17 June 2015
ET120054

County of St. Paul
ldemoissac@county.stpaul.ab.ca

Attention: Mr. Leo deMoissac

Dear Sir,

Re: Moosehills Road Grade Failure - Scope and Cost Estimate for Engineering Services

Further to our instrumentation readings on 24 April 2015 and the subsequent visit to the site on 21 May 2015, AMEC Foster Wheeler Environment and Infrastructure ("Amec Foster Wheeler") is pleased to submit this proposal to provide an updated engineering evaluation of the site conditions and cause of the road grade failure, and preliminary assessment of remediation alternatives for repair of the subject road. Presented below are relevant project background information, recent findings, a proposed scope of work, and a cost estimate and proposed schedule.

1.0 BACKGROUND

The site is located in SE 28-75-6-W4M and is about 6 km northeast of the Town of Elk Point, Alberta. The roadway (Twp. Road 574A) is along a hill side and the failed section of the roadway is situated along a portion of the road near the north end of Moosehills Lake. The road was upgraded from a gravel road to an asphalt covered road in 2000. The upgrade included raising the vertical grade up to 4 m and construction of an embankment. The embankment height of the current road in the failure area is in the range of 4 to 6 m.

The grade failure was first reported to AMEC in August 2011, when it was indicated that a crack with an approximately 150 mm drop in surface grade had developed within the roadway over a weekend. After re-paving the road in the failed section, a further drop in road grade by

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approximately 100 mm developed within 1 week of the initial reported failure along the same section.

1.1 SUMMARY OF 2012 ASSESSMENT

A preliminary assessment was performed by Amec Foster Wheeler (formerly AMEC Earth and Environmental) in 2011/2012. The assessment included two site visits between August 2011 and May 2012, a drilling and instrument program in October 2011, and instrumentation readings in late 2011 and April 2012. A draft Geotechnical Evaluation was submitted to the Country of St. Paul on 18 May 2012 that summarized observations and instrument measurements at that time and provided some remedial options for consideration. A brief summary of the work conducted, key findings, and recommendations from the 2012 assessment are provided below.

- Additional propagation of the cracking in the roadway surface and drop in grade was observed in the months following the initial observation by the County. The road cracking and drop in grade in the main slide area measured approximately 130 m in length.
- A total of 5 boreholes were advanced in the immediate vicinity of the main slide area, within the upslope ditch and on the downslope embankment. The main slide area is shown in Figure 1. Three pneumatic piezometers and three slotted piezometers were installed to measure groundwater levels. Two slope inclinometers were also installed (shown in Figure 1).
- At the time of the assessment in 2012, instrument readings had been obtained on two occasions - 9 November 2011 and 24 April 2012. There were no obvious movement zones noted during this time. Piezometers indicated generally low groundwater conditions, ranging from 2-3 below ground surface (b.g.s.) on the upslope side of the road, and 7 to 10 m b.g.s. on the downslope side beneath the embankment.
- It was postulated that the cracking and drop of grade was related to movement occurring within the roadway embankment and through the weaker fill and a buried organic layer at depth. The overall valley was identified as landslide terrain from historical air photos, and while not confirmed, it was noted that there was also the possibility that the overall slope is marginally stable, and creep-like movement may be occurring at a greater depth, within clay shale or at the surface of the clay shale and clay till interface.
- Stabilization alternatives were presented to the County for review and were based on postulation of a local movement mechanism within the failed embankment and through the buried organic layer, and included the following:
    - Lowering the grade of the existing road by 1.3 m, including some flattening of the embankment slope
    - Replacing soils at the toe of the embankment and installing a shear key with a small toe berm
    - Placement of a toe berm/buttress over the existing embankment
- It was also recommended that additional assessment be conducted prior to finalizing a preferred design, including: additional sub-surface investigation, additional instrument measurements, and a detailed topographic survey.

- Feedback was not received from the County following the preliminary assessment.

