaction of material and ease of construction. The construction window could also be limited by DFO further limiting the instream works to a window of six weeks only.

3.3.4 Service Life

Service Life is the expected operational life, after which time replacement or rehabilitation is necessary. Given the arctic marine environment, appropriate consideration of the material being used is important to extend the life of the structure and reduce maintenance costs. Although estimating an exact service life is challenging given the variability of the site conditions, estimates have been developed based on the familiarity with the project site and information provided by the material suppliers. All bridge Alternatives evaluated were evaluated based on two service lives: one which reflects the expected lifespan of the bridge superstructure and one which reflects the substructure lifespan.

3.3.5 Life Cycle Costs

Life cycle costs include the costs associated with installation and long term replacement and decommissioning. The Net Present Value (NPV) of each Alternative was calculated based on the initial construction cost and expected rehabilitation/replacement costs calculated based on each Alternative's service life. The NPV is a useful value for comparison as it takes into account the long-term costs of each Alternative, benefitting Alternatives with high initial costs, but minimal rehabilitation required. Maintenance costs were not included in the analysis. The life cycle cost analysis was based on a duration of 75 years, the period of time selected for evaluating lifecycle costs across all Approaches/Alternatives.

3.3.6 Environmental Impacts

The various Alternatives considered have different impacts on the environment both during and post construction. During construction, preference is given to Alternatives which have the least impact (duration and effected area) on the existing water system and local habitat. Once construction is complete, some Alternatives will continue to have a long term impact on the habitat as well. Closed-bottomed structures will not allow for a natural substrate at the crossing location, locally impacting aquatic life. Open-bottomed structures allow for the preservation or reinstatement of the natural substrate and habitat.

In general, the construction of a clear span bridge is the preferred option to avoid or minimize adverse effects on fish and aquatic habitat. Culverts installed in streams known to possess fish must be designed to permit unimpeded fish passage, which requires that they be adequately sized based on site-specific hydrological and hydraulic conditions. In addition, culverts must be installed according to best management practices to facilitate fish passage and to avoid bank and stream bottom erosion and culvert shifting and perching, which are of particular concern in northern climates. Since valued fish species, including Arctic Char, Lake Trout, and Whitefish potentially inhabit streams and lakes in the project area, these issues should be considered in the selection of a suitable Alternative for this project.

Instream works in Nunavut, including the construction of bridges and the installation of culverts, require review and the issuance of Class B Licences by the Nunavut Water Board. This process involves the completion of an application form and submission of relevant supporting information. Depending on the nature of the project, Fisheries and Oceans Canada (DFO) is normally consulted during project assessment and review. However, the simultaneous submission of a Request for Review directly to DFO may be advisable to expedite the review process, if it determined that the project may result in the potential for serious harm to fish, which is prohibited under the *Fisheries Act* except where duly authorized. It should also be noted that the presence of valued fish species in the project area may restrict the timing of any instream works to July 1 to August 14.

3.3.7 Aesthetics

Although aesthetics are secondary to structural engineering design, aspects such as symmetry and professional finishing can promote confidence in the structure. Alternatives which may be adapted to match local design norms and blend with the site location may be preferable; however, at this stage of the assignment, we would recommend to let the local residents make the choice, allowing the community to take ownership over the proposed structure/s.

3.4 Review of Alternatives

Tables 3.1 and 3.2 present a comparison chart with all the structural Alternatives for each Approach and an assessment of their suitability based on the above selection criteria. Alternatives which were considered unfavourable for one or more design criteria were gradually removed from the evaluation process.

Through the evaluation process, culverts were found to be the least favourable solution for this particular project. This is largely due to number of culvert barrels which are needed to match the capacity of a single bridge. In the case of concrete box culverts, the amount of culverts required results in high shipping costs associated with the weight of the culvert sections. In the case of multi-plate or bridge-plate culverts, the number of arches required to match the bridge capacity add up to a number of structures each of which will have to be assembled and placed on multiple footings extending significantly the construction duration. Finally, C-Cans, though inexpensive to install, were found to have a short service life and typically used for temporary explorations roads. From an environmental standpoint, all the culverts Alternatives fall short of matching the benefits an open span bridge offers, as culverts lack the ability to offer the wide natural channel characteristics which could be maintained through the construction of a bridge.

