THURBER ENGINEERING LTD.

celebrating 60 YEARS

September 11, 2017 File: 13351

Alberta Transportation
3rd Floor, Provincial Building
9621 – 96 Avenue
Peace River, Alberta
T8S 1T4

Attention: Mr. Ed Szmata

GEOHAZARD ASSESSMENT PROGRAM
CALL-OUT INSPECTION
HWY 688:02 km 15.42 MCKINNEY CREEK

Dear Sir:

There is an active grade widening project underway on Highway 688:02 North of St. Isidore. Approximately two weeks ago, an excavation for a culvert extension at McKinney Creek (BF72477-1 at km 15.422) mobilized an existing landslide which rapidly progressed up the embankment and began affecting the paved highway surface. Under the GeoHazard Assessment Program, Thurber was requested by Mr. Khalid Manzar, P.Eng., of Alberta Transportation (AT) to conduct a call-out inspection. The inspection was completed on September 6, 2017, by Mr. Ken Froese, P.Eng., Thurber in the presence of Mr. Manzar and representatives of the Prime Consultant, WSP Canada, the Contractor, In-Line Contracting, and the Bridge Consultant, MPA Engineering.

1. SITE HISTORY AND CONDITIONS

The site is located on the west side of Hwy 688:02 (the highway is oriented north-south) about 11 km north of St. Isidore, Alberta. There is an existing 3.3 m diameter culvert for McKinney Creek at this location and the embankment height is approximately 15 m above the culvert inlet. The existing sideslopes were inclined at between 3H to 2.5H:1V. It is understood from WSP that movement at this location had been documented by AT as far back as 1998. Thurber conducted a call-out inspection at this site in 2013 for slide movements on the west embankment. At the time of Thurber's first call-out, the main area of movement was the west embankment where a toe roll was identified in the lower third of the slope with scarp cracking partway into the SBL. Other zones of concern were identified during the visit including a shallow slump on the east embankment just north of the culvert centerline and slumping along the creek banks particularly in the NW quadrant.

At the time of this 2017 call-out inspection, grade widening construction was underway in the area, the embankment slopes had been stripped of vegetation, and the culvert extensions were being installed. The culvert extensions are required as the grade widening design includes flattening fill sideslopes to 4H:1V with two 3 m-wide intermediate benches. The existing culvert had been lined for approximately 60 m in the center of the pipe and at the time of the visit, the lining had been extended to the ends of the existing culvert. The annulus between the culverts will be grouted and the extensions to the west and east will be the diameter of the original culvert.

It was noted that the east culvert extension had been installed and MPA confirmed that backfilling of the excavation can proceed. The excavation is about 4 m in height with a 1H:1V backslope.

The west culvert extension is on a 48° bend to accommodate the alignment of the creek. Excavation for this west extension began approximately two weeks ago. The Contractor cut a vertical excavation approximately 2 m deep along the length of the extension. It is understood that stockpiling of this excavated material was placed further up on the slope above the excavation. The Contractor had also cut a bench across the slope at about mid-height to provide access for construction equipment. Approximately 2 days after the excavation was cut open, a 75 mm drop at the pavement was noticed along with heaving of the base of the excavation. Shortly after the slope started moving, there was about 50 mm of rainfall. Approximately 4 days after the excavation, the drop at the pavement surface had increased to 0.5 m and the Contractor began to excavate material from the landslide to try to slow the movement. Since the evening of September 4, the highway surface had dropped an additional 3 m. Attempts to place fill adjacent to the highway to maintain the driving surface were unsuccessful as the slide continued to drop. Survey of the slide extents was undertaken by WSP on September 1 and again on September 6?, 2017, and shown in plan view on Figure 1 and comparatively in profile in Figure 2.

On September 6, 2017, the scarp located 1 m into the highway was between 5.5 m to 6 m high, inclined at 55° (from horizontal), and about 38 m wide along (north-south) the highway surface. A secondary bench was about 2.5 m below the highway which it is understood represented an intermediate stage before the latest significant movement. The exposed soils appeared to consist of medium to high plastic clay and were obviously slickensided. Organic seams identified from the geotechnical investigation test holes (Hoggan Engineering and Testing, November 2011) were not visible on the exposed face. Groundwater seepage was not observed. Intermediate cracking was visible in the slide mass slope and there was a large perpendicular crack over top of the culvert where the slumping soil had fallen to either side. Heave was evident in the base of the west culvert extension which the Contractor estimated at about 1 m overall from the original cut surface. Tension cracks were visible in the surface of the north access road and potentially continued into the topsoil stripping stockpiles further north. MPA conducted a rise/run survey of the culvert lining on September 5, 2017, and identified that there is a deflection in the roof of the culvert about 30 m from the existing inlet. Note that the annulus has not yet been grouted so the overall amount of movement will have crushed the ceiling of the outer culvert before impacting the liner. The distance appears to be roughly coincident with the projected slide plane.

