Bow River Bridge near Gleichen, AB, after the flood

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Sign-off Sheet

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Abstract

This report entitled "*Bow River Bridge Near Gleichen, AB, After the Flood*" submitted by Stantec describes the weather pattern leading up to the flood, the damage to the bridge near Gleichen, AB caused by the flood, and what is being done to repair the bridge. The concrete abutment on the north end of the bridge was compromised during the flood in June 2013. The abutment was undermined and is now tilting and leaning along with approximately 60 m of road washed out at the north end. The initial scope was to rebuild the abutment and 60 m of road. In the preliminary stages of design the City of Medicine Hat donated an Acrow bridge to Alberta Transportation which will be used as an added span on the north end. The Acrow bridge is 42 m (140 ft) long leaving approximately 20 m of roadway construction remaining.

The existing bridge structure was built in 1907 and is a 3-53.3. m through truss structure. The bridge is a single lane bridge with a 5.1 m clear roadway. The new pier consists of 2-1219 mm drilled concrete filled steel pipe piles supporting w-beam pile caps. The abutment proposed is as per AT's standard drawings for a steel substructure.

The roadway was designed to an Alberta Transportation RAU-208 standard cross section for a 30 km/hr design speed in the vicinity of the bridge. The highway transitions from an 8.3 m width to the 4.2 m clear roadway of the Acrow bridge limiting the design options to the site conditions in the 20 m stretch of road.

Construction started in April 2014 and work was expected to be completed by August 2014.

BOW RIVER BRIDGE NEAR GLEICHEN, AB, AFTER THE FLOOD

September 15, 2014

1.0 Introduction

Between the days of June 19th and 22nd, 2013 Southern Alberta experienced one of the largest rainfall events in recent history. This event, combined with significant antecedent soil moisture as a result of an above average snowfall year, resulted in major flooding of many streams and rivers arising out of the Eastern Foothills. Many bridge and culvert crossings were threatened and some roadways were closed. One of the worse hit sites was provincially owned bridge (BF1293) crossing the Bow River south of Gleichen, AB on Highway 547. Extent of damage included erosion of approximately 60 m of the north roadway embankment, and local scour causing the north abutment to drop and truss superstructure to twist. This report will provide a brief background of the bridge site and flood event, and discuss design and construction of repairs needed at this site.

2.0 Site Background

BF1293 is located on Highway 547:04, within the Siksika First Nation and south of the Town of Gleichen, Alberta (approximately 1 hour East of Calgary). This three span bridge was constructed in 1908 with a length of 159.9m, a clear roadway width of 5.1m, a deck height of 8.5m, and detour route of over 70 km. The through trusses are on concrete abutment and pier spread footings in the active channel. The general layout is shown in Figure 1.

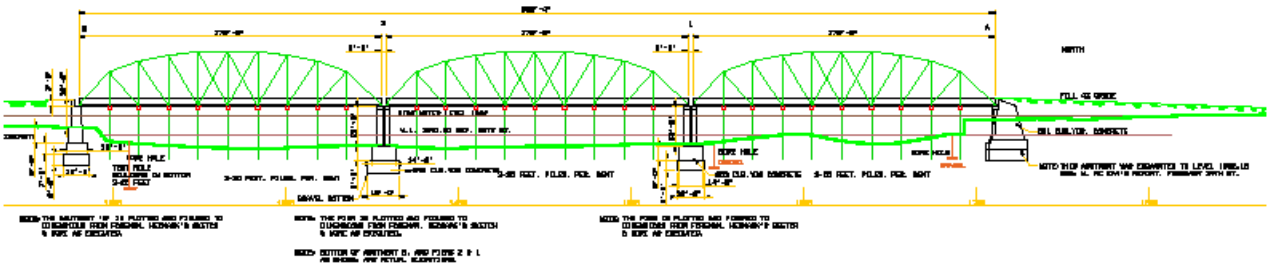


Figure 1: BF 01293 General Layout (Alberta Transportation)

This site had a known history of scour concerns, with scour inspections noted on file in 1908, 1915, 1967, 1974, 1988, 1990, 1996, 1999, and 2005. Remediation work in the form of rock riprap placement around the pier was completed in 1909. Bank erosion was also a known concern with inspections noted in 1932, 1974, 1999, and 2005. Figure 2 below shows a typical scour report completed in 2005 showing streambed elevations in the vicinity of the bridge. Figure 3 shows a post flood aerial photograph, overlaid with historical banklines to show how much the river has moved laterally over the years.

