**ALBERTA TRANSPORTATION**
**GEOHAZARD ASSESSMENT PROGRAM**
**PEACE REGION (PEACE RIVER DISTRICT)**
**2021 INSPECTION**

THURBER ENGINEERING LTD.

| Site Number | Location | Name | Hwy | km |
|---|---|---|---|---|
| SH016-1 | Little Smoky River | West Bridge Abutment | 49:12 | 1.90 |
| **Legal Description** | | **UTM Co-ordinates** | | |
| NE33-74-21-W5M | | 11U E 489,573 | N 6,145,499 | |

| | Date | PF | CF | Total |
|---|---|---|---|---|
| **Previous Inspection:** | 2-Jun-2020 | 14 | 6 | 84 |
| **Current Inspection:** | 28-Jun-2021 | 14 | 6 | 84 |
| **Road AADT:** | 1290 | | **Year:** | 2020 |
| **Inspected By:** | Rocky Wang, TRANS<br>Ed Szmata, TRANS<br>Max Shannon, TRANS<br>Chase Milligen, TRANS | | Barry Meays, Thurber<br>Mark Gallego, Thurber | |
| **Report Attachments:** | ☑ Photographs<br>☑ Plans | | ☐ Maintenance Items | |

| | |
|---|---|
| **Primary Site Issue:** | West abutment of bridge is located on toe of deep-seated landslide as well as affected by local bank slumping from river erosion. |
| **Dimensions:** | The west abutment and west-most pier (Pier 1) are affected by landslide movement as well as some minor pavement distortion extending about 100 m further west.<br>The width of the scarp of the local slump at the river edge adjacent to Pier 2, estimated from LiDAR, is 60 m. |
| **Date of Remediation:** | 1999: Geotechnical investigation by Thurber including SI99-1 through SI99-5 installation.<br>2000: Pier 1 wing walls installed.<br>2017: Slump and erosion above Pier 2 repaired with stone columns, granular fill, and riprap. |
| **Maintenance:** | 2015: Bridge superstructure painted<br>2019: Pier 1 adjusted with new shims and slider plates<br>Fall 2020: Pavement overlay and guardrail replacement |

| Observations: | Description | Worsened? |
|---|---|---|
| ☑ Pavement Distress | Sag in pavement profile just west of the bridge abutment. | ☐ |
| ☑ Slope Movement | There is overall slope movement although the localized failure at Pier 2 has been repaired. | ☑ |
| ☑ Erosion | Ongoing erosion of valley toe at river's edge (repaired 2017) – south end over steepened and north end displaced.<br>Erosion gullies forming on south side of West Abutment, Abutment #1, and Pier #1 | ☑ |
| ☑ Seepage | Seepage below Pier 1 from drainage pipe. | ☐ |
| ☑ Bridge/Culvert Distress | The West Abutment, Abutment #1, and Pier 1 are routinely adjusted to compensate for ongoing slope movement. | ☑ |
| ☐ Other | | ☐ |

**Instrumentation:**

| | |
|---|---|
| Damaged/ Destroyed | SP-2B (Fall 2014). SP-3C (Fall 2015), TH99-1 through TH99-5 (SI, PN, PZ) |

**Assessment:**

The overall valley slope is moving as several separate slide blocks resulting in numerous scarps, sag ponds, and differential movement zones all coalescing on a common base failure plane in the base of a disturbed clay shale unit immediately above an underlying gravel layer. This gravel layer daylights in the river immediately upslope of Pier #2.

Based on GPS survey of the inSAR points conducted by Alberta Geological Survey (AGS Open Report 2013-14), the west abutment of the bridge is situated on a faster-moving block (greater than 90 mm per year) compared to the rest of the west slope which is moving at 5 mm to 40 mm per year. Figure 1 shows a high-level view of the LiDAR (flown in 2008 and provided by Alberta Transportation) for the overall west slope where slide scarps and sag pond features can be readily identified.

Information on the relative deformations between Abutment #1 and Pier #1 indicate that Pier #1 is likely situated on or near the intersection of two different blocks. The deformation at Pier #1 is further complicated by the presence of additional, near-surface movements (likely creep) zones in the upper 4 m. The dominant driving mechanism appears to be toe erosion due to lateral migration of the Little Smoky River; correlation with precipitation levels and stability analyses indicate that a high ground water table may also be contributing.