An inspection of the east sideslope identified a potential slide bowl forming coincident with the area where movement had been seen in 2013. WSP observed that there appeared to be move gravel exposed below the asphalt than had been present after topsoil stripping and guardrail removal. Repeated surveys of a few points along the embankment indicated minor vertical movements less than 100 mm overall. A survey of the highway centerline a day or two before this call-out inspection did not show a significant difference between the original survey taken during design indicating that the highway surface is not subsiding except at the west slide.

2. ASSESSMENT

There has been a history of instability at this location although previous inspections had observed a mid-slope bulge indicating a shallower failure surface than appears to have occurred this time. The potential contributing factors for this slide are:

- Zones of poor quality material in the existing embankment fill
- Potential for incomplete removal of original streambank organic materials
- Established slip surface from previous movements where the strength of the clay fill had already been reduced perhaps as a loss of cohesion of the fill due to ongoing weathering of the embankment sideslope material
- Rainfall when the slope was vulnerable (cracks had begun to open allowing infiltration directly to the slip surface)
- Recent excavation at the toe of the embankment
- Recent stockpiling of material on the slope above the excavation.

The landslide condition was a pre-existing condition which likely resulted because the original sideslope inclination was too steep for the high plastic clay fill and weaker upper native soils, once weathering had reduced some of the sideslope fill cohesion. However, the ongoing movements were of a creep nature. It is likely that the excavation at the toe of the slope for the culvert extension triggered the more aggressive movements that are now being seen on the pre-existing slip surface. Stockpiling of the excavated material on the slope above the excavation may also have been a contributing factor. It is possible that the slide affecting the highway is from retrogressive movement that started with a smaller slide near the toe of the slope where it was oversteepened for the extension excavation. However, given that the movement was observed at the highway surface at the same time as the excavation base heaved, it is also possible that this is one large landslide mass.

Based on the test holes from the previous Hoggan Engineering investigation and the topographic survey by WSP, we have plotted the inferred stratigraphic conditions and slip surface of the landslide on Figure 2. Based on this information, we believe that the slip surface extends down through the high plastic clay fill into the upper native soils but likely does not extend deep down into the hard native till material.

The assessed risk level for this site, based on AT's guidelines is 90, based on a Probability Factor of 15 (between active with a high rate of movement with additional hazards) and a Consequence Factor of 6 (road closure is a direct and unavoidable result of movement).

3. RECOMMENDATIONS

Two stages of recommendations are required for this site to consider both the short-term safety of the highway and the travelling public and the long-term reconstruction of the slope. The following three options were discussed on site to address the short-term situation:

1. Immediately backfill the culvert excavation and reconstruct the slope to at least 4H:1V or flatter to reduce movements until a permanent solution can be determined; or

2. Excavate the highway surface to reduce the driving force of the slide and allow traffic to be moved further away to the east, from the active slope

3. Establish a detour and close the road.

It was concluded on site that some component of all three of these steps will be taken. AT will institute an immediate load ban for truck traffic and will be speaking to the County to establish a local road detour. Once the detour is in place and WSP has determined the geometric parameters, the highway will be cut down approximately 3 m and gravel-surfaced. It may then be possible to place some fill to buttress the highway surface. In the interim, the Contractor has agreed to have 24-hour watch on the highway in case movements occur further into the pavement. Once the unloading has taken place, consideration should be given to temporarily backfilling the west sideslope to about 3H:1V or flatter to further mitigate against further movements until such time as the permanent fix can be undertaken. It is also recommended that the excavation for the west culvert extension be temporarily backfilled to provide additional weight on the toe of the landslide which may also assist in reducing movement.

It was also recommended on site by Thurber that stockpiles on or close to the west embankment and creek valley slopes be moved away. In particular, the large stockpile located on the north slope should be moved as soon as practical as the 2013 call-out identified slumping along that portion of the creek valley.

It was recommended that the east culvert excavation be backfilled as soon as possible and that, in the interim, the stockpile adjacent to the excavation be reduced in height with material moved downslope to provide a buttress. It was recommended to WSP that additional monitoring points be established on the east slope to identify if movement is continuing on that side of the embankment. Establishing and monitoring of survey points along both sides should be maintained after the sag curve has been constructed to provide warning of potential movements. The frequency of monitoring should be at least daily initially which can be reduced if movement is not observed.

