BC Ministry of Forests, Lands and Natural Resource Operations

Thompson Okanagan Region

Investigation of the 2014 Cooke Creek Debris Flood

Prepared for:

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1.0 INTRODUCTION

Early in the morning on May 2, 2014, a debris flood travelled down Cooke Creek impacting the alluvial fan, carving through the Mabel Lake highway and entering the Shuswap River. The debris flood initiated at Dale Lake, located 7 kilometres upstream, when the road across the outlet of the lake failed and a large volume of water was released into a tributary of Cooke Creek. This water funneled down the tributary channel (hereafter named Dale Creek for convenience), removing 30 m of the Cooke Creek FSR, and joined the main stem of Cooke Creek. All along the main stem of Cooke Creek the passage of the water was confined in a deep valley where it scoured and undercut the side-slopes causing or re-activating numerous bank collapse landslides. When the debris flood reached the alluvial fan, the flow began to spread laterally, avulsing on the upper fan into new channels and depositing large volumes of sediment and woody debris. The debris flood reached the highway crossing, rapidly plugging the arch and culvert in the road grade and diverted to the east where it cut a new channel across the highway.

2.0 BACKGROUND

Dale Lake is located in a flat pass between Cooke and Hunters Creek drainages (Figure 1) at an elevation of around 790 m asl. The watershed draining into Dale Lake is approximately 1065 hectares in size and extends both northwest and southeast. The drainage divide between the Cooke and Hunters Creek is located between Dale and Spruce Lakes in a broad swampy area. Various aerial photographs of the Cooke Creek and Dale Lake area were reviewed. The oldest imagery available in-house is from 1959 and the road infrastructure along the main valley of Cooke Creek and into the Dale Creek drainage was fully established and appears very similar to present. Widespread selective forest harvesting is apparent across both Cooke and Hunter Creek drainages. A listing of the aerial photographs reviewed is provided below in Table 1.

Year	Flight Line	Image Numbers	Date of Exposure
1959	BC 2640	66 – 69	July 22, 1959
1967	BC 5246	122 – 124	June 15, 1967
1971	BC 7322	106 – 108	July 16, 1971
1980	BC 80078	273 – 274	July 31, 1980
1984	BC 84051	28 – 29	July 28, 1984
1990	BCC 90089	162 – 165	September 10, 1990
1994	BCC 94092	169 – 170	July 23, 1994
1997	BCB 97082	40 – 41	September 8, 1997
2001	BCC 01026	38 – 39	September 16, 2001
2002	BCC 02003	63 – 64	August 11, 2002
2004	BCC 04041	112 – 113	August 10, 2004
2007	BCC 07008	196 – 198	July 5, 2007

Table 1: Aerial photographs reviewed in the completion of this report.

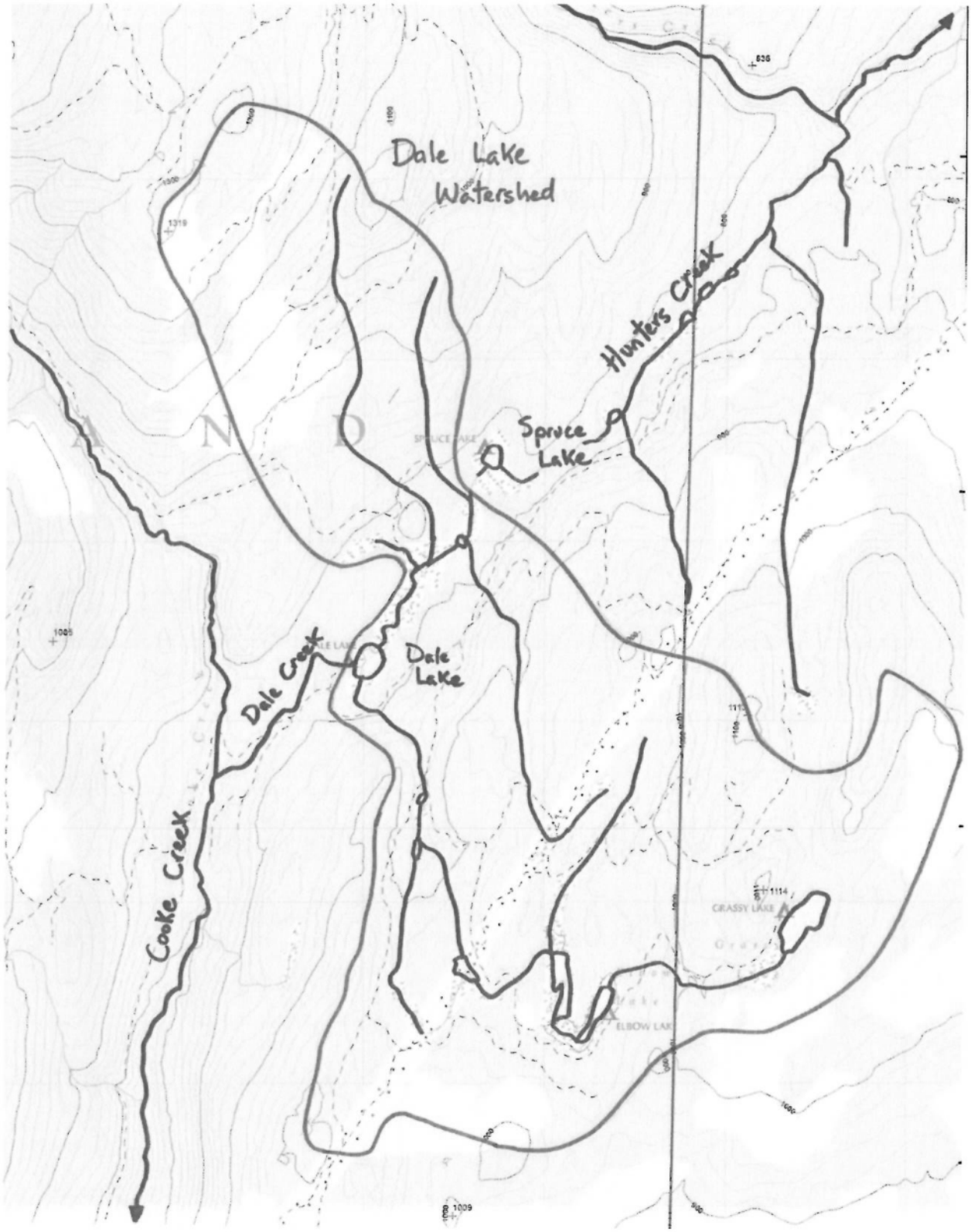


Figure 1: 1:20,000 topographic map showing the Dale Lake watershed. Creeks and watershed boundary were derived from interpretation of contours and fieldwork. The location of the breach is at the outlet of Dale Lake as it enters Dale Creek.

Weather

Data from three Environment Canada climate stations, Vernon North, Silver Creek and Salmon Arm, was reviewed and compared versus 1981-2010 climate normals. Climate normal temperatures for the region are average daily maximum temperatures averaging 15°C, average daily minimum temperatures averaging 2°C, and average mean temperatures around 9°C. During April and May 2014, temperatures were very close to these normals, with peak temperatures reaching around 25°C as is typical.

Precipitation normals were only available for the Vernon North and Silver Creek climate stations. Vernon North typically has 27.2 mm during April, but in April 2014 there was 57.6 mm. Two days accounted for over half the total; 17 mm on April 17 and 13.8 mm on April 22. Silver Creek typically has 29 mm during April and received 27.1 during April 2014; maximum daily rainfall was 8.1 mm on April 16. It should be noted that no data was collected on April 17 at the Silver Creek station; no reason was provided. The Salmon Arm station has no climate normal data. Total recorded rainfall in April was 35.7 mm with 7.6 mm on April 16, 10.8 mm on April 17 and 8.2 mm on April 22.

Data was reviewed from the Environment Canada weather radar at Silver Star Mountain. No rainfall was detected by the radar in the proximity of Cooke Creek watershed for the 4 days preceding May 2.

Collectively, the climate data shows no intense or prolonged rainfall events or period of extreme heating that might affect the Cooke Creek watershed. All indications are that the weather was nice, warm during the day and remaining warm overnight. The period from April 29 to May 2 has temperatures consistently above 20°C and overnight lows rising from -1°C to 9°C across the three climate stations. These daytime temperatures would promote strong melting and the overnight warmth would allow snowmelt to continue.

3.0 FIELD OBSERVATIONS

Initiation Point

The flood initiated at the outlet of Dale Lake. Dale Lake was a small lake with extensive marshy wetlands that had a low outlet through Dale Creek into Cooke Creek. The outlet was blocked by the road with drainage maintained through the road in two 800 mm metal culverts. The mechanism of failure is believed to be overtopping of the road surface, erosion of the roadfill by water to create a channel, probable saturation of a portion of the roadfill and subsequent catastrophic failure.

The road section immediately to the east of the outlet of Dale Lake shows signs of water flowing over the road and into Dale Creek. The main overflow was likely in the portion of the road which has been removed by the roadfill failure, probably incising an increasingly larger channel into the road surface until complete failure occurred. The ditch on the downstream east side of the road also shows signs of significant flow as it enters Dale Creek. The flow across the road may have saturated the roadfill sediments which helped initiate failure. Piping along the culvert may also have played a role in the initiation of water release. The ensuing rush of water washed down Dale Creek, into Cooke Creek and then continued down to the Mabel Lake highway crossing and into Shuswap River as a flood or debris flood.

