

MEMORANDUM

Date: June 12, 2012

To: Dan Plamondon, Director Planning Services, RDCO

From: Don Dobson and Michelle Cook

File: 1179.0077.01

Subject: Shorts Creek Risk Assessment

Shorts Creek Risk Assessment

This report has been prepared at the request of the Central Okanagan Regional District with authority from the Provincial Emergency Program to summarize the erosion risks resulting from the high water on April 26, 2012 on the Fintry delta. The report includes background information from an earlier assessment completed for a local landowner in 2009 and summarizes the potential risks to infrastructure and private property.

Area

The lower section of Shorts Creek, at the Fintry Delta is located in the Regional District of Central Okanagan on the west side of Okanagan Lake about 35km north of the William R. Bennett Bridge off Westside Road (refer to Figure 1). The area of substantial erosion that was assessed is located on the east side of Fintry Delta Road, below the road bridge into Fintry Provincial Park (refer to Figure 2).

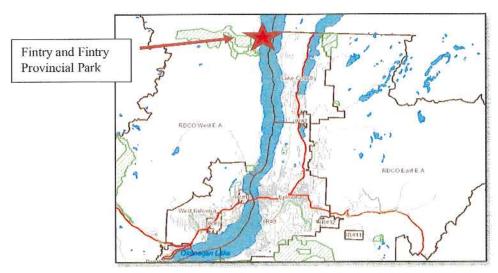


Figure 1. Location Fintry delta on Shorts Creek

June 12, 2012 1179.0077.01 Shorts Creek Risk Assessment

2 of 17



The Shorts Creek channel upstream and downstream of the assessment area is located within Fintry Provincial Park. The area of erosion has shifted the Shorts Creek channel into the private property on the east side of Fintry Delta Road.

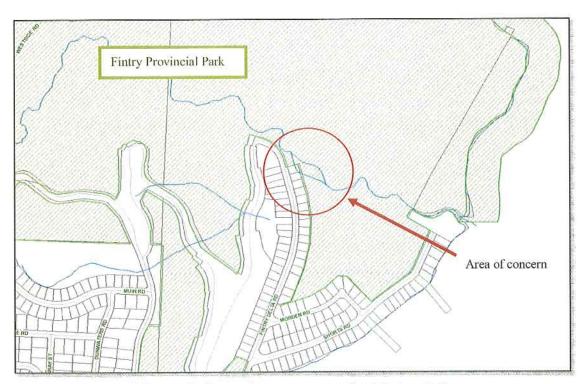


Figure 2. Area of concern on the Fintry delta

Background

Erosion along the Shorts Creek channel on the Fintry delta downstream of the bridge into Fintry Provincial Park was documented in 2009 by Dobson Engineering. The report, Assessment of Erosion affecting Lots 88, 87, and 86, Plan 15329 ODYD (refer to Appendix A) was completed on behalf of the private landowners after much of Lots 88 and 87 was lost when the south banks of Shorts Creek began to erode after a major flood event in 1997. Dobson's 2009 report stated that the condition of erosion at the time was likely initiated during the 1 in 50 year event in 1997.

Prior to 1997, the Shorts Creek channel was located north of the private lots on the east side of Fintry Delta Road and flowed directly east into Lake Okanagan. Since the initial bank erosion in 1997, the main channel has continued to migrate to the south eroding into Lots 88, 87, 86, and threatening Lot 85. Review of historic air photographs,

June 12, 2012 1179.0077.01 Shorts Creek Risk Assessment



collected during the 2009 Dobson report, indicate that until 1992 the active channel was to the north of the private lots and the alignment of the south bank was generally uniform with no active erosion (refer to Figure 2, 3, 4 in Appendix A).

It is likely that as a result of a logjam upstream of Westside Road that disrupted the natural bed load transport that the stream power has increased significantly downstream notably on the fan and that this increased the rate of erosion. The situation was further aggravated by a tree that fell into the channel when the bank was undercut downstream of the bridge that deflected the flow towards the south bank. Dobson 2009, emphasises that there was no indication prior to 1997, that the active Shorts Creek channel was anywhere near to, or threatening the private lots on Fintry Delta Road.

Current Conditions

A field assessment and risk analysis was completed on June 4, 2012 by Don Dobson and Michelle Cook and revisited by Michelle Cook on June 11th to assess the impacts of the high flows on June 9/10. The creek channel, north and east of Fintry Delta Road continues to aggressively erode the south bank. There is no vegetation or roots to stabilize the bank, and because of the large deposition of gravel within the middle and north side of the channel, the thalweg has been shifted along the south bank.

Photos taken in 2009 and 2012 have been compared to show the channel movement over the three-year period. Comparison 1 identifies the two most significant areas of risk. The photos show the erosion of the 'hook,' and the loss of land between the channel and the road. The channel is now running parallel to the road in this section and the fine sediment composition of the bank means that the road will likely be threatened with the next major flood or rain event.

In the 2009 Dobson report it was noted that "the channel has formed a very well defined 'hook' on the right bank upstream of Lot 88 that creates a further threat to Lot 88 when the flow erodes the bank at this location." During the April 25/26, 2012 flood event this indeed did occur and the hook was completely washed away (refer to Comparison 2). The loss of the 'hook' resulted in a change in flow pattern with the flow now tight against the south bank as can be seen in Comparison 1, 2 and 3.

Date: File: Subject: June 12, 2012 1179.0077.01 Shorts Creek Risk Assessment

Page 4 of 17



Risk to Infrastructure

The first risk area is to the Fintry Delta Road. Between 1997 and 2008 The Ministry of Transportation and Infrastructure maintenance contractor installed riprap along the south bank of the creek along the Fintry Delta Road right of way, upstream of the hook to protect road at this location. If this riprap had not been in place the creek would have undermined the road. Comparison 2 shows the end of the current riprap, located just under the fallen tree. When the fallen pine tree in Comparison 2 that has it top resting on the south bank collapses into the channel, it will divert the flow into the south bank downstream of the riprap and threaten the Fintry Delta Road. This is the most significant risk to public infrastructure. Comparison 3 shows Shorts Creek bank erosion movement towards the Fintry Delta Road looking west.