The West Abutment, Abutment 1, and Pier 1 were designed to compensate for movement of the landslide and foundation below the bridge. The West Abutment compensation is done by adjusting the location of the west half of the finger joints along with adjustment of the length of the approach slab by removing steel I-beams (see photos). Since 2000, three of the five beams have been removed with the fourth likely to be taking out in the next couple of years. As each beam is approximately 368 mm in width, there has been 1104 mm of horizontal displacement in 20 years for an annualized rate of 55 mm/year. Based on measurements between the bridge deck and wingwall, there has been 220 mm of displacement in the last three years which is 73 mm/year.

Abutment 1 teflon bearing pads move laterally over stainless-steel slide plates and are adjusted vertically using shim plates above the bearing pads, and like Pier 1, require frequent adjustment. When additional shim plates are added, the contractor also jacks the bridge transversely to correct the alignment. Measurements taken at the south-most bearing pad indicate 110 mm of movement between October 28, 2020, and May 29, 2021 for an annualized rate of 264 mm per year.

Pier 1 has a similar bearing pad and slide plate arrangements and, in June 2019, new shims and slider plates (to extend the distance the bearing pads can travel) were installed by Ardy Rigging. There is currently 0.84 m of shim between the foundation and the pier. The height of shims was 0.62 m in 2018 and 0.75 m in 2019 giving approximate annual settlements of 130 mm between 2018 and 2019 and 80 mm between 2019 and 2020. Since 1958, there has been 2.97 m of vertical settlement at this pier (approximately 48 mm/year average). Comparing current bolt holes in use on the wingwall with the ones that appear to have been used in the past, there has also been 1.18 m of horizontal movement since the wingwalls were installed in 2000 (74 mm per year). Previous measurements of marks on the slider plates estimated movement annual movement rates of 96 mm in 2016 and 89 mm in 2018. New slider plates were installed during the inspection in 2019. As of October 28, 2020, there had been 220 mm of displacement since June 16, 2019 (160 mm/year), 185 mm since May 29, 2020 (444 mm per year), and 110 mm since June 2, 2020 (271 mm per year). The Pier 1 foundation had a maximum cross-slope angle of 5°.

Dave Morrison, Bridge Technologist, AT, inspected the western portion of the bridge on April 29, 2020. His measurements, as compared to the previous ones made June 10, 2019 (324 days earlier) indicate that:

- Abutment #1 moved 5-6 mm south and 24-43 mm east (relative to the bridge)

- Relative to the south bearing pad of the bridge, the Pier #1 foundation moved 3 mm north and 39 mm east but relative to the north bearing pad, the foundation moved 4 mm north and 40 mm east. Unlike the previous year, the bearing pads are not being “pushed” together.
- The concrete foundation at Pier 1 tilts between 0.80° and 2.45° downward toward east (along the fall of the slope) which is an average increase in the dip angle of 0.15° from 2019 and 0.25° and 0.55° south.
- Steel guardrail posts are continuing to twist (inclined between 4° to 5° upslope and spacers are starting to shift. Potholes and cracking are forming immediately west of the finger joints.
- The vertical members above Pier #1 have an average lean about 0.6° which, combined with tilting of the concrete foundation, may indicate stress buildup in the structure.
- Despite some jacking in 2019, he estimates that the West Abutment is still out of alignment by 200 mm transversely (to the south) and Abutment 1 by 80 mm which will require a major rehabilitation to move.

The cracking and accelerating movements and tilting observed in the concrete foundation at Pier 1 might be related to a change in foundation support conditions. The older downstream part of the foundation was supported on deep reaching steel piles; however, the landslide has moved the foundation to the transition point with the south part of the concrete slab which has no piles. The change in loading condition might be causing the slab to tilt and the side walls to crack.

Ongoing river erosion had caused a localized slump between Piers 1 and 2. The slumped material was impacting against the west side of Pier 2 where ongoing river erosion kept the slide active. A repair of this slump was undertaken by AMEC in 2017 which involved the installation of stone columns, a subdrainage system, and riprap slope protection. The potted willows shown at the toe of the slope on the drawings have died. Future observations will be required to determine if the repair is effective; however, this will likely have only a limited effect on the overall valley movements. River erosion has over steepened the south section of the riprap apron resulting in the loss of some material which worsened in 2020. This was also observed in 2021. At the lower water levels in October 2020, it was also noted that there is some erosion and slumping cutting into the apron north (downstream) of the bridge.