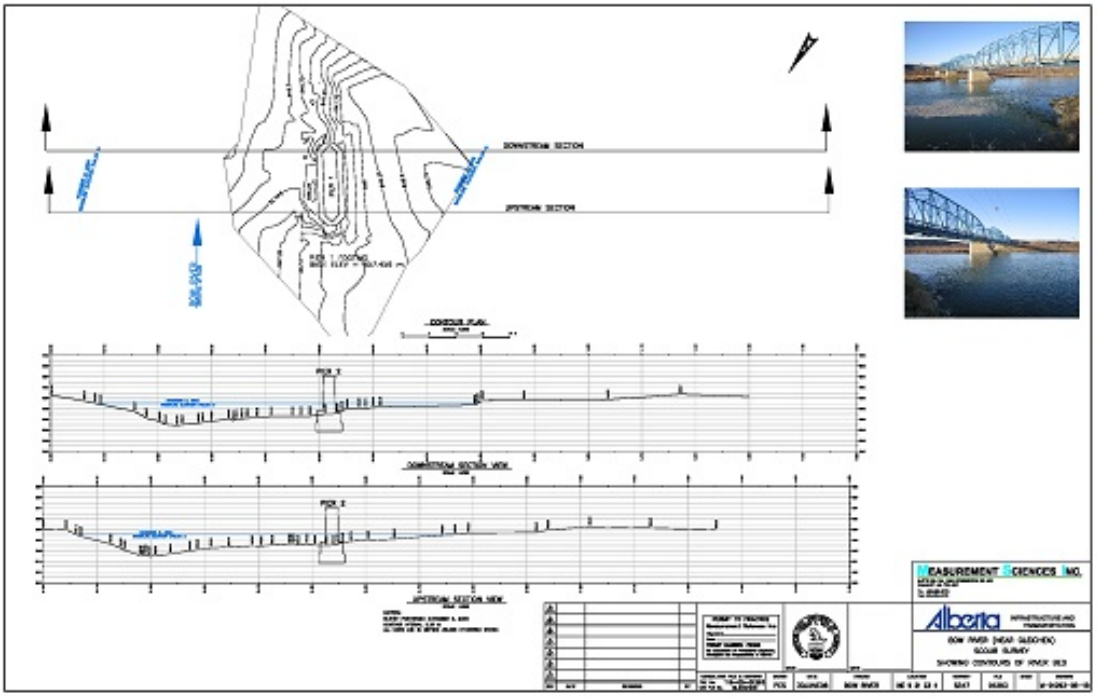


Figure 2: 2005 Scour Report (Alberta Transportation)

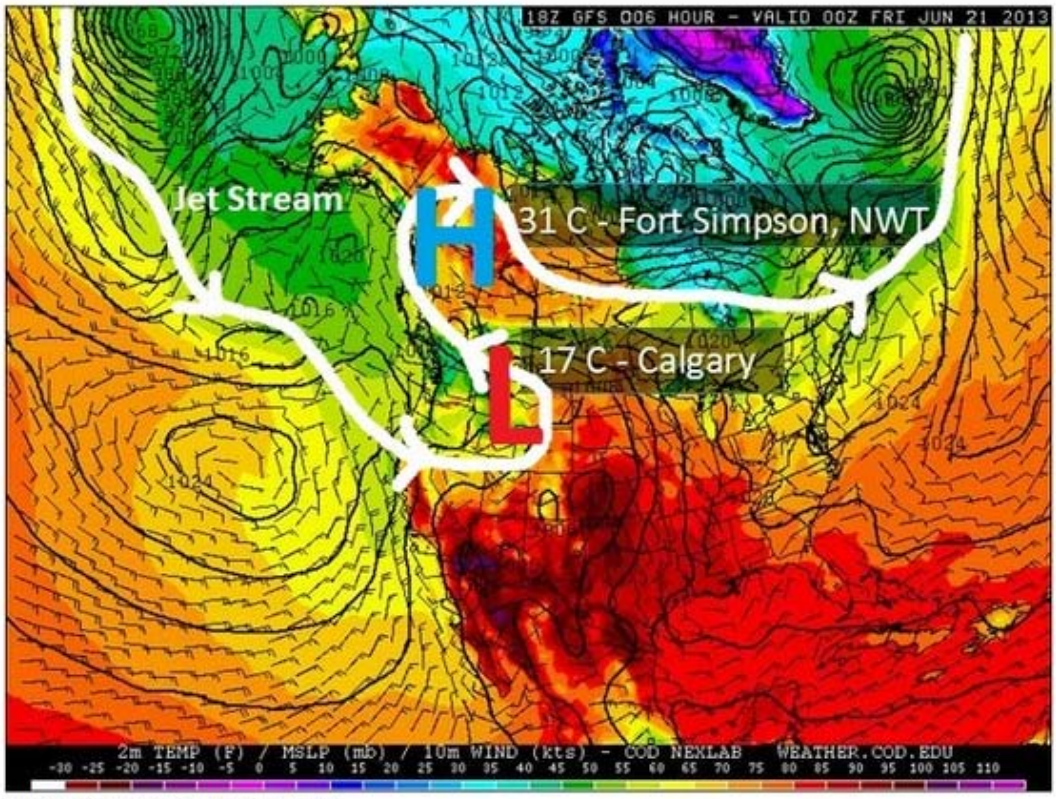
Figure 3: Historical Banktracking on the 2013 Aerial Photograph (Green - 1907, Blue – 2009)

In 2012, a planning study was commissioned by Alberta Transportation to look at potential bridge replacement options, with construction anticipated in the five to ten year horizon. This study is still ongoing and is expected to be updated in lieu of the 2013 flood. At the completion of preliminary engineering, detailed structure design will be undertaken, with construction scheduled in the future based on structural adequacy and provincial budgeting.

3.0 Flood Event Background

3.1 THE WEATHER PATTERN

The heavy rains in the Calgary area were the result of an upside weather pattern with warmer temperatures observed in the north (Fort Simpson, NT +31°C) than the south (Calgary, AB +17°C). The upside weather pattern is created when the jet stream that moves from east to west in this part of Canada becomes stuck or blocked. Figure 4 shows the jet stream in the western North American leading up to the flood on June 19th.

