

**ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION – HIGH LEVEL
2020 INSPECTION**



Site Number	Location	Name	Hwy	km
PH048-1 (S) PH048-2 (N)	Northwest of Fort Vermillion, Alberta	Fort Vermillion Bridge (BF74227-1) Abutments	88:18	29.47 (South) 29.96 (North)
Legal Description		UTM Co-ordinates		
South Abutment: SE29-108-13-W5M		11U E 550,889	N	6,473,826
North Abutment: NE29-108-13-W5M		11U E 550,950	N	6,474,310

	Date	PF	CF	Total
Previous Inspection:	16-May-2019	South: 5 North: 9	4 4	20 36
Current Inspection:	5-Jun-2020	South: 5 North: 9	4 4	20 36
Road AADT:	1670		Year:	2020
Inspected By:	Rocky Wang, TRANS Ed Szmata, TRANS		Ken Froese, Thurber	
Report Attachments:	<input checked="" type="checkbox"/> Photographs	<input checked="" type="checkbox"/> Plans	<input type="checkbox"/> Maintenance Items	

Primary Site Issue:	Abutment headslope movement (north) and river erosion (south).		
Dimensions:	See Drawings		
Date of Remediation:	2015: Toe berm and riprap constructed at south abutment with driven steel shear piles. 2016/17: North-most pier foundation underpinned with concrete piles, drainage blanket and gravel toe berm installed against north headslope		
Maintenance:	2011: Repairs to the concrete drainage troughs at the north abutment and concrete added to the base of the south abutment wall.		
Observations (North Abutment):	Description	Worsened?	
<input type="checkbox"/> Pavement Distress		<input type="checkbox"/>	
<input checked="" type="checkbox"/> Slope Movement	Continuing distortion of concrete drainage elements from headslope settlement/movement as well as further deterioration of scarps and cracks adjacent to the abutment.	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Erosion	Riling forming in recent silt deposits east of the toe berm. Gully forming below and beside concrete drainage trough and along east wingwall Recent damage to riprap armour of toe berm.	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> Seepage	One seep in upper slope bench area; lower headslope seepage now handled by toe berm drainage layer and subdrain flows steadily when not buried by silt. Additional seepage from headslope noted previously immediately above top of toe berm.	<input type="checkbox"/>	

<input checked="" type="checkbox"/> Bridge/Culvert Distress	Gap between abutment wall and bridge beams changes likely due to thermal contraction and expansion of bridge deck. Ongoing spalling of the concrete and rusting of the underlying rebar observed at several locations. Cracking of the concrete facing observed beneath the approach slab.	<input type="checkbox"/>
<input type="checkbox"/> Other		<input type="checkbox"/>
Observations (South Abutment):	Description	Worsened?
<input checked="" type="checkbox"/> Pavement Distress	Slight dip in pavement surface just south of the approach slab. Recent patch at edge of approach slab and transverse crack further south – pothole has been patched.	<input type="checkbox"/>
<input checked="" type="checkbox"/> Slope Movement	Shallow headslope failure located on the east side of the headslope with only minimal changes since 2012.	<input type="checkbox"/>
<input checked="" type="checkbox"/> Erosion	River erosion at toe repaired with toe berm and riprap construction in 2015 but minor flood-damage on top of toe berm in 2018 and 2020. Minor erosion occurring at base of abutment wingwalls and worse at the south one in 2020.	<input checked="" type="checkbox"/>
<input type="checkbox"/> Seepage		<input type="checkbox"/>
<input checked="" type="checkbox"/> Bridge/Culvert Distress	Gap between bridge beam and abutment wall changes likely due to thermal contraction and expansion of bridge deck. There is also ongoing spalling of the abutment concrete.	<input type="checkbox"/>
<input type="checkbox"/> Other		<input type="checkbox"/>
Instrumentation (as of Fall 2020):		
Recent Installations	Several instruments were installed in 2013. SI13-4 and SI13-6 (and corresponding PN13-4A and -4B, and PN13-6A and -6B) were damaged by river ice in 2014. SI13-6 (S abut.) was repaired in June 2015 and SI13-4 was replaced by the new SI15-4 in July 2015 (PN not repaired or replaced).	
South Abutment	SI3: no discernable movement pattern has developed. SI13-6: has some deflection in the upper 5 m but has not resolved into a discernable pattern of movement. Downhole camera images taken in Fall 2017 show a blockage at 25.8 m and the SI was reset above this depth but was destroyed by a vehicle in 2018. SP13-5: Water level had been dropping since Fall 2016 and has stabilized over the last year at about 14.9 m BGL aside from a historical high of 13.4 m in Spring 2020.	
North Abutment	SI13-2: relatively significant, albeit shallow, cumulative movement of 138 mm at an average depth of 2.5 m. Movement appears cyclical (slower or reversed in Fall), and jumped 21 mm since Fall 2019, but has a continuous movement trend that might explain the shallow earth rotation along the outside of the concrete gutter. SI15-4: A discernable movement pattern had not developed since this replacement inclinometer was installed in July 2015. It was extended in late 2016 during toe berm construction and was obstructed at 5.5 m in spring of 2017. From downhole camera images, the pipe is broken at 1.5 m and obstructed at 6.7 m and should be replaced.	