**Recommendations:**

**Short-Term:**

- Routine assessment of the bridge should be undertaken such that adjustments can be made when required (it is understood that AT’s Bridge Branch is routinely inspecting this structure). Should cracking form on the highway to the west of the abutment, crack sealing should be undertaken to minimize water infiltration.
- Milling and patching of the pavement surface at the west end of the bridge should be carried out on a periodic basis as required to maintain a safe riding surface.
- Annual GeoHazard Inspection should observe the south end of the riprap apron as there is the potential for loss of further material.

**Medium Term:**

Carry out repairs to Pier 1 to deal with the accelerated movements and tilting that have been observed there in recent years.

**Long-Term:**

It is understood that the potential realignment options that have been considered for this valley crossing have maintained the same river crossing. Thus, a new bridge at a more-stable location is not currently being considered. It is understood that AMEC’s High Water Related Mitigation Works reports for SH003 and SH004 recommended erosion control at the toe of the slope to limit river erosion which would also benefit this site.

**Ongoing Investigation:**

- It is recommended that the annual GeoHazard inspection should continue as scheduled.
- A geotechnical investigation was carried out at Pier 1 in 2021 (after the annual geohazard site visit) by Thurber on behalf of Most Engineering, who are assessing why the Pier 1 foundation is cracking and designing improved foundation support conditions for the pier. As part of the investigation, new

instruments were installed at Abutment 1 and Pier 1 to investigate the foundation conditions below the Pier 1 foundation slab and to monitor subsurface movements and groundwater levels in the vicinity of the west end of the bridge. The instruments included slope inclinometers wrapped with fibreoptic strands, and vibrating wire piezometers.
- A routine robust and detailed terrestrial survey of points on the bridge and the ground surface would also help track movement rates at a relatively low cost.

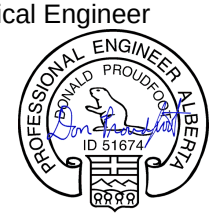
Consideration should be given to re-surveying the InSAR (interferometric synthetic aperture radar) targets, perhaps annually, to supplement the work done by the AGS as this will provide an overall view of ground movements.

## Closure

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

Don Proudfoot, P.Eng.
Principal | Senior Geotechnical Engineer


October 13, 2021




October 13, 2021

**PERMIT TO PRACTICE**
**THURBER ENGINEERING LTD.**
RM SIGNATURE: Don Proudfoot
RM APEGA ID #: 51674
DATE: October 13, 2021
**PERMIT NUMBER: P005186**
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Mark Gallego, P.Eng.
Geotechnical Engineer

THURBER

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This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

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All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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## 5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

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Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