Of the bridge Alternatives reviewed, any alternatives involving the use of cast-in-place concrete structures are discouraged. These designs are not typical across northern Canada and the amount of time required to prepare the formwork and rebar and cast and cure the concrete would impact the quality of the work and possibly be impacted by the 12-week construction window. Temperature is another factor the successful contractor will have to battle against. In general, the use of construction techniques the local contracting community is unfamiliar with will likely add unpredictability to the construction activities and likely drive prices higher as the contractor tries to recover some of the unpredicted costs.

The use of pre-cast concrete C-Span structures as abutments is an alternative which would result in the shortest bridge deck of all the reviewed alternatives, as each abutment provides some hydraulic capacity; however, we do not recommend pursuing this alternative as the cost of shipping the materials and erecting the structure is higher than some of the other Alternatives Tetra Tech is recommending for consideration.

The use of gabion baskets abutments is an alternative which has a longer construction duration than other abutment options such as Binwalls or Lock-Block; as such, the construction cost for this alternative is higher. Lifecycle costs of this alternative are significantly higher than the other alternatives as we expect major remediation work will be required to the abutments every 25 or 30 years. The existing bridge at Crossing 7 has gabion abutments which have started to fail. We estimate that the bridge was installed in the late 1980's which is in agreement with our estimated lifespan of gabion baskets. Due to the high lifecycle costs, we do not recommend pursuing this Alternative.

The remaining three Alternatives: Binwall abutments, Lock-Block abutments, and riprap armoured slope embankments are all favourable design Alternatives. Material and construction costs across these three options are all very similar and we expect all three designs to be reasonably straight-forward to construct in an area as remote as Coral Harbour.

3.4.1 Alternative 1 - Binwall Abutments

Binwall abutments are easy to transport to site, assemble, install, and backfill. Only minor bedrock preparation would be required prior to installation. As most contractors are familiar with Binwall construction, we do not expect any major difficulties to be encountered during construction.

Corrosion is a concern with Binwall abutments, especially in the marine environment. As extensive corrosion has been observed on the eight culverts at Crossing #4, we estimate that the standard galvanised Binwall abutment continually exposed to water would have an expected lifespan of only 20 years. However, different measures to extend the service life of the structure do exist including installing the Binwalls at a higher elevation, above the 2 or 3 year return event. This will reduce the amount of oxidation taking place and will increase lifespan. Riprap would need to be installed at the toe of each binwall to protect each abutment during periods of lower flow. Another option which may be considered to extend the lifespan is the use of a protective polymer coating applied on the binwalls. During installation attention will have to be placed on not damaging the protective coating with either the equipment or the backfill. Employing these simple techniques should extend the lifespan of the Binwalls to more than 50 years.

3.4.2 Alternative 2 - Lock-Block Abutments

Lock-Block abutments are less common and more expensive than Binwall abutments, but due to the ease of construction and the long lifespan, the use of this Alternative should be considered. As Lock-Blocks can be stacked in a near vertical manner, this option would allow for slightly shorter bridge decks relative to the binwall alternative.

Similar to the Binwall abutments, only minor bedrock preparation will be required prior to installation of the Lock-Blocks and the bottom row of blocks could be dowelled into the bedrock for additional resistance against slippage. The stackable nature of Lock-Blocks makes them easy to construct. Each Lock-Block weighs approximately 2 tonnes and can be transported and placed into position with a wide range of construction machinery including a backhoe excavator. Unlike Binwall abutments, concrete Lock-Blocks are resilient in all climates and applications, as such we would expect a lifespan to be in excess of 75 years for this abutment type.

