



REVIEW OF THE
TESTALINDEN DAM
FAILURE

JULY 2010



ACKNOWLEDGEMENTS

The completion of this report was reliant upon the timely, professional and diligent support of the staff of the BC Conservation Officer Service Commercial Environmental Investigations Unit, Emergency Management BC, BC Forest Service, RCMP, and various other supporting ministries and agencies, including the staff of the Regional District of the Okanagan-Similkameen. I wish to thank everyone involved for their support in addressing a complex disaster situation and for their thoughts and ideas on how such an event could be prevented in the future.

This report is an independent review of the context leading up the failure of the Testalinden Dam, the circumstances of the event itself, the response and recovery efforts, and a review of dam safety oversight in British Columbia.

I extend my condolences to those impacted by this event and hope that the findings and recommendations I have outlined will provide answers to many of their questions.

David Morhart
Deputy Solicitor General

July 13, 2010

EXECUTIVE SUMMARY

At approximately 2:15pm on Sunday June 13, 2010, a privately-owned earthen dam on a man-made reservoir on Testalinden Creek failed, causing an enormous debris and mud torrent that severely impacted a number of homes and an agricultural area eight kilometres south of Oliver, British Columbia.

On June 15, Solicitor General Michael de Jong announced an independent review of the circumstances leading up to the debris and mud torrent. This review examines the circumstances leading up to the failure of the privately-owned dam, the chain of events following the initial reports of the dam overtopping received prior to the incident, the response and recovery efforts following the incident and a review of dam safety oversight in British Columbia.

The Testalinden Dam was constructed in the 1930's for the purpose of water storage and irrigation. The dam has had a series of licensed owners since that time, with the current owner being responsible for the structure since 1981. Documentation is limited, but there is a consistent pattern of concerns and warnings issued by the Ministry of Environment, or predecessor agencies with responsibility for the *Water Act*, to make needed repairs to the structure to maintain its integrity. There is no indication that the needed repairs were acted upon but also no indication that the owner was being held accountable to make those repairs.

A potential early warning prior to the dam breach unfortunately did not reach the right officials. The days leading up to the breach of Testalinden Dam saw heavy rains in the area. On June 11, 2010, a hiker noticed that Testalinden Lake was full of water and that the water was overflowing the lake onto the road. He reported the overflow to the Osoyoos Tourist Information Booth, who relayed the information to the local RCMP detachment via a non-emergency number. The RCMP dispatcher contacted the District Office of the Ministry of Forests and Range, Vernon, and spoke with an engineering technician who then relayed the request to a Ministry of Forests Compliance and Enforcement Technician, leaving a voice message which was not retrieved until after the breach of the dam. The information relayed concerned a road washout on a "non-status road" (as opposed to a forest service road), so it was not described as an urgent priority as there are many such reports after rainstorms and at no point did this information make reference to a potential dam stability issue. Some recommendations have been made in this report to improve awareness of "who to call when" and to enhance the timely sharing of emergency information.

Following the dam breach, local government officials and provincial ministry and agency staff worked quickly to evacuate the impacted area and respond to the needs of the impacted individuals. Emergency social service supports and other services were promptly provided and recovery efforts began within a few days. The integrated emergency response system appears to have operated quite effectively and demonstrates the efficiency of a coordinated approach at all levels of government. Some recommendations have been made to further enhance the emergency management model and to raise public awareness of how they can assist.

British Columbia is one of the few jurisdictions in Canada to have a formalized dam safety system in place. A review of the dam safety program indicates that the risk based approach and self-regulating owner accountability model used by the Province are consistent with the approach used in other jurisdictions. A number of recommendations are made to further strengthen the dam safety program and to ensure appropriate enforcement and compliance. The investigation by the Commercial Environmental Investigations Unit into the activities and responsibilities of the current and past owners/licensees is still underway.

A full list of recommendations is summarized below.

SUMMARY OF RECOMMENDATIONS

Recommendation 1: The Ministry of Environment should review its record keeping practices to ensure that proper and complete files are kept and archived on all dam structures, including details of water licenses, transfers of appurtenancy, and correspondence with owners.

Recommendation 2: The Ministry of Environment should review the historical warnings about the conditions of the dam and any actions taken to hold the owner(s) responsible for inspection and maintenance as per the Dam Safety Regulation.

Recommendation 3: The Ministry of Environment should consider implementing signage at all dam locations to make it clear to passersby that the structure is a dam and to provide direction and emergency contact information, including contact information for the owner, to report any issues observed.

