Akamina Parkway Reconstruction and Hazard Mitigation

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ABSTRACT

Waterton National Park is in southwestern Alberta, it is the southernmost National Park in the Canadian Rocky Mountains. On June 19, 2013, over a 24 hour period, between 60 mm and 125 mm of rain fell (rainfall records provided by Parks Canada for the Akamina and Waterton Warden Office) on the steep mountain sides adjacent to the Akamina Parkway triggering catastrophic flooding, landslides, debris flows and debris floods. The widespread impacts from the various natural hazards resulted in severe impacts to the roadway and severed access to Akamina Lake, Cameron Lake and the associated nearby hiking and camping areas. The flooding and damage as experienced by the city of Calgary, during the same precipitation event, is described by the Government of Alberta as the worst in its recorded history.

The Parkway is located in a geomorphically active mountainous area subject to regular flooding and debris flow events. The processes that led to the road damage were primarily related to inadequate control of debris and water passage at eight locations. Tetra Tech EBA was retained by Parks Canada, through their emergency services contractor, Maglio Installations, to provide emergency analyses and design guidance for remediation and mitigation along the Parkway. Tasks included: hydrology assessments, hydraulic analysis, design drawings for culvert replacements, debris storage catchment basins, debris berms, debris racks, rock scaling, retaining walls, specification of riprap prescription and reinforcement of roadway, support for bridge construction, and general field design guidance. The initial design criteria included the 100 year clear water event and the 10 year debris flow event. Gabion and rock walls were designed and constructed at wash-out locations to re-open the vital tourist access.

Tetra Tech EBA also provided construction monitoring and materials testing services for this fast-paced project and has adapted designs to suit field conditions. Construction began in July 2013 and was substantially completed by November 30, 2013.

INTRODUCTION

On June 19, 2013, the rain began falling in Waterton Lakes National Park. Over the next 24 hours, between 60 mm and 125 mm of rain fell (rainfall records provided by Parks Canada for the Akamina and Waterton Warden Office) on the steep mountain sides adjacent to the Akamina Parkway triggering flooding, landslides, debris flows and debris floods. The widespread impacts from the various natural hazards resulted in severe impacts to the parkway and severing of access to Akamina Lake, Cameron Lake and the associated hiking and camping areas. The flooding and damage is described by the Government of Alberta as the worst in its recorded history.