1.2 RECENT OBSERVATIONS

In spring 2015, Amec Foster Wheeler was contacted by the County to perform additional instrument readings at the site. Readings at piezometers and slope inclinometers were obtained on 21 April 2015. Key findings from the instrument readings are summarized below:

- Groundwater levels at the main slide area were significantly higher than previous readings in 2012. On the upslope side of the road, levels were 1 to 2 m higher. On the down slope side of the road, levels were up to 7 m higher in the foundation below the embankment and approximately 1-2 m higher within the embankment fills.
- The downslope inclinometer was found to be pinched at a depth of 8.5 m, within clay till, approximately 4 m below the base of the embankment fills. The inclinometer probe could not be lowered below this depth and a total deformation could not be calculated. Readings at the upslope inclinometer indicated no significant movement to the 14.1 m installation depth.

At the request of the County an additional site visit was performed on 21 May 2015 to observe new road deformation and discuss a path forward. It was reported that the road had dropped an additional 150 mm in the weeks following the instrument reading and that the area had been re-paved shortly after. Observations during the site visit indicated that an additional 50-100 mm of grade drop had occurred since re-paving.

The extent of cracking on the road was mapped with a hand-held GPS during the site visit and is shown in Figure 1. The extent of the main slide area was found to be similar to that reported in 2012, however additional cracking not reported in 2012 was identified on the road up to 170 m south-east from the main slide. Based on these observations, the total length of affected roadway is estimated at approximately 350 m. Some of the cracks extended downslope on the embankment. There were no obvious signs of toe bulging at the toe of the embankment.

The ground conditions in the forested slopes below the embankment were observed during the site visit. It was noted that the topography was benched with steep rounded slopes between benches, which is suggestive of landslide topography. However there were no obvious signs of recent slope distress (i.e. leaning trees, bare earth, cracks, seepage, etc.).

Following the site visit, aerial survey data (LIDAR) was obtained with approval from the County. A brief review of the data indicated that the site is located on the periphery of large historical landslide along the east slope of the valley. Several headscarps were noted passing above the site, and several possible toe bulges were noted downslope and parallel to the road. Based on the updated preliminary assessment, the roadway distress is likely associated with one or more of the relict landslide features identified in the LIDAR data. Detailed findings will be included in the engineering report for the proposed work, discussed below.

2.0 PROJECT RATIONALE AND PROPOSED SCOPE OF WORK

The recent instrument readings (discussed above) along with the detailed topographic survey of the area provided by LiDAR suggest that the slide mechanism at the site is deep-seated, rather than a local embankment instability as assumed in the 2012 assessment which was based on limited information. Recent observations also indicate the affected area is larger than documented in 2012 and further supports a deep-seated sliding mechanism. These new findings suggest that the ongoing road grade failures may be associated with shear planes that developed during historical landslide activity along the east slopes of the valley.

The depth of movement below the embankment has been partially confirmed by the single down-slope inclinometer, however the characteristics (depth, extent and rate) of the sub-surface deformation further downslope from the main slide area, and below the cracking further SE along the road, have not been confirmed.

With the exception of the road grade lowering, it is reasoned that the remedial measures proposed in the 2012 assessment may not be appropriate as they were developed based on a local slide mechanism within the embankment. A revised assessment is proposed to evaluate the landslide mechanism, depth, and extent, and to develop alternative remedial measures based on a more thorough understanding of the site conditions.

The scope of work proposed for the revised assessment is summarized below:

- **Drilling Program**: A total of six (6) boreholes are proposed at this time to investigate the soil, bedrock, and groundwater conditions in a broader area of the site. The borehole locations will be selected to supplement information collected near the main slide area as well as to collect data in the extended area of cracking SE of the main slide. Holes will be positioned primarily on the downslope side of the embankment. Six (6) slope inclinometers will be installed with 1 to 2 piezometers in each hole. The drilling program includes a site visit by a 2-man survey crew to survey borehole locations once drilling is complete.
- **Asphalt Coring**: It is recommended that the County confirm the depth of asphalt at select areas along the road that have a history of subsidence and have been resurfaced. This information can be used to supplement instrumentation data by providing an estimate of the rate of subsidence at the roadway. This item has not been included in the scope of work but can be included at the request of the County.
- **Laboratory Investigation:** Following the completion of the drilling program, a laboratory testing program will be undertaken for the classification and evaluation of the engineering properties of the encountered soil/bedrock. A key part of the laboratory program will include detailed logging of the recovered core. Testing will generally consist of moisture contents and Atterberg Limits. More extensive strength testing such as direct shear tests are not planned or budgeted at this time.
- **Instrument Monitoring and Site Reconnaissance**: Instruments will require initialization approximately 1 week after installation. In order to characterize the depth and extent of

sliding below the road, instrumentation reading events are proposed for 1 to 2 months after installation, and a set of follow up readings in late spring 2016. The spring reading is proposed in order to evaluate the influence of the spring snow melt, and is expected to provide the most value as it allows for more time to observe rates of movement and corresponds to the time of year when most of the cracking has been reported. A site reconnaissance by senior geotechnical personnel is proposed coincident with the spring 2016 instrument readings.