Recommendation 4: Emergency Management BC should work with local officials, local and provincial policing and first response agencies, and ministry provincial and regional offices to provide a quick reference list of key contact numbers, focused on “who to call when,” and develop an alert matrix to quickly escalate priority issues.

Recommendation 5: The Ministries of Forests and Range and Environment should review their call-out procedures to ensure that compliance and enforcement personnel are familiar with the issues escalation process noted in Recommendation 4, as they are often among the first individuals aware of local incidents.

Recommendation 6: Building on Recommendation 4, Emergency Management BC should continue to coordinate awareness and encourage training and orientation for local emergency response agencies, local government officials, and provincial government agency personnel to prepare for emergency situations. Local governments are required to have emergency plans in place, per the *Emergency Program Act*, and Emergency Management BC can assist with the development and testing of these plans.

Recommendation 7: The Ministry of Environment should review and update the Dam Safety Regulation to incorporate best practices on dam safety found in other jurisdictions. This would include but is not limited to an update to the downstream consequence classification tool, inclusion of a requirement for the owner to develop an emergency preparedness plan for the structure, and consideration of further regulatory oversight to enhance enforcement and compliance.

Recommendation 8: The Ministry of Environment should complete its Rapid Dam Assessment Project and update its consequence rating system accordingly to determine priority areas in need of attention. The Ministry should develop an action plan to address those areas needing immediate attention and schedule appropriate follow up based on overall findings.

Recommendation 9: The Ministry of Environment should continue its work in building a robust Dam Registry, with linkages through to geo-reference tools which can be utilized by other partners.

Recommendation 10: The Ministries of Environment and Transportation and Infrastructure need to continue to ensure effective communication and information sharing of community development and transportation initiatives as they relate to downstream consequences for dam safety. This information should be periodically reviewed on a priority basis to account for any historical changes. In addition, other ministries such as Forests and Range and Energy Mines and Petroleum Resources should be linked in to any consequence review initiatives to ensure that all appropriate information is considered on a periodic basis.

Recommendation 11: The Ministry of Environment should ensure the consistent oversight and regulation of all water related structures, including licensing, standards and risk assessments, by working with the ministries that have the legislative authority. The Ministry should build a business case to rationalize the types of resources and supports that would be needed to accomplish this recommendation.

Recommendation 12: The Ministry of Environment should continue and expand its education and awareness initiatives with dam owners and should work with Emergency Management BC to ensure that dam owners are working directly with local government officials in tying together their emergency preparedness and response plans. In addition, the Ministry of Environment should publish an annual Dam Safety Program report on its public website for the information of the public.

INTRODUCTION

At approximately 2:15pm on Sunday June 13, 2010, a privately-owned earthen dam on a man-made reservoir on Testalinden Creek failed, causing an enormous debris and mud torrent that severely impacted a number of homes and an agricultural area eight kilometres south of Oliver, British Columbia.

Initial reports indicated that a local hiker noticed water overflowing a roadway on Friday June 11 and reported this observance to a local tourism office. This information was then relayed to the local RCMP detachment, which referred it to the District Office of the Ministry of Forests. Unfortunately, the message was not received by appropriate authorities until after the dam failure event on Sunday June 13, at which point the immediate requirement was for emergency response and evacuation of those impacted.

PURPOSE OF THE REPORT

On June 15, 2010, Solicitor General Michael de Jong announced an independent review of the circumstances leading up to the debris and mud torrent. The information bulletin is attached as Appendix A.

This review examines the circumstances leading up to the failure of the privately-owned dam, in conjunction with an investigation by the B.C. Conservation Officer Service. The review also examines the chain of events following the initial reports of the dam overtopping received prior to the incident and the response and recovery efforts following the incident. In addition, the report includes a review of dam safety oversight in British Columbia. The review establishes the circumstances and provides appropriate recommendations.

In particular, and in the interest of public safety and preventing similar occurrences in the future, the review includes:

- a fact framework – a description of the incident and what was known by whom and when.
- a review of dam and water licensing policy and procedure as related to this structure.
- analysis of the incident response and recovery effort.
- any further issues that arise during the course of the review.

A BRIEF HISTORY OF THE TESTALINDEN DAM

The Testalinden Dam sits on the upper south fork of Testalinden Creek on Mount Kobau. It sits within the South Okanagan Grasslands Protected Area. The reservoir is locally known as Testalinden Lake, Kobau Lake and Kobau Reservoir.

Ownership and licensing records are light in the early years of the dam and periodic in later years.