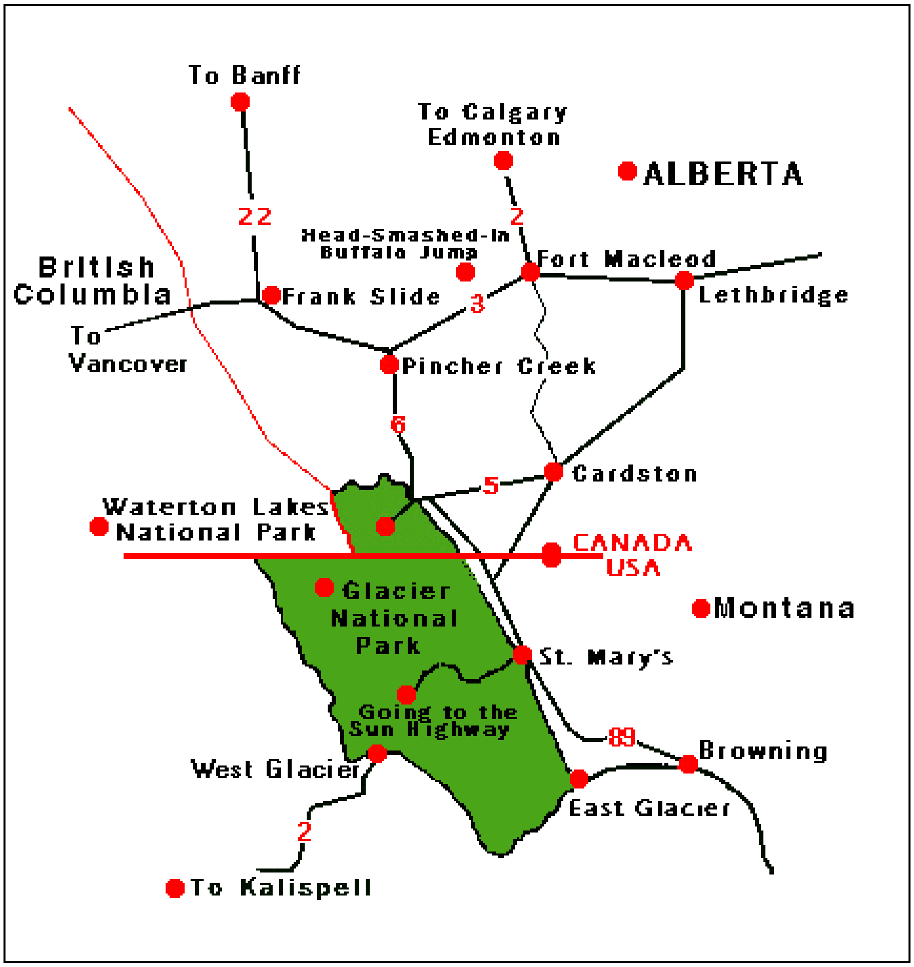

Figure 1: Waterton Lake Nation Park Location Plan

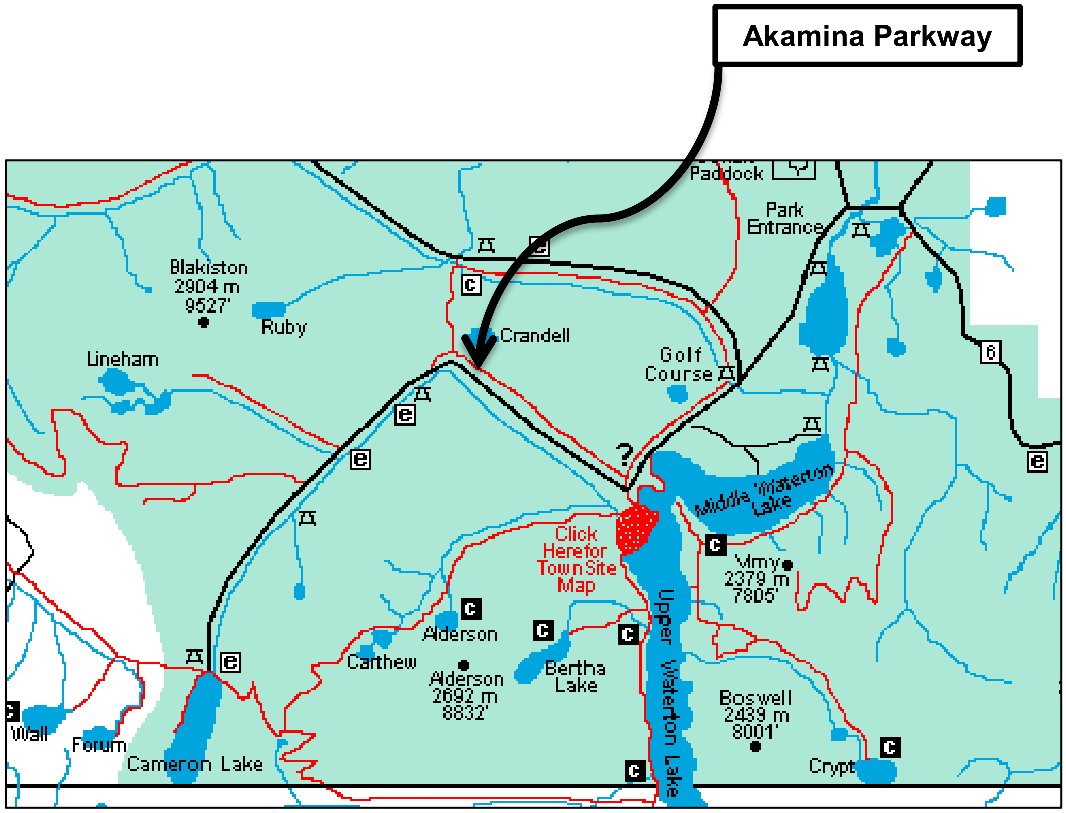

Figure 2: Akamina Parkway Location

The Akamina Parkway is a 2-lane, paved road that accesses Cameron Lake and various hiking areas on Mount Crandall and Mount Blakiston. The road was constructed about 50 years ago, and is located along the steep, east and north banks of Cameron Creek. The Town of Waterton is located on the broad alluvial fan of Cameron Creek. The Akamina Parkway is used year-round and the road is routinely plowed during the winter months to provide access to skiing, and other winter recreational activities. The road has been impacted by previous events in 2005, 1995, 1984 and 1967.

Tetra Tech EBA was retained by Parks Canada, through their emergency services contractor, Maglio Installations, to provide emergency, innovative solutions to remediate the damage and mitigate the possibility of future impacts. When Tetra Tech EBA first undertook a helicopter overview of the area the Akamina Parkway was closed due to several large washouts (one in excess of 70m in length), immense piles of debris, unstable slopes, buckled pavement, broken guardrails and plugged culverts. Lineham Creek and Ruby Creek had altered their courses and now flowed over the roadway.

Parks Canada mandated that the re-opening of the Parkway had to occur as soon as possible. Therefore all work to restore and remediate the Parkway as well as to mitigate against future debris flows and floods had to occur during 2013. The consequences of an extended construction period into 2014 would have had a severe impact on the businesses and community of Waterton. Simply put, for the survival and viability of the town, the Parkway reconstruction work had to be completed in 2013.

Photo 1: Typical washout of the Akamina Parkway following June 2013 Flood

Photo 2: Debris deposited on Akamina Parkway and failure of fill slope retaining wall

Tetra Tech EBA, Maglio and Parks personnel worked closely together to develop appropriate short-term and longer-term solutions that worked within Parks budget constraints. The initial work included the clearing of debris at eight sites that had been identified during the initial site reconnaissance.

Repairs continued throughout the summer and fall, and the Akamina Parkway re-opened on November 30, 2013 in time for winter recreationists to access Cameron Lake as usual.