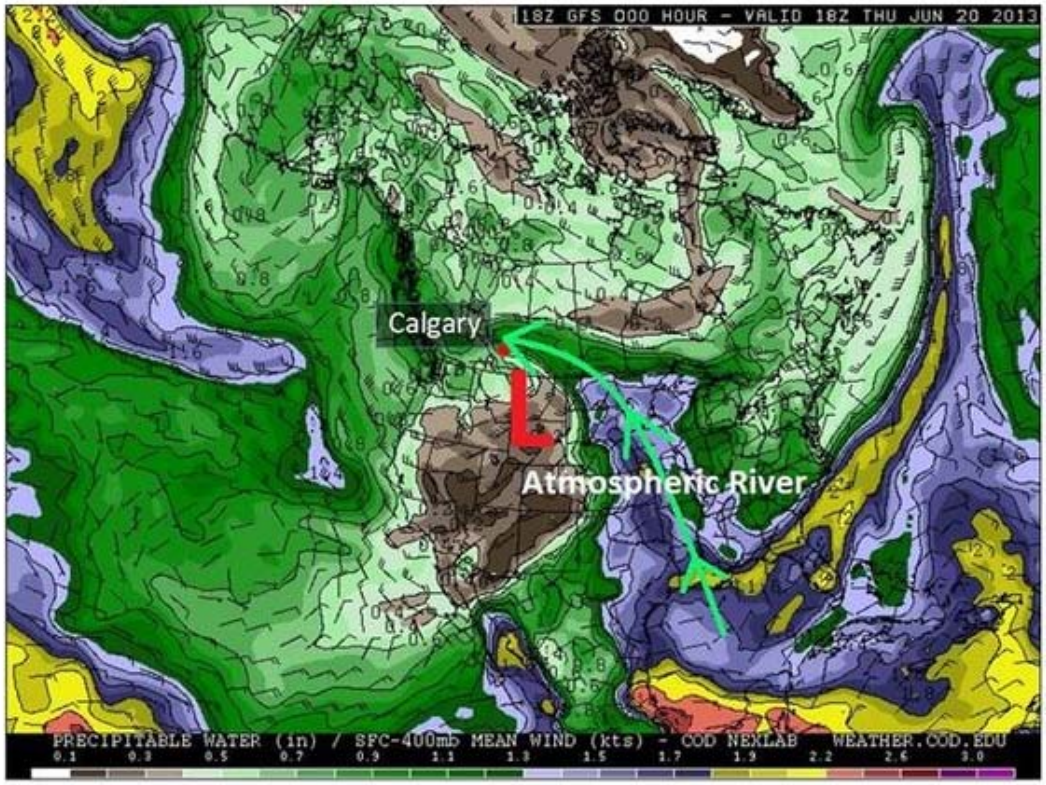


Courtesy: College of DuPage Weather Lab

Figure 4: Jet Stream Pattern

Counter clockwise winds form around the low pressure system funneling very moist air from the Gulf of Mexico to Alberta. This air is then pushed up against the foothills and Rocky Mountains, rising, cooling,

condensing, and releasing vast amounts of precipitation. Based on meteorological data this weather pattern occurred quite frequently prior to 1932 when Calgary experienced its last major storm. For some reason this storm had been absent for about 80 years, till June 2013. Figure 5 shows the wind patterns on June 20th.



Courtesy: College of DuPage Weather Lab

Figure 5: Wind Patterns

3.2 THE STORM

The event was one of the largest rainfalls events experienced in recent Alberta history and tested the capacity of many bridge and culvert structures. Rainfall storm duration and intensity, and resulting flows were examined in comparison to historically documented events dating back to around 1900. This review revealed that the 2013 flood event was a large event on many of the impacted rivers, generating an estimated flow of 1,740 m3/s and stage rise of over 4 meters on the Bow River, but did not generate the highest flows in documented history at this site.

Figure 6 shows the stage rise recorded at the Water Survey of Canada gauge at Calgary while Figure 7 shows a comparison of the estimated 2013 river stage and flow levels to historical levels on the Bow River. The 2013 values are based on highwater (stage rise) observations made during TRANS flood inspections and by other agencies with flow values back calculated from these values. Although it is the first major

flood in Calgary in over 80 years, it is about the 3rd or 4th highest known event since 1879 (these historic events are noted in AESRD floodplain studies for Calgary).