PN13-1A has been dry since installation and became non-operational in Fall 2015; PN13-1B was damaged as of Fall 2019. PN13-2A has varied less than 0.6 m since 2015 stabilizing at an average of 3.8 m BGL. The water level at PN13-2B dropped about 3 m from the average of the past 3 years and is now at 19.8 m BGL which is similar to the pre-2017 levels.

Assessment:

RECENT HIGH WATER EVENTS:

Spring 2018: Estimated at 255 m EI which is 2 m below the north abutment toe berm and 3 m above the south abutment toe berm

Spring 2020: Peak water level recorded at the town of Fort Vermilion downstream of the bridge was 257.8 m EI (April 28). At the bridge, the north abutment toe berm does not appear to have been overtopped but debris was located just below the crest putting the peak at 257.0 m EI which is 2 m higher than in Spring 2018 and 5 m above the south abutment toe berm.

NORTH ABUTMENT:

The toe berm was constructed through the winter of 2016/17 and was complete at the time of the 2018 visit. Underpinning of the Pier 4 foundation and resetting of the bridge deck connection was completed at the same time. The presence of the toe berm should result in a decrease in the amount of displacement observed on the headslope due to the rotational movement previously documented at this site. The portion of the headslope immediately above the toe berm was over steepened in 2017 which was corrected by the contractor who placed a small fillet of material at the edge of the toe berm. Seepage was observed at several locations on the headslope, particularly below the drain trough. Significant silt has accumulated at the toe of the slope and in the riprap facing of the toe berm from the 2018 and 2020 floods. Although the subdrain from the toe berm was not visible in 2018 and 2019, there was seepage and erosion through the silt at the toe where the subdrain is likely located. The subdrain was buried again in 2020 and seepage was not evident at the ground surface. There was also seepage and erosion happening to the east of the toe berm in the accumulated silt sediments. The geogrid at the top of the toe berm was exposed in a few small locations. Of greater concern was the displacement of riprap over much of the toe berm face. The underlying geotextile was exposed at the upstream corner (southwest) and rock has been displaced up to 6 m away from the toe of the protected slope.

However, the slope at the north abutment continues to show signs of movement as indicated by the tilted concrete mats adjacent to the abutment walls, depressed ground around the abutment, and increasing crack widths on the headslope. The scarps at the east and west sides of the slope also appear to be intermittently active with fresh movement observed in 2019 east of the abutment. The inclination of the headslope, which ranges from 2.0H:1V to 2.35H:1V, is steeper than typical for slopes in the area. It is likely that the local factor of safety against slope failure is lower than normal design standards and has led to the observed rotational creep movement. A high water table in the abutment fill area, as evidenced by increased seepage observed in 2015, is likely a contributing factor to the observed slope movements. The depressed area around the abutment also might trap water and add to the problem.