With the depletion of the snowpack in the upper watersheds, the flow rate has decreased since the April 25/26, 2012 event however in our opinion the risk of further erosion due to large rainfall events remains high. This is primarily due to the lack of any resistance to erosion of the south bank and the potential for blockages in the creek that would further divert the flow to the south.

It is important to note that Fintry Delta Road is the only access in and out for residents living in the area.

Risk to Private Property and Residents

The second risk is to private property. Erosion of private lands, as reported in the Dobson 2009 report has been taking place in this area since 1997. Mr. Macpherson, a private landowner reported that the channel has continued to migrate to the south each year since 1997 as more of the south bank erodes (Dobson, 2009).

Comparison 4 shows the RDCO GIS photography dated the spring of 2005, and again the spring of 2009. Between 2005 and 2009 a significant amount of private land was lost from both Lot 88 and 87 as the channel continued to migrate to the south. During the 2012 field assessment the depth of Lot 88 on the north property line is now 10.6 m. (The original property line length was 120 feet or 30.6 m.) It is understood that it is no longer possible to build on Lots 88 and 87 due to the loss of land and the ongoing flood risk. The erosion has now progressed into Lot 86. There is a residence under construction on Lot 85. In 2009 the south side of the creek was approximately 23 m

Date: File: Subject: June 12, 2012 1179.0077.01

Page 5 of 17

t: Shorts Creek Risk Assessment



north of the northeast corner of Lot 85. The bank erosion in 2012 has moved the bank within approximately 16 m of the northeast corner of that lot (refer to Comparison 5).

Comparison 6 shows the downstream and Comparison 7 the upstream view of the second risk area. The location of the cottonwood (Tree 2) on the bank in the 2009 photo (refer to Comparison 6) that is now lying in the creek in the 2012 photo illustrates the extent of erosion during the 2012 high flow event. In Comparison 7 it can be noted that the channel is no longer flowing on the north side of Tree 3. Aggradation of the channel since 2009 has shifted the flow to the south.

Constraints

As indicated previously in this report, the section of Shorts Creek that is of concern is located within Fintry Provincial Park. It is our understanding that any remedial works on the creek to reduce the risks to infrastructure and private property that may be proposed within the park lands would require approval from BC Parks. Any emergency instream works would require referral to the Ministry of Forests, Lands and Natural Resource Operations. Any instream works other than emergency works would likely require a Section 9 Approval under the *Water Act*.

Recommendations

- The ongoing erosion of the south bank of Shorts Creek on the Fintry delta that is
 placing public infrastructure, private property, and residents at risk should be
 addressed immediately to prevent further damages and reduce the risks to public
 safety.
- The option of a permanent solution that could restore the flow within the original channel on the north side of the present channel and keep flows away from the section of the south bank that is currently eroding should be considered by the province, the regional district and the residents.

Remedial Works

As clearly indicated in the attached photos the changes to the channel from 2009 to 2012 are substantial as the creek continues to erode the south bank line, closer to the road. The following recommended remedial works would divert Shorts Creek flow back to the north side of the channel and protect Fintry Delta Road.

June 12, 2012 1179.0077.01 Shorts Creek Risk Assessment



A bypass channel should be constructed upstream from the current active area of erosion in the proximity of Location A in Figure 3.

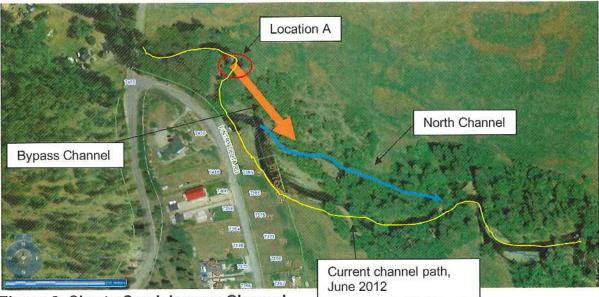


Figure 3: Shorts Creek bypass Channel

The bypass would restore the flow to the north channel and provide a permanent solution for protecting Fintry Delta Road and private property. At location A, the creek is already eroding into the bank (Photo 1). Photo 2 shows some flow to the north was occurring on June 11th. The bypass channel would divert all the flow into the north side in this general area.

The bypass channel would reduce the risk to Fintry Delta Road, the risk of further erosion of the park lands on the south side of the creek, reduce the risk to residents living south of the creek and would possibly allow for restoration of Lots 88, 87, and 86.

Constructing the bypass and closing off the channel flowing to the south would provide restore flow through existing fish habitat that has been dried out as a result of the shifting of the thalweg to the south.

June 12, 2012 1179.0077.01 Shorts Creek Risk Assessment 7 of 17



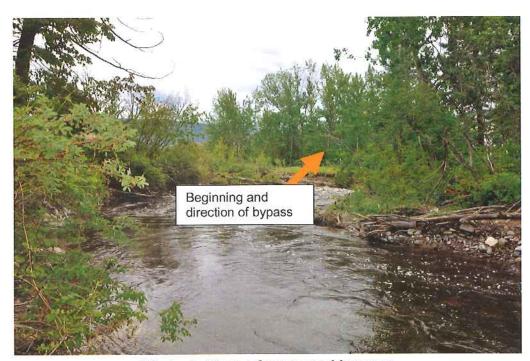


Photo 1: Start of proposed bypass

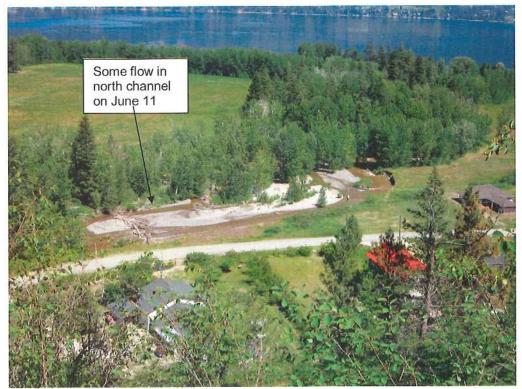


Photo 2: June 11, high water has moved creek flow into the North Channel

Date: File: Subject: June 12, 2012 1179.0077.01 Shorts Creek Pie

t: Shorts Creek Risk Assessment

Page 8 of



Estimated Cost of Remedial Works

A preliminary estimate of the costs to construct the bypass channel, close the channel flowing to the south and install the necessary riprap is in the range of \$175,000 - \$200,000. Approximately 50% of the estimated cost is for riprap since it is likely that a suitable supply may be some distance from the site. Before a commitment is made to a project cost, a more detailed estimate is required.