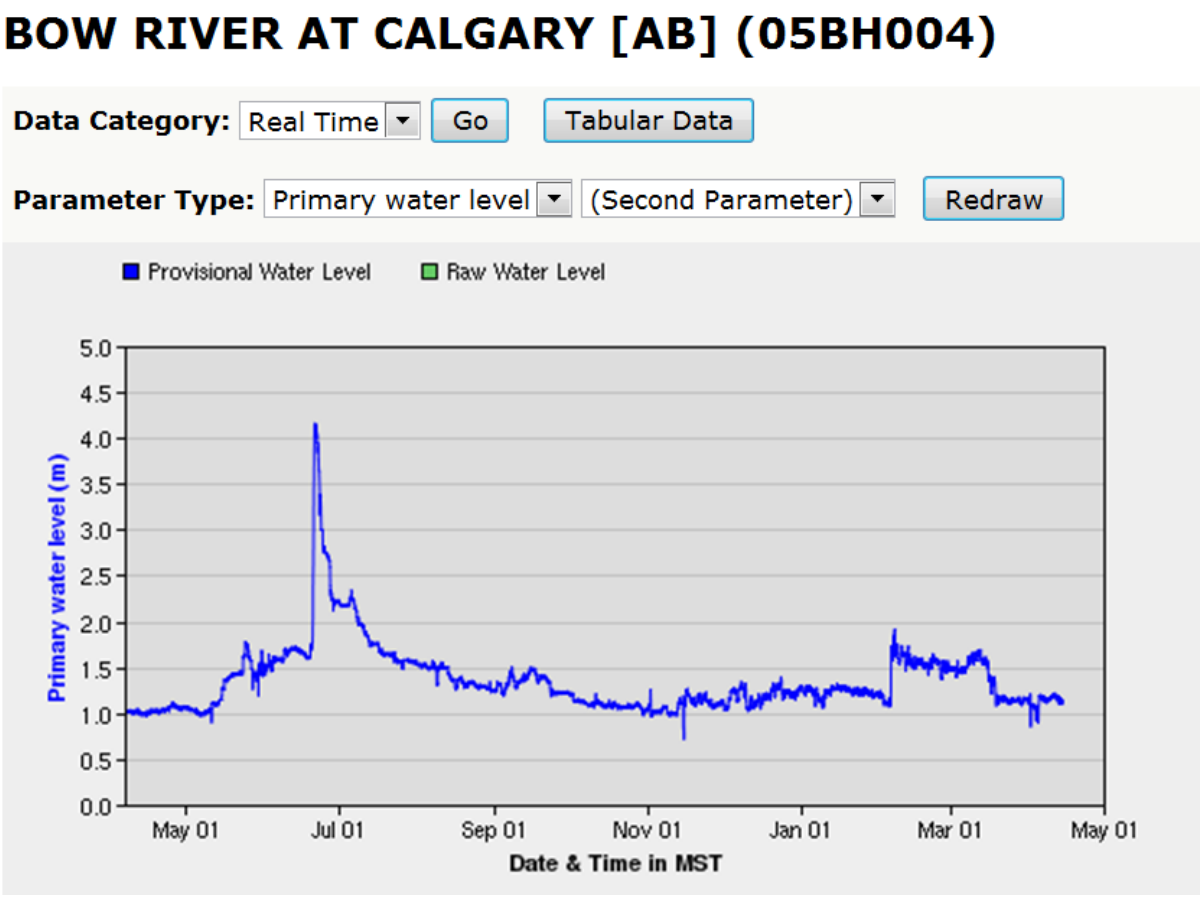


Figure 6: Water Survey of Canada Gauge Data

Year	Flow (m^3/s)	Stage (m)
1879	2265	4.5
1897	2265	4.5
2013	1740	4.1
1902	1550	4.0
1932	1500	4.0

Figure 7: Historical Flow Records at the Bow River in Calgary

During the timeframe from June 19-22, 2013, the maximum recorded precipitation, as reported by AESRD (http://www.environment.alberta.ca/forecasting/reports/index.html), was in excess of 325mm. As shown below in Figure 8, the storm occurred in the southwest corner of the Province, southwest of the City of Calgary. Major areas impacted were in the areas of Canmore, High River, and Calgary.