Physiography

The actual division between the Dale Lake and Spruce Lake watersheds, as seen on TRIM 1:20,000 maps, is not clearly defined. Dale Lake drains into Cooke Creek; Spruce Lake drains into Hunters Creek. During fieldwork we circumnavigated Dale and Spruce Lakes to determine direction of flow and obtain crude estimates of flows into Dale Lake. As seen in Figure 1, the Dale Lake watershed is approximately 1065 hectares in size, with 345 hectares drainage from the north and 720 hectares draining from the south including Grassy and Elbow Lakes. The divide between the two watersheds is 500 m north-east of where the topographic map suggests it should be.

The northern tributaries are 100 and 245 hectares in size and feed into the north end of Dale Lake. The southern tributaries are 100 and 620 hectares in size, with the smaller tributary feeding in at the north-eastern end and the larger one at the south-eastern end of Dale Lake. All of these creeks are small and flow in well-defined draws upslope of Dale Lake. Culverts on the roads around Dale Lake were reviewed for flow volumes, damage or blockages and size. All culverts were active and passing water; only the 900 mm culvert on the southeast tributary from Grassy and Elbow Lakes showed any sign of excess flow and that was overflow onto the road surface. No sign of blockage was observed so it is believed that the culvert was simply undersized to pass the flow.

Lake level changes

Lake levels change through the years of photography, but the basic form of the lake remains similar between 1959 and 2004 (Plate 1). The lake has three basins: south, central and north. The south basin has always had an open pond of water, approximately a hectare in size, through all years of imagery prior to 2007. The central basin is elongate, up to 600 m long over 100 m wide with marsh grasses and a defined stream channel running through the centre of it. In a few images the north end of the central basin has open ponds, likely associated with beaver dams. The north basin is small, 100 m by 80 m wide and originally had a small open pond which over the years has ingrown with marsh grasses. The stability of the lake levels implies that the drainage systems into and out of Dale Lake were sufficient to manage the streamflow.

During this investigation it was discovered that between 2004 and 2007 the second 800 mm metal culvert was installed at the breach site; prior to this one 800 mm metal culvert drained Dale Lake. The new culvert had a beaver-stop culvert end attached on the inlet side. The heavy-duty, plastic beaver-stop attachment is designed to protect against beaver-cut woody detritus plugging the open-ended culvert and is reputed to be unpluggable. The beaver-stop end is T-shaped with inlets at the ends of the T arms covered by a metal grate. Flow enters through either the lower or upper arm of the T and flows into the culvert through the stem of the T. The installation of the second, upper culvert should not have changed the lake level as it would still have been controlled by the original culvert. The original culvert was set deeper in the road fill and the beaver-stop culvert was installed higher in the roadfill to act as an overflow. There are reports that the lake did overflow the road at the outlet suggesting that inflow to Dale Lake exceeded outflow, but the cause was never confirmed. Overflow could be due to natural conditions where too much water entered Dale Lake for the culverts to release or the culverts were blocked by something.

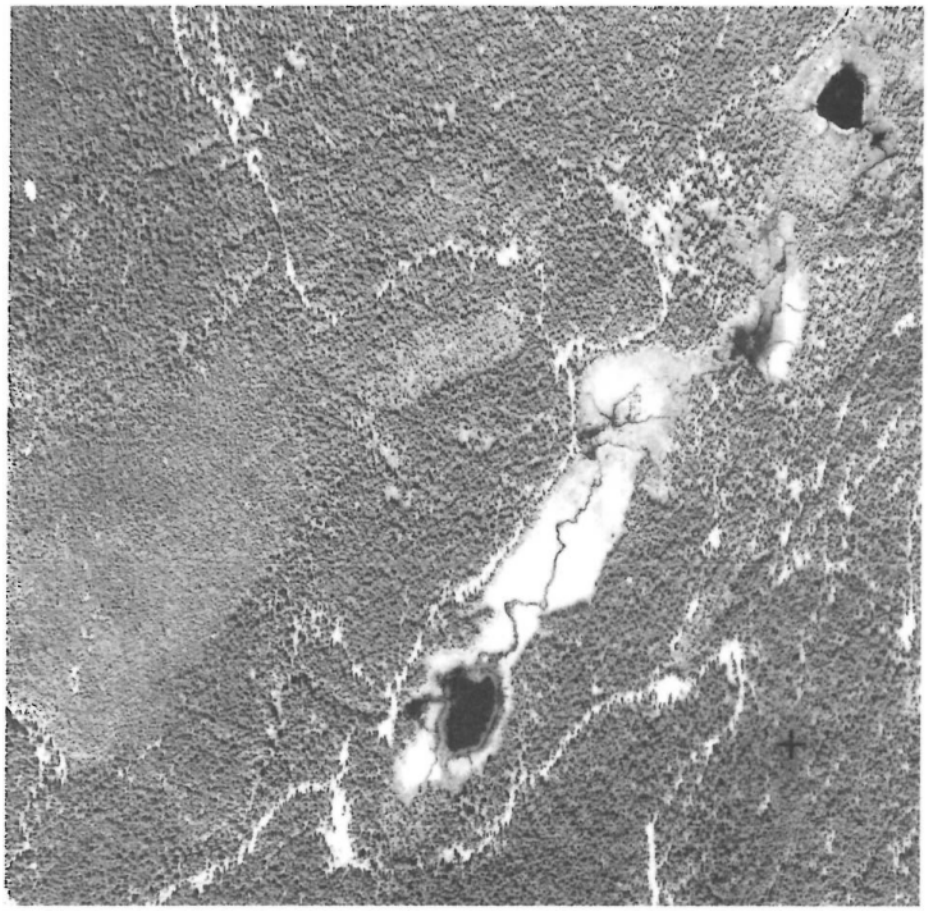


Plate 1: Aerial photograph BC2640-67, date of exposure is July 22, 1959. The open water in the south, central and north basins can be clearly seen on this black and white image. The pale coloured areas around the open water are marsh grasses. Spruce Lake, with a pond of open water, can be seen to the upper right. The breach site is on the west side of the south basin where the road is closest to the water.

In the 2007 imagery a major change in the water level of the lake can be observed and indicates that something has changed at the outlet. The lake expands from a small pond in the south to a large lake which covers the south and central basin. The south basin can still be seen, outlined by a ring of marsh grass, and the central section of the lake is inundated with water, covering as far north as the first beaver dam. Change at the outlet may signify an increase in the flow coming into the lake, but with no change in the outlet level only excess inflow to outflow beyond the capacity of the lower culvert would cause the lake level to rise. This, however, is unlikely as this image is from July 5, 2007 and the peak inflows from freshet have passed allowing the culvert time to pass the water and lower the lake level. For the lake to cover this aerial extent the water level must rise significantly, and impoundment must be maintained. I believe this indicates that the old culvert was non-functional in 2007 and that the new upper culvert now controlled the lake level. The elevation difference between the base of the old and new culverts is approximately 1 m which due to the shallow sloping nature of the shorelines probably means a large increase in the surface area of the lake.

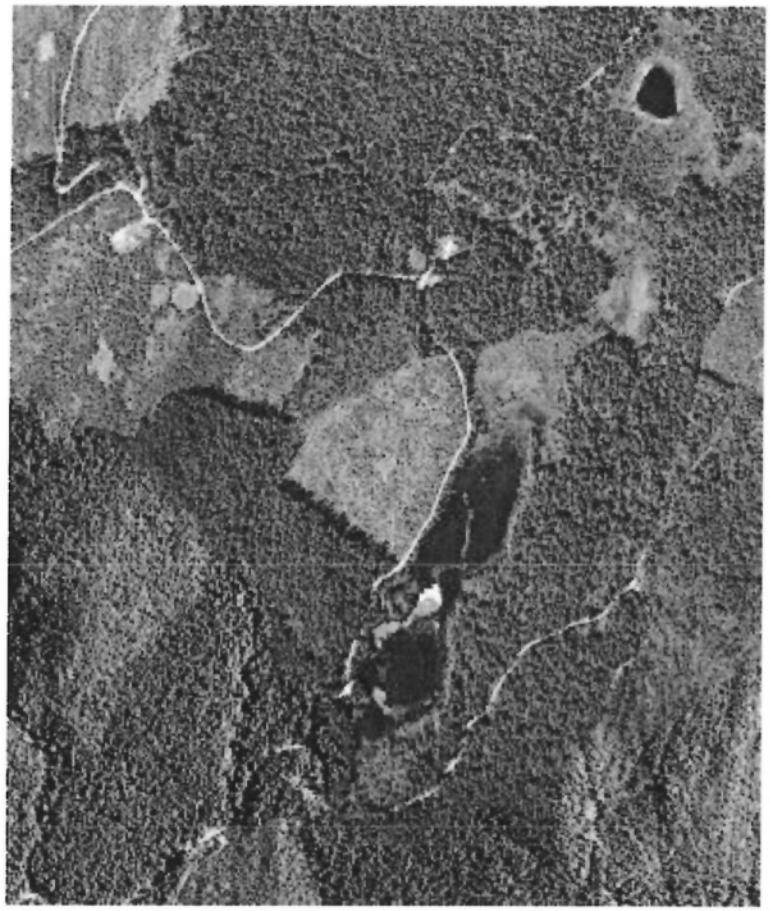


Plate 2: Aerial photograph BCC07008–197, date of exposure is July 5, 2007, illustrating the elevated lake levels. The marsh grasses are a lighter shade than the trees or water.