Risk of Doing Nothing

By doing nothing at the site, the creek channel will continue to erode the south bank and safety of the residents on the delta will be at risk. Since the initial assessment was completed on June 4, 2012 there has been further high flows on June 9 and 10 due to further heavy rains. These flows resulted in the loss of additional 5 m along the south bank line with the erosion progressing closer the closest residence on Lot 85.

Conclusions

- Shorts Creek will continue to erode the south bank within the Fintry delta and place
 public infrastructure, resident's safety, private property and park land at risk unless
 aggressive measures are taken to reduce the risks.
- If the erosion is left unchecked there is the potential for a major channel avulsion during a future flood event that could result in a new channel being formed flowing to the southeast, rather than to the east as it does now, through the residential area into Okanagan Lake.
- The high flows on April 25/26 and June 9/10, 2012 caused significant new erosion along the south bank of Shorts Creek on the Fintry delta within Fintry Provincial Park and private lands.
- The 2012 erosion has placed the Fintry Delta Road at risk of being undermined and washed out.
- If the road was washed out the majority of the residents on the delta who live beyond the potential wash out would have no alternate road access and their safety would be at risk.
- The erosion of the south bank has eroded Lot 88 (undeveloped) such that more than 60% of the lot area has been lost and the property in its current condition could not be developed.

June 12, 2012 1179.0077.01

bject: Shorts Creek Risk Assessment

e 9 of 17



- Similarly the erosion has impacted Lot 87 (undeveloped) where approximately 50% of the lot area has now been lost and this property could not be developed in its current state.
- In April 2012 the bank erosion has now started to impact Lot 86 (undeveloped). If the erosion was stopped this property likely still could be developed.
- In 2009 the northeast corner of Lot 85 was approximately 23 m south of the south bank of Shorts Creek. In 2012, as a result of the aggressive bank erosion, the northeast corner of the lot is now approximately 16 m from the eroding bank. Unless the erosion at Risk Area 2 is checked, the residence on Lot 85 will be at risk during a future flood event.

Should you have any questions regarding the above, please feel free to call at any time

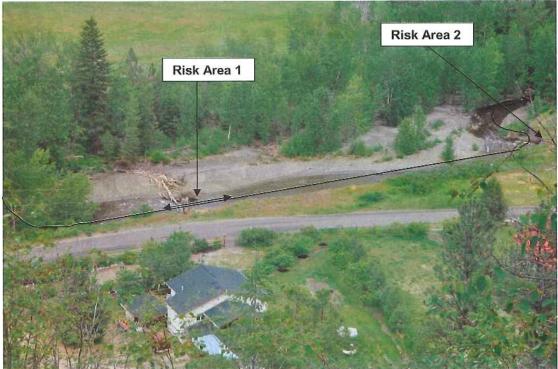
URBAN SYSTEMS LTD.

Don Dobson, P. Eng Senior Water Engineer Michelle Cook, MASc Water Resource Planner

Comparison 1: Shorts Creek 'hook' erosion along Fintry Delta Road south bank



May 27, 2009



June 4, 2012

Comparison 2: Shorts Creek total loss of hook, tree and land mass.



May 27, 2009



Comparison 3: Shorts Creek bank erosion movement towards the Fintry Delta Road



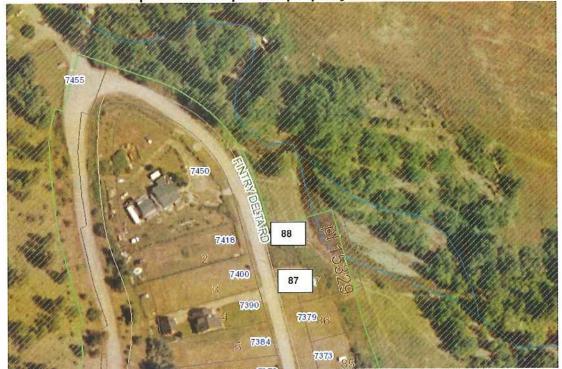
Sept 27, 2008



June 4, 2012

Comparison 4: Regional District of Central Okanagan Geographic Information System

Map erosion of private property Lot 88 and 87.



Spring 2005



Spring 2009

Comparison 5: Distance between Lot 85 residence and the Shorts Creek channel



June 4, 2012



June 4, 2012

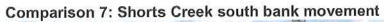
Comparison 6: Shorts Creek erosion downstream of 'hook' loss and private property



