

December 2013

CG25399

Alberta Transportation
2nd Floor, 803 Manning Road NE
Calgary, AB T2E 7M8

Attention: Mr. Ross Dickson

Dear Ross:

**Re: Southern Region Geohazard Assessment
2013 Annual Inspection Report
Site S40: Highway 848:02, Dorothy Sinkholes**

This report documents the 2013 annual site inspection of Site S40 – Dorothy Sinkholes, on Highway 848:02, approximately 1.4 km west of Dorothy, Alberta, along Highway 848, 1.2 km southwest of the junction of Highway 848 and Highway 570, southwest of the Red Deer River. This segment of Highway 848 is a gravel, two lane undivided roadway at a hairpin turn segment of a switchback that winds up through a tributary valley draining towards the Red Deer River. Various sections of the road have been undermined by sub-surface erosion as a result of the highly erodible soils and water flow throughout the site.

AMEC Environment & Infrastructure (AMEC), a division of AMEC Americas Limited, performed this inspection in partial fulfilment of the scope of work for the supply of geotechnical services for Alberta Transportation's (AT's) Southern Region (AT contract CON0013506).

The site inspection was performed by Bryan Bale, P.Eng., Hugh Wang, P.Eng., and Tyler Clay, E.I.T., of AMEC; and Roger Skirrow, P.Eng., and Ross Dickson of AT during the May 2013 Annual Tour.

1.0 SUMMARY

The number and extent of sinkholes and other erosion features near the highway has increased since the 2012 inspection. The risk factor increased from 72 to 80 as a result. Several sinkholes encroached to the edge of the highway and erosion tunnels appeared to exist under the road. There is high risk that these areas could cause the highway to become unstable or collapse. The erosion seems to be primarily driven by groundwater movement and piping. AMEC's 2011 short-term recommendations including installation of signs; repair of sinkholes with specified fill; and general management and maintenance of surface water controls remains valid. Long-term options may include excavation and replacement, spanning void locations and construction of an interceptor ditch to reduce groundwater flow through areas highly susceptible to erosion. Investigation of soil and water conditions at the site would be required to design any effective mitigation. The site should be inspected during the 2014 annual tour.

2.0 BACKGROUND

A general description of the geohazard conditions at this site is provided in the call-out report¹ from AMEC's November 21, 2011 inspection of the site. The inspection was requested by AT after the Maintenance Contract Inspector (MCI) reported that several sinkholes developed in the road surface. AMEC understands that the November 2011 inspection was the first as part of the Geohazard Monitoring Program, and that no repairs were implemented at the site aside from ongoing maintenance by the MCI. The site was inspected in 2012 during the Annual Tour.

A general site layout with the relative location of the highway to the surface drainage and sinkhole features is shown on Figure S40-1.

3.0 SITE OBSERVATIONS

Key observations of the site conditions from the May 2013 inspection are summarized as follows, and illustrated on Figure S40-1 and Photos S40-1 to S40-3:

- During the 2012 site inspection, approximately 17 sinkholes or erosion features were identified within approximately 50 m of the road (shown on Figure S40-1). During the 2013 inspection, 7 additional features were identified. The largest erosion features were up to 6 m wide and 4 m deep and some appeared to be connected by subsurface erosion tunnels. All significant sinkholes that were found were measured and their positions were recorded via handheld GPS. Refer to Table 1 for a comparison of the sinkhole dimensions from the 2013 inspection and dimensions of the new sinkholes or erosion features. The majority of the sinkholes had widened at the surface and decreased in depth or had not significantly changed since the 2012 inspection. No sinkholes or other damage to the road surface was observed.
- The sinkhole near the road edge, marked at WPT 99 on Figure S40-1, appeared to have an erosion tunnel connected that ran beneath the road surface.
- A new, recent sinkhole collapse area was observed south of the road at WPT 60. Refer to Photo S40-1.
- The sinkhole in the road shoulder (marked at WPT 100 on Figure S40-1) had been partially filled in from what appeared to be grading work.
- The sinkhole marked at WPT 105 on Figure S40-1 had expanded into the road shoulder, creating an exposed vertical soil face that extended over 3 m below the road surface. A tunnel appeared to run beneath the road and connect to a sinkhole above the road. Refer to Photo S40-2.