In the spring of 2014, the only outlet from Dale Lake was through the two 800 mm culverts leading into the draw of Dale Creek. Both culverts were removed by the escaping lake waters and were located bent and crumpled but intact, 200 m and 300 m downstream of the breach. The plastic beaver-stop end piece, complete with one of the two metal grates was found 300 m downstream from the breach.

4.0 DISCUSSION

The failure of the roadfill in the spring of 2014 is odd as previously only one culvert had been sufficient to drain Dale Lake, thus with two you would expect no issues would arise. Staff from the Ministry of Forests, Lands and Natural Resource Operations ensured correct functioning of the beaver-stop culvert in the summer of 2013. The condition of the lower culvert was not noted and is assumed to be under water at the time of that review. The only reasonable explanations for the elevated lake levels are that:

- the lower culvert was blocked (anecdotal evidence and aerial photography suggest that the lower culvert had been of limited functionality for years), causing inflow to the lake to exceed outflow through the new culvert, thus raising the lake level and triggering failure,

- the upper culvert was blocked, causing inflow to the lake to exceed outflow through the lower culvert, thus raising the lake level and triggering failure, or
- both culverts were blocked, causing inflow to exceed outflow and triggering failure.

Numerous agents may have been the cause of the blockage, the following are discussed below: beavers, ice, mats of marsh grass, human intervention or natural overflow.

Beavers

Review of aerial photographs shows a beaver lodge on the margin of the south basin, immediately north of the breach site, prior to 1984. This lodge was viewed in the field as it had been exposed by the lowered lake level, it was flattened, broken and inactive (Plate 3). The exit runs from the lodge were still visible but have become infilled with shrubbery. Remnants of an old beaver dam were observed on the upstream side of the breach (Plate 4) and this suggests that at some time beavers may have controlled the elevation of outflow of the lake. No sign of this dam can be seen on the 1959 aerial photographs.

A second lodge can be seen on images from 1959 through present in the northern portion of the central basin. Presently, this appears to be an active beaver lodge with several recently maintained dams stretching across the marshy wetland creating small lakes at slightly different elevations. Recent chew marks on several large and small trees or stumps around the lakeshore indicates that there is still a beaver in the area. Beavers have maintained relatively open water passageways between Spruce and Dale Lakes indicating that the lakes are close to the same elevation. Beavers tend to construct dams in low-lying areas with shallow moving water with the intention to flood more land and make it easier and safer to access food and float edible branches back to the lodge.

Plate 3: Old beaver lodge in the embayment 100 m north of the breach. The main lodge, with the lighter coloured sticks, has collapsed in on itself. One exit run can be seen on the lower left and is ingrown with grey coloured branches.

Plate 4: Remnants of a beaver dam near the breach. The dam is composed of beaver-cut sticks, stones and organic detritus. The dam is elongate across the breach suggesting it was originally across the lake outlet into Dale Creek.

The installation of the second culvert, with the plastic beaver-control inlet, in the roadfill at the breach site suggests that beavers might have been causing land managers some concern with insufficient capacity of the original 800 mm culvert and elevated lake levels. Flooding of the road surface prior to installation of the second culvert has been reported by some users. The lower culvert might have been blocked or partially blocked by beaver detritus in the fall making it easier to freeze over completely before spring runoff. Once the second culvert was installed this should no longer have occurred; if the lower culvert did become blocked, then the upper overflow culvert should have been open and ready to pass full flow as it does not get blocked by beaver detritus.

Two beaver lodges, several beaver dams and associated ponds can be seen on imagery through the years in all three basins of Dale Lake. Photos from the summers of 2012 and 2013 indicate that beavers were not active around the culvert inlets and that all the detritus blocking the culverts was of human origin. The lower culvert appears to be blocked with debris and is unlikely to be functioning and the lake level is being maintained by the upper culvert. The beavers appear to have migrated away from the south end of Dale Lake and presently appear to occupy a lodge 600 m north of the breach. The presence of beavers in the Dale Lake area is not an indication that they are causing any problems at the outlet of Dale Lake. There is no evidence that they were actively in the south basin in the summer of 2013 and it is considered very unlikely that they had anything to do with the blocking the inlets of the culverts.

Ice

Scarring of the bark on trees at the margin of the breach was initially thought to be the result of passage of ice downstream. However, when we flew over the area on the afternoon of the day the event occurred, no ice was observed in or around the south basin of the lake. There was also no ice visible downstream of the breach along Dale Creek. The northern portions of the lake, including isolated ponds behind the beaver dams, also had no sign of ice (Plate 5).

Plate 5: Photograph of Dale Lake looking south on the afternoon of May 2, 2014. Breach site is towards the upper right corner of the lake as viewed. No floating ice can be seen on lake or in the stream, nor is there any ice along the margins of the lake in the marsh grass.

Ice is discounted as a factor in the failure of the culverts to convey the water out of the lake and into Dale Creek. No ice was seen on the lake, in the vegetation along the margins of the lake or along Dale Creek.

Mats of marsh grass

From the earliest images in 1959 through 2004, large areas of Dale Lake are infilled with marsh grasses. Marsh grasses growing on the edge of the south basin were consistent in size and location from the earliest imagery in 1959 through 2004.

In the 2007 image (Plate 6), despite the presence of the new culvert in the roadfill, shows the lake with elevated water levels and two sections of marsh grass appear to be floating. This implies that the lower culvert was non-functional in 2007 and the new upper culvert maintained the lake level at a slightly higher elevation. One grass mat is located in the bay 100 m to the north of the breach and the second at the north edge of the south basin.

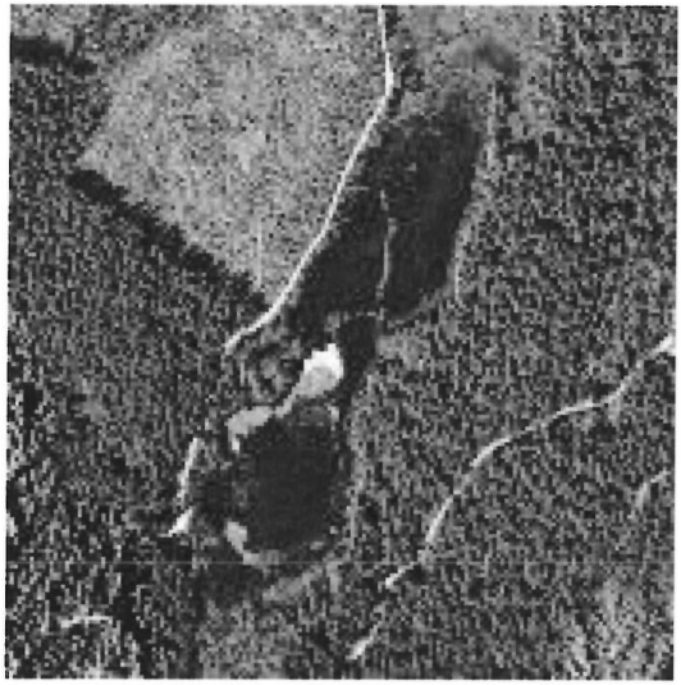


Plate 6: Close up view of Dale Lake from 2007; only the south and central basins are visible. The breach site is towards the bottom left of the image (southwest corner of the lake). Two large sections of floating marsh grasses are visible.

Plate 7: Floating grass mat on Dale Lake, May 2, 2014. This mat of marsh grass can be moved to the right and fits the area inside the stream channel at right centre (circled). Breach is at left centre of photograph.

In the summer of 2014, both large sections of the marsh grasses have moved. The grasses that were once in the bay immediately north of the breach have completely disappeared. The large floating grass mat now present in the middle of the south basin matches the shape and size of marsh grasses visible immediately north of the south basin on the 2007 aerial photograph (Plates 6 and 7).

The marsh grasses rose with the new higher lake levels and dropped when the lake level fell. The grass mats seem to be only partially connected to the underlying muds, such that we could observe a distinct break between the sediments and the organic grasses. The grasses were anchored by their roots along the elevated shoreline which kept the marsh grass mats in place during the rise and fall of the water. The grass mats have the ability to float, as seen in Plate 7, but in a photograph from the summer of 2013 they were still in place along the shoreline. The next elevated lake level would have been the spring of 2014 and at some point, either from the stress of the rising waters or from the drawdown effect once the roadfill failure occurred, they ripped free from the shoreline and floated away. Of the two large marsh grass mats visible in the 2007 imagery (Plate 6), the larger mat remains floating on the lake while the smaller mat was drawn down through the outlet when the breach occurred.

The scarring on the trees at the margins of the breach is a result of passage of one of the large marsh grass mats that used to exist in the lake. A piece of grass mat can be seen surrounding the trunk of the tree on the north side of the breach (Plate 8). Large accumulations of marsh grasses were observed in the first 300 m of the Dale Creek channel (Plate 9). These mats were readily entangled by standing trees along the margins of the flow, by large woody debris in and across the creek, and in overbank areas.

Marsh grasses growing on the periphery of the south basin appear to have been partially submerged by the change in lake levels as a result of possible abandonment of the lower culvert and installation of the upper culvert. These mats were attached to the shoreline but had the ability to rise and fall with the changing lake levels. This movement would have stressed the attachment areas along the shoreline until they broke and the mats were free to float away. It is likely the excessively high waters in the lake in the spring of 2014, or the sudden drawdown of the lake as the roadfill failed, instigated the final release of the grass mats. It may be possible that the more southerly marsh grass mat was released earlier and floated over to and plugged the culvert inlets. This is unlikely as I believe it is the combination of high water and sudden water release that caused the mats to become free, thus the breach had already occurred before the grass mat was free to float away.