METEOROLOGY

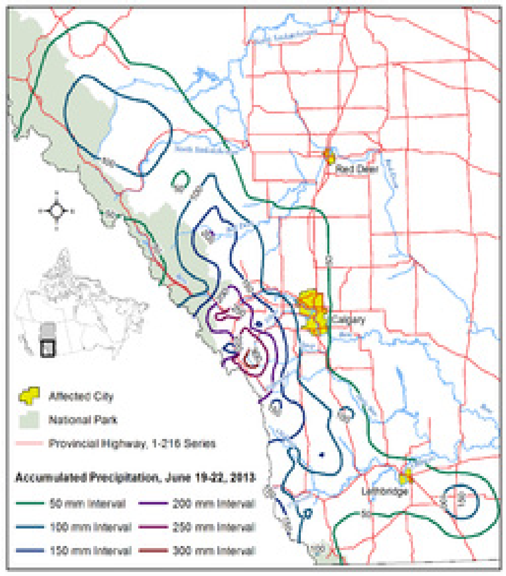

Figure 3: Accumulated precipitation contours showing the June 19–22, 2013 rainfall event within Alberta's Rockies and the foothills that triggered the flooding

Situated east of the Canadian Rockies, southern Alberta is a semi-arid region that does not usually receive high amounts of rainfall. A high-pressure system in northern Alberta blocked the passage to a low-pressure area to the south. This blocked circulation and easterly winds pumped humidity on the rising slopes of the Rocky Mountains foothills, causing heavy rain to fall onto the province with rainfall amounts of over 200 millimetres (7.9 in) to fall in less than two days (June 19/20) in many regions of the province, particularly west and southwest of Calgary. In Canmore, a town in Alberta's Rockies, over 220 millimetres (8.7 in) fell in just 36 hours, nearly half of the town's annual average rainfall. In the Town of High River, rainfall amounts at one weather station recorded 325 millimetres (12.8 in) in less than 48 hours. The rain falling on already saturated ground, coupled with the steep watershed and heavy snow loads remaining in the front ranges of the Rocky Mountains, resulted in a rapid increase in the size and flow of numerous rivers emanating from the east side of the Rockies with flow rates several orders of magnitude of what might normally be expected.

ENGINEERING SERVICES

Hazard Assessment

Tetra Tech EBA undertook an assessment of the terrain conditions above a 12 km section of the Akamina Parkway, specifically, eight areas adversely impacted by sediment, debris, and water identified by Parks Canada that required remedial works.

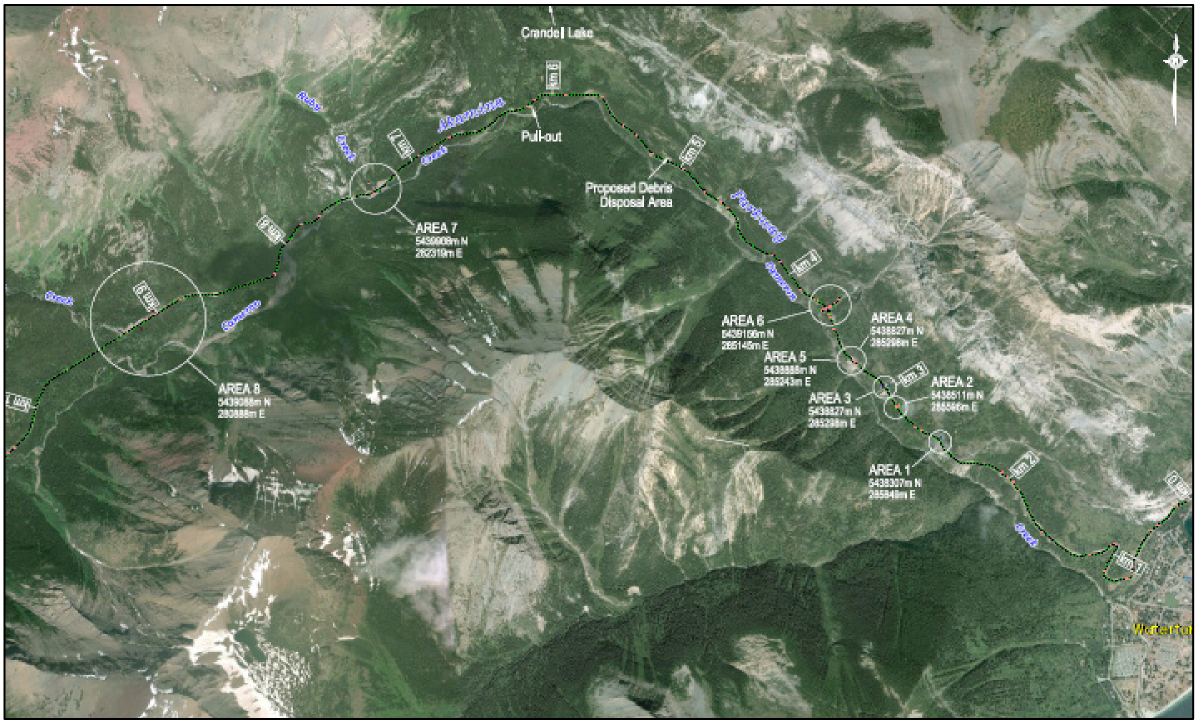

Figure 4: Overview of effected sections of the Akamina Parkway

The scope of Tetra Tech EBA's assessment included review of the upper slope conditions above the Akamina Parkway in order to determine the potential for future events, estimation of the possible magnitude of future events, and initiation of the design process using the provided return periods for the design of any required hazard mitigation structures.