The displacements of the slope are likely adding vertical and lateral loads on the bridge abutment piles. The drainage gutters along the wing walls continue to settle and rotate as the headslope fill settles and rotates. Ongoing slope movement has resulted in cracking and separation of a portion of the gutter which will contribute additional water into the slope causing further undermining of the gutter and gabion baskets. The concrete trough below the bridge noticeably deteriorated since 2019 and the formation of erosion gullies beside and below will lead to an increased rate of movement.

SOUTH ABUTMENT:

The riverbank on the south abutment had shown continued retrogressive erosion towards the abutment slope caused by river water and ice. It may have been exacerbated by localized eddying from the abandoned test piles located adjacent to the toe of the slope. The tension cracks were about 4.3 m to 5.5 m from the toe of the headslope in 2014. This was mitigated by constructing a toe berm and riprap facing which was complete by 2016. There were no signs of river erosion along the toe of the riverbank in the vicinity of the bridge in 2017. However, high flood waters in Spring 2018 and 2020 rose to about 3 m and 5 m, respectively, above the toe berm. The flood removed significant

quantities of vegetation and eroded the banks beyond the riprap protection. Some displacement of rocks in the riprap facing was observed and gravel was lost from behind the riprap exposing, and damaging, the geocell containment. Silt was embedded into the riprap and piles of dead trees were observed on both sides of the abutment fill. The much higher water level in 2020 deposited a significant amount of driftwood on the west side of the approach fill.

In 2019, there did not appear to be further degradation of the toe berm; however, there was significant bank erosion noted beyond the riprap apron. There is some potential for this erosion to undermine the riprap apron but not in the near future.

It was also observed that some patching had been done immediately south of the approach slab in the SBL as well as a transverse crack just south of the end of the abutment walls. In the SBL, the transverse crack patch has been broken out in 2019 creating a pothole in the outside wheel path which was patched in 2020. Rusting of the metal plates over the finger joints was also noted and the plates appear to be somewhat loose and able to move vertically under traffic loading.

Recommendations:

Thurber undertook a geotechnical investigation at this site in 2012 to 2013 for CH2M Hill and was involved with the construction which commenced in 2014 and was completed in late 2017. The repairs at the north abutment consisted of a toe berm to stabilize the headslope against shallow failures and placement of 16 concrete piles to underpin Pier 4 as well as to provide lateral resistance to a potential failure surface along a bentonite seam in the bedrock. The repairs on the south abutment consisted of removing slump soil and reconstituting the bank with granular fill installing driven steel shear piles and a riprap facing and was complete at the time of the 2016 annual site inspection.

Recommendations were made in 2015 for changes to the north abutment toe berm design to accommodate the additional seepage observed in 2015 which were incorporated. The over steepened slope immediately above the top of the toe berm was repaired by placing gravel material at a 3H:1V to buttress the slope.

Short-Term:

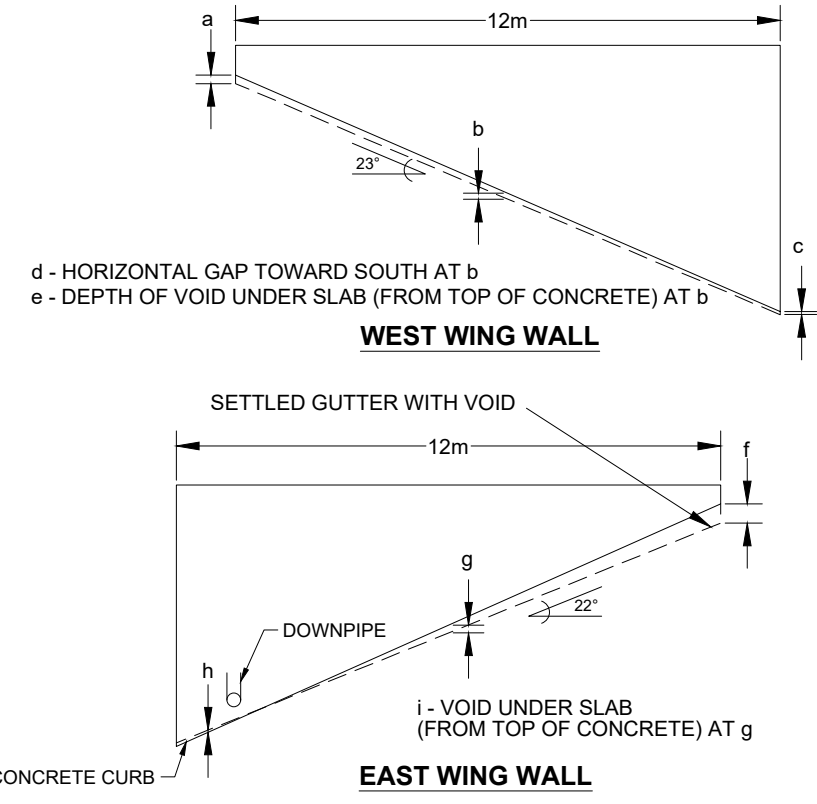
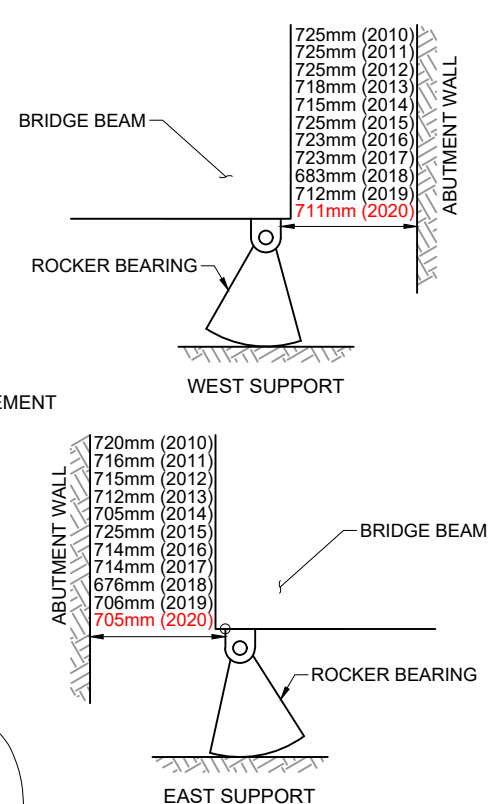
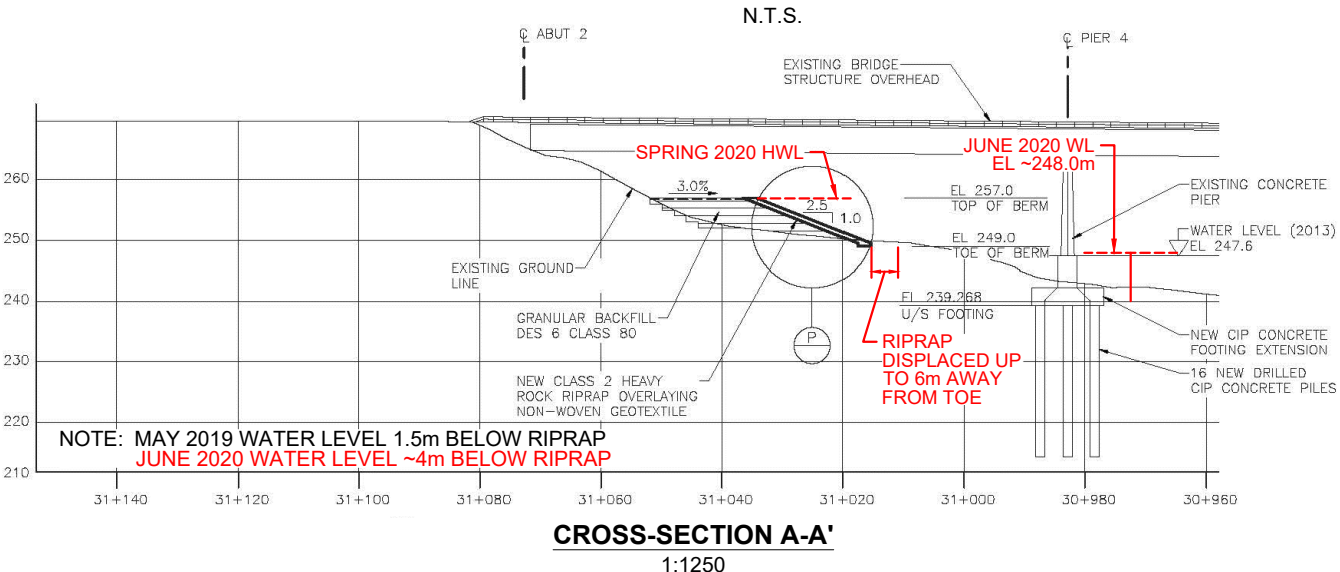
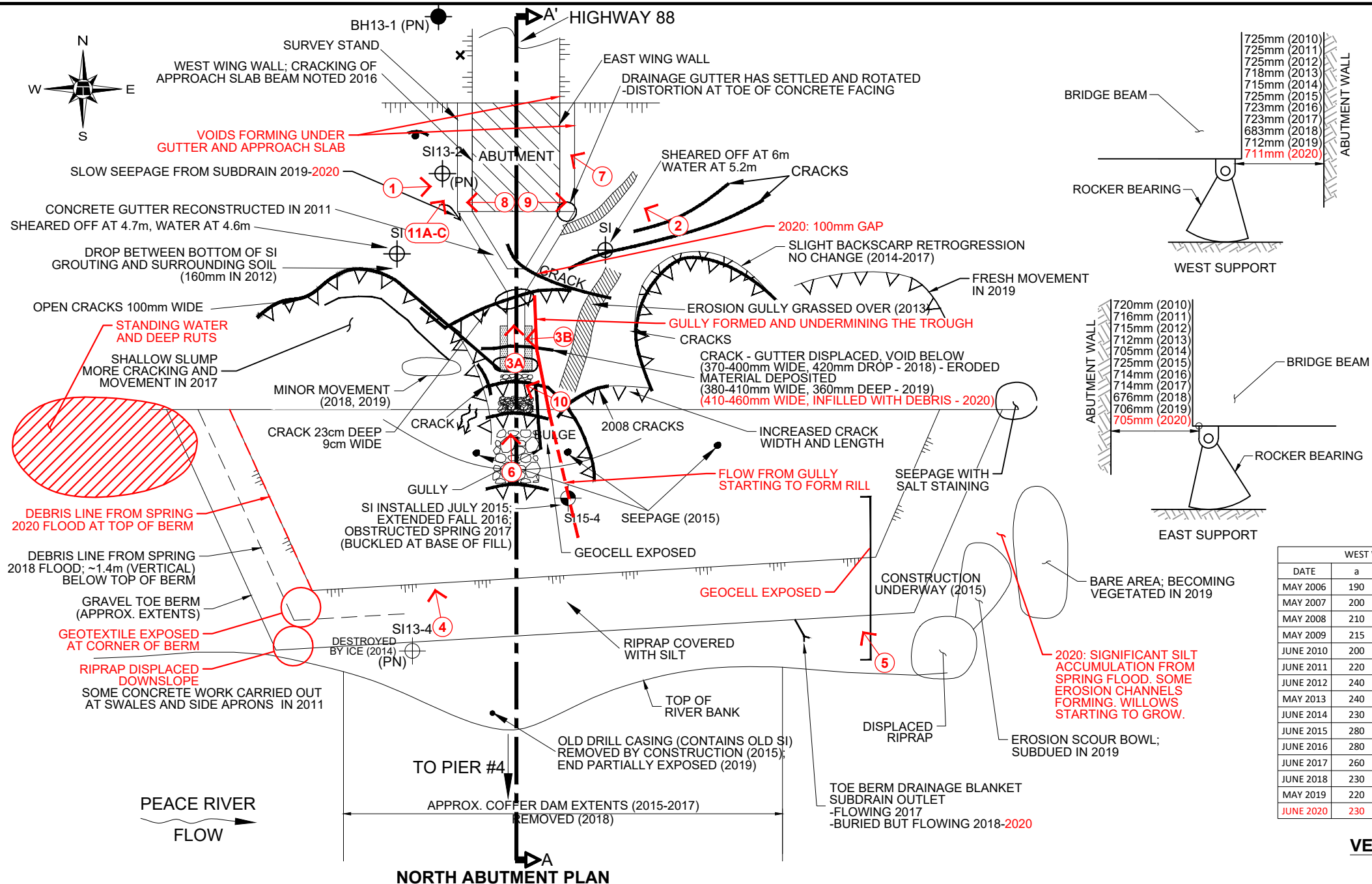
- North Abutment: Riprap on toe berm needs to be fixed and/or augmented due to the amount of rock displaced during the flood of Spring 2020 which could lead to greater damage in the next flood.
- North Abutment: Erosion gullies should be backfilled with compacted clay and erosion control measures (such as Filtrexx socks) placed across the slope to reduce surface water flow velocities.
- North Abutment: Voids under the concrete slabs adjacent to the wingwalls should be filled with fillcrete or urethane foam to reduce water infiltration.
- South Abutment: Replace or repair the plate over the finger joints as it currently moves under traffic.
- South Abutment: Repair the erosion gullies on either side of the abutment wing walls. Grouting the voids might be the most-economical method.