April 9, 2009

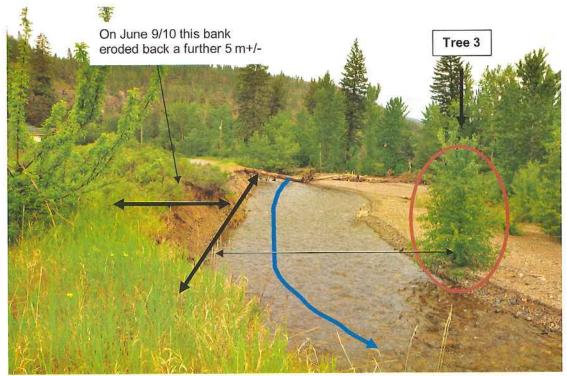


June 4, 2012





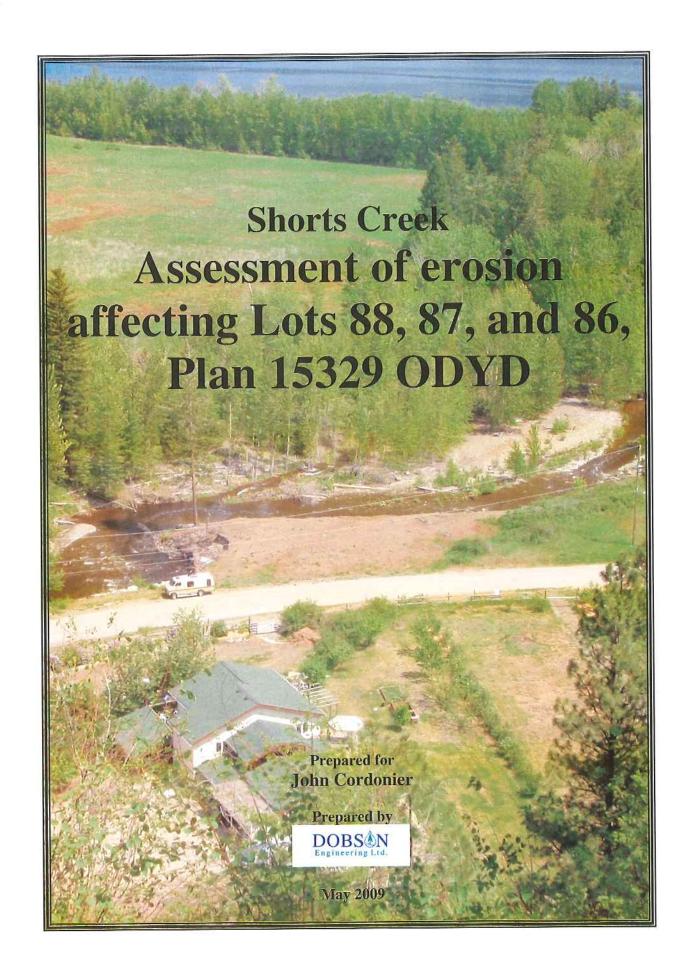
May 27, 2009



June 4, 2012

Appendix A

2009 Assessment Report for Lots 88, 87 and 86



Shorts Creek Assessment of Erosion affecting Lots 88, 87, and 86, Plan 15329 ODYD

1. Introduction

In 1965 the province approved the subdivision of District Lot 686, ODYD on the south side of Shorts Creek on the Shorts Creek fan (refer to copy of original subdivision plan, Appendix A). Lots 71 to 88 are situated on the east side of Fintry Delta Road. Lots 88, 87 and 86 are the northerly lots that were located immediately south of Shorts Creek. Figure 1 illustrates the approximate configuration of the lots and the creek channel based on 2007 Google imagery. It is obvious from Figure 1 that the creek channel now occupies approximately 50% of Lot 88, approximately 25% of Lot 87 and is approaching the northeast corner of Lot 86. The lands to the north and east of lots 71 to 88 are within the Fintry Park and are managed by BC Parks.

Historical air photographs, prior to the high spring runoff in 1997, indicate that the creek channel was located to the north of these lots and was not impacting any of them. Since the high flows of 1997 initiated the bank erosion east of the road bridge into the Fintry Provincial Park, spring freshet flows have continued to erode the south banks and the channel is steadily migrating to the south. The owners of Lots 88, 87 and 86 contacted the province requesting action to prevent further damage to their private lands but with no success.

2. Project Scope

The scope of this project is to identify the likely causes of the bank erosion in the Shorts Creek channel that are affecting Lots 88 and 87 and to provide recommendations for remedial action to restore the flow in the creek to the original channel and also to restore the lots to their original condition.

3. Assessment

Streamflow

Information on the history of the erosion problems on the Shorts Creek fan was provided by John Cordonier, registered owner of Lot 88 and by Rob Macpherson, registered owner of Lot 86. The erosion of the private lands was initiated during the high flows in 1997.

There was a hydrometric station on Shorts Creek (08NM151) that was operated for the period 1969 – 1982. The maximum peak flow for the period of record was 21.9 cubic meters per second in 1975. There were also high flows in 1972, 21.5 cubic meters per second, and 1974, 20.4 cubic meters per second. Unfortunately this station was shut down in 1982 so no data was available for 1997.

Fortunately there is an active hydrometric station on Whiteman Creek – Whiteman Creek above Bouleau Creek (08NM174) that has flow data from 1971 and remains in operation. Data was used from this station, in combination with data from Shorts Creek, to estimate the peak flow in 1997. The 1997 maximum daily discharge in Shorts Creek was estimated at approximately 33 cubic meters per second and had an estimated return period of 64 years. For comparison the peak flow at Whiteman Creek for 1997 was approximately 20 cubic meters per second. The estimated 1997 peak flow of 33 cubic meters per second was 51% greater than the 1975 peak flow. Based on data from the Whiteman Creek station there have been no unusually high flows since 1997.

The 100-year and the 200-year maximum daily discharges were estimated for Shorts Creek using the record from Whiteman Creek. The 100-year maximum daily discharge was estimated to be approximately 34 cubic meters per second, and the 200-year maximum daily discharge was approximately 38 cubic meters per second.

Review of Air Photographs

A review of air photographs of the Fintry fan for 1973 (Figure 2), 1984 (Figure 3), and 1992 (Figure 4) with those for 2004 (Figure 5) confirmed that the channel was well north of Lot 88 in 1984. Based on the information provided



by the property owners and from the review of historical and current air photographs, the crosion was initiated during the high spring runoff flows in 1997 and has continued each year since.

Bridge to Fintry Provincial Park

Mr. Cordonier and Mr. Macpherson reported that the bridge constructed in 1996 for BC Parks had less capacity than the old bridge and that this compounded the problems during the 1997 freshet and likely contributed to the downstream erosion. In 1996 BC Parks was authorized by the Ministry of Environment, Lands and Parks to replace the bridge across Shorts Creek that provided the principle access to Fintry Provincial Park. In its letter to BC Parks it is stated that "The hydraulic capacity of the bridge is equivalent to the hydraulic capacity of the stream channel, or, is capable of passing the 1 in 200 year maximum daily flow, and the height of the underside of the bridge is also adequate to provide free passage of flood debris and ice flows". The tender documents from BC Parks does not include nay details on the bridge capacity other than to refer to Drawings 3230-01, 3230-02 and 3230-03 that were not provided. Mr. Macpherson subsequently contacted BC Parks about concerns over the bridge capacity and requesting data on the design of the new bridge. Some information such as the 1996 letter of authorization, the Invitation to Tender, and a copy of a 1996 letter from Horizon Geotechnical Ltd. was provided. No bridge design plans or as-constructed plans were provided. Several requests were made for the drawings from BC Parks in Summerland but all requests were refused.