Several options for the long-term reconstruction of the slope were discussed on site. Input will be required from WSP and MPA in selecting the most appropriate solution considering economics, construction feasibility, and scheduling. It is understood that the highway grade will need to be re-established to the original alignment (the temporary vertical sag curve will not meet the final design speed) and that it would be ideal, but not mandatory, that the repair be completed within the current construction season. The potential methods are:

- Excavate the existing slide mass and replace with compacted clay. The excavation will need to be done in segments including the culvert extension excavation. This will require backfilling the current culvert extension excavation, likely with a temporary culvert to maintain creek flow, so that the slope can be temporarily rebuilt prior to commencing excavation of the slide mass. Excavation will need to be at 1H:1V starting about 1 m to 2 m behind the existing slide plane and may require excavation below the culvert invert elevation in order to remove the slip surface. If the slip surface is shallower than the invert, trench boxes should be considered for the deeper excavation that will be required for the culvert extension. Each segment of excavation should be limited to about 15 m in width (in north-south direction) and will need to be partially backfilled to a prescribed elevation before commencing the next segment. The planned 4H:1V sideslope should still be appropriate if the entire slide mass and slip surface is removed. A gravel shear key may also be necessary.

- Excavate the existing slide mass as above and replace with compacted granular material. This might allow a steeper sideslope thus reducing the amount of imported material. For the height of this embankment, the sideslope should be no steeper than 3H:1V. Placement and compaction of gravel will be quicker than clay but will require that the excavated material be wasted or used elsewhere on the project.

- Reinforce the slope with driven H-piles near the toe. This would provide shear reinforcement through the toe of the slide which may allow some of the slide mass to remain in place reducing the amount of excavation required. The shear piles could also provide temporary support for the excavation of the culvert extension. The shear piles would consist of relatively thick H-piles spaced at approximately one pile diameter and would necessitate sourcing of the steel and mobilizing of pile driving equipment.

- Encapsulate the slide mass and stabilize the slope using flatter sideslopes and/or a toe berm. The use of overall flatter sideslopes could compensate for leaving some of the weaker, sheared material in the embankment though would require additional extension of the culvert and additional right-of-way and clay fill. It is understood that additional ROW can be readily obtained. There may be issues with extending the culvert considering both the limitations of the current Water Act approval and downstream alignment of the McKinney Creek channel.

Other considerations were discussed on site that could be incorporated individually or collectively:

- Install a new culvert via trenchless or open-cut methods. The current configuration has a bend at each end to accommodate the wider fill and is already lined indicating potential concerns with the original pipe. Installing a new pipe would allow selection of a better alignment and would allow repair of the slide without incorporating excavation for the west culvert extension which is within the slide mass or having to expose the damaged section below the slide.

- If excavation is required to replace the existing culvert below the slide, a flatter angle might be incorporated which could improve the hydraulic performance of the culvert and may better align it with the downstream channel of McKinney Creek.

- The use of light-weight fill (Expanded Polystyrene EPS blocks or cellular concrete) to re-build the upper portion of the embankment would reduce the weight of the embankment reducing the driving forces on the slide. Assuming a temporary 3 m subcut of the embankment, the lower approximately 2 m could be built up with EPS blocks and capped with 1.2 m of fill and pavement structure. Light-weight fill could be considered if using shear piles to reduce the pile section that would be required to reinforce the embankment. At this time, the logistics of obtaining light-weight fill have not been determined.

- It may be possible to construct a detour on the east side as the culvert extension is nearly complete there. This may be needed during excavation of the slide mass and would avoid having to use the local County roads. It is recommended that truck traffic continue to be routed away from this site. However, it is important to not build the detour fill out over the existing sideslope such that the fill angle becomes steeper than it already is since this might trigger more movements in the east side slope.

Note that the damage observed in the roof of the culvert will need to be assessed by others for structural integrity. AT has recommended against entering the portion of the culvert below the slide mass for safety reasons; however, once the short-term measures have been implemented to slow the slide movement, this should be reviewed as additional measurements to determine if the culvert is continuing to deflect will likely be necessary to assess how much repair or replacement may be required. In addition, sizing of a replacement culvert will need to be done by others.

Once an option is selected, further slope stability work will be required to better define the stages of work and geometry. If piles are used, analyses will be required to assess the required location, size, spacing and depth of embedment which will require input from a structural engineer.