BOW RIVER BRIDGE NEAR GLEICHEN, AB, AFTER THE FLOOD

September 15, 2014

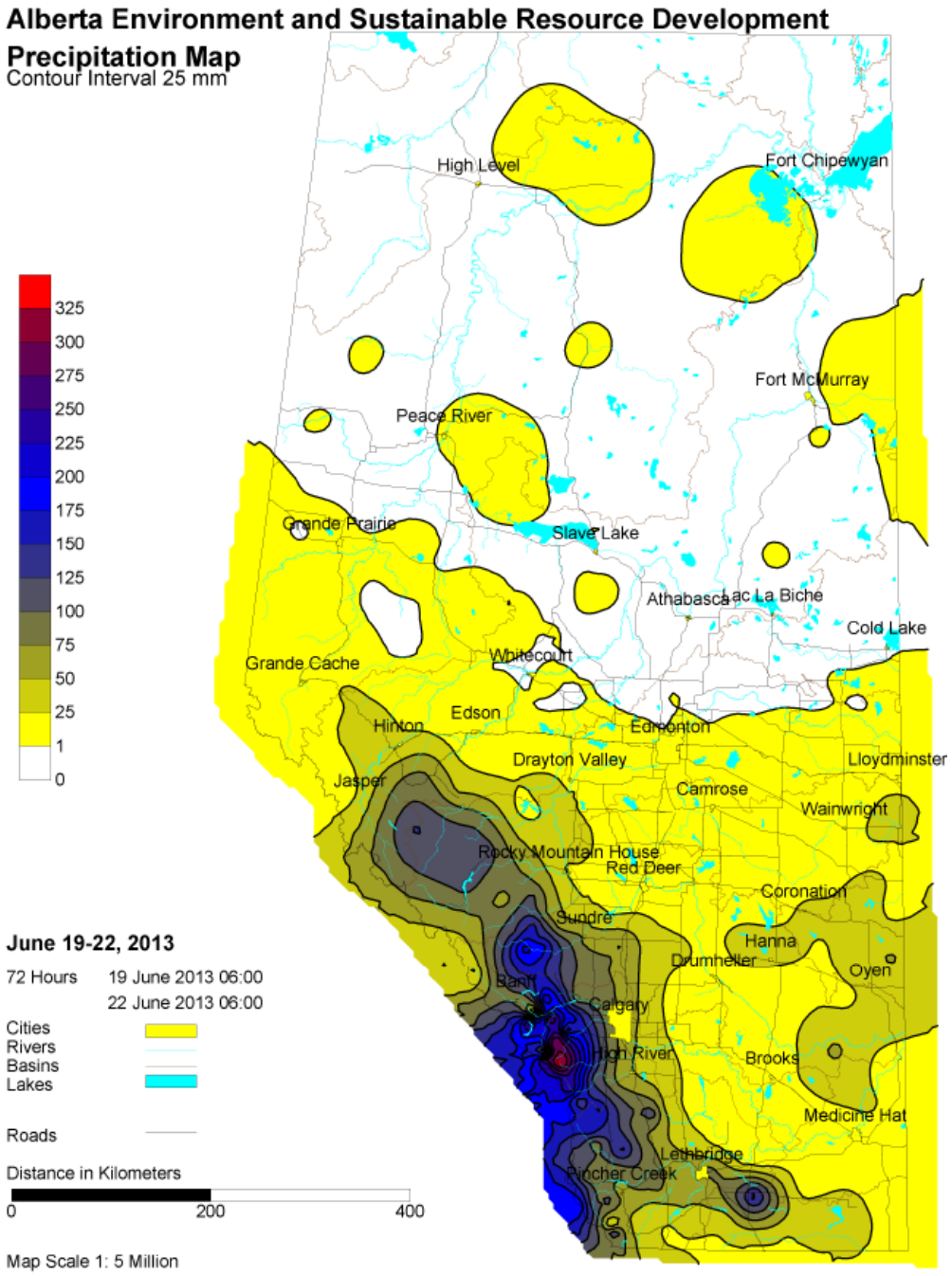


Figure 8: Precipitation Map

4.0 Bridge Emergency Repairs

The Bow River originates in Banff National Park on the east side of Waputik Mountains, makes it way to this crossing and travels east from this crossing before joining South Saskatchewan River near Bow Island, AB. Many of the bridges closed during the 2013 event were impacted by lateral migration of the river, with road embankments adjacent to bridge structure being washed out. Of the inspected sites, there was one report of a bridge being overtopped - the Bow River crossing near Gleichen. Figure 3 shows the river moving laterally, but based on photos in Figure 9 the river was so wide at the time of flooding that a bridge in any location in the Bow River valley was at significant risk.

During the flood event and following it, this bridge site was visited and inspected multiple times to ensure the safety of the public and to assess the condition of the structure. During initial inspections, it was noted that about 60 m of the north road embankment was washed out and there was an elevation difference of the deck over the abutment, indicating undermining had occurred. Additional observations included debris on the deck and caught on the piers and severed utility lines that were previously affixed to the structure. Figure 9 shows photos from a couple of these early site visits. At a subsequent inspection, buckled members of the truss were noticed. It was these observations, which threatened the structural integrity of the bridge, which resulted in an emergency declaration at this site. This emergency declaration allowed for the relaxation of some of the regulatory requirements, including those issued through Alberta Environment and Sustainable Resources, Fisheries and Oceans Canada, and Transport Canada. It should be noted however, that stringent environmental guidelines such as those related to erosion and sediment control, were adhered to throughout the project.

There is a sense of urgency to reopen this crossing as soon as possible, users of Highway 547 are required to drive a 72 km detour significantly extending trip lengths and limiting access to emergency services and schools. Since a replacement bridge design had not yet been completed and was estimated to take a minimum of three years, a repair option was the selected alternative with an opening date expected in 2014.

	Taken on June 22, 2013. On the deck, looking north
	Taken on June 22, 2013, looking north.
	Taken on July 10, 2013. Looking at the north span and abutment.

Figure 9: Post Flood Inspection Photos

With the declaration of an emergency, work began immediately to stabilize the abutment and protect the bridge from further damage. This work involved berm design work by Alberta Transportation to access the abutment, and design and construction work by Volker Stevin Contracting for a temporary support system. The berm is about 3 m high and provides a large working area surrounding the abutment to 60 m north where it meets the part of Hwy 547 that did not wash out. The berm was designed for normal winter water levels and could be overtopped with increased ice levels or high water experienced during the spring or summer months. The compromised abutment steps out numerous times at and below the water level. Vertical H-piles were put in place with the base supported on one of the steps on the abutment. A cap was placed horizontally, supported by the vertical H-piles and the compromised abutment, as shown in Figure 10. Working through freeze up and varying water levels, the bridge was stabilized by mid – January 2014.

Figure 10: Stabilized on Existing Abutment

4.1 THE CHALLENGES AT THE PIER

With a desirable construction completion prior to the 2014 flood season, work had to consider ice moving in and out of the river. The design had to be simple to limit time in the river while accommodating construction around the existing abutment and bridge. Initial options considered either rebuilding approximately 60m of road and constructing a new abutment or adding an additional span and converting the old abutment into a pier. On September 16th, 2013 Alberta Transportation notified Stantec that a 42m long Acrow Bridge was donated by the City of Medicine Hat. This modular bridge was to be

used in design of the repair work as an additional span to the north, where the roadway embankment had been lost. Several alternatives were initially considered but disregarded for various reasons. The list of options is presented below, along with the final recommendation.