Medium-Term:

- It is recommended that the concrete gutters at the north abutment be removed and rebuilt ensuring a controlled drainage path down to and across the toe berm. A combination of concrete, half-round culverts, and erosion control products could be used.
- The upper part of the north headslope should be regraded on both sides of the abutment to a flatter inclination to improve drainage along the slope and reduce driving forces on the shallower slip surfaces that may be present. Subdrains should also be installed to dewater the upper slope.
- There is no functioning slope inclinometer at the toe of the north abutment that will measure whether or not the remedial measures have been effective. It is recommended that at least one inclinometer be installed through the toe berm for this purpose. Consideration could be given to also installing one or two additional inclinometers and piezometers in the upper portion of the slope while a drill rig is on site.
- The concrete in the wing walls is in poor condition and should be assessed by a bridge engineer to determine when structural repairs are warranted.

Ongoing Investigation:

- It is recommended that the annual GeoHazard inspection should continue as scheduled.
- The GeoHazard instrumentation readings should continue as scheduled.



WEST WING WALL MEASUREMENT (mm)

DATE	a	b	c	d	e
MAY 2006	190	150	65	-	-
MAY 2007	200	160	75	120	-
MAY 2008	210	200	50	110	280
MAY 2009	215	210	60	110	290
JUNE 2010	200	180	45	120	-
JUNE 2011	220	215	60	123	-
JUNE 2012	240	220	70	130	290
MAY 2013	240	220	80	130	290
JUNE 2014	230	220	70	145	330
JUNE 2015	280	240	70	150	330
JUNE 2016	280	-	-	160	300
JUNE 2017	260	240	85	150	310
JUNE 2018	230	240	90	150	230
MAY 2019	220	240	-	160	240
JUNE 2020	230	230	90	160	255

EAST WING WALL MEASUREMENT (mm)

DATE	f	g	h*	i
MAY 2006	420	230	75	-
MAY 2007	285	100	90	-
MAY 2008	315	100	70	750
MAY 2009	250	100	70	750
JUNE 2010	475	235	75	-
JUNE 2011	490	260	75	-
JUNE 2012	520	270	60	770
MAY 2013	520	290	60	840
JUNE 2014	510	270	55	605
JUNE 2015	560	220	35	750
JUNE 2016	560	-	35	600
JUNE 2017	540	300	40	630
JUNE 2018	560	360	20	610
MAY 2019	600	360	-20	650
JUNE 2020	640	375	-20	730

* HEAVE

VERTICAL DISPLACEMENTS AT NORTH ABUTMENT
 N.T.S.