Plate 8: View from the lake bed of two scarred trees located on the upstream side of the breach. The tree on the right has a section of marsh grass wrapped around it.

Plate 9: Aerial view of marsh grasses mats entangled with culverts and trees about 200 m downstream from the breach location on Dale Creek.

Humans

Wood debris

Several photographs from Dale Fennell show the condition of the culvert inlets in the summers of 2012 and 2013. In a photograph dated August 21, 2012, only the upper culvert with the beaver-stop attachment is visible (Plate 10). There is no sign of the lower culvert, but the water level is below the upper culvert suggesting that there is flow out of the lake and that the lower culvert is passing water. All of the wood pieces are of human origin, either logs cut for firewood or stump seats, or plywood sheets. The beaver-stop attachment is jammed open with pieces of wood placed between the metal culvert and the plastic. This does not occur without human intervention as the attachment is heavy and does not float, thus someone must have pulled the attachment up to insert the wood.

In two photographs from July 12, 2013, the beaver-stop attachment is correctly aligned on the end of the upper culvert (Plate 11). In one photo the lower culvert can be seen (Plate 12) and the water level is at the base of the upper culvert indicating that even though the lower culvert is visible, it is partially blocked by debris.

Removal of plywood sheets covering the culvert inlets in the years preceding 2014 has been reported. A plywood sheet would not be as easy to install on the beaver-stop culvert, two pieces would need to be attached and held firm to the base and top of the T inlets. Opening of the beaver-stop culvert end and installation of a plywood sheet would likely be sufficient to block the flow but would require someone to have simple working knowledge of the beaver-stop culvert.

Plate 10: Dale Fennell photograph from August 21, 2012, showing the inlet of the upper culvert on the road crossing. The lower culvert is not visible but the lake is below the base elevation of upper culvert suggesting the lower culvert is allowing some flow and controlling lake level.

Plate 11: Dale Fennell photograph from July 12, 2013, showing the inlet of the upper culvert on the road crossing. Woody debris around the inlet is cut by humans. The base of the upper culvert is at lake level, suggesting that this culvert may be controlling lake level and that the lower culvert is partially blocked.

Plate 12: Dale Fennell photograph from July 12, 2013, showing the inlet of the lower culvert on the road crossing. The culvert appears to be partially jammed with debris as water is halfway up the culvert but it may still be active and controlling the lake level.

Plastic sheets

Several pieces of plastic were found near the breach site and along Dale Creek. These occurred as fairly large sheets, 1 to 2 mm thick and were a dark blue-black color. These were definitely large enough to have covered 800 mm culvert inlet, but might not have been strong enough to hold back the lake water to allow over-topping of the road. Folding the plastic over or using multiple layers may have been sufficient to prevent flow through the culvert.

Plate 13: One of the pieces of heavy-duty plastic that was found near the breach site.

Natural overflow

A crude estimation of flow into and out of Dale Lake in days preceding the May 2, 2014 failure was completed. Assumptions made include:

- as of mid-April, 2014, that the lake level was at the base of the upper culvert as the lower culvert was non-functioning,
- the distance between the base of the upper culvert and the road surface was 3 m, and
- the Dale Lake watershed at 1056 hectares could produce at least 2 m^3 per second of water into the lake at peak flow during freshet (For comparison the closest monitored creeks in the region are Corning Creek, a 2620 hectare watershed which has peak flows typically around 6 m^3 per second and East Canoe Creek, a 2080 hectare watershed, which has peak flows around 2 m^3 per second.)

The lake surface was divided into two sections, the south basin and the central basin. The south basin has a surface area of 200 m by 200 m equalling around 40,000 m^2. The central basin has a surface area of 400 m by an average width of 125 m equalling around 50,000 m^2. The total area is 90,000 m^2 and assuming the 3 m of elevation between the base of the culvert and the road surface it would require a maximum of 270,000 m^3 of water to fill the

lake to capacity if there was no outflow. Assuming inflow to Dale Lake was 2 m^3 per second and outflow was 1 m^3 per second, there would be a 1 m^3 gain per second. At 86,400 seconds per day (60 seconds x 60 minutes x 24 hours) this would take just over three days to overtop the road surface.

The climate records indicate that, between April 29 and the morning of May 2, daytime temperatures in the Okanagan Valley, and correlatively extended to the Dale Lake area, were above 20°C and nighttime temperatures remained above zero, allowing the melt to progress rapidly. During these three days it is possible that the inflow to Dale Lake was in excess to the outflow in the range of 1 m^3 per second thus it is possible that natural conditions could have caused the lake level to rise, flow to cross the road and failure to occur.

5.0 CONCLUSIONS

The debris flood that ran down Cooke Creek initiated at the outlet of Dale Lake when the road across the outlet was overtopped by lake waters. Erosion by the escaping water cut down and eventually caused failure of the roadfill sediments. The flood waters picked up sediment and woody debris as they travelled down Dale Creek and then along Cooke Creek. Numerous bank slumps are visible along both creeks and are the result of the elevated flows undercutting the sidewalls. This flood was much larger than a typical freshet flow.

Climate conditions for the previous do not appear to have been much different than normal for the region. All of the climate data is from three climate stations in the Okanagan valley, approximately 40 km to the west, and between 200 and 300 m lower elevation. Typical rainfall amounts were recorded for the month and temperatures were similar to what is expected. The last two days in April and on May 1, the daytime temperatures were elevated and peaked between 20°C and 25°C degrees. Overnight lows were well in excess of 0°C in the Okanagan valley, staying over 7°C on the night of May 1-2. Dale Lake is at approximately 790 m elevation, thus we would expect the temperatures to be 2-3°C cooler during the day and overnight than in the Okanagan Valley. The highs would still be around 20°C during the day but the crucial part may be the overnight heating that would likely have been below freezing prior to April 29.

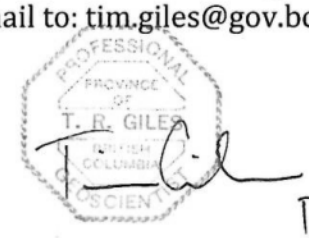
The functionality of the lower culvert appears questionable from 2007 onward and efforts to maintain it may have been abandoned. The installation of the second culvert with the beaver-stop inlet in 2007 suggests that land managers had identified the beavers as the probable culprit blocking the original culvert. I have assumed that the lower culvert was almost completely if not completely non-functional by the summer of 2013 and nothing was done to clear or maintain it. Thus only the upper culvert was open and actively draining Dale Lake in the spring of 2014.

The ability of Dale Lake to drain through the lower 800 mm culvert prior to 2007 and through the upper 800 mm culvert post-2007 is uncertain. In the years preceding 2014 there are reports of the road being overtopped by water escaping the lake during freshet. This suggests that either the capacity of the culverts was overwhelmed by inflow to the lake or that the culvert inlets were blocked. It may be that the warm weather, and especially the warm nights, elevated flows into Dale Lake such that the new 800 mm culvert was unable keep up and the lake level rose above the road elevation. Several small

creeks flow into Dale Lake and it is very likely that the watershed can produce in excess of 2 m^3 per second at peak. If the main southeast drainage was in excess of the 900 mm culvert then it stands to reason that the 800 mm on Dale Lake was also undersized. Overflow of lake waters across the road would have rapidly incised a channel into the road surface and failure ensued. If the culverts were blocked, and we have reports of plywood sheets being removed from the culvert inlets, then the speed of infilling would have been much faster and overtopping much easier to achieve.

My conclusion as to why the flood initiated is leaning towards that someone blocked the upper culvert inlet in the fall of 2013 over natural excess inflow over outflow. The blockage could have been a sheet of plywood, a piece of plastic sheeting, or any other article which would prevent flow through the culverts. Why the culverts were blocked is also uncertain, but it may be that it was to increase the water depth to promote ice fishing on the lake. Greater water depth would ensure the lake did not freeze to the base and fishing conditions would be better. Who would have blocked the culvert inlets remains unknown, but I doubt they were aware of the potential consequences that their actions might trigger.

Questions on the foregoing can be directed to the undersigned at 250-828-4168 or via e-mail to: tim.giles@gov.bc.ca



December 18, 2014

Tim Giles, P. Geo.
Research Geomorphologist
Thompson Okanagan Region
Ministry of Forests, Lands and Natural Resource Operations

INVESTIGATION REPORT INTO THE COOKE CREEK/DALE LAKE LANSLIDE OF MAY 2, 2014

Report prepared by:
Natural Resource Officer Lisa Hudema
Ministry of Forests, Lands And Natural Resource Operations
Thompson Okanagan Region

in co-operation with

Fishery Officer Brian Levitt
Department of Fisheries and Oceans Canada

Dale Lake / Cooke Creek Investigation Report

Incident Number: 2014-1571 **Incident Date:** May 2nd, 2014

Region: Thompson Okanagan Region

Geographic Location: Dale Lake, which is located on Crown Land, NE of the community of Ashton Creek, British Columbia.

Legal Description: Crown Land

Latitude: 50 39.45 **Longitude: -118 49.56**

Investigated by: Natural Resource Officer (NRO) Lisa Hudema, and Fishery Officer (FO) Brian Levitt

Investigation Initiated Date: May 9th, 2014 **Investigation Concluded Date:** July 21, 2015

Introduction:

On the morning of May 2nd, 2014 a debris flood occurred that initiated at the outlet of Dale Lake, then travelled down Cooke Creek, through Mabel Lake Road and into the Shuswap River. The debris flood occurred as a result of a road failure at Dale Lake outlet, which caused a large volume of water to be released into a Cooke Creek tributary, then into Cooke Creek. Due to the large volume of water it scoured the creek banks which released woody debris and sediment that flowed downstream. The woody debris plugged the Mabel Lake Road crossing (culverts); therefore Cooke Creek diverted to the east where a new channel was created across Mabel Lake Road to the Shuswap River. The debris flood deposited woody debris and sediment into the Shuswap River, damaged the King Fisher Interpretive Centre, and caused fish mortality.