We have estimated that the shipping cost of each block will cost between two to three times the cost of the block itself. As such, if this alternative was to be selected, the viability of shipping Lock-Block forms and cement to Coral Harbour rather than blocks could be investigated. This could reduce the overall project cost, but the quality of the concrete attainable onsite would play a large role on determining whether this is a viable option or not. Ability to secure all the required blocks on time for installation would also be an unknown which could be eliminated by importing all the blocks.

3.4.3 Alternative 3 - Riprap Protected Sloped Embankments

The least expensive of the three Alternatives being proposed for the Coral Harbour project is the use of riprap to protect the roadway embankment supporting the bridge structure from the erosive forces of the Post River. In addition to being the least expensive alternative suggested, this alternative is also the easiest to construct and has a short expected construction duration.

A concern with this Alternative is that a longer bridge span is required. The embankments are expected to be sloped at approximately 2:1 which would mean bridge decks for this alternative would need to be approximately 4 m longer than for the same crossing with Lock-Block abutments. Longer bridges require heavy equipment for installation which may need to be barged into Coral Harbour at a large cost.

A second concern with this option would be the procurement of adequate riprap. To avoid barging in rock, it would need to be sourced within Southampton Island and transported to the site using the local trucks. We expect some blasting will be necessary both upstream and downstream of the roadway to formalize the wider channels.