This initial assessment was based on available topography (100 foot contours), bedrock and surficial geology, a review of available satellite imagery, a review of available photographs of the site and a site review.

Site Physiography and Geology

As mentioned, the Akamina Parkway is located within the steep valley slopes of the Cameron Creek Valley. Elevations over the area of interest range from about 1430 m above sea level (masl) to 2380 masl. The slopes are very rugged and irregular due to the dominant bedrock control in the area. The valley slopes transition from timbered slope sections at lower valley elevations to sub-alpine and alpine slope sections at upper elevations. All slopes sections are generally well drained.

Photo 3: General topography of the Waterton Lake/Akamina Parkway area

Site Reconnaissance

Key observations from the site reconnaissance include the following:

- The Akamina Parkway road is generally to the north of Cameron Creek within a steep sided valley, having rugged terrain that is bedrock controlled;
- Cameron Creek is entrenched over the section reviewed, and received a lot of debris and sediment from the June 19, 2013 event, but little of this material was observed in the Creek, suggesting that most of it has likely deposited on the fan or was deposited in Upper Waterton Lake;
- Most of the affected areas on the Akamina Parkway resulted from impacts by debris flows and debris floods that originated from the valley sides;
- Most debris flows/debris floods were initiated at multiple points within the catchment area;
- Stream channels that experienced the debris flow/debris flood events all contain residual debris – they were not scoured to bedrock;
- Review of the initiation and transport zones of the June 19, 2013 event show that these zones are very similar to those observed on older satellite imagery, suggesting that these same tracks reactivate frequently. From the recurrence record provided by Parks Canada, this appears be about every 10 years;
- Area 8 is different from Areas 1 through 7, in that Area 8 is located where Lineham Creek crosses the roadway. Lineham Creek has a significant catchment area of about 14 km^2 (the next largest catchment is Area 7 at approximately 1.4 km^2). Valley slopes defining the catchment area upstream of Area 8 have experienced previous landslide events; however no obvious failures were noted during our helicopter review; and

- The west and south sides of the Cameron Creek valley appear to be more stable than the east and north sides, along which the Akamina Parkway is located. This is likely due to many factors such as slope aspect, but a large contributing factor is likely the structural orientation of the bedrock. The sedimentary bedrock forming the mountains has bedding planes that dip out of the slope on the valley slopes containing the Akamina Parkway and dip into the valley slope on the opposite side. Bedding planes dipping out of the slope mean that they dip parallel or obliquely to the valley slope, and can form a kinematic sliding surface for surficial failures, which appears to be what we are seeing on the slopes containing the Akamina Parkway.

- There was a significant buildup of winter sand which in some cases has created a windrow of material which in turn has prevented water from exiting the roadway;

- There did not appear to be enough culverts and drop culverts to adequately manage the water on or beside the roadway;

- Debris catchment volume was insufficient in some of the areas;

- Some sections of road support had washed out;

- Some culverts were constructed with a vertical drop at the outlet;

- Debris conveyed to the roadway by the June 19, 2013 event was principally cobble-sized sediment with some small boulders contained in a sand matrix. Organic debris was also incorporated consisting generally of small to medium sized woody debris.

Design Criteria

The agreed Design Criteria for the remediation and mitigation included:

- Design of debris catchment structures for the minimum 1 in 10 year event. It was agreed that debris structures are commonly designed to accommodate the 1 in 100 year event and, therefore, more frequent occurrence will require more frequent maintenance; and

- Design culvert structures for the 1 in 100 clear-flow event with average annual snowmelt.

Remedial and Mitigation Options

Parks Canada did not wish to simply repair the road, as has been done in response to previous events. Instead, they wished to carry out necessary engineering design and construction of the affected road sections, such that the roadway could withstand a similar, future event. Parks was looking for cost effective mitigation options that are relatively low maintenance.

Engineering options considered:

- **Armoured ford** – this option allows a future event to overtop the road without removing the road. However, because the public uses this road, this is not considered a suitable option since members of the public could be potentially impacted by an event as it travelled over the road. There were also public safety concerns with cyclists crossing such a ford. In terms of cost, this is the most cost effective option for both construction and maintenance;

- **Low point in road to act as overflow area** – this option is a variation of the armoured ford but is simply an established low section in the road which would pass flows across the road if the culvert were unable to convey all of the flow due to a blockage. The low area would be at a different location from the culvert crossing, would be paved and have a low profile as not to disrupt traffic flow and would have an armoured downslope road fillslope to prevent road washout.

- **(Earthen) Debris control structures or debris berms** – this option allows the debris from a future event to be collected upstream of the road and mostly clear-water to be conveyed below the road by bridge or closed or open bottomed culvert. This option is only applicable in the depositional zone of the geomorphic event (landslide, debris flow, debris flood). The disadvantage of this option is that a considerable area of gentle terrain is required in order to control and contain debris. Additionally, access must be provided for removal of accumulated debris, particularly after events, and also requires routine maintenance and inspection; Cost wise, this is a moderate construction and maintenance cost option; and

- **Debris rack** – this option involves the use of railway rails, "H" piles, etc. to create a type of trash rack to prevent debris from blocking the culvert or bridge. The structure could be either a simple option of driving or excavating piles into the stream bed or a more complex option using concrete footings, reinforced support piles with cross bracing, etc. Such racks can be either standalone structures incorporated into channels, or incorporated in debris berms.