- **Engineering Assessment and Reporting**: Assessment of the sub-surface conditions, instrumentation results, analyses and cause of roadway grade failure will be evaluated. Based on the updated information and findings, preliminary design options will be developed for consideration by the County. The assessment will also incorporate input from transportation engineers to evaluate alternatives involving road alignment, and review from senior hydrotechnical personnel to evaluate surface water drainage conditions and remedial options involving surface water management in the project area. A brief environmental review will be performed to identify regulatory requirements and potential constraints to be considered for each alternative. A report will be prepared summarizing the findings of the assessment and will outline the potential remedial measures, relative risks, and approximate costs for implementation.
- **Design Review Meeting**: To discuss design options and receive feedback from the County and establish next steps (i.e. design drawings and specifications, tendering, and construction) if requested by the County.

3.0 COST ESTIMATE AND ASSUMPTIONS

A cost estimate to perform the scope of work discussed above has been prepared and a detailed task and cost breakdown is provided in Table 1, attached. A detailed breakdown of drilling and laboratory costs is provided in Table 2. A summary of costs for the key tasks is provided below.

TASK	ESTIMATED COST *(excluding GST)*
Drilling Contractor • *Includes contractor disbursements*	$27,000
Drilling Program Field Supervision, Instrumentation, and Survey • *Includes program planning (utilities, safety, etc.)* • *Includes instrument supplies* • *2-man survey crew*	$29,200
Laboratory and Logging • *Testing, detailed logging, borehole log preparation and lab data synthesis*	$9,700
Instrument Readings and Site Visits	$8,300
Engineering Assessment and Reporting	$23,900
TOTAL	**$98,100**

The following assumptions have been made to prepare the above cost estimate:

- The County of St. Paul will prepare access for the drilling contractor at the locations specified during the planning stages of the drilling program. It is assumed that drilling locations will be accessible by a track-mounted auger rig.
- The County of St. Paul will provide all required traffic safety accommodation and the temporary removal of roadway guardrails for drilling on the downslope side of the road
- Drilling program is based on 6 holes to depths of 15 to 20 m and a total drilling time of approximately 40 hrs (4 days).
- Instrumentation to be installed includes approximately 100 m of slope inclinometer casing and 10 vibrating wire piezometers. Allowance has been made for separate site visits for instrument initializing and two subsequent readings.
- Allowance has been made for 1 site visit by a senior geotechnical engineer. Additional site visits requested by the County will require a scope change.

4.0 SCHEDULE

At the time of writing, drilling rigs are available for mobilization within 1 week of notice. Authorization and clearance of underground utilities must be completed in advance and typically requires about 2 weeks. Once initiated, the drilling program would be completed by Amec Foster Wheeler's field personnel within 4 days. The soils laboratory testing program and detailed examination of the bedrock core will be completed within about 3 weeks following the field investigation.

It is understood that repair of the road is a high priority for The County. Amec Foster Wheeler requests that the County allow for instrument initialization and at least 2 sets of readings prior to completing an updated assessment of the mechanism and options available for stabilization. This timeline is proposed in order to obtain the minimum amount of field data to characterize the slide mechanism, including depth of movement zones, such that the remedial options can be calibrated to site conditions. A minimum of 1 to 2 months is recommended between instrument initialization and first readings, in order to allow for an accumulation of sufficient deformation that can be detected by our instruments. Engineering assessment, analyses, and report preparation is estimated to be completed 4 to 5 weeks following initialization and two sets of instrumentation readings.