Site visits were made by D. Dobson in the fall of 2008 and it was noted that there has been significant down cutting of the Shorts Creek channel from upstream of the new bridge under the bridge (hat terminating ~20 m downstream of the bridge (Photo 1). The down cutting was typically 0.6 m deep by 3 m wide under the bridge. The cause of the down cutting was not known but it indicated that the stream power had increased and that could have been the cause of the crosion downstream. It was also noted that the riprap had not been installed properly in that it was placed on the original stream bank and had not been keyed in at the toe or at the upstream and downstream ends.

A review of the BC Parks tender package indicates that the new bridge was to be a single span vehicle bridge with an approximate length of 50 feet. In the Horizon Geotechnical Ltd. letter² it is stated that the existing bridge was 10 feet wide by 50 feet long and that the new bridge was to be 16-24 feet wide and 60 feet long. The actual measurements for the new bridge are 20 feet wide by 60 feet.

In May 2009 Dobson completed a survey of the channel from ~60 m upstream of the new bridge to ~20 m downstream (Figure 6). In total three cross-sections were surveyed upstream of the bridge, three cross-sections at the bridge and two cross-sections downstream. Manning's Equation was used to estimate the water level for the 1997 estimated peak maximum daily discharge of 33 cubic meters per second. The results indicated that the 1997 peak flow would have been contained within the channel upstream of the bridge except at cross-section 6 near the dwelling on the south bank upstream of the bridge where it would likely have overtopped the bank. Water levels were estimated through the bridge, the first was through the existing channel with the riprap in place, the second was for the estimated original channel cross-section without the riprap. The results indicate that the water level through the existing channel would likely have been approximately 0.30 m higher than they might have been if the riprap had been placed to maintain the original channel cross-section.

The maximum discharge that could be passed through the channel under the bridge was estimated to be approximately 64 cubic meters per second. The 200-year maximum daily discharge was estimated to be 38 cubic meters per second. The existing capacity under the bridge is adequate to safely pass the 200-year flood when allowance is made to safely pass debris as well.

It was reported by the resident at 7450 Fintry Delta Road that during the 1997 high flows in Shorts Creek that there was a debris jam on the upstream side of the bridge resulting in elevated water levels upstream that overtopped the south bank threatening the dwelling upstream of the bridge. Downstream of the bridge it was reported that a large fallen tree diverted flows towards the south bank that may have contributed to the erosion problems (Photo 2). It was noted that the channel has formed a very well defined "hook" on the right bank upstream of Lot 88 (Site 1, Figure 1, Photo 3) that created a further threat to Lot 88 when the flow erodes the bank at that location. A large dead

² Horizon Geotechnical Ltd., Vernon to Ministry of Environment, Summerland, dated February 9, 1996, Horizon file - 96-106.



¹ Letter from the Fisheries and Wildlife Management Program, Penticton to the Parks Division, Summerland, dated April 9, 1996, file: R801934.

Ponderosa pine on the bank at the "hook" has fallen into the creek across the channel at the hook and may divert additional flow onto the bank increasing the risk of additional bank failures in this location (Photo 3).

Logjam

The Shorts Creek channel was reviewed from the headwaters to the fan as part of another project undertaken by Dobson Engineering in 2008. A major logjam was identified in the main channel approximately 1.5 km upstream from the Westside Road crossing (Figure 7). This logjam had a large accumulation of gravel upstream of the jam (Photo 4) and appeared to have interrupted the natural bedload transport downstream. Although the date of the logjam is not known, it is likely that additional logs were added to the jam during the 1997 high flows that was the last major flood event in the system. The jam was in tact in 2009 and continues to trap bedload causing a major disruption to the stability of the stream downstream.

The down cutting noted in the channel on the fan originates at the mouth of the canyon below the falls and extends downstream past the new bridge ending approximately 20 m downstream of the bridge. This down cutting is symptom of excessive stream power that is likely caused by the disruption to the natural bedload transport at the logiam upstream. The flow downstream of the jam is out of equilibrium due to the increase in energy resulting from the loss of the bedload. In order for the flow to return a more stable state, it tries to entrain new sediment. The result is the down cutting of the bed below the canyon and the erosion of the unconsolidated banks on the fan.

4. Discussion

Prior to the high flows of 1997 the Shorts Creek channel was north of Lot 88 on the Fintry delta on the east side of Fintry Delta Road. Since the initial bank crosion occurred in 1997 the main channel has continued to migrate to the south croding well into Lot 88 and 87 and threatening Lot 86. Review of historical air photographs indicates that until1992 the active channel was to the north of the private lots and the alignment of the south bank was generally uniform with no active crosion sites such is present now at the hook and downstream.

The current erosion was likely initiated during the high flow in 1997 as a result of a combination of events. The debris jam upstream of Westside Road stopped the natural bedload transport in the stream and increased the stream power downstream of the jam. Based on a review of the channel capacity upstream of the bridge the capacity under the new bridge is adequate although the placement of the riprap on the bank rather than flush with the bank does constrict the flow somewhat. The new bridge is capable of passing the 1 in 200 year maximum daily flow but may have problems providing "free passage" for flood debris.

The maximum capacity under the bridge has been calculated to be ~64 cubic meters per second, if the water level was equivalent to the elevation of the underside of the upstream girder. The water level under the bridge for the estimated 1997 flood may have been ~0.30 m higher due to the placement of the riprap on top of the original bank instead of embedding the armour into the bank line that would have maintained the channel capacity. The constriction under the bridge would also have increased the flow velocity but it is unlikely that it was a significant factor in the downstream erosion.

It has been reported that after the 1997 flood it was noted that there was a large log in the channel extending out from the left bank downstream of the bridge that deflected the flow towards the right bank. Mr. Macpherson recommended to BC Parks that the log be removed to allow the flow to return to the original channel closer to the north bank. No action was taken on this suggestion.