- **Flexible Mesh Debris Barriers** – this option is a type of debris control structure that works most effectively when anchored into bedrock but can also be supported with posts. They offer the advantage that they can be erected within the transport zone of debris flows/debris floods. However, they generally cannot contain the same volume of debris as an earthen debris control structure. They also must have access for occasional maintenance and clean-out. Depending on the size, debris barriers are the most expensive cost option, especially if support posts are required, but the costs are typically not excessive.

- **Reinforced Concrete Structures** – this option was not considered due to reasons of cost and construction within the tight schedule. Very large reinforced concrete structures have been used on other projects to control the hazard from debris flows and floods.

After the initial assessment and preliminary engineering, it was decided to focus on the following options:

- Debris barriers to contain future 1 in 10 year return period debris flow events due to space limitations.

  - Approximate lengths of debris barriers ranged from 50 to 100 m;

  - The required debris barrier height to contain the 1 in 10 -year event is about 13 m at all locations.

- Debris berms with a debris rack were recommended to contain future 1 in 10 year return period debris flow events at one location.

  - Approximate length of the berm (including the debris rack) was 50 m;

  - The required berm height was 2 to 7 m.

HYDROLOGIC ANALYSIS AND HYDRAULIC DESIGN

Hydrology

A regional based hydrology analysis and a HEC-HMS model were developed to support the design of the reconstructed drainage structures and debris basins.

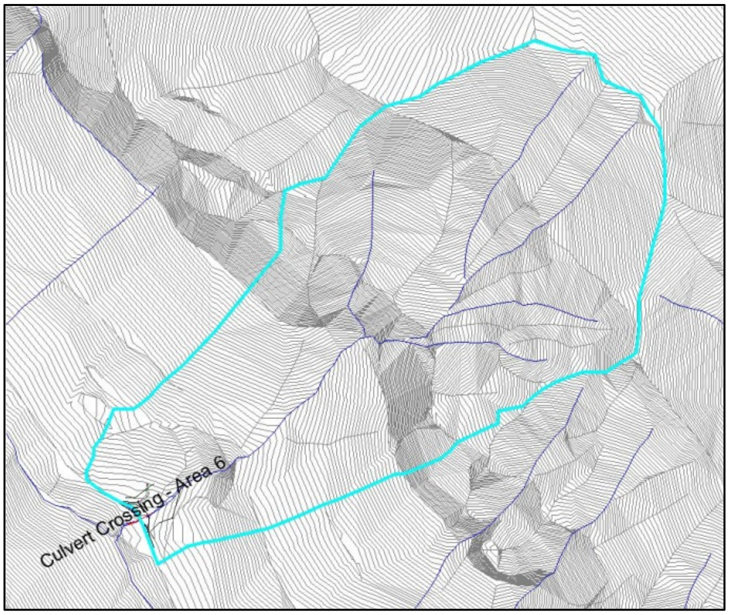

Figure 5: Area 6 Delineated Watershed

Regional Analysis

As there was no hydrometric station or flow data available for the watershed, a regional based statistical approach was used to estimate peak flows. Flood frequency statistical analysis software, HYFRAN, was used to fit the flow data to selected statistical distributions. While several probability distributions were tested, the three-parameter Log Pearson distribution was considered appropriate for this assessment. Flows were then scaled to compensate for differences in watershed area.

Anecdotal information acquired subsequently to the regional analysis revealed that the project site is subject to intense precipitation events. It is also understood that this precipitation is isolated to the project site and is not represented in the surrounding watersheds utilized in the regional analysis. As such, it was realized that a regional analysis would underrepresent flood flows for the subject catchment; therefore, a HEC-HMS model was proposed to better represent local catchment conditions and is described in the section below.

HEC-HMS Model

For the purpose of developing the HEC-HMS model, 30 years of precipitation data for the Akamina Pass meteorological station (05AD803) obtained from Alberta Environment were used. This meteorological station is located nine kilometres southwest of the proposed culvert crossing and is at an elevation of 1809 metres which falls in the middle of the elevation range for the Area 6 drainage basin (1450 to 2350 metres). Watershed parameters applied in the HEC-HMS model included watershed elevation, slope, roughness, drainage distances, soil properties, snowmelt, and curve numbers.

A statistical analysis was performed on the precipitation data to obtain the 100-year rainfall for 3-hour and 24-hour storm durations. These values were 44.3 millimetres and 193 millimetres respectively. In order to establish a design flow, both of these rainfalls were modelled in HEC-HMS with the larger of the two values being taken as the more conservative. Recorded precipitation data for June 19, 2013 shown in Figure 6.