Witnesses:

Surname	Given Name	Title	Statement Taken Y/N	Contact Number
Witness A		Government Employee	Y	
Witness B		Government Employee	Y	
Witness C		Government Employee	Y	
Witness D		Government Employee	Y	
Witness E		Government Employee	Y	
Witness F		Government Employee	Y	

Witness G		Government Employee	Y	
Witness H		Government Employee	Y	
Witness I		Government Employee	Y	
Witness J		Government Employee	Y	
Witness K		Member of Public	Y	
Witness L		Member of Public	Y	
Witness M		Member of Public	Y	
Witness N		Government Employee	Y	
Witness O		Member of Public	Y	
Witness P		Member of Public	Y	
Witness Q		Member of Public	Y	
Witness R		Member of Public	Y	
Witness S		Government Employee	Y	
Witness T		Government Employee	Y	
Witness U		Government Employee	Y	
Witness V		Member of Public	Y	
Witness W		Member of Public	Y	
Witness X		Member of Public	Y	
Witness Y		Government Employee	Y	

Other Contacts:

Surname	Given Name	Title	Statement Taken	Contact Number
Witness Z		Member of Public	Y	

INCIDENT CAUSE ELIMINATION AND EXPLANATION

BEAVER
POSSIBLE / UNLIKELY

There was no evidence found to suggest that "beaver" was the cause of this incident.

Statements from witnesses that have worked and / or recreated at Dale Lake indicate that beavers and / or beaver sign has been observed at Dale Lake, coupled with the fact that there were older inactive beaver lodges observed at Dale Lake proves that there has been historical beaver activity at Dale Lake.

One active beaver lodge and dam on the North end of Dale Lake approximately 600m from the breach, coupled with recent chew marks on trees along the lakeshore provides evidence of recent beaver use at Dale Lake. There however there was no evidence found of recent beaver activity near the outlet of Dale Lake where the incident occurred, nor were there any recent reports of problems with beavers at Dale Lake outlet.

Photographs taken the summer of 2012 and 2013 indicate that there was no beaver activity around the culverts inlets at the outlet of Dale Lake, and that the woody debris observed in the photographs is of human origin. The photographs also show that there is a plastic "Beaver Proof Add On" (BPAO) present on the inlet side of the overflow culvert. This type of BPAO is specifically designed to prevent woody debris from plugging the culvert; therefore beaver are unable to plug the overflow culvert.

Geomorphologist Report from Tim Giles states the following;

- "if the lower culvert did become blocked, then the upper overflow culvert should have been open and ready to pass full flow as it does not get blocked by beaver detritus."
- "The presence of beavers in the Dale Lake area is not an indication that they are causing any problems at the outlet of Dale Lake."
- "There is no evidence that they were actively in the south basin in the summer of 2013 and it is considered very unlikely that they had anything to do with the blocking the inlets of the culverts."

There is no witness information that suggests that "beaver" is the cause of this incident.

ICE
EXCLUDED

There was no evidence found to suggest that "ice" was the cause of this incident.

The Investigators completed a file review, and spoke to persons that worked and recreated at Dale Lake and found no history of ice jams at Dale Lake.

Geomorphologist Report from Tim Giles states the following;

- "When we flew over the area on the afternoon of the day the event occurred, no ice was observed in or around the south basin of the lake."
- "There was also no ice visible downstream of the breach along Dale Creek."

- "The northern portions of the lake, including isolated ponds behind the beaver dams, also had no sign of ice."
- "Ice is discounted as a factor in the failure of the culverts to convey the water out of the lake and into Dale Creek.
- "No ice was seen on the lake, in the vegetation along the margins of the lake or along Dale Creek."

Photographs provided by Tim GILES, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) Geomorpholgist, that were taken the day of the incident provide evidence that there was no ice on Dale Lake the day of the incident; therefore ice is eliminated as a potential cause.

There is no witness information provided that supports "ice" as the cause of this incident.

NATURAL OVERFLOW (HIGH WATER EVENT / RAPID MELT)

EXCLUDED

There was no evidence found to suggest that "natural overflow" was the cause of this incident.

The Investigators inspected the culverts at Dale Lake inlets following the incident, and observed that all culverts were actively passing water, and that all but one culvert did not show any sign of excess flow. The culvert that did show access flow was a 900mm on the South East tributary

Geomorphologist Report from Tim Giles states the following;

- "Collectively, the climate data shows no intense or prolonged rainfall events or period of extreme heating that might affect the Cooke Creek watershed."
- "The climate records indicate that, between April 29 and the morning of May 2, daytime temperatures in the Okanagan Valley, and correlatively extended to the Dale Lake area, were above 20°C and nighttime temperatures remained above zero, allowing the melt to progress rapidly. During these three days it is possible that the inflow to Dale Lake was in excess to the outflow in the range of 1 m^3 per second thus it is possible that natural conditions could have caused the lake level to rise, flow to cross the road and failure to occur."
- "Typical rainfall amounts were recorded for the month and temperatures were similar to what is expected."

The weather conditions (temperature and rainfall) the day of the event, and days prior to the event were normal, therefore normal snowmelt expected.

There is no witness information provided that supports "high water event /rapid melt" as the cause of the incident.

CAPACITY OF CULVERTS

EXCLUDED

There was no evidence found to suggest that "culvert capacity" was the cause of this incident.

The Investigators determined through interviews with witnesses that worked / recreated in the Dale

Lake area that there was only one 800mm culvert at the breach location until approximately 2007. At that time an additional 800mm overflow culvert was installed with a "Beaver Proof Add On" (BPAO). The installation of the second culvert doubled the outflow capacity.

HUDEMA contacted Beaver Culvert and was informed that the BPAO does not reduce culvert capacity.

Due to the fact that one 800mm culvert handled the outlet flow for approximately 40 years prior to 2007, and that two 800mm culverts handled the outlet flow for approximately 8 years prior to the incident, the Investigators have no reason to believe that culvert capacity was the cause of the incident.

The culverts were inspected and maintained in the summer of 2013 by the Ministry of Forests, Lands, and Natural Resource Operations, where both culverts were deemed operational at that time.

Photographs provided by MFLNRO staff that maintained the culverts in 2013, coupled with photographs provided by WITNESS P, complainant regarding the lack of maintenance, provide evidence that the culverts were not operating at full capacity.

There is no witness information provided that supports "culvert capacity" as the cause of this incident.

GRASSY MATS

POSSIBLE /UNLIKELY

There was no evidence found to suggest that "grassy mats" was the cause of this incident.

Investigators observed the location of grassy mats in Dale Lake using air photos. The Investigators found that the grassy mats were in the same location according to air photos from 1959 – 2004, however there was a change in location of two grass mats in the 2007 air photo, with the closest grassy mat approximately 100m north of the breach.

Following the incident, photographs were taken that show that the grassy mat that was once 100m north of the breach is no longer in the lake. The Investigators found evidence of the grassy mat in the trees adjacent the breach and downstream of the breach.

Photographs taken the summer of 2012 and 2013 indicate that there were no grassy mats observed at the outlet of Dale Lake, however it is unknown if the grassy mats became dislodged from its former location prior to the incident, or at the time of the incident.

In the Geomorphologist Report, Tim Giles states the following;

- "It is likely the excessively high waters in the lake in the spring of 2014, or the sudden drawdown of the lake as the roadfill failed, instigated the final release of the grass mats."
- It is unlikely, however possible that "the more southerly marsh grass mat was released earlier and floated over to and plugged the culvert inlets."
- "I believe it is the combination of high water and sudden water release that caused the mats to become free, thus the breach had already occurred before the grass mat was free to float away."

There was no witness information provided that supports "Grassy Mats" as the cause of this incident.

CULVERT DAMAGE
EXCLUDED

There was no evidence found to suggest that "culvert damage" was the cause of this incident.

Witnesses that had been at Dale Lake prior to the incident did not provide any information that would indicate that there was damage to the lower / main 800mm culvert.

Photographs taken in 2012 and 2013 at the Dale Lake outlet do not provide any evidence that there was any damage to the two 800mm culverts or the "Beaver Proof Add On" (BPAO).

The investigators were informed by Geomorphologist Tim Giles that he inspected the displaced 800mm main culvert downstream of the breach following the incident, and that he observed rust inside the culvert and holes in the culvert end.

Senior Engineering Technician Martin Fennel informed the Investigators and Geomorphologist that if there were holes in the culvert prior to the incident, the soil would have become saturated below the culvert, and there would have been evidence of the soil slumping. Fennel however said that it is highly unlikely that there would be holes in the culvert prior to the incident as holes are usually associated with rock movement through culverts which is usually associated with streams, not lakes. Fennel also informed the Investigators and Geomorphologist that it is normal to see rust on galvanized culverts

The Investigators observed the photographs taken in 2012 and 2013, prior to the incident and they did not observe any evidence of soil saturation, slumping or culvert damage.

There was no witness information provided that supports "culvert damage" as the cause of this incident.