- LEGEND**
- TEST HOLE WITH PIEZOMETER
 - SLOPE INCLINOMETER (SI) (currently using)
 - SLOPE INCLINOMETER (SI) (not in use)
 - (PN) PNEUMATIC PIEZOMETER(S)
 - ~ SCARP
 - ~ SEEPAGE
 - ① → PHOTO AND DIRECTION

NOTE: JUNE 2020 OBSERVATIONS SHOWN IN RED

CROSS-SECTION TAKEN FROM ISSUED FOR CONSTRUCTION DRAWINGS (CH2M HILL, SEPTEMBER 19, 2014)

Alberta

PEACE REGION (PEACE RIVER / HIGH LEVEL)

PH048-1: HWY 88, FT. VERMILION BRIDGE (NORTH ABUTMENT) - km 29.96

2020 GEOHAZARD ASSESSMENT

DWG No. 13351-PH048-1-1

DRAWN BY	KLW
DESIGNED BY	KEF
APPROVED BY	DWP
SCALE	AS SHOWN
DATE	DECEMBER 2020
FILE No.	13351

THURBER ENGINEERING LTD.



Photo 1, North – Looking east at north abutment finger joints.



Photo 2, North – Looking north at east wing wall.



Photo 3A, North – Looking north at north abutment concrete gutter.



Photo 3B, North – Looking west at cracked and shifting north abutment concrete gutter. Void below the lower portion of the slab up to 350 mm (measured from top of concrete).



Photo 4, North – Looking north at west side of north abutment.



Photo 5, North – Looking north at east side of north abutment.



Photo 6, North – Seepage along toe of headslope face just above the top of the toe berm.



Photo 7, North – Looking northwest at gap between the concrete gutter and north abutment wing wall resulting from settlement of abutment fill.



Photo 8, North – Looking west at north abutment west rocker bearing.



Photo 9, North – Looking east at north abutment east rocker bearing.



Photo 10, North – Looking northwest at tension cracks on the east side of the north abutment.



Photo 11A, North – Looking northeast at north abutment west side wing wall. Cracking of beam denoted by red arrow shown in Photo 11B.



Photo 11B, North – cracking of approach slab beam above west side wingwall.



Photo 11C, North – Hump of material creeping into concrete drainage trough adjacent to west wingwall.



Photo 12, South – Looking northeast at top of east side wing wall.



Photo 13, South – Looking southeast at south abutment west side wing wall. Erosion occurring at the base of the wall.



Photo 14, South – Looking east at south abutment concrete wall.



Photo 15, South – Looking west at new toe berm at south riverbank. Erosion of gravel at the top of toe berm occurred with high flood levels in Spring 2018 exposing GeoCell at several locations.



Photo 16A, South – Looking southwest at south abutment concrete wall.



Photo 16B, South – Looking southwest at spalling on south abutment wall.



Photo 17, South – Looking east at south abutment east rocker bearing.



Photo 18, South – Looking west at south abutment west rocker bearing.



Photo 19, South – Looking south at east side of south abutment with completed construction of toe berm.



Photo 20, South – Looking south at west side of south abutment.



Photo 21, South – Looking east at new toe berm under south abutment.



Photo 22, South – Looking east at south abutment finger joints which was covered with a plate between the 2017 and 2018 visits. Plate is loose and rusting at south side (see inset).



Photo 23A, South – Riprap placed in 2015 on south headslope below west deck drains.



Photo 23B, South – Riprap placed in 2015 on south headslope below east deck drain.