In discussions with the Contractor after the site inspection, a method combining several of the above options arose. This method would involve a deeper subcut of the roadway to perhaps 7 m below original grade such that the traffic could be moved farther east which would simplify excavation of the slide mass on the west side into a single segment rather than multiple segments as proposed above. This method would facilitate installing a new culvert via open-cut and the alignment could be selected so as to utilize the new east extension on a relatively straight alignment. Once the west side has been built back up to about 7 m below the original road level, the traffic detour could be moved to the west to do the east portion of the open-cut installation. This cut would also remove the zone of previous instability identified on the east sideslope which may have been reactivated as well. During reconstruction, the existing culvert could be left in place to handle water and then be grouted off once the new culvert is operational. The Contractor has suggested that excavated material could be hauled away from the landslide area to be used for grade widening elsewhere on the project and this embankment reconstructed using material from the borrow pit(s). From a logistics and scheduling perspective, this method is straight-forward, doesn't involve assessment of the existing culvert structural integrity, won't require a

change from the planned sideslope flattening, and doesn't require extensive slope stability analyses. It is recommended that Thurber be involved with on-site inspection to ensure that the slip surface is fully removed.

4. CLOSURE

We trust this is the information you require at this time. If you have any questions, or if you require further information or recommendations, please contact us at your convenience.

Yours very truly,
Thurber Engineering Ltd.
Don Proudfoot, M.Eng., P. Eng.
Review Principal

Dup

Ken Froese, M. Eng., P. Eng.
Project Engineer
/lg

Attachments:

- Photos (taken September 6, 2017, by Thurber unless noted otherwise)
- Figure 1 – Site Plan
- Figure 2 – Cross-Section
- Drawing 36131-P: Design Drawing by MPA and WSP.

H:\13000\13351 Geohazard Assessment - Peace River\High Level (CON0017602)\Drafting\2017\KEF\Callout - Hwy 688\Callout Figures.dwg - Layout1 - Sep. 11, 2017

SW 22-84-20-W5M

NW 15-84-20-W5M

NE 16-84-20-W5M

SE 21-84-20-W5M

BOTTOM OF BANK

TOP OF BANK

PROVIDE SMOOTH TRANSITION TO EXISTING CHANNEL (TYP BOTH ENDS)

FULL CONCRETE END TREATMENT (U/S END ONLY) REFER TO STANDARD DRAWINGS S-1444-93 AND S-1445-93. SUPPLY AND INSTALL BRIDGE PLAQUE AS PER STANDARD DRAWING S-1424-04. LOCATE PLAQUE CENTERED ON THE FRONT FACE OF THE CONCRETE HEADWALL SEE DETAIL A

SUPPLY AND INSTALL GUARDRAIL FROM STA 25+660 TO 25+915 ALONG EAST SIDE OF HWY AND STA 25+690 TO 25+915 ALONG WEST. EXISTING GUARD RAIL TO BE REMOVED AND DISPOSED OF OR SALVAGED. (SEE HIGHWAY PORTION OF CONTRACT FOR ADDITIONAL DETAILS)

EXCAVATE AS REQUIRED TO REMOVE EXISTING SPCSP BEVEL AND CONCRETE END TREATMENTS. EXTEND 2600 mm CSP LINER 2.0 m PAST EXISTING SPCSP TO PROVIDE A 2.0 m OVERLAP BETWEEN 2600 mm CSP & NEW 3360 mm SPCSP SEE DETAIL Q 3 (TYP BOTH SIDES)

TYPICAL SILT FENCING TO BE PLACED AS NOTED OR AS DETERMINED BY THE CONSULTANT. EXTEND SILT FENCE TO UNDISTURBED VEGETATION (TYP BOTH ENDS)

DITCHLINE IS APPROXIMATE. SEE HIGHWAY PORTION OF CONTRACT FOR EROSION PROTECTION DETAILS (TYP ALL 4 CORNERS)

CONSTRUCT 13.0 m WIDE BENCH AT ELEV 559.90 (TYP BOTH SIDES)

CONSTRUCT 3.0 m WIDE BENCH AT ELE 554.90 (TYP BOTH SIDES)

INSTALL 16° LHF HORZ ELBOW

INSTALL 48° LHF HORZ ELBOW

EXTENSION INSTALLED BUT NOT BACKFILLED

EXCAVATION

STRIPPING WINDROW

STOCKPILE

TEMPORARY CONSTRUCTION ACCESS

STRIPPING STOCKPILE

APPROXIMATE LOCATION OF SLUMP SEEN IN 2013

TOPSOIL STOCKPILE

TENSION CRACKS

INTERMEDIATE BENCHES CONSTRUCTED FOR EXCAVATING SLIDE

POSSIBLE CRACK

TOPSOIL WINDROW

TOE ROLL CRACK

BASE HEAVING

HAUL ROUTE

CULVERT LINER EXTENSION DAMAGED

SUMP

EXTENSION EXCAVATION

CLASS 2 ROCK RIPRAP TO BE PLACED 800 mm THICK (TYP)