MAINTENANCE
POSSIBLE / UNLIKELY

Although Compliance and Enforcement received a complaint that there was a lack of maintenance at Dale Lake outlet, the Investigators determined that the Ministry of Forests, Lands, and Natural Resource Operations Engineering staff inspected Dale Lake outlet on June 12, 2013. At the time of inspection, the Engineering staff maintained the overflow culvert including the "Beaver Proof Add On" (BPAO), and completed an inspection report. The Engineering staff reported that the main culvert (lower culvert) was operational at the time of their inspection.

The Engineering staff provided photographs in their inspection of the overflow culvert, however did not provide photographs of the main (lower) culvert; therefore it is hard to determine the condition of the lower culvert at the time of, and immediately following inspection / maintenance.

In the Geomorphologist Report, Tim Giles states the following;

- "Anecdotal evidence and aerial photography suggest that the lower culvert had been of limited functionality for years."
- "Staff from the Ministry of Forests, Lands and Natural Resource Operations ensured correct functioning of the beaver-stop culvert in the summer of 2013"
- "The condition of the lower culvert was not noted and is assumed to be under water at the time

of that review."

- "The functionality of the lower culvert appears questionable from 2007 onward and efforts to maintain it may have been abandoned."

The Investigators observed photographs provided by WITNESS M that were taken on June 3rd, 2014. The Investigators observed in the photographs that there was more water coming out of the overflow culvert outlet with BPAO, than the main lower culvert outlet, which suggests that the lower culvert is partially plugged. This was one month prior to the inspection and maintenance of culverts.

In photographs provided by WITNESS P on July12th, 2013 after the peak flow, the BPAO appears to be aligned correctly, however the lake water remains at the base of the overflow culvert, which suggests that the lower culvert may be plugged. The woody debris observed in WITNESS P's photographs appears to be of human origin. This is one month after inspection and maintenance of culverts.

Beaver Culvert informed HUDEMA that the BPAO is maintenance free. The main culvert (lower culvert) however does not have a BPAO, therefore would require maintenance to keep it operational.

With the contradictory information above, the condition of the main (lower) culvert at the time of this incident is unknown.

HUMAN TAMPERING

POSSIBLE / MOST LIKELY

The Investigators completed a file review where they found a history of human tampering at the outlet of Dale Lake where the incident occurred. Human tampering consisted of the lower culvert plugged with cut firewood and plywood, as well as the upper overflow culvert with "Beaver Safe Add On" (BPAO) hinged open with a block of firewood jammed in the hinge. The BPAO is extremely heavy therefore can only be opened by human intervention.

The Investigators completed a review of air photographs of the Dale Lake area from 1959-2007, where they observed that the lake was relatively the same size, until 2007. However in 2007 the lake appears almost double in size. The 2007 imagery was taken on July 5th, therefore not at the lakes Peak, therefore it appears that something was impeding the flow at the outlet of Dale Lake at that time.

In the Geomorphologist Report Tim Giles states;

- "In the 2007 imagery a major change in the water level of the lake can be observed and indicates that something has changed at the outlet."
- "The lake expands from a small pond in the south to a large lake which covers the south and central basin."
- "…this image is from July 5, 2007 and the peak inflows from freshet have passed allowing the culvert time to pass the water and lower the lake level."
- "I believe this indicates that the old culvert was non-functional in 2007 and that the new upper culvert now controlled the lake level."
- "The elevation difference between the base of the old and new culverts is approximately 1 m which due to the shallow sloping nature of the shorelines probably means a large increase in the surface area of the lake."
- "The failure of the roadfill in the spring of 2014 is odd as previously only one culvert had been sufficient to drain Dale Lake, thus with two you would expect no issues would arise."

- "My conclusion as to why the flood initiated is leaning towards that someone blocked the upper culvert inlet in the fall of 2013 over natural excess inflow over outflow. The blockage could have been a sheet of plywood, a piece of plastic sheeting, or any other article which would prevent flow through the culverts."
- "If the culverts were blocked, and we have reports of plywood sheets being removed from the culvert inlets, then the speed of infilling would have been much faster and overtopping much easier to achieve."

Tim Giles also states in the Geomorphologist report that "the only reasonable explanations for the elevated lake levels are that:

- the lower culvert was blocked (anecdotal evidence and aerial photography suggest that the lower culvert had been of limited functionality for years), causing inflow to the lake to exceed outflow through the new culvert, thus raising the lake level and triggering failure,
- the upper culvert was blocked, causing inflow to the lake to exceed outflow through the lower culvert, thus raising the lake level and triggering failure, or
- Both culverts were blocked, causing inflow to exceed outflow and triggering failure."

In photographs provided by WITNESS P on July12th, 2013 after the peak flow, the BPAO appears to be aligned correctly, however the lake water remains at the base of the overflow culvert, which suggests that the lower culvert may be plugged. The woody debris observed in WITNESS P's photographs appears to be of human origin. This is one month after inspection and maintenance of culverts.

In photographs provided by WITNESS M on June 3rd, 2014, the Investigators observed more water coming out of overflow culvert outlet with BPAO than the main lower culvert outlet, which also suggests that the lower culvert is partially plugged. This was one month prior to inspection and maintenance of culverts.

During a field review of the incident, the Investigators observed several pieces of heavy duty plastic at the breach and downstream of the breach adjacent the displaced culverts. This heavy duty plastic is not a material that is used for road construction, therefore suspicious in nature.

In the Geomorphologist Report, Tim Giles describes the plastic as "fairly large sheets, 1 to 2 mm thick and were a dark blue-black color". Giles also states that "these were definitely large enough to have covered 800 mm culvert inlet, but might not have been strong enough to hold back the lake water to allow over-topping of the road. Folding the plastic over or using multiple layers may have been sufficient to prevent flow through the culvert."

DAM (authorized or unauthorized)

Water Stewardship Branch confirmed that there is no licensed dam at Dale Lake.
Investigators did not observe evidence of an unauthorized dam.

CAUSE DETERMINED

The investigators believe that the most likely cause of this incident is "Human Tampering".
Beaver, Grassy Mats, and Maintenance cannot be ruled out as possible causes, however the investigators believe that they are unlikely the cause of this incident.

"Beaver" are unable to plug the inlet of the overflow culvert due to the "Beaver Proof Add On" (BPAO); however beaver may have contributed to the incident if the beaver became active at Dale Lake outlet and plugged the main culvert. There however was no evidence provided that Beaver were active at the outlet of Dale Lake.
It is unlikely that the "grassy mats" could plug the BPAO; however the grassy mats may have contributed to the incident if the grassy mats plugged the main culvert at Dale Lake outlet. There however is no evidence to suggest that grassy mats were located at Dale Lake outlet.
It is also unlikely that "maintenance" is the cause of the incident as an inspection / maintenance was conducted by MFLNRO Engineering Staff on June 12, 2013.

Based on the field examination, file review, and witness interviews, I offer the following;

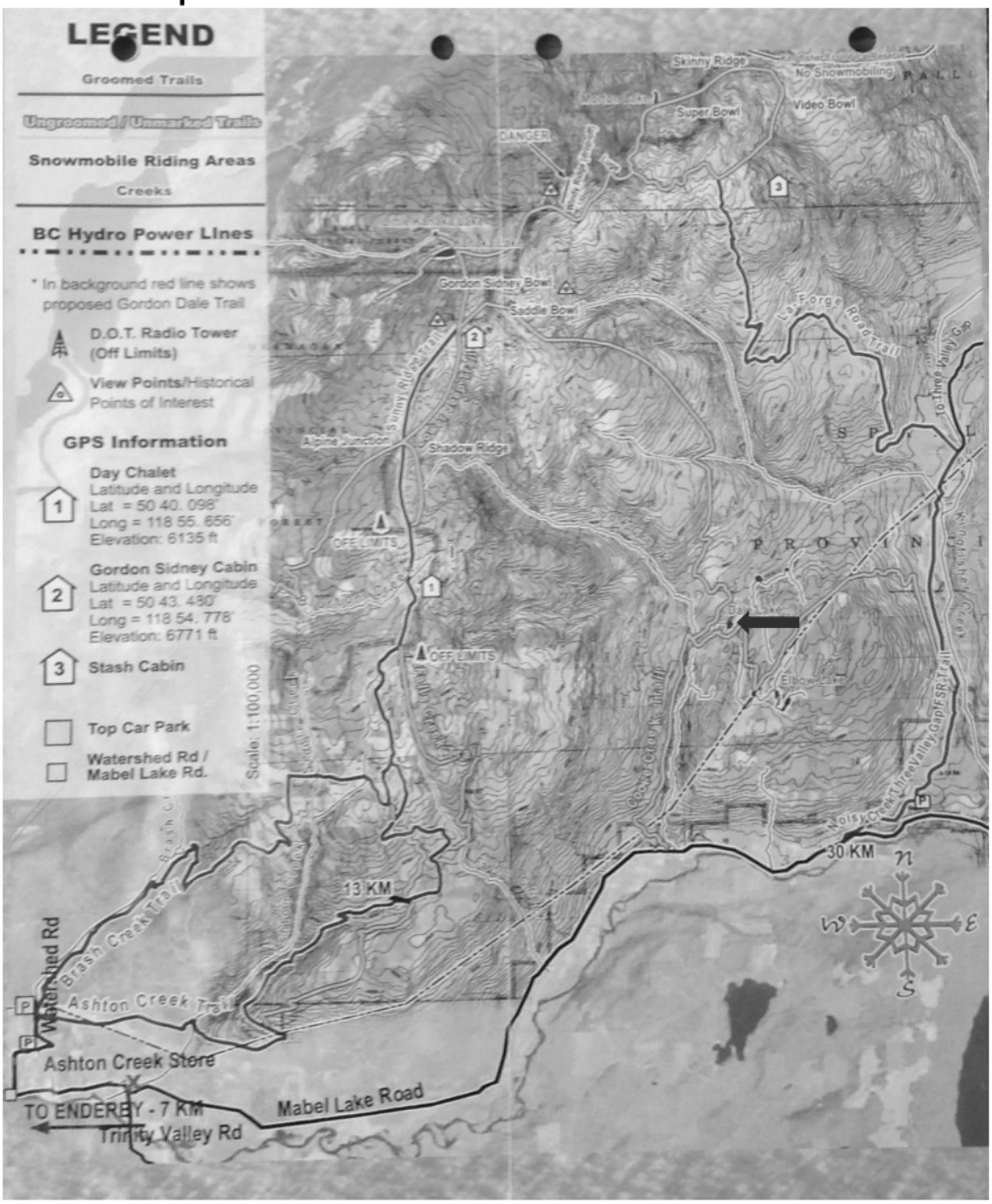
The weather at the time of the incident was taken from three Environment Canada climate stations (Vernon North, Silver Creek, and Salmon Arm) where warm temperatures were recorded both days and overnight. The temperatures up to one month prior to the incident were such that would support snowmelt; however the temperatures were close to the normal for the region, therefore not unusually warm. There were also no intense or prolonged rainfall events up to one month prior to the incident, with precipitation for the Dale Lake area also close to normal for the region.