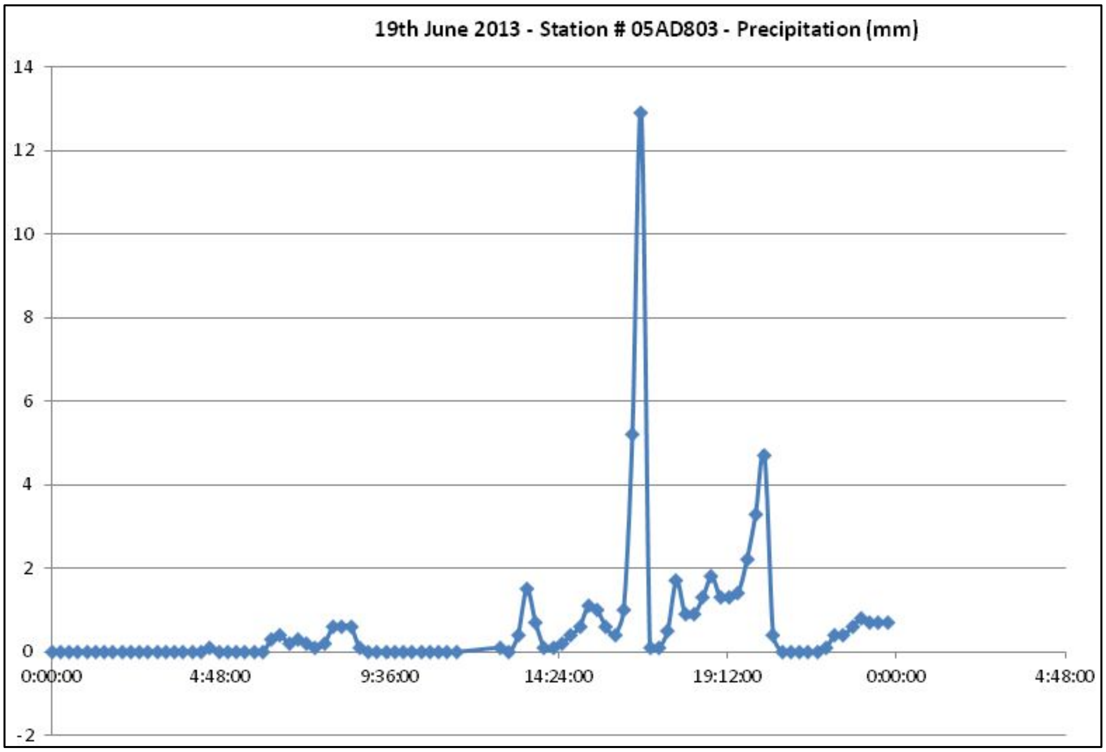

Figure 6: Recorded precipitation data from Station 05AD803 - June 19, 2013

Area 6 Hydraulics

A separate hydraulic analysis was completed using PC-SWMM to determine minimum culvert dimensions required to convey the 100-year flow without overtopping the crown. However, to account for the maintenance frequency likely to take place at the site, a culvert with a larger diameter was considered. Selection of the ultimate size was based on availability and costs.

Areas 1-5

All culverts are re-used galvanized CSPs installed at a 5% slope. The CSPs were excavated and salvaged from the larger crossings at Areas 6, 7 and 8. Pipe size, location, length and slope were determined in the field based on site constraints and it was accepted by Parks Canada that the installations may not handle the 100-year clear water flows due to limitations set by field conditions, such as depth to bedrock or impracticality of disturbing an existing rock wall to accommodate a larger pipe.

Culvert slopes were built at 5% at all areas. On account of this relatively steep slope, all culverts were assumed to be inlet controlled. The hydraulic capacities of the culverts installed were determined using the Handbook of Steel & Drainage Highway Construction Products, 2007 and the nomograph Fig 4.10 on page 151. Standard practice is to use a headwater depth equivalent to the elevation of the crown of the pipe (HW/D=1) when determining pipe capacity. Additional capacity would be available if the headwater depth increased above the crown of the culvert. A debris rack was specified by Tetra Tech EBA to be built at the inlet of the culverts and scour protection was specified to be built at the outlet in the splash zone.

Photo 4: New culvert installation to replace effected location

Storm events in excess of the pipe capacity will overflow at a low point on the road and may cause damage to the roadway. No design or construction has been carried out in anticipation of this occurrence. Water caught on the roadway poses a significant risk to the structural integrity of the road. For example the damage done at Area 5 during the June 19, 2013 event was the direct result of water not being able to exit the roadway. Catch basins and other controls are recommended to be placed at strategic locations along the roadway to reduce similar damage in the future.

Areas 7-8

A separate hydraulic analysis was completed using hydraulic modelling software PCSWMM and HEC-RAS to determine minimum culvert dimensions required to convey the 100-year flow at Areas 6 and 7 and to validate potential crossing designs considered for Area 8.

Culvert sizing was specified to convey the 100-year design flows without overtopping at the culvert crown (top of pipe). Culvert crossings are typically designed to convey smaller return events while allowing water to backup above the crown of the culvert inlets during the more infrequent events. However, in this case larger diameters could be considered at these sites based on the recent large event, high sediment transport, culvert availability, construction and maintenance costs, risk of failure, traffic safety, aesthetic considerations, and construction expedience. Culvert sizes were developed using the PCSWMM model for each of the sites and verified utilizing nomographs included in the Handbook of Steel Drainage & Highway Construction Products.

Due to the magnitude of flow at Area 8 and the road geometry at the crossing, Maglio proposed to install a bridge crossing rather than a culvert. Initial modelling results confirmed that the flow within the creek at the crossing is sensitive to small changes in either geometry or channel roughness, quickly shifting the flow regime from supercritical to subcritical, therefore creating a hydraulic jump.