PLAN 952 0764

PLAN 822 0433

FUTURE EDGE OF ROAD

EXISTING EDGE OF ROAD

HWY 688

DITCH

ROADWAY WIDTH 12.600

EXISTING R/W 50.000

TH 11-1

TH 11-2

TH 11-3

TH 11-4

BM-3

BM-4

FLOW

5.000

3.400

3.000 (TYP)

6.700

60.000

66.666

25+807

25+757

25+882

25+711

25+728

25+774

25+900

25+850

25+800

25+750

25+700

25+650

0+100

0+080

0+060

NOTE: SITE FEATURES AS OF SEPTEMBER 6, 2017

LEGEND

LANDSLIDE SCARP (SEPTEMBER 1, 2017)

0 10 20 30 40 50 60m

SCALE 1:1000

BASE PLAN AND SURVEY PROVIDED BY WSP

Alberta Transportation

HWY 688 CALLOUT BF72477

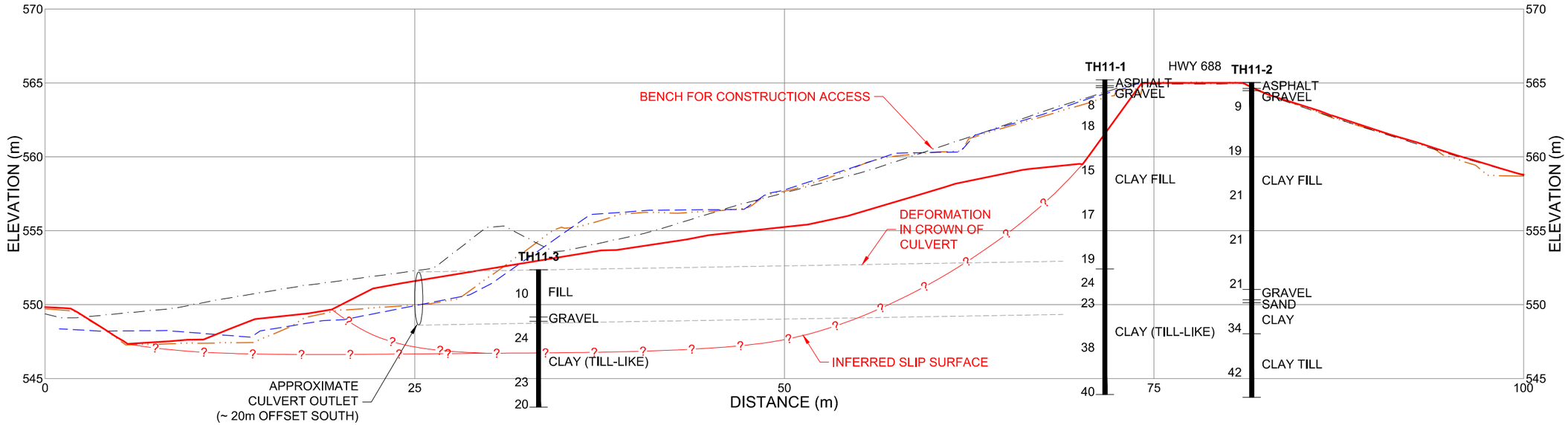
SITE PLAN

FIGURE 1

DRAWN BY	KLW
DESIGNED BY	KEF
APPROVED BY	DWP
SCALE	1:1000
DATE	SEPTEMBER 2017
FILE No.	13351

THURBER ENGINEERING LTD.

SECTION A-A'



LEGEND

- STRIPPED SURFACE
- EXCAVATED SURFACE - AUGUST 24, 2017
- INITIAL SLUMP - SEPTEMBER 1, 2017
- SLUMP - SEPTEMBER 7, 2017

SURVEY PROVIDED BY WSP

Alberta Transportation

HWY 688 CALLOUT BF72477

CROSS-SECTION A-A'