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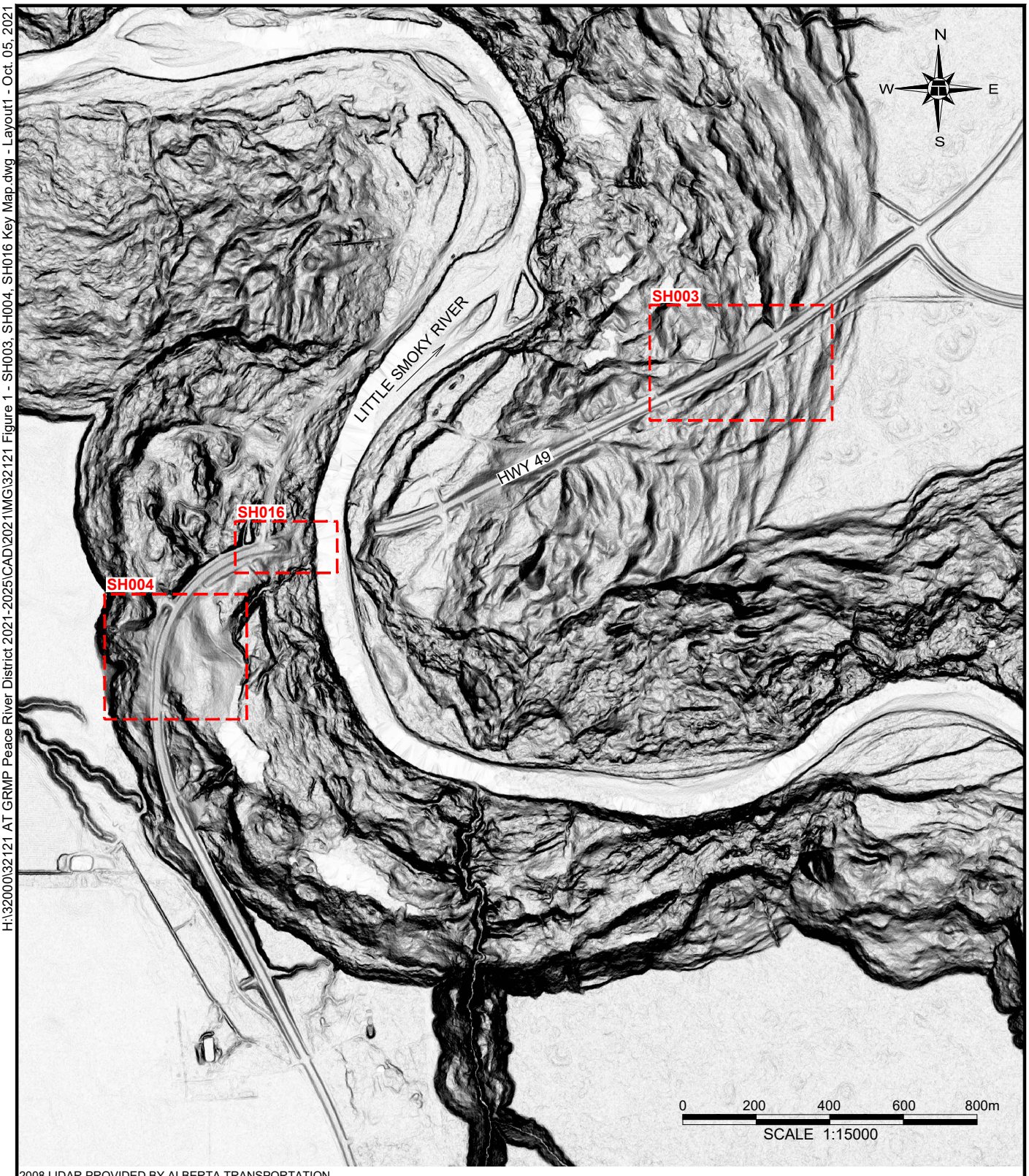
H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2021\MG\32121 Figure 1 - SH003, SH004, SH016 Key Map.dwg - Layout1 - Oct. 05, 2021




2008 LIDAR PROVIDED BY ALBERTA TRANSPORTATION.

**PEACE REGION (PEACE RIVER DISTRICT)**

**SH003-1, SH004-1, SH016-1 KEY MAP**

**FIGURE 1**

| | |
|---|---|
| DRAWN BY | KLW |
| DESIGNED BY | MG |
| APPROVED BY | DWP |
| SCALE | 1:15000 |
| DATE | OCTOBER 2021 |
| FILE No. | 32121 |

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H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2021\MG\32121 SH016-1.dwg - 1 - Oct. 05, 2021

~50m FURTHER: SEEPAGE ~2 OR 3m ABOVE RIVER LEVEL

HIGHWAY RIGHT OF WAY BOUNDARY IS 91 m FROM THE HIGHWAY CENTERLINE (OUTSIDE OF DRAWING LIMITS)

INTERMEDIATE SCARP

INFERRED SCARP (FROM LIDAR 09/2008 AND VISUAL RECONNAISSANCE)

TELUS FIBER OPTIC CABLE (SURVEYED NOVEMBER 2016) (NEW LINE HANGING ON BRIDGE)

TREE LINE

OVERSTEEPENED

PONDING WATER

EDGE OF WATER (LIDAR 09/2008) EL 479.5 m

100 mm DIA NON-PERFORATED HDPE PIPE

200 mm DIA CORRUGATED STEEL OUTLET PIPE (NO FLOW) 2019-2020

SOME FRESHNESS

ORDINARY HIGH WATER LEVEL (1:2 YEAR) EL 480.9 m (LIMIT OF WORKING AREA)

DISPLACED RIPRAP

STONE COLUMNS BACKFILLED WITH 40 mm AGGREGATE IN 2 LIFTS WITH VIBRATORY PROBE COMPACTION

LIMIT OF WORKING AREA / EXTENT OF 2017 PROJECT

100 mm DIA PERFORATED HDPE PIPE

DIAGONAL CRACKING ON SIDE OF FOUNDATION
- WIDER CRACKS 20-30°
- NARROWER 30-35°

2018-2021:TREE DEBRIS

MAIN SCARP (FIELD MAPPING)