Based on notes kept by Mr. Macpherson that channel has continued to migrate to the south each year since 1997 as more of the south bank was eroded. The continued requests to BC Parks, the Ministry of Environment and to the local Provincial Emergency Program representative from Mr. Macpherson and Mr. Gretzinger since 1997 have had no results from any agency to address the erosion.

The results of this investigation suggest that the bank erosion that is now impacting Lots 88 and 87 was initiated in 1997 as result of the high flows that likely exceeded the 1 in 50 year event. The erosion was likely exacerbated by the increased stream power as a result of the logiam upstream of the Westside Road that disrupted the natural bed



load transport as well as the reduced capacity under the new bridge to the Fintry Provincial Park including the impacts on flow velocities under the bridge caused by the debris jam at the bridge. The situation was further aggravated by the tree trunk downstream of the bridge that likely deflected the flow towards the south bank and by the beaver dams in the channel near of Lot 88.

There is no argument that depositional fans near the mouth of streams are a feature of geomorphology of the stream and by their nature are subject to crosion. There is also no argument that there are remnants of old channels near Lots 88 – 71. However, there is no indication that the active Shorts Creek channel was any where near these lots or threatening these lots prior to the 1997 flood. The fact that the lots were created indicates that the land in that proximity was not considered to be at risk from Shorts Creek.

Based on the pre-1997 air photography the channel downstream of the bridge to Fintry Provincial Park did not indicate any crosion problems along the south bank as a result of the high flows of 1972, 1974 or 1975.

Had steps been taken after the 1997 flood to redirect that flow downstream of the bridge back towards the original channel along the north bank, the crosion would have been stopped before it affected Lot 88. Since the erosion has been allowed to continue it has now eroded more than 50% of Lot 88 and approximately 25% of Lot 87. It is not possible to build on Lot 88 or Lot 87 due to the loss of land and the ongoing flood risk. Before a building permit would be issued by the Regional District of Central Okanagan it will require proof that the proposed dwelling can meet the setback requirements from Shorts Creek, a septic tank and disposal field permit, and a development permit from the RDCO Environment Department. As a result of the extent of erosion that has occurred to lots 88 and 87, it is unlikely that a Development Permit would be used since the setback requirements for a dwelling could not be achieved on the properties in their current condition, and a septic tank and disposal field permit would not be issued either. As a result the lots could not be built on in their present condition. Lot 86 is also at risk and it is unlikely that the RDCO would issue a building permit for this lot unless bank protection works were constructed to reduce the risk of erosion.

5. Remedial Works

The solution to this problem is beyond the capability of the owners of these lots. As a minimum action needs to be taken immediately to restore the flow downstream of the new bridge back into the original channel near the north bank. This will require approximately 150 m of armour starting approximately 80 m downstream of the new bridge on the right bank and extending downstream past the private lots. This armoured restored bank line would maintain the flow in it original channel and provide an overall channel width of at least 40 m that would be similar to the channel widths upstream of the bridge and downstream (Figure 8).

Restoring the flow to the original channel would prevent further erosion on the private lands and would protect the lots from future damage. It would not restore the lots to their original condition. It will require a large volume of fill to be imported to replace the material that has been eroded and restore the lots to a condition that would permit the lots to be built on.

The logism upstream of the Westside road should be breached to restore the natural bed load transport. If this was done the stream power would gradually return to a natural level and the down cutting downstream of the canyon would eventually cease and the original channel geometry restored bed load from upstream moved downstream.

The riprap under the new bridge should be installed properly so that it is flush with the natural bank line and properly keyed in to the bank upstream and downstream of the bridge as well as at the toe. This would restore the flow capacity under the new bridge to approximately what it was for the original bridge and reduce the velocities and the risk of erosion downstream.



6. Estimated Cost for Remedial Works

The cost to restore the flow to the original channel is estimated to be approximately \$25,000.00. The cost to the breach the logjam would be approximately \$5,000.00, and the cost to remove and reinstall the riprap under the bridge would be approximately \$5,000.00. The cost to replace the fill on Lots 88 and 87 is estimated to be \$10,000.00. The total cost for all the work would be approximately \$45,000.00.

7. Conclusions

Based on the results of the investigations into the erosion on the Shorts Creek fan in the vicinity of Lots 86, 87 and 88, it is concluded that:

- The current bank erosion along Shorts Creek on the Fintry fan was initiated during the high flows in Shorts Creek in 1997.
- 2. Based on the hydrometric data from Whiteman Creek, it is likely that the maximum daily peak flow in Shorts Creek in 1997 exceeded the 1 in 50 year event.
- Based on a review of current and historical air photography the Shorts Creek channel was north of Lot 88
 prior to the 1997 and was not impacting the private lands to the south of the creek.
- 4. The likely causes of the erosion are related to the high flows in Shorts Creek combined with a decrease in bedload caused by a large logjam located in the Shorts Creek main channel approximately 1.9 km upstream from the Westside Road. The increase in stream power due to the loss of bedload resulted in significant down cutting in the channel from the top of the fan at the outlet of the canyon below the falls, to downstream of the road bridge. The bed material that was secured from this section of channel was deposited in the channel downstream of the bridge aggrading the channel and diverting the flow towards the south bank.
- The erosion downstream of the bridge providing access to Fintry Provincial Park may have been aggravated by a debris jam at the upstream side of the bridge and by re-directed flows caused by large trees that fell into the creek downstream of the bridge.
- 6. The erosion that was initiated in 1997 has continued in subsequent years due to the flow being directed onto the south bank by the aggraded streambed and by beaver dams further eroding the south bank of Shorts Creek in the vicinity of the private lands and also with the parklands.
- 7. By 2008 approximately 50% of Lot 88 has been washed away and approximately 25% of Lot 87. Unless protective works are constructed there will be further crossion to these properties during the 2009 freshet and into the future. It is likely that the erosion will extend onto Lot 86 within the next year or two.
- 8. The crosion of the private lands could have been prevented or reduced if proactive steps had been taken to restore the flow in Shorts Creek to its original channel after the 1997 freshet.
- 9. The estimated costs to design and construct the protective works and restore lots 88 and 87 is estimated to be approximately \$50,000.00.
- 10. During the replacement of the bridge to the Fintry Provincial Park in 1996, riprap was placed on the banks under the bridge to reduce erosion at the abutments. The riprap was placed on the banks instead of being embedded into the banks resulting in a constriction in the channel under the bridge. The constriction does increase flow velocities under the bridge. The capacity of the channel under the bridge is greater than the estimated 1 in 200 year maximum daily flow in Shorts Creek.