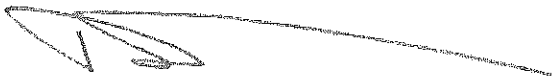
Based on previous experience at the site and reported dates of previous cracking, it is likely that the majority of ground deformation occurs in the spring following the snow melt and in the wetter summer months. Readings obtained in summer/fall 2015 may not be adequate to characterize the slide and develop suitable remedial repair options. Amec Foster Wheeler invites the County to consider a project schedule that allows for incorporation of the spring 2016 readings into the final assessment. In the interim period (summer 2015) it may be possible to develop interim remedial repairs based on data collected in 2015, such as surface water control measures, to be implemented in late summer/fall 2015. We look forward to discussing project constraints and timelines further to develop a preferred schedule that meets the needs of the County.

5.0 CLOSURE

If you have any questions, or wish to discuss this proposal in more detail, please do not hesitate to contact the undersigned.

Respectfully submitted,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited



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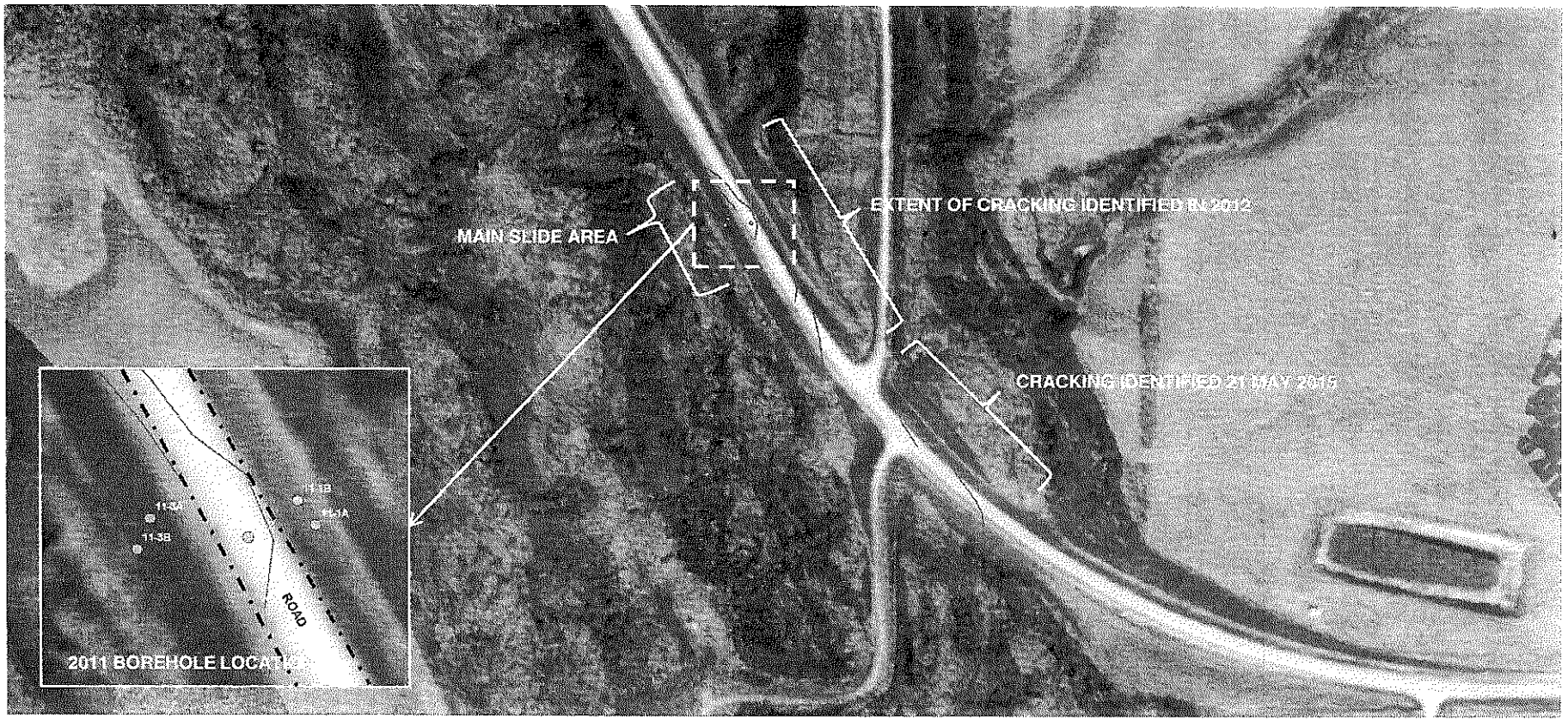

amec foster wheeler ENVIRONMENT & INFRASTRUCTURE EDMONTON, ALBERTA	CLIENT: COUNTY OF ST. PAUL	DRAWN BY: DJM CHK'D BY: CRT SCALE: AS SHOWN DATE: JUNE 2015	PROJECT: MOOSEHILLS ROAD GRADE FAILURE TITLE: SITE PLAN SHOWING EXTENT OF CRACKING AND 2011 BOREHOLE LOCATIONS	JOB NO: ET120054 REV. NO: – FIGURE 1	