The final channel design proposed by Maglio was trapezoidal, with a base width of 6.6 m, side slopes of 1.5H:1V, and a depth to the underside of the bridge deck of 2.6 m. These crossing dimensions were reviewed using HEC-RAS modelling software.

Photo 5: Inlet end of new culvert installation and associated debris storage basin

Natural Hazards Mitigation

Tetra Tech EBA provided the services of a senior geotechnical engineer full time on site for construction review. The engineer attended weekly project progress meetings either in person or via the phone and was responsible for project coordination. At the request of Maglio, the senior geotechnical engineer traveled to site, generally biweekly, spending time on site identifying challenges, determining field conditions, and understanding local configuration. Following consultation with topic experts within Tetra Tech EBA field fit design recommendations were then presented to Maglio and Parks for approval. To support the rigours and challenges of the emergency repair work the senior geotechnical engineer was available 7 days a week on an on-call basis.

Rock Scaling

Parks Canada routinely maintains all rock slopes above Highways and secondary roads. The actions of weathering, freeze thaw and kinematic instability mean that routine rock slope remediation is required. The rock slopes adjacent to the Akamina Parkway were last worked upon in 2010. The slopes were therefore in reasonable condition prior to the severe weather events of 2013. However, during the course of the work on the Akamina Parkway rock slope remediation was undertaken. It was recognized that machine scaling of the slopes could both mitigate the rock fall hazard as well as provide a source of coarse rock fill and rip rap to be used in the construction. A rock engineer from Tetra Tech EBA therefore directed the contractor as to which slopes required machine scaling so as to mitigate this risk. Excavation of the catchments at the base of the rock slopes was also undertaken. These excavations both improved the effectiveness of the catchments, and again provided a source of material for general fill in construction. Although the rock slope work along the Akamina Parkway was not extensive it did reduce the rock fall hazard, enabled locally sourced materials to be used (thereby reducing haulage costs) and will reduce the cost of the next rock slope maintenance program that is planned for Akamina in the near future.

Photo 6: Rock scaling along the Akamina Parkway

Debris Basins/Debris Berms

Mitigation design was carried out for the eight sites along the Parkway which included hydrology assessments, hydraulic analysis, and design drawings for culvert crossings, debris storage catchment basins, debris berms, debris racks, and retaining walls. The hydraulic analysis provided water levels and velocities for the design event.

Of the eight crossings being reviewed only two were impacted by debris floods. Sites 6 and 7 were impacted by such events. The existing culverts were either plugged with sediment or the roadway was washed out following overtopping of the parkway. During the analysis the existing culverts crossings were found to be undersized for the design event.

It was not feasible to design new culverts or bridges to accommodate debris floods at Sites 6 and 7. Therefore it was decided to design new culvert crossings to accommodate the 100-year clear water event and construct debris basins with debris racks upstream of the culvert inlets to minimize the potential for the culverts to become blocked with sediment and debris during debris flood events. The debris basins were designed to provide the maximum possible storage volume for sediment and debris, which was controlled by channel and hillside conditions at the two sites. The relatively narrow V-shaped gullies of the creek area immediately upstream of the parkway and the steep creek gradient, limited the storage area of the basins. The downstream end of the basins was defined by an armoured berm that was set back from the fillslopes of the parkway. The optimum height of the berm crests were designed to maximize the storage volume while recognizing the limitations of the local topography.

Photo 7: Newly excavated debris basin and trash rack at debris flow prone catchment

Debris racks were incorporated in the berms to allow small and medium sized sediment and debris to pass through. The intent of the debris racks were to capture the sediment and debris from large events, allowing the creek to convey clear water events through the opening in the berms. All large boulders and large woody debris would be trapped at the rack and contained within the debris basin while still allowing water to pass through the rack and into the culverts. The debris basins were designed to allow machine access (e.g., excavators and trucks) into the basins for dredging sediment and cleaning debris from the racks.

Photo 8: Installation of new trash rack and debris basin/berm

Retaining Walls

The design of three retaining structures and one engineered slope reconstruction were provided along the Akamina Parkway where damage/washouts of the existing road structure and/or adjacent slopes required rehabilitation. Several retaining wall options were considered such as bin walls, gabion baskets/facing, MSE panels, lock-blocks, etc. However, in such a pristine environment where aesthetics of the designed solution are important, Tetra Tech EBA used locally sourced materials and rock stacked walls to build the majority of the retaining walls. The rock stacked walls provided an aesthetic solution that is in keeping with the environment and landscape. The retaining structure and engineered slope requirements were as follows for each designated project area:

- Area 1 – A retaining rock-stacked rockery was constructed with a 4.7 m maximum vertical height (combination of retaining function and facing aspects) and an approximate 5.5 m longitudinal length parallel to the Akamina Parkway roadway behind/above the rockery. The rockery was backfilled up to the reconstructed roadway surface with 75 mm minus pit-run backfill and localized surficial drainage was constructed adjacent to the roadway to mitigate water infiltration behind the rockery.

- Area 3 – A rock-stacked gravity retaining structure was constructed with a 4.6 m maximum vertical height and an approximate 15.0 m longitudinal length parallel to the Akamina Parkway roadway behind/above the retaining wall. The retaining wall was backfilled up to the reconstructed roadway surface with 75 mm minus pit-run backfill and localized surficial drainage was constructed adjacent to the roadway to mitigate water infiltration behind the retaining wall.