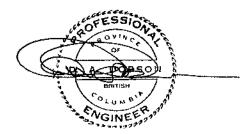
8. Recommendations

It is recommended that:

- Remedial works be designed and constructed to restore the flow in Shorts Creek, downstream of the bridge to Fintry Provincial Park, to the original channel that existed prior to the 1997 freshet. These works will include restoring the south bank alignment and armouring the bank with riprap.
- The owners of Lots 88, 87 and 86 request a meeting with BC Parks and the Ministry of Environment to discuss the result of this investigation and to request action by the province to restore the flow in Shorts



Creek to its pre-1997 channel and to request assistance in restoring the condition of Lots 88 and 87 to their pre-1997 condition so that the lots can be developed.



D.A. Dobson, PEng



Figure 1. Shorts Creek Fan subdivision.



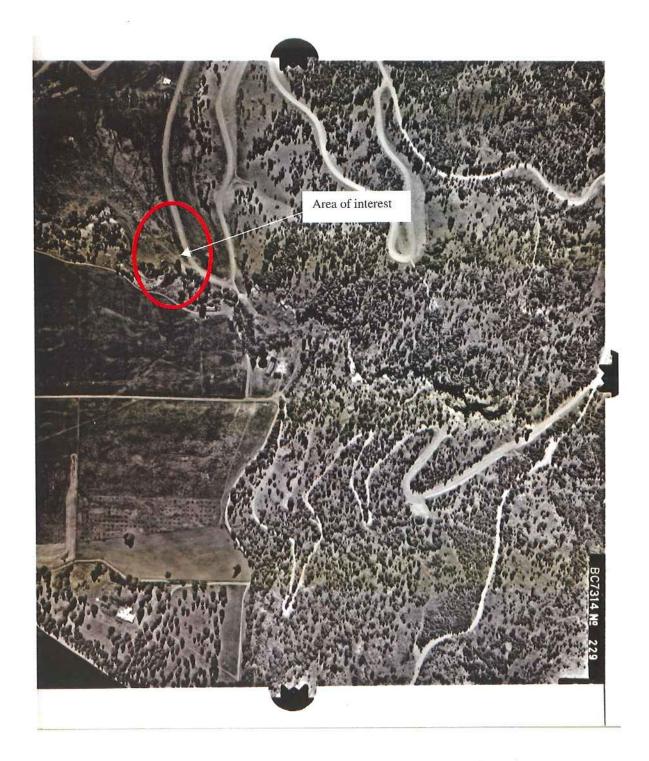


Figure 2. 1973 Air photograph (BC7314_229) of Shorts Creek fan.

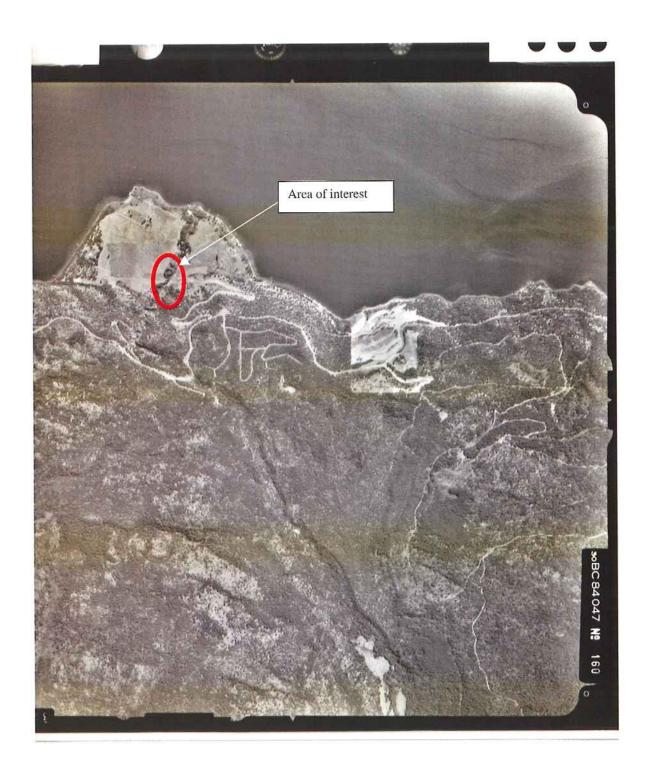


Figure 3. 1984 Air photograph (BC84047 No160) of Shorts Creek fan.

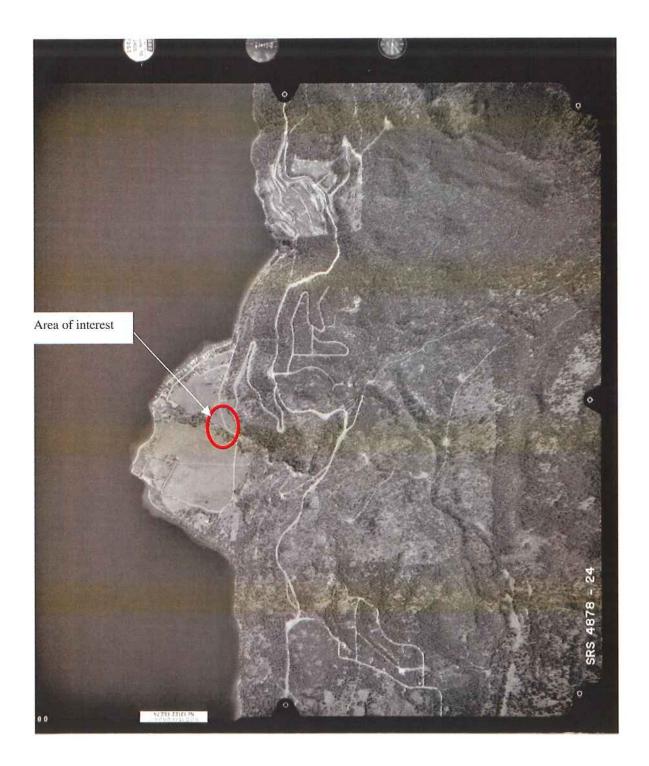


Figure 4, 1992 Air photograph (SRS 4878-24) of Shorts Creek fan.