FIGURE 2

DRAWN BY	KLW
DESIGNED BY	KEF
APPROVED BY	DWP
SCALE	1:300
DATE	SEPTEMBER 2017
FILE No.	13351

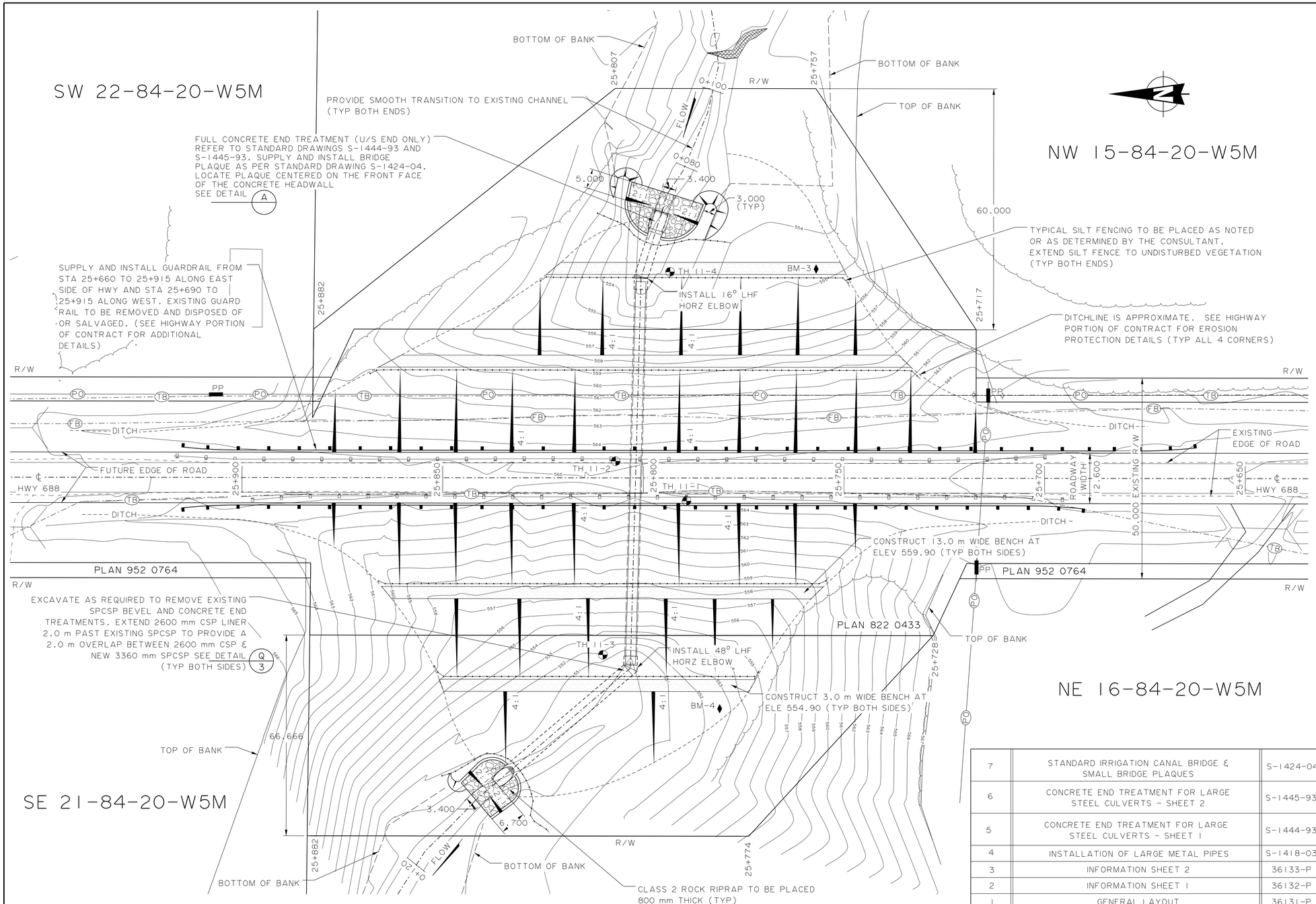
THURBER ENGINEERING LTD.

SW 22-84-20-W5M

NW 15-84-20-W5M

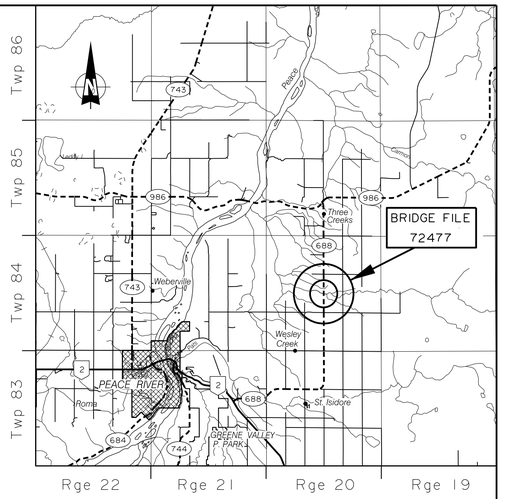
NE 16-84-20-W5M

SE 21-84-20-W5M



SITE PLAN

1 : 500



SITE MAP

1 : 250 000

LEGEND

- 2 — HIGHWAY 1-216
- 614 — HIGHWAY 500-986
- LOCAL ROAD

BENCH MARK

- BM-3, 52.06 m EAST OF HWY ℄ LOCATED AT STA 25+756.99, ELEVATION 555.073
- BM-4, LOCATED 57.44 m WEST OF HWY ℄ AT STA 25+780.91, ELEVATION 553.562