- Area 5A (construction scheduled for May 2014) – A geogrid reinforced SierraScape retaining wall system was designed with a 7.6 m maximum vertical height, a typical geogrid spacing of 0.457 m (SierraScape system requirements), a minimum geogrid length of 4.6 m, and an approximate longitudinal length between 18.8 m and 26.6 m (dependent of the maximum length the adjacent engineered slope can be constructed based on available site geometry) parallel to the Akamina Parkway roadway behind/above the retaining wall. The retaining wall is to be backfilled up to the reconstructed roadway surface with 75 mm minus pit-run backfill layered between geogrid layers. Localized surficial drainage is also designed adjacent to the roadway to mitigate water infiltration behind the retaining wall.

- Area 5B (construction scheduled for May 2014) – A geogrid reinforced engineered slope of 1.25H:1V was designed with a 8.0 m maximum vertical height, a typical geogrid spacing of 0.75 m, a minimum geogrid length of 6.0 m, and an approximate longitudinal length between 12.0 m and 19.8 m (dependent of the maximum length the engineered slope can be constructed based on available site geometry) parallel to the Akamina Parkway roadway behind/above the engineered slope. The engineered slope is to be backfilled up to the reconstructed roadway surface with 75 mm minus pit-run backfill layered between geogrid layers. Localized surficial drainage is also designed adjacent to the roadway to mitigate water infiltration behind the engineered slope.

Photo 9: Newly constructed stacked boulder wall to support failed Akamina Parkway fill slope

No site-specific geotechnical investigation was completed for the retaining structure layouts and engineered slope reconstruction area in advance of the compressed design/construction stages. Tetra Tech EBA relied on the existing geotechnical information obtained from the initial visual site reconnaissance conducted at the initial proposal stage, coupled with a site-specific site review and limited test pitting undertaken at the commencement of the detailed design stage at each development area. The risk of variances encountered for geotechnical information during construction were assumed by the contractor, in order to save project costs and schedule associated with an upfront geotechnical investigation program.

Design requirements for global and internal stability for the retaining structures and engineered slope were practically governed by bearing soils/rock (adequacy of and depth to bearing soils/rock verified during construction), height constraints (due to potential variability of bearing soils/rock depth), available facing slope geometry (dependent on existing exposed rock slopes above and below the existing roadway), and the adjacent roadway traffic surcharge. All design geometry and project specific criteria for the retaining structures was during construction by Tetra Tech EBA and field-fit adjustments made as required to facilitate construction processes and any encountered variations in the assumed geotechnical information at each development area.

Photo 10: Construction of new fill slope retaining wall

Tetra Tech EBA project innovation facilitated the design of the Area 1 and Area 3 retaining structures via the use of available limestone rock from other construction work sites and some additional rock slope scaling along the Akamina Parkway as an acceptable material for construction (i.e., rock source similar to surrounding rock outcroppings in composition/strength, the contractor has a readily available source of adequately sized rocks with the ability to shape the rocks if required for strategic stacking arrangements, etc.), avoiding the costly purchase and installation of manufactured retaining wall products (i.e., bin walls, gabion baskets/facing, MSE panels, lock-blocks, etc.). Due to practical constraints in height for gravity retaining structures, geogrid reinforcement was required for the retaining wall in Area 5A. The client decided to limit the amount of scaling the contractor was permitted; thus, resulting in insufficient local rock source available to construct the retaining wall in Area 5A using a rock-stacked retaining structure. Area 5A was required to be redesigned with a geogrid reinforced SierraScape retaining wall system. As well, the contractor was able to facilitate an on-site crushing operation to produce the 40 mm drain rock and 75 mm minus pit-run backfill specified for all retaining structures and the engineered slope, as initially suggested by Tetra Tech EBA for appropriate backfill materials that were available on-site from ongoing construction elsewhere on the project, eliminating the need for costly import of backfill products to site.

Conclusion

Parks, Maglio and Tetra Tech EBA worked closely together to develop sound, practical, cost-effective solutions to a number of complex geohazards within a tight time frame. Open and constant communication allowed Parks to make informed decisions with regard to long-term risk and maintenance costs versus capital costs of various mitigative measures. The use of a continual “feed-back” loop between the field construction team and the office design team resulted in timely refinements and solutions for issues that could take weeks to resolve using a more formal design change approach.

Critically the work was completed at the end of November 2013, in time for the winter sports season in 2013 /2014. For a town such as Waterton that is dependent on tourism for its economic viability and sustainability, completing the work within the stipulated timeframe is of vital importance.

The effectiveness and integrity of the installed mitigation measures will only be measured in future years when another “once-in-a-lifetime” storm visits Waterton National Park.

Acknowledgements

I would like to acknowledge the input and assistance of all members of the Tetra Tech EBA Akamina Parkway team. Our involvement in the project and the successful implementation of our recommendations wouldn’t have been possible without our colleagues at Maglio Installations. Finally, I would like to thank the end client, Parks Canada and Public Works and Government Services Canada, who understand the risks that they manage on a daily basis on behalf of the people of Canada better than anyone else.