Incident #1571 occurred in the early morning of May 2nd, 2014 on Crown Land at Dale Lake outlet, which is located NE of the community of Ashton Creek, British Columbia, approximately 8.2km up the Cooke Creek Grassy Forest Service Road.

Dale Lake **(Below are photographs of Dale Lake following the debris flood incident).**

The incident involved a debris flood that initiated at the outlet of Dale Lake, then travelled down Cooke Creek, through Mabel Lake Road and into the Shuswap River. The debris flood occurred as a result of a road failure at Dale Lake outlet, which caused a large volume of water to be released into a Cooke Creek tributary, then into Cooke Creek. Due to the large volume of water it scoured the creek banks which released woody debris and sediment that flowed downstream into the Shuswap River. The woody debris plugged the Mabel Lake Road crossing; therefore Cooke Creek diverted to the east where a new channel was created across Mabel Lake Road and into the Shuswap River. This debris flood event damaged the King Fisher Interpretive Centre and caused fish mortality.

Location Map

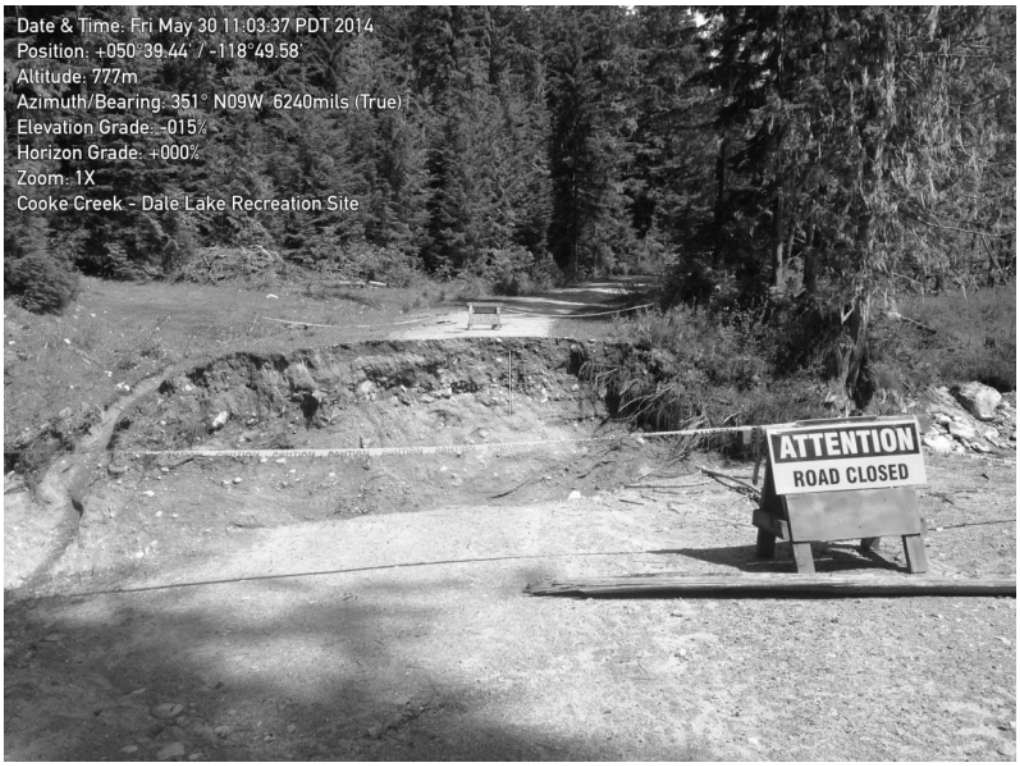


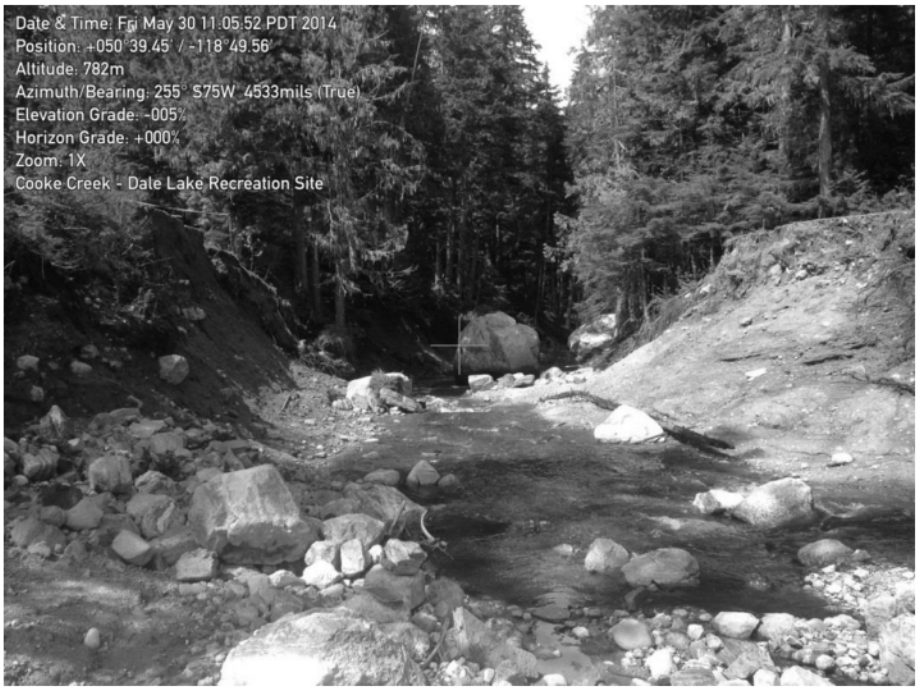
Natural Resource Officer (NRO) Lisa HUDEMA was assigned to investigate the incident, on behalf of Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Compliance and Enforcement Division, and Fishery Officer (FO) Brian LEVITT was assigned to investigate the incident on behalf of the Department of Fisheries and Oceans (DFO). HUDEMA and LEVITT (the Investigators) investigated the incident collectively.

On May, 30th, 2014 the Investigators arrived at Dale Lake and completed a field examination of the incident with Geomorphologist Tim GILES. The Investigators and GILES accessed Dale Lake on ATV's via the King Fischer Road.

The Investigators and GILES inspected the area of the breach which was located immediately adjacent Dale Lake Recreation Site, and at the outlet of Dale Lake. The Investigators observed that the culverts and road material that were once at the breach location were now downstream.

Photographs of Breech





The Investigators observed aquatic vegetation in the trees above the road surface at the breach location, which indicated that the lake water had overtopped the road. View from the lake bed of two scarred trees located on the upstream side of the breach. The tree on the right has a section of marsh grass (grassy mats)wrapped around it.

The Investigators also observed heavy duty black plastic which appeared to be a recent arrival, therefore not in a discoloured or deteriorated condition.

Plastic Found at Breech

The Investigators walked downstream to where the culverts were deposited. While walking downstream the Investigators observed aquatic vegetation (grass mats) in the trees adjacent the creek.