SURVEY BY

- FOCUS CORPORATION, MARCH 2011

HYDROTECHNICAL SUMMARY

- DRAINAGE AREA = 110 km²
- DESIGN DISCHARGE = 25 m³/s (ESTIMATED MAXIMUM INSTANTANEOUS DISCHARGE)
- MEAN VELOCITY THROUGH PROPOSED CULVERT FOR DESIGN DISCHARGE = 2.8 m/s
- AVERAGE SURVEYED STREAM SLOPE = 0.0046 m/m

PROPOSED STRUCTURE

- LINE EXISTING PIPE WITH 2600 mm DIA x 65.0 m INVERT LENGTH CSP AND EXTEND EXISTING CULVERT WITH 3360 mm SPCSP OUTLET EXTENSION x 47.0 m INVERT LENGTH C/W 1-48° HORIZONTAL ELBOW AND WITH 3360 mm SPCSP INLET EXTENSION x 20.0 m INVERT LENGTH C/W 1-16° HORIZONTAL ELBOW
- SPCSP WALL THICKNESS IS 3.0 mm (915 gm/m² GALVANIZED COATING)
- CORRUGATION PROFILE 152 x 51 mm
- CSP WALL THICKNESS IS 3.5 mm (610 gm/m² GALVANIZED COATING)
- CORRUGATION PROFILE 125 x 26 mm
- VOID BETWEEN CSP LINER AND EXISTING CULVERT TO BE FILLED WITH MODIFIED CLASS B CONCRETE WITH 14 mm MAXIMUM AGGREGATE SIZE AND INITIAL SLUMP OF 75 mm
- SUPERPLASTICIZER TO BE ADDED TO CONCRETE PRIOR TO PUMPING TO OBTAIN 200 mm SLUMP
- MAXIMUM GROUTING PRESSURE 55 kPa

GENERAL NOTES

- ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE
- ROADWAY DESIGN STANDARD FOR CULVERT: RAU-211-110
- CULVERT INSTALLATION TO BE IN ACCORDANCE WITH DRAWING NO S-1418-03
- DESIGN SPECIFICATION CAN/CSA-S6-06
- DESIGN LIVE LOAD: CL 800 AB
- SCALES SHOWN ARE CORRECT FOR 22" x 34" SHEET SIZE

INDEX

SHEET	DESCRIPTION	DRAWING
7	STANDARD IRRIGATION CANAL BRIDGE & SMALL BRIDGE PLAQUES	S-1424-04
6	CONCRETE END TREATMENT FOR LARGE STEEL CULVERTS - SHEET 2	S-1445-93
5	CONCRETE END TREATMENT FOR LARGE STEEL CULVERTS - SHEET 1	S-1444-93
4	INSTALLATION OF LARGE METAL PIPES	S-1418-03
3	INFORMATION SHEET 2	36133-P
2	INFORMATION SHEET 1	36132-P
1	GENERAL LAYOUT	36131-P

72477
STRUCTURE 1
1975

BRIDGE PLAQUE

P — 1 REQ'D — NTS

BRIDGE PLAQUE TO BE INSTALLED ON THE FRONT FACE OF U/S HEADWALL. FABRICATE PLAQUE AS PER STANDARD DRAWING S-1424-04

MPA ENGINEERING LTD

WSP

REV	DATE	REVISIONS	BY
6			
5			
4			
3			
2			
1	2015-10-13	ISSUED FOR TENDER	BMC

ORIGINAL PERMIT TO PRACTICE STAMPED AND SIGNED BY: KRISTOPHER BOSTERS OCTOBER 13, 2015

PERMIT NUMBER: P 6432
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

DESIGNER — PROFESSIONAL ENGINEER ALBERTA — ORIGINAL STAMPED AND SIGNED BY: BRIAN M. COTE — DATE 2015-10-13

CHECKER — PROFESSIONAL ENGINEER ALBERTA — ORIGINAL STAMPED AND SIGNED BY: KRISTOPHER BOSTERS — DATE 2015-10-13

Alberta Transportation

MCKINNEY CREEK CULVERT
ON HWY 688, 22 km E OF PEACE RIVER
GENERAL LAYOUT

DEPARTMENT BAR CODE	DATE	STREAM	LOCATION	HIGHWAY	FILE	SHEET	DRAWING
	2012-03-14	MCKINNEY CREEK	NW 15-84-20-5	688:02	72477	1 OF 7	36131-P

Photo 1: Looking south at west slide shortly after movement commenced (by others, Sept. 1, 2017).