¹ AMEC Environment & Infrastructure, *Southern Region Geohazard Assessment Program, Site S40 – Highway 848 – Dorothy Sinkholes Site – Report on November 21, 2011 Site Inspection*, CG25352.400, April 12, 2012.

- An erosion gully up to 500 mm deep and approximately 100 to 200 m long was found at the east end of the site, within the south road ditch. Refer to Figure S40-1 and Photo S40-3.
- No major changes were noted at the two culvert outlets. During the 2011 callout inspection, one of the culvert outlets was observed to be broken. Significant soil erosion around the culvert outlets was also observed. The culvert inlet locations could not be confirmed during the inspections, but one possible culvert inlet is shown on Figure S40-1.

4.0 ASSESSMENT

The erosion features at the site generally expanded in size and extent compared to the previous inspections. There are numerous voids near the road and voids with subsurface tunnels that may create a hazard to the road. The number of erosion features near the roadway has increased since 2012, either due to the more intensive search that was performed in 2013 or continued erosion since 2012.

The erosion features are caused by groundwater flow, likely worsened by poorly controlled surface water run-off. High pressure gradients at the seepage discharge locations near the ravine leads to piping of the dispersive soil. The formation of these voids may be sudden following precipitation events or periods of high groundwater flow. Subsurface investigation to identify these voids would provide little benefit because the voids would likely form again, rendering the investigation obsolete.

Mitigation work involving control of surface water would likely be beneficial. Construction of lined ditches with discharge outlets would minimize the contribution of surface water entering and eroding the subsurface soils. A deep trench drain to intercept groundwater flow could also be considered. Regardless of mitigation work, it will likely not be practical to remove all risk at the site since the soils are highly susceptible to continued void formation.

Please refer to the November 2011 call-out report for additional assessment of the site conditions.

5.0 RISK LEVEL

AMEC recommends the following Risk Level for this site, based on AT's general geohazard risk matrix:

- Probability Factor of 10 based on the numerous active sinkhole formations in the area and apparent increase of the extent and number of erosion features found near and below the roadway.
- Consequence Factor of 8, reflecting the fact that the sinkholes form with little warning, could potentially be large enough to cause damage to vehicles or injuries and warrant a road closure and detour pending repair of the sinkhole(s).

Therefore, the recommended Risk Level is 80. This is increased from the Risk Level of 72 assigned during the 2012 Annual Inspection due to the increase in the number and extent of apparently active erosion features observed near and beneath the roadway.

6.0 RECOMMENDATIONS

6.1 Maintenance and Short Term Measures

The short term recommendations for this site are summarized as follows:

- Sinkholes that develop in or near the road surface should be backfilled with dirty gravels (fines $\geq 20\%$). A gravel fill stockpile on site could help ensure timely repairs.
- Clean gravels should not be used as backfill since this may create preferential pathways.
- Maintenance crews should inspect the site daily and keep records of any sinkhole formations in the road.
- Warning signs and reduced speed limit signs should be placed at the site.
- Surface water throughout the site should be managed and infiltration limited by means of impermeable ditch liners and culvert maintenance (keeping open inlets and preventing additional erosion at the outlets).

Please refer to the November 2011 call-out report for further detail on the short-term recommendations and maintenance.

6.2 Long Term Measures

The long term recommendations for this site are summarized as follows:

- Potential repair options could include altering the groundwater flow at the site away from the roadway by constructing an interceptor ditch, excavation of erodible soils and rebuilding with erosion-resistant fill or constructing pile supported slabs to span known void locations. An investigation of the soil and water conditions at the site would be required to determine the viability of this option and the effective construction location.
- Further study to determine site conditions could include a geophysical survey and subsurface investigation for correlation. Mapping void locations by subsurface investigation is likely not practical as they form rapidly.

Please refer to the November 2011 call-out report for further detail on long-term measures.

7.0 CLOSURE

This report has been prepared for the exclusive use of Alberta Transportation for the specific project described herein. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. AMEC Environment & Infrastructure, a division of AMEC Americas Limited, cannot accept responsibility for such damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report has been prepared in accordance with accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

We trust that this meets your needs at this time. Please contact the undersigned if you have any questions or require any further information.

Respectfully Submitted,

**AMEC Environment & Infrastructure,
a division of AMEC Americas Limited**



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APEGA Permit to Practice No. P-04546

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