1. Keep the existing abutment and modify it to accommodate the existing bridge properly and provide support for the new Acrow bridge. The condition of the foundation beneath the abutment is unknown, adding materials to stabilize the abutment could possibly compound the problem, therefore it was disregarded.

2. Remove the deck and drive piles between stringers. In reviewing the as builts, the distance between the stringers was too narrow.

3. Driving H-pile clusters on either side of the bridge to support a cap; however pile group effects would have to be taken into consideration, and was not considered further.

4. Two large caissons driven on either side of the existing bridge to minimize time and disturbance in the river. Caissons are required large enough to support cap dimensions, and differing configurations of the existing bridge and Acrow bridge. This option was chosen and 1.219 m diameters caissons were required.

Due to the timelines, the new abutment design followed modified standard Alberta Transportation drawings.

4.2 EXISTING TRUSS AGAINST ACROW BRIDGE

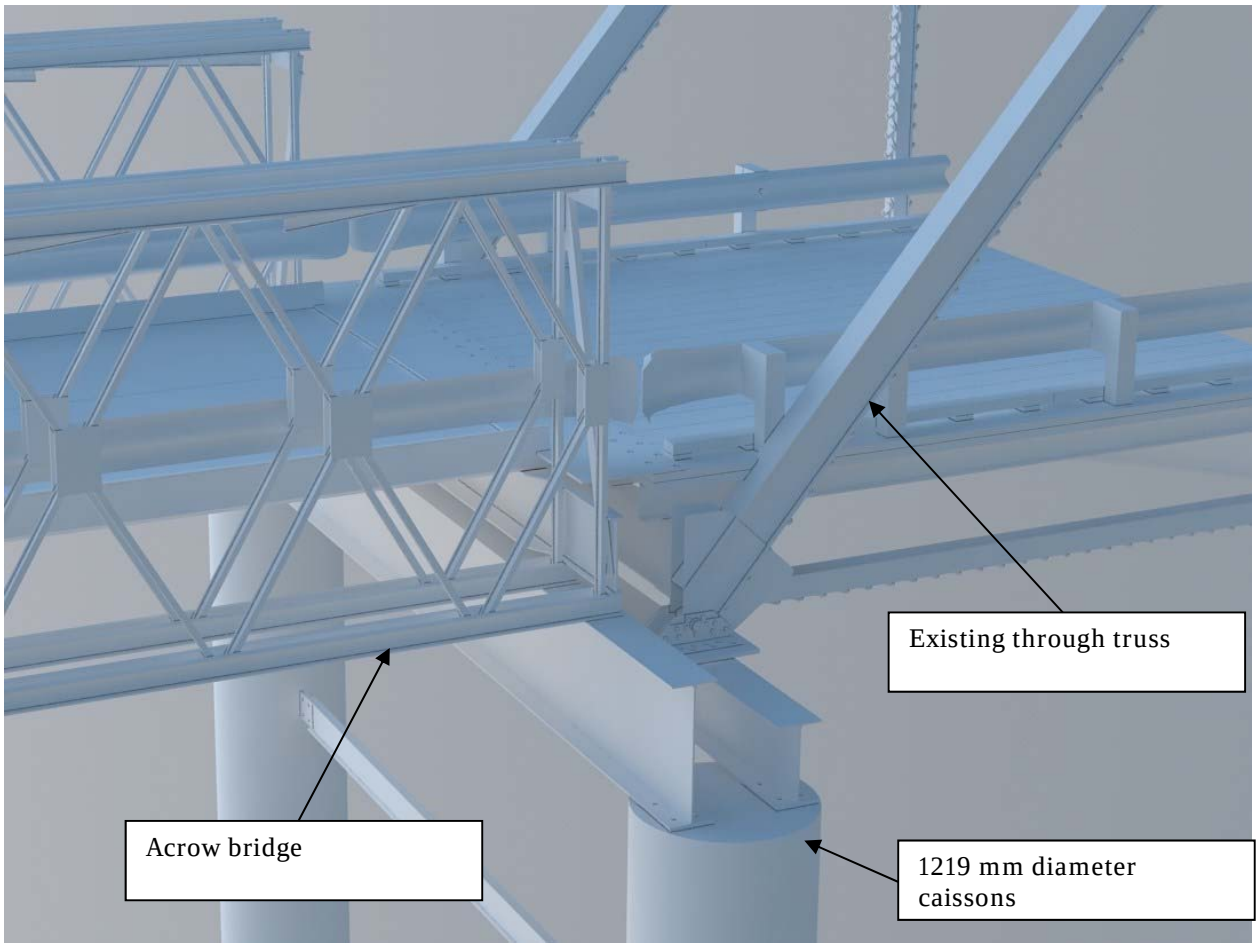


Figure 11: Bridge Design

There were complexities in designing a bridge system that would connect two very different bridge systems, in terms of overall geometry and design features. The existing through truss has a 5.1 clear roadway and timber deck and the Acrow bridge has a 4.2 m clear roadway and steel deck and these two bridge are not intended to be together. To necessitate movement of both bridges, there is a significant gap where they meet, although neither is intended to have an expansion joint. The only option is attach a steel deck plate to the timber deck of the existing through truss that is narrow enough to accommodate the clear roadway of the Acrow bridge. Additionally, the Acrow bridge has a diamond plated deck that is not preferred for winter driving. Therefore, a polymer wearing surface will be applied to the deck.