Photo 2: Looking south at north edge of cracking shortly after slide initiated (by others, Sept. 1, 2017)

Photo 3: Start of heave in base of culvert extension excavation. Note cracks and leaning grade stake in the foreground (by others, Sept 1, 2017)

Photo 4: Looking south at west slide. Note that there has been excavation and fill placement in the slide bowl in efforts to reduce movement rates.

Photo 5: Looking northeast at west slide. It is recommended that topsoil stockpiles on the north slope be removed.

Photo 6: Looking southeast at west edge of slide.

Photo 7: Looking at basal heave in west culvert extension excavation.

Photo 8: Slickensides on face of scarp.

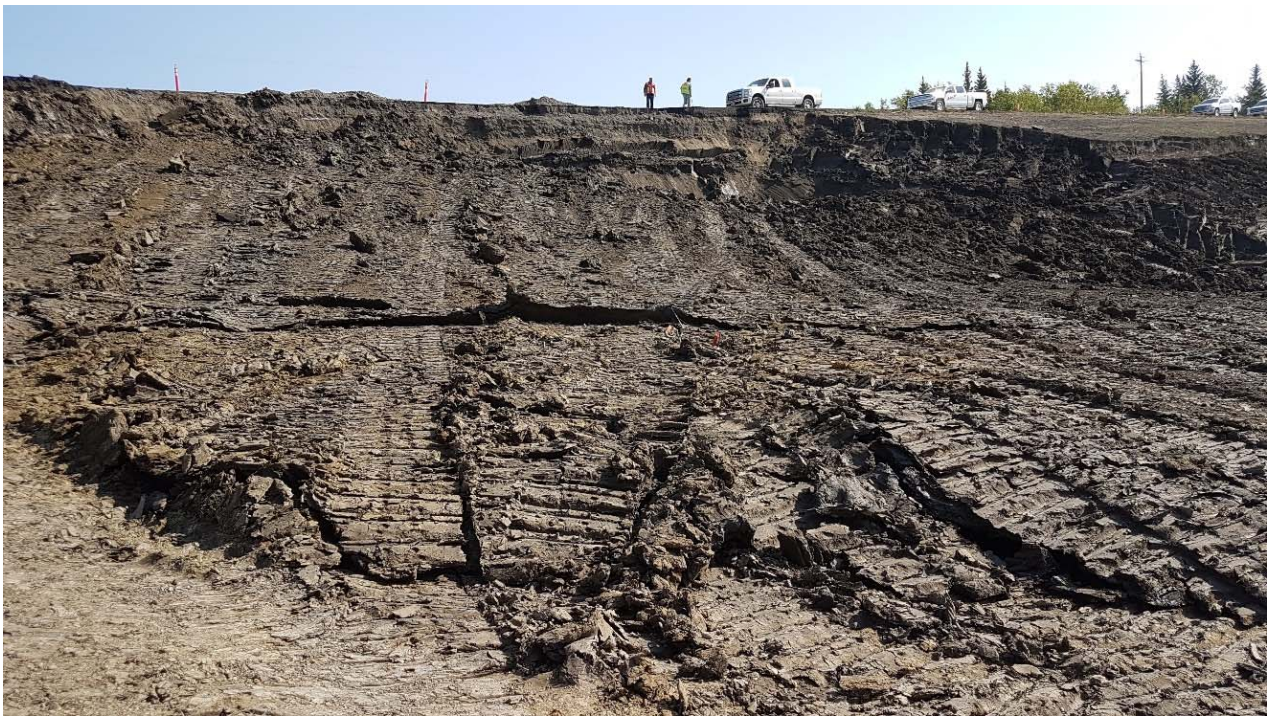


Photo 9: Looking east at toe roll material from upper portion of the slide.

Photo 10: Looking east at deformed liner of the culvert extension.

Photo 11: Deflection in roof of culvert liner approximately 30 m from the current outlet.

Photo 12: Looking southeast at east culvert extension. It was recommended to remove the stockpile of material located south of the excavation.

Photo 13: Looking north at stripped east sideslope above culvert extension excavation.