POSSIBLE SCARP AND/OR DEEP RUTTING

EROSION UNDERMINING OLD PORTION OF ABUTMENT #1

SOIL ACCUMULATION

PILE SUPPORTED

SLAB-ON-GRADE

SPLASH PAD

WEST ABUTMENT

MORE MOVEMENT IN ABUTMENT FOOTING

ABUTMENT

GULLY 0.2m WIDE AND 0.3m DEEP

BRIDGE ℄

PIER 1

PIER 2

TO GUY

A

A'

200 mm DIA CORRUGATED STEEL OUTLET PIPE

100 mm DIA NON-PERFORATED HDPE PIPE (INSIDE 200mm DIA STEEL PIPE)

200 mm DIA CORRUGATED STEEL OUTLET PIPE; NO SIGN IT EVER HAD FLOW

100 mm DIA NON-PERFORATED HDPE PIPE

HWY 49:12

TO VALLEYVIEW

OUTLET OF GROUND WATER WEEPING TILE (IN THE WEST-EAST DIRECTION); SLIGHTLY CRACKED, SLOW TRICKLE

SI

TH99-1

TH99-2

TH99-3

TH99-4

TH99-5

CP2

2018:WET

SMALL EROSION GULLY

GULLY 0.4m DEEP

SWALE; 0.6 m DEEP, ECSC TYPE B OVER SEEDED TOPSOIL

2019-2021:WET ZONE

RIVER EROSION HAS OVERSTEEPENED TO 40°, ABOUT 2m HIGH

HIGH WATER LEVEL (1:100 YEAR) EL 483.4 m

INTERMEDIATE SCARP

LITTLE SMOKY RIVER

POTTED WILLOW; ALL DEAD

RIPRAP A BIT STEEPER

EROSION GULLIES UNDER COMPOST SOCK; 2020: SOCK HAS DISINTEGRATED

100 mm DIA PERFORATED HDPE PIPE

TREE LINE

3 ROWS STONE COLUMNS 5.2-5.6 m DEEP

1 ROW STONE COLUMNS 3.8 m DEEP

HEAVY ROCK RIPRAP CLASS 2

SCARPS CONTINUE DOWN BANK - ALL HAD FRESH MOVEMENT

1. SOUTH GIRDER RIDING ON OLD WEST ABUTMENT FOUNDATION ELEMENT

2. SMALL EROSION GULLY

3. MORE MOVEMENT IN ABUTMENT FOOTING

4. OUTLET OF GROUND WATER WEEPING TILE (IN THE WEST-EAST DIRECTION); SLIGHTLY CRACKED, SLOW TRICKLE

5. GULLY 0.2m WIDE AND 0.3m DEEP

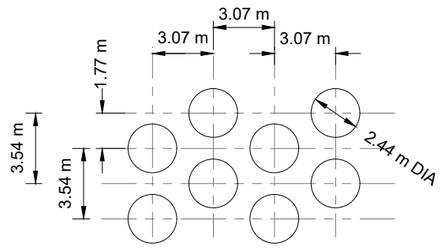
6. POSSIBLE SCARP AND/OR DEEP RUTTING

7. SPLASH PAD

8. 100 mm DIA NON-PERFORATED HDPE PIPE

9. 200 mm DIA CORRUGATED STEEL OUTLET PIPE; NO SIGN IT EVER HAD FLOW

10. HIGH WATER LEVEL (1:100 YEAR) EL 483.4 m




**TYPICAL DETAIL OF STONE COLUMN SPACING**

SCALE 1:300

LEGEND

- 1999 BOREHOLE
- PHOTO LOCATION AND DIRECTION

NOTES

1. JUNE 2021 OBSERVATIONS SHOWN IN RED.

0 5 10 15 20 25 30m

SCALE 1:500

BASE PLAN PROVIDED BY AMEC FOSTER WHEELER

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**PEACE REGION (PEACE RIVER DISTRICT)**

**SH016: HWY 49:12 LITTLE SMOKY RIVER 2021 SITE INSPECTION PLAN**

**DWG No. 32121-SH016-1-1**

| | |
|---|---|
| DRAWN BY | KLW |
| DESIGNED BY | MG |
| APPROVED BY | DWP |
| SCALE | 1:500 |
| DATE | OCTOBER 2021 |
| FILE No. | 32121 |