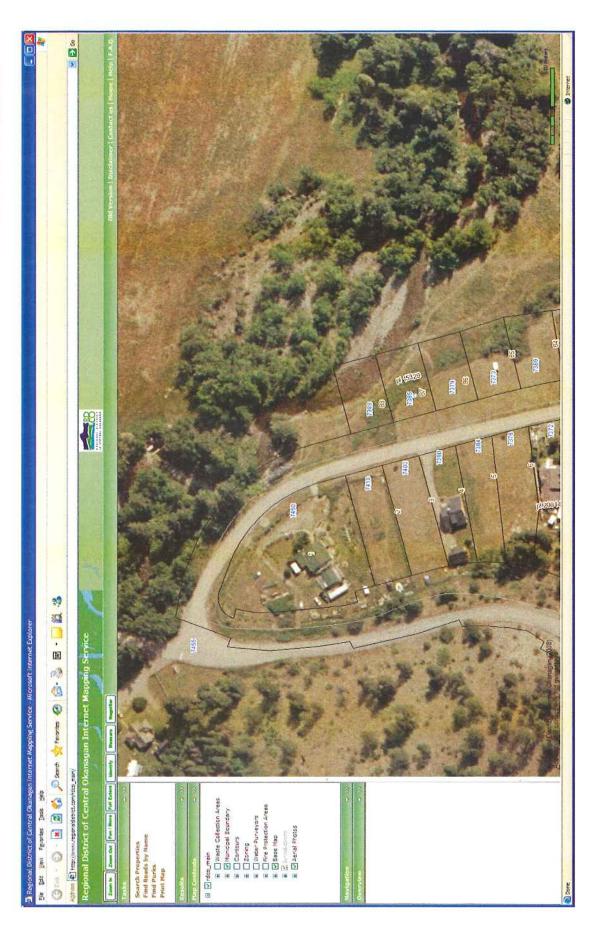


Figure 5. 2006 image of Lots 88, 87 and 86 on the Shorts Creek fan (RDCO Map Server).





Figure 6. Shorts Creek channel survey cross section locations.

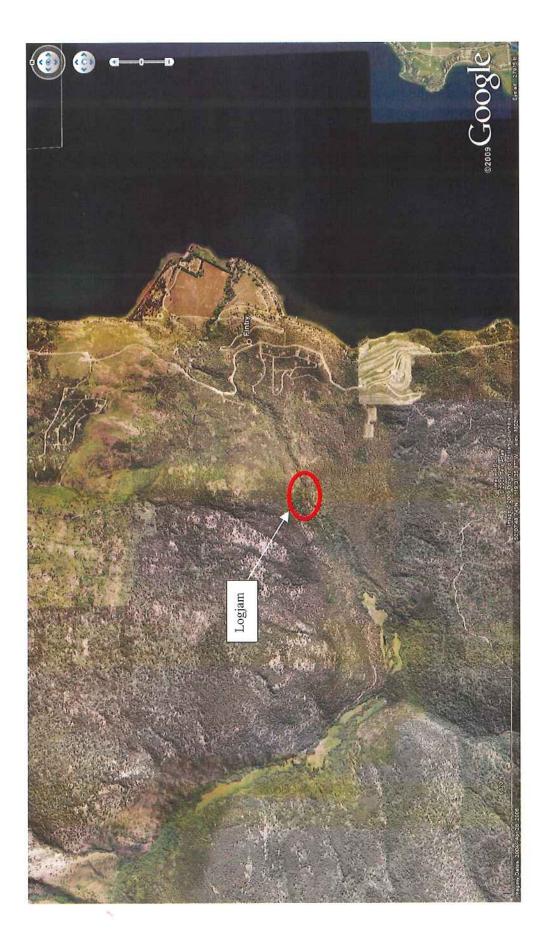


Figure 7. Location of logjam on Shorts Creek upstream of Westside Road



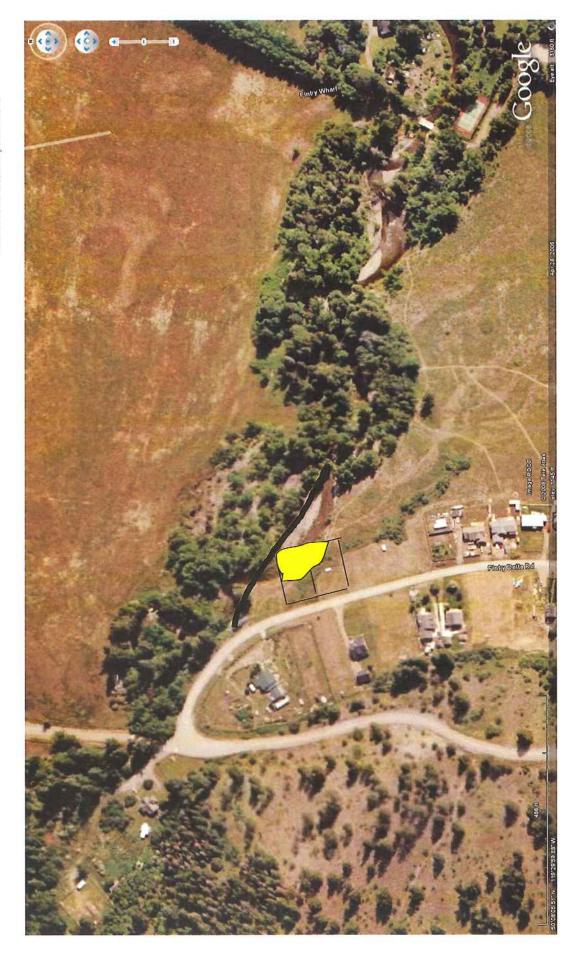


Figure 8. Approximate location of reconstructed and armoured bank alignment and reconstruction of Lots 88 and 87.