Table 3.1: Bridges Alternatives

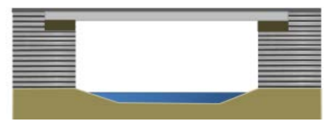
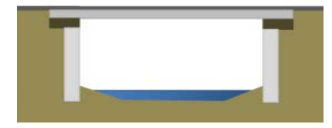
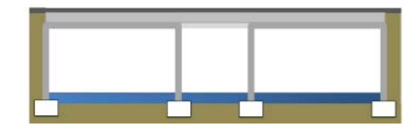
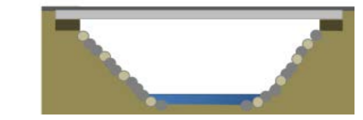
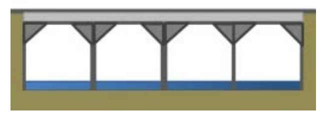
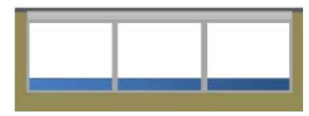
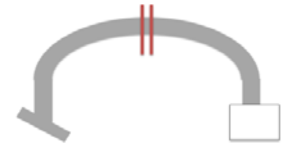
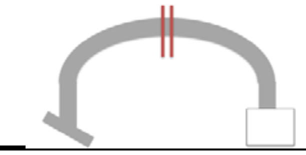
	Bridge Abutments						
	BinWalls	Concrete Piles	Lock Block	Concrete Cast In Place	Concrete C-Spans	Gabion	Sill on Ground - Sloped Embankment
Criteria							
Constructability	Easy to construct. Bridge deck can be assembled prior to the instream work. Binwalls could be filled with uniformly graded and screened native material. A large excavator will be required for the installation. Local contractors are familiar with this construction technique.	Very difficult to construct. Concrete will need to be mixed and cured onsite. Construction of the piles can not commence until the end of the freshet. Bridge deck can be assembled prior to the instream work. A large excavator and a concrete mixer will be required for installation.	Easy to construct. Bridge deck can be assembled prior to the instream work. Precast Lock-Blocks can be placed by an excavator and backfilled with native material. A large excavator is required for installation. Assembly of the abutments is very quick.	Time consuming and difficult to construct. Large amount of concrete will need to be mixed and poured onsite. Construction window will be tight for formwork and rebar placement. Bridge deck can be assembled prior to the construction of the abutments. A large excavator and a concrete mixer will be required.	Not simple to construct. Bridge deck can be assembled prior to the placement of the C-Spans forming the crossing abutments. Some preparation of the bedrock prior to the placement of C-Span structures will be necessary to develop a plane surface on which to place the bridge deck. A large excavator is required for construction.	Somewhat challenging to construct. Bridge deck can be assembled prior to the construction of the abutments. Gabion baskets can be filled with native material. A large excavator is required for installation.	Very simple to construct. Bridge deck can be assembled prior to the grading of the channel side slopes. Abutments can be sloped and covered with native riprap. A large excavator is required to install the bridge deck.
Construction Cost	Approach 2: $1,725,000		Approach 2: $1,688,000		Approach 2: $2,035,000	Approach 2: $1,870,000	Approach 2: $1,546,000
	Approach 3: $1,988,000		Approach 3: $1,952,000		Approach 3: $2,256,000	Approach 3: $2,134,000	Approach 3: $1,810,000
	Approach 4: $2,373,000		Approach 4: $2,287,000		Approach 4: $2,637,000	Approach 4: $2,431,000	Approach 4: $2,138,000
Construction Duration	Approach 2: 6 Weeks		Approach 2: 6 Weeks			Approach 2: 8 Weeks	Approach 2: 5 Weeks
	Approach 3: 7 Weeks		Approach 3: 7 Weeks			Approach 3: 9 Weeks	Approach 3: 6 Weeks
	Approach 4: 8 Weeks		Approach 4: 8 Weeks			Approach 4: 10 Weeks	Approach 4: 7 Weeks
Service Life	Bridge Deck: 75 Years Abutments: 50 Years		Bridge Deck: 75 Years Abutments: 75 Years			Bridge Deck: 75 Years Abutments: 25 Years	Bridge Deck: 75 Years Abutments: Over 75 Years
Life Cycle Cost Analysis	Approach 2: $2,775,000		Approach 2: $2,639,000			Approach 2: $3,221,000	Approach 2: $2,498,000
	Approach 3: $2,188,000		Approach 3: $2,052,000			Approach 3: $2,634,000	Approach 3: $1,910,000
	Approach 4: $2,773,000		Approach 4: $2,487,000			Approach 4: $3,431,000	Approach 4: $2,338,000
Environmental Impacts	Negligible during and post construction. Construction within the open channel to take place following the freshet. Design will result in an unobstructed open channel with natural substrate.		Negligible during and post construction. Construction within the open channel to take place following the freshet. Design will result in an unobstructed open channel with natural substrate.				Negligible during and post construction. Construction within the open channel to take place following the freshet. Design will result in an unobstructed open channel with natural substrate.
Aesthetics	To be discussed with the Coral Harbour community.		To be discussed with the Coral Harbour community.				To be discussed with the Coral Harbour community.

Table 3.2: Culverts Alternatives

	Box Culvert		Arch Culvert	
	C Cans	Prefab Box Concrete	Multi-Plate CSP	Aluminium Bridge-Plate
Criteria				
Constructability	Simple to assemble. Preparation of the bedrock prior to the placement of C-Can structures may be necessary to ensure the uniform placement and minimize the presence of gaps. A smaller excavator will be required for construction.	Simple to construct. Preparation of the bedrock prior to the placement of box culvert structures will be necessary to ensure the horizontal placement of the concrete box sections and minimize gaps between each section. A medium size excavator will be required for installation of the box sections.	Very simple to erect and install. Culverts will required significant assembly time. Preparation of the bedrock prior to culvert installation is required. Culvert may be backfilled with the site gravel used to construct the road embankment. A small excavator is all that is needed to erect and install the culverts.	Very simple to erect and install. Culverts will required significant assembly time. Preparation of the bedrock prior to culvert installation is required. Culvert may be backfilled with the site gravel used to construct the road embankment. A small excavator is all that is needed to erect and install the culverts.
Construction Cost	Approach 2: $1,136,000	Approach 2: $2,865,000	Approach 2: $2,077,000	Approach 2: $2,066,000
	Approach 3: $1,417,000	Approach 3: $3,592,000	Approach 3: $2,370,000	Approach 3: $2,397,000
	Approach 4: $1,417,000	Approach 4: $3,592,000	Approach 4: $2,370,000	Approach 4: $2,397,000
Construction Duration	Approach 2: 4 Weeks		Approach 2: 12 Weeks	Approach 2: 10 Weeks
	Approach 3: 6 Weeks		Approach 3: 14 Weeks	Approach 3: 12 Weeks
	Approach 4: 6 Weeks		Approach 4: 14 Weeks	Approach 4 12 Weeks
Service Life	20 Years			75 Years
Life Cycle Cost Analysis				Approach 2: $3,018,000
				Approach 3: $2,497,000
				Approach 4: $2,597,000
Environmental Impacts				Construction will have to take place within the watercourse, disrupting fish passage and increasing suspended solids. Final crossing will be open bottom enclosed culverts with minor effects on fish passage.
Aesthetics				