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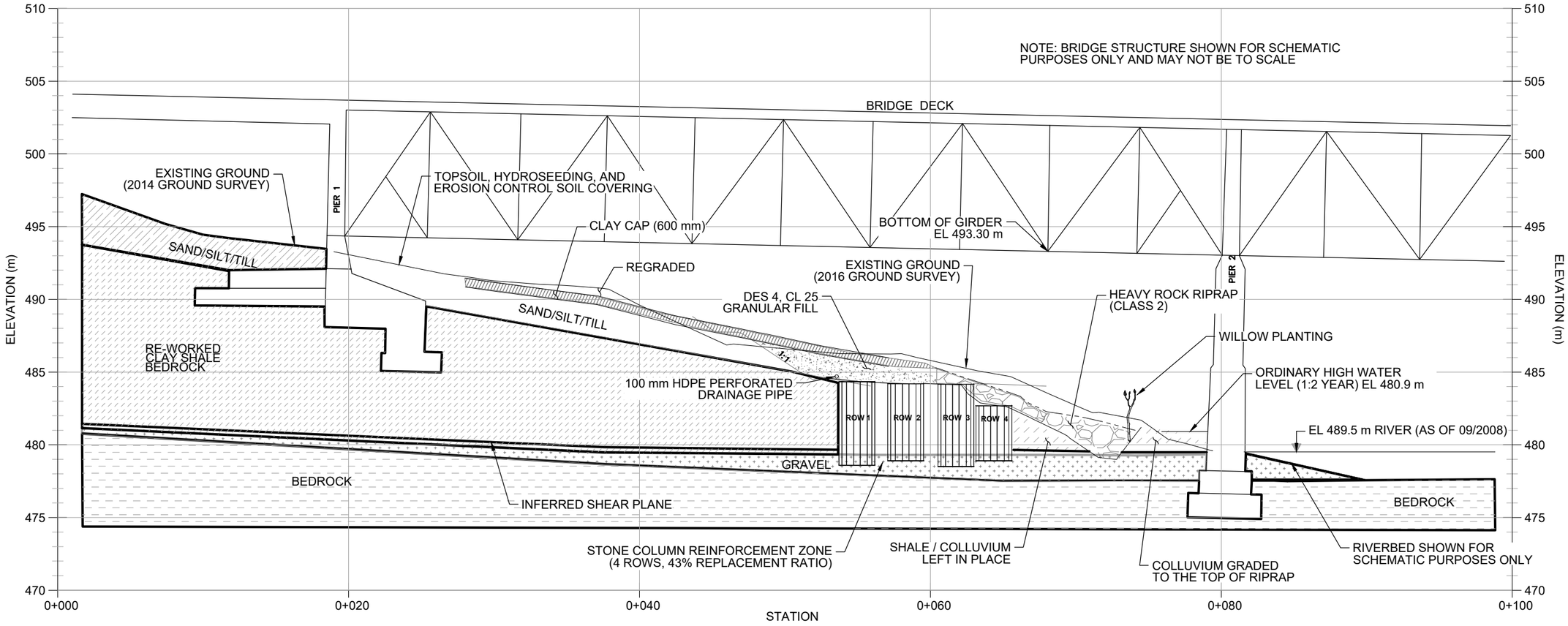


BASE PLAN PROVIDED BY AMEC FOSTER WHEELER

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**PEACE REGION (PEACE RIVER DISTRICT)**

**SH016: HWY 49:12 LITTLE SMOKY RIVER**
**DESIGN CROSS-SECTION A-A'**

**DWG No. 32121-SH016-1-2**

| | |
|---|---|
| DRAWN BY | KLW |
| DESIGNED BY | KEF |
| APPROVED BY | DWP |
| SCALE | 1:300 |
| LAST UPDATED | OCTOBER 2021 |
| FILE No. | 32121 |

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Photo 1 – Looking north at paved surface at the abutment expansion joint where cracks were previously observed


Photo 2 – Looking north at west bridge abutment. The two I-beams at the edge of the wingwall are the remainder of the 5 installed in 2000.

Photo 3 – Void on northeast corner of Abutment #1 exposing rusting H-pile.

Photo 4: Sliding configuration at abutment.

Photo 5 – Shims under rocker bearings at Pier 1.

Photo 6 – Looking south at Pier 1 wingwall at arc-shaped crack pattern in foundation. Left-hand portion of foundation is pile supported; right-hand is on-grade.

Photo 7 – Looking west at Pier 1 foundation which is tilted downward to the south.

Photo 8 – Looking north at accumulated tree debris against Pier 2.

Photo 9 – Looking south at erosion along toe of riprap and riverbank.

Photo 10: Oversteepening of riprap south of Pier 2.