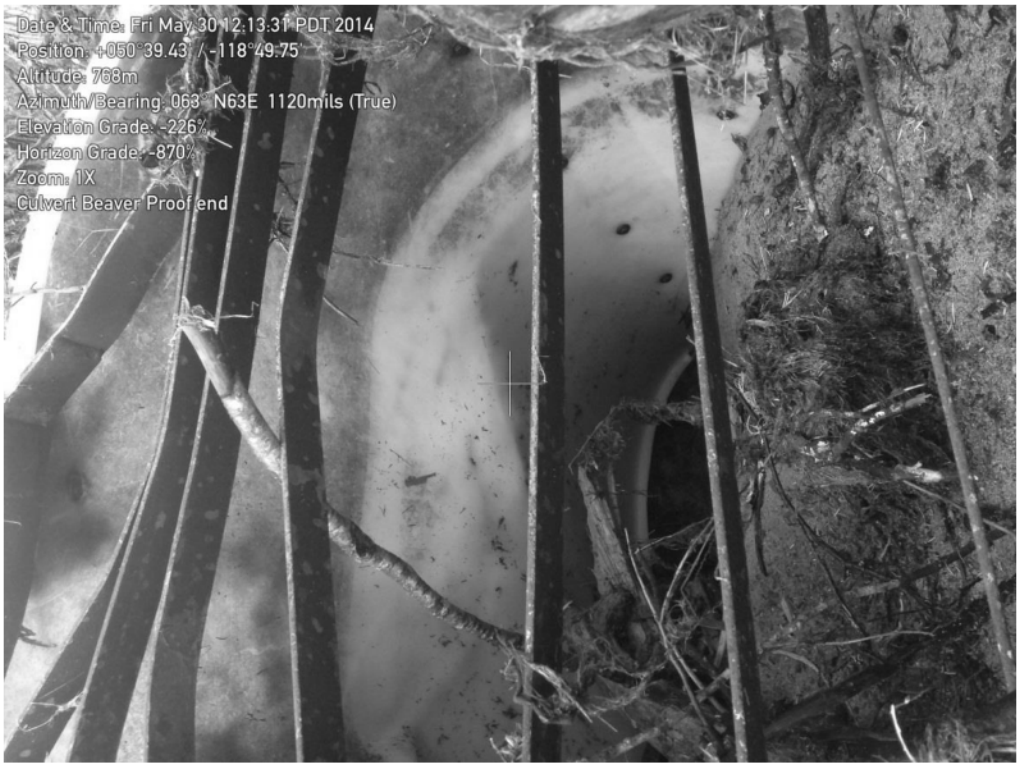
The Investigators found the culverts in relatively close proximity of each other, and found that the "Beaver Proof Add On" (BPAO) was still attached to the overflow culvert.

Grass Mats located downstream

Main Culvert found downstream

Overflow Culvert found downstream

Beaver Proof Add On attached to the Overflow Culvert



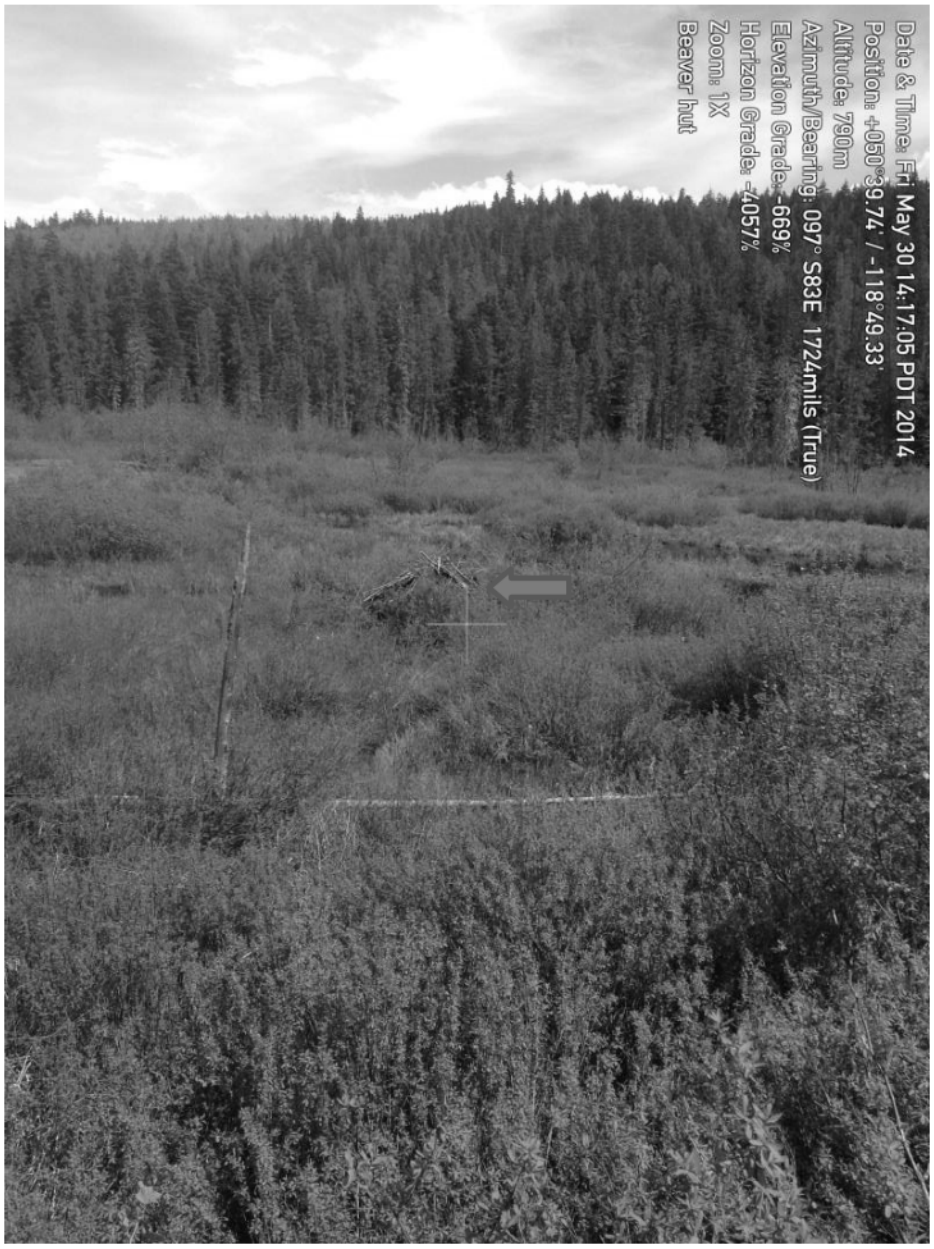
The Investigators observed heavy duty black plastic adjacent the culverts. The black plastic also appeared to be a recent arrival, therefore not in a discoloured or deteriorated condition.

Black Plastic

The Investigators inspected the inlets to Dale Lake to see if there was any evidence of a large volume of water entering Dale Lake from the inlets that may have caused or contributed to the incident. The Investigators found that all but one of the inlets did not show any evidence of higher water than normal. The only inlet observed as having had more volume than culvert capacity was a 900mm culvert located on the Sleepy Hollow Road, which is on the SE side of Dale Lake; however the excess was determined minor by Tim GILES, Geomorphologist.

The Investigators observed what appeared to be an active beaver hut and a beaver dam on the north end of Dale Lake on route to Spruce Lake, however there was no evidence found of recent beaver activity at the outlet of Dale Lake.

Beaver Lodge



Close-up of Beaver Lodge

Hydro Technical Engineer Jeptha BALL, and Dam Safety Officer Brian NUTTEL, from Water Stewardship Division of the Ministry of Forests, Lands and Natural Resource Operations were also at Dale Lake the day of the field examination. BALL and NUTTEL informed HUDEMA that there was no licenced dam at Dale Lake. The Investigators did not observe any evidence of an unauthorized dam.

On June 11th, 2014 the Investigators conducted a file review of all files pertaining to Dale Lake / Cook Creek submitted to HUDEMA from the Okanagan Shuswap District and found evidence of Human Tampering which included plywood obstructing the main culvert at the outlet of Dale Lake.

The Investigators viewed photographs taken by Tim Giles, from the air the day of the event, and observed that there was no ice on Dale Lake.

On July 3rd, 2014, the Investigators reviewed air photos with GILES that were available from 1959 to 2007. The Investigators found that Dale Lake was approximately the same size from 1959 to 2004; however in 2007 Dale Lake appeared to be twice the size.

Dale Lake Air Photo Coverages

Flight Line	Photo #	Date of Exposure
BC 2640	67-68	July 22, 1959
BC5246	123-124	June 15, 1967
BC7322	106-108	July 16, 1971
BC80078	273-274	July 31, 1980
BC84051	28, 98, 100	July 28, 1984
BC90089	163-164	Sept 10, 1990
BCC94092	169-170	July 23, 1994
BCB97070	30-31	Aug 4, 1997
BCB97082	40-41	Sept 8, 1997
BCC01026	38-39	Sept 16, 2001
BCC02003	63-64	Aug 11, 2002
BCC04041	112-113	Aug 10, 2004
BCC07008	197-198	July 5, 2007

Lake appears to be roughly the same size. JH

Lake Appears to have doubled in size.

Dale Lake size from 1959 – 2004

Dale Lake in 2007

The Investigators conducted the following interviews to gather information regarding Dale Lake prior to the incident, at the time of incident, and following the incident. Below is information collected during each interview that the Investigators considered with determining possible cause.

TABLE REDACTED to maintain integrity of ongoing investigation.

The Investigators received a signed copy of the Geomorphologist Report from Tim Giles, which has been referenced in this report. The Geomorphologist Report is attached to this document.

CONCLUSION

After considering all possible causes, the Investigators believe that the most likely cause is "human tampering"; however they cannot rule out "beaver", "grassy mats", or "maintenance" as possible causes.

The Investigators believe that "human tampering" is the most likely cause based on evidence found. Evidence includes;

- Recent arrival of black plastic located at the outlet of Dale Lake, and downstream adjacent displaced culverts,
- Photographs taken prior to incident that show debris of human origin at the outlet of Dale Lake,
- History of suspected human tampering which include the obstruction of the main culvert (lower culvert) with plywood, and firewood debris jammed into the Beaver Proof Add On.
- Dale Lake appeared to double in size in 2007, based on aerial footage.

Lisa Hudema, RFT
Natural Resource Officer,
Thompson Rivers Field Unit, Thompson Okanagan Region Compliance & Enforcement Branch
Ministry of Forests, Lands and Natural Resource Operations

Dated: 2015/07/23