4.0 RECOMMENDATIONS

All the Approaches/Alternatives presented in this Feasibility Review will address the reoccurring washouts along Airport Road. Selection of the best solution should thus be based on the environmental impacts, the construction cost, and the lifecycle costs analysis. Table 4.1 below presents each of the four Approaches and the expected cost of construction and long-term costs over a 75-year service life. Approaches 2, 3, and 4, are based on the single span bridge Alternative assuming the use of Binwall abutments.

Table 4.1: Expected Construction and Lifecycle Costs

Approach	2016 Construction Cost	75-year Lifecycle Cost - Net Present Value
Approach 1 – Maintain Existing System	$0	$2,813,000
Approach 2 – Augment Capacity of the Existing System	$1,725,000	$2,775,000
Approach 3 – Replace Existing System with One Bridge	$1,988,000	$2,188,000
Approach 4 – Replace Existing System with Two Bridges	$2,373,000	$2,773,000

Approach 1 requires the least amount of money immediately, but has the highest lifecycle cost, not including the cost associated with the potential damages to the fuel line feeding the Hamlet. Pursuing this Approach would limit access to the Airport for a period of approximately two weeks, each time a washout occurs. Given the possible impacts it might have on the community of Coral Harbour and given the need to maintain access to the Airport for medical evacuations, we are recommending that this Approach not be considered.

Approaches 2, 3, and 4 all involve completing major upgrades along Airport Road. Each of these will increase the overall hydraulic capacity to a level sufficient to pass the 100-year return period flow of 94.2 m^3/s. Although Approach 3 has the lowest overall lifecycle cost, we would not recommend pursuing this Approach as a single span bridge with a deck length in excess of 40 m may be challenging for the local contractor to erect. In addition, it forces CGS to allocate sufficient budget during the first year of construction to cover the entire cost associated with the construction of one large bridge. Approaches 2 and 4 allows CGS to complete the project over a longer period offering greater flexibility in terms of funding.

Both approaches, 2 or 4, will satisfy the needs of the GNU and the residents of Coral Harbour. Approach 2 is the most cost effective in the immediate future as it involves the replacement of only one of the existing crossings and relies upon the existing bridge to continue to provide the required hydraulic capacity needed to meet the 100-year return flow. Approach 4, though expensive upfront, will result in two crossings which are expected to last for the next 75 years.

Tetra Tech is recommending that either Approach 2 or Approach 4 be considered and that the final selection between the two should ultimately be based on the amount of funding the Government of Nunavut is able to secure towards construction in 2016.

Specific to the selection of the preferred Alternative, Tetra Tech recognised the fact that the use of Lock-Blocks or slopped embankments for abutments may be a more cost effective solution. Unfortunately, based on initial discussions with contractors familiar with the challenges of working in the Arctic, the use of Binwalls appears to be more common. During the design phase, further discussions with the local contractors should be initiated to explore the more durable Alternatives Tetra Tech has presented.