The superstructures of both bridges have different depths, so the pier cap was designed with different sized beams to not only support each bridge, but accommodate the differing dimensions, as seen in Figure 11. The pier cap has stiffeners welded to the caissons, designed to resist vehicle movement forces. The north end of the through truss is a fixed joint so the base of the bearing is welded directly to the new pier

cap. The Acrow bridge is a prefabricated bridge with bearings included. The dimensions of the bearings have been taken into consideration when determining the width of the caps at the pier..

4.3 NEW SUBSTRUCTURE

Referring to the as built drawings of the existing bridge, there was no indication of rebar or steel in the abutment. Since it was built soley with river rock and concrete, drilling the proposed caissons through the existing abutment was considered as part of the design. The pier is located in the active channel but due to the simplicity and depth of the caissons, does not require scour protection

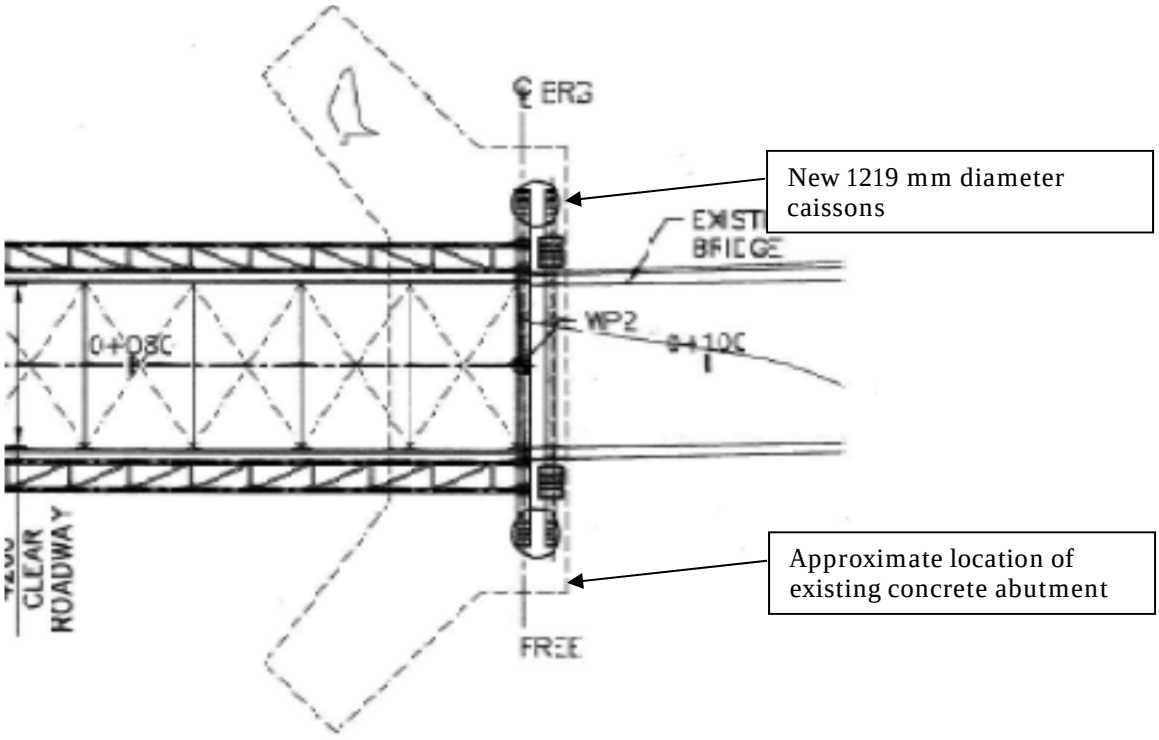


Figure 12: Caisson Locations

4.4 GEOTECHNICAL

Since the bridge was scheduled for complete replacement and a design was underway prior to flooding, a geotechnical report had been completed for this site. This report indicated that new abutment and pier piles would be drilled and driven to approximately 8 m below the berm into bedrock.

4.5 BARRIERS

The existing through truss bridgerail will be repaired as required due to damage. The disassembled Acrow bridge in Medicine Hat was inspected and the bridgerail installation procedure could not be determined. The 1 m difference between the clear roadways of the bridges raises concerns, in addition to the unknown height of the bridgerail on the Acrow bridge. Field decisions will be required to attach the

bridgerail to both bridges and provide a seamless transition. Approach rail on the north end of the bridge will be low height retrofit approach rail in accordance with AT's standard drawings S-1654 with a TL-3 Fleat 350 Energy Absorbing Terminal.

4.6 STEEL MEMBERS

During initial inspections, damaged truss members were noted which resulted in the need to inspect all the steel members. An ultrasonic inspection was completed in mid-January but access was difficult so only interior bolt and rivet locations could be inspected. On January 23rd, 2014 a snooper truck was mobilized to site to complete the UT inspection; however the weather was too cold. L1U1N and L1U1S are cracked and scheduled to be replaced during construction. Once the existing through truss is adequately supported on the new pier, another UT inspection will be completed to inspect the remaining connections.