County of St. Paul
Moosehills Road Grade Failure
Scope and Cost Estimate for Engineering Assessment and Preliminary Design

TABLE 1 - TASK BREAKDOWN AND COST ESTIMATE

STAGE / Task	Position/Name	Senior Geotechnical Review - Curtis Treen	Sr. Geotechnical Engineer - Dustin McLachlan	Geotechnical Engineer - Junwen Yang	Geotechnical Support	Senior Field Program Coordinator - Martin Gautier	Geotechnical Technician	GIS/Drafting	Transportation Lead - Gabe Rohr	Trasnporation Support	Senior Hydrotechnical Engineer - Marcel Chichak	Junior Hydrotechnical Engineer	Sr. Environmental Review - Paul Kalashnikoff	Environmental Biologist - Ryan Wonnacott	2-man Survey Crew	Clerical	Total Hours Per Task	Total Fees per Stage/Task (includes 6% for incidental disbursements)	Travel, Field Supplies, Laboratory, and Misc Expenses	Disbursements (Subcontractor)	TOTALS PER TASK/STAGE
	Classification	630	619	617	613	529	518	521	533	612	628	613	625	619		809					
	Rate	$225	$165	$145	$115	$160	$115	$125	$160	$110	$220	$115	$205	$165	$210	$80					
	Quantity	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	(hrs)				
DRILLING PROGRAM - CONTRACTOR																					
Drilling Subcontractor																				$ 24,571	$24,571
Drilling Program 10% contingency																				$ 2,457	$2,457
Sub-total																				$ 27,028	$27,000
DRILLING PROGRAM - AMEC Foster Wheeler																					
Drilling Program Planning (Technical, permits, ground disturbance, safety)		0.5	0.5		2	8	8	2	0.5								22	$3,132			$3,132
Field Supervision (mob/demob, drilling time, daily travel)							67										67	$8,167	$ 3,908		$12,075
Instrumentation																			$ 9,442		$9,442
Borehole Survey										1					10		11	$2,343	$ 100		$2,443
Drilling Program 10% contingency																		$817	$ 1,335		$2,152
Sub-total		0.5	0.5		2	8	75	2	0.5	1					10		100	$14,459	$ 14,785		$29,200
LABORATORY AND LOGGING																					
Laboratory Testing																			$ 4,393		$4,393
Detailed Core Logging		0.5	3	1	30												35	$4,455			$4,455
Borehole Log Preparation and Data Synthesis				1	6												7	$885			$885
Sub-total		0.5	3	2	36												42	$5,340	$ 4,393		$9,700
INSTRUMENT READINGS AND SITE VISITS																					
Instrument Initialization			1				10										11	$1,394	$ 280		$1,674
2015 Instrument Readings (x2)			2				20										22	$2,788	$ 560		$3,348
2016 Site Reconnaissance and Instrument Reading (x1)			10				10										20	$2,968	$ 280		$3,248
Sub-total			13				40										53	$7,150	$ 1,120		$8,300
PRELIMINARY DESIGN																					
Project Management and Project Meetings		1	6	4		1			3								15	$2,581			$2,581
Assessment and Analysis of Design Options		2	14	32	4	1		6	4	6	6	8	0.5	4			88	$13,857			$13,857
Design Report and Cost Estimate		2	6	20	4			12								2	46	$6,848			$6,848
Design Review Meetings			2	2													4	$657			$657
Sub-total		5	28	58	8	2		18	7	6	6	8	0.5	4		2	153	$23,943			$23,900
TOTALS (ROUNDED, EXCLUDES GST)		6	44.5	60	46	10	115	20	7.5	7	6	8	0.5	4	10	2	347	$50,900	$ 20,300	$ 27,000	$98,100