5.0 Construction

The project was tendered in January 2014 and later awarded to Innovative Civil Constructors with construction starting in mid – April.

5.1 SCHEDULE

The initial schedule was as follows:

- Tender documents issued in January 2014 with a tender close date in February.
- Contract awarded Innovative Civil Constructor Inc.
- Construction started in mid – April.
- Installation of the caissons and abutment piles first week of May.
- Late May, lower the existing through truss onto the new pier and launch the Acrow bridge.
- Highway 547 opened on June 30, 2014.

5.2 SEQUENCE OF EVENTS

The Acrow bridge was assembled by the end of April on the north part of Hwy 547 that did not wash out, and is currently awaiting launching.

In the contract, ICCI was to build a temporary shoring tower at L2 to support the truss and keep as much of the existing abutment as a secondary support in case high waters were encountered while constructing the new pier. Once the pier was constructed and the existing through truss supported, demolition of the remaining existing concrete abutment and removal of the temporary shoring tower was to commence. The temporary shoring tower was installed under L2 on May 8, 2014 as seen in Figure 13

Figure 13: Shoring Tower under L2

The old concrete abutment was built with river rock, contained no rebar, and as built drawings indicates that there are timber piles at the base of the abutment driven into the ground. During partial demolition of the abutment, a wide horizontal crack propagated along the cold joint near the middle of the abutment, further compromising the entire structure. The abutment could no longer be used as a secondary support and for safety reasons was demolished to the top of the berm.

Pile driving for the new abutment was completed on the abutment on May 28, 2014.

Supply and galvanizing the caissons delayed their installation and drilling of the caissons started on May 30, 2014. Despite this delay, this task was not on the critical path and the project could still meet the opening date of June 30, 2014. On May 31, 2014, the drilling of the caisson had come to a halt just 2.5 m below the berm and the driller indicated that an obstruction was encountered that could not be drilled through with the industry standard equipment onsite. According to the as builts and survey, the driller was still within the confinements of the abutment. The as builts were studied further and there was no indication of any other material within the abutment other than concrete. The contractor then awaited further direction from the Consultant and Owner.

During the downtime, the survey came into question. The survey for the site was completed in October 2013 prior to the north span being stabilized and the centerline of the new pier was based on the misalignment of the north span. The two south spans were resurveyed to confirm centerline of the north span. We were expecting the spans to have some sort of misalignment since they were built over 100 years ago, but they were straight and a new centerline for the north span was determined. The locations of the caissons were restaked about 0.5 m east and drilling of the caissons commenced again on June 7, 2014. At both new locations, the driller hit an obstruction, again about 2.5 m below the berm.

Many theories were debated as to what the driller could be hitting in the old abutment with ideas on how to determine what it is and remove it without compromising the shoring tower less than 11 m away.

Due to unforeseen circumstances, the driller demobilized about 1 week later. The truss was now only on a temporary shoring tower in the middle of the Bow River and June rains and mountain runoff was

looming. The water levels under the berm are also the same as the water levels in the Bow River. On June 16, due to heavy rains and runoff from the mountains, a stream flow advisory was put in place by Alberta Environment and Sustainable Resources for the Bow River. A mitigation plan was developed to protect the shoring tower and was implemented shortly after. During heavy rains and rising waters, about 150 m^3 of riprap was placed around the temporary shoring tower and we braced ourselves for the high waters as seen in Figure 14. The Bow river peaked on June 20, 2014 at 975 m^3/s, and once the waters began to recede there was a sigh of relief since the shoring tower appeared virtually unscathed.

	Taken on June 18, 2014, looking at the existing truss on the temporary shoring tower.
	Taken on June 20, 2014, just after the Bow River peaked.

Figure 14: Shoring Tower under High Water Conditions

With no remaining options available, on June 27th a decision was made to redesign the pier cap and relocate the caissons outside the footprint of the abutment with a proposed opening date of August 30th. The center to center width of the caissons went from 8.5 m to 13.6 m. Drilling of the caissons

recommenced on August 7th with the upstream caisson installed with no concerns. During drilling of the downstream caisson, concrete was encountered but was drilled through with minimal issues and both caissons were installed by August 12th, 2014. The pier cap was ordered but fabrication would not be feasible prior to August 30th using the proposed new design. The design engineer and fabricator worked closely to make modifications to the design to expedite fabrication. The beam arrived onsite on August 20th and was erected on August 25th with the Acrow launched the following day. The existing through truss was lowered onto the new pier on September 9th and the temporary shoring tower was removed. Attempts are currently being made to remove the obstacle to determine what it is, but due to water levels in the excavation and on the Bow River, abandoning the investigation has been proposed.

As of September 15th, the bridge was not yet opened and outstanding items to open the bridge included:

- Roadway work
- Polymer wearing surface
- Weld Stiffeners, weld angle irons on the pier, remove weld on pier bearing.
- Grout top of caissons,
- Bridgerail/Guardrails/Wheelguards
- Coverplate

The only other outstanding item which remains to be completed that does not affect bridge opening is berm removal and install the pier brace.

BOW RIVER BRIDGE NEAR GLEICHEN, AB, AFTER THE FLOOD

September 15, 2014

	Taken on September 9, 2014, looking at the existing truss and Acrow on the new pier.
	Taken on September 9, 2014, looking at the existing truss and Acrow.

Figure 15: Almost Complete

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