Records indicate that the dam's construction was completed in 1937 for the intent of storing water for irrigation in the drier months of the year. A valve was installed that was closed when the lake was drawn down to allow the lake to replenish. Seasonal snowpack is the primary determinant in the amount of water stored in the reservoir and it is well known locally that Testalinden Creek is one of the only creeks that continue to run through the dry summer months.

By 1942, a district water engineer had inspected the dam and noted considerable seepage near the outlet culvert. Given the steep creek grades below the reservoir, a recommendation was made to create a berm of well-draining rocky material along the outlet culvert to stabilize the structure and minimize potential damage downstream. This work was completed in 1942.

In 1960, the Water Rights Branch was advised that a road had been constructed across the dam to access forestry lands and to assist in fire prevention. The spillway had been filled in with earth and a metal culvert was installed in the spillway.

An inspection in 1961 found that the dam was generally in good condition but that a wood rack constructed to prevent erosion of the downstream end of the spillway had decayed. It was also noted that the spillway culvert was not of an adequate size according to the Water Branch requirements at that time and that the gate valve on the outlet culvert had become inaccessible due to the collapse of the tower and bridge to access it. The resulting recommendations to the licensee were to remove all the accumulated debris on both sides of the dam, place a log boom in front of the spillway entrance, remove the earthen bridge and spillway culvert and replace them with a bridge, increase the freeboard above the spillway invert from two feet to three feet, and rebuild the tower and bridge access to the outlet culvert gate valve.

In 1967, the National Research Council (NRC), through the federal Ministry of Energy Mines and Resources, was issued a conditional water license to store water in support of a planned astrophysical observatory development.

A dam inspection report in 1977 noted seepage along the embankment, limited or no access to the (outlet culvert) gate valve, no (spillway) log boom in place, and an even smaller pipe (spillway culvert) was in place with a buried outlet (culvert) sluice. A further inspection that year indicated that "the dam is in deplorable condition and should, in my (the inspector) opinion, be breached or rebuilt."

Later in 1977, the regional water engineer wrote to a local forest ranger advising of the need to reconstruct or remove the dam. In order for the reconstruction or removal of the dam, the road constructed on the dam would have to be relocated prior to dam construction or removal. The district forester later replied that the forest service no longer had an interest in the road or access.

In early 1978, as a result of an inspection, the regional water engineer wrote to the licensee, NRC, to confirm their responsibilities under the water license to maintain the structure. To quote: “The dam in its present condition is a hazard to life and property to some of the settled areas along the Osoyoos-Oliver highway which lies downstream of the Testalinden Lake Dam. We recommend that the dam either be breached or reconstructed. The dam should be breached by April 1, 1978 should a decision be made not to reconstruct.” Items noted during the inspection included downstream seepage, the outlet sluice pipe (outlet culvert) could not be located as it was buried but should be replaced, the access to the sluice control needed replacement, the corrugated 12” diameter spillway pipe (spillway culvert) should be removed and replaced with an open channel, and the high water mark indicates that the water rises to within one foot of the dam crest and any wave action may cause subsequent failure of the dam.

Later that year, NRC was granted two extensions for the 1978 and 1979 freshet seasons. A similar letter to NRC in 1980 highlighted the same issues and again established a deadline of May 15, 1981 for resolution of the deficiencies.

Transfer of license and responsibility of the Testalinden Dam to its current owner effectively occurred between 1981 and 1987, although the paperwork is not clear and is the subject of further review by the Commercial Environmental Investigations Unit. Following a dam inspection on September 11, 1985, the owner was advised of concerns over minimal freeboard, continued seepage near the sluice pipe (outlet culvert), complete collapse of the catwalk to access the (outlet culvert) gate valve, and the pipe (spillway culvert) being insufficient for the spillway. The recommendation was that the structure be replaced, and that the (outlet culvert) gate valve be opened, to lower the reservoir level, and remain open until the new structure is completed.

An inspection was carried out on July 13, 1988, and concluded that “this structure is in a very poor state of repair. The dam has reached the end of its lifespan and should be replaced by a new one. Most of the repairs ... have been requested previously ... No attempt has been made to carry out our instructions.”

In August 1992 an inspection of the dam noted there was no access to the (outlet culvert) gate control valve, the outlet works were not able to be inspected, the spillway utilized a 12” corrugated metal pipe and the inlet of the spillway pipe (spillway culvert) had a rock slab covering it.

General correspondence to all dam owners in the spring of 1997 reminds all dam owners that the heavy snowpack will impact water flows and that owners should inspect their structures to

ensure dams have three feet of freeboard and stable outlet structures, and that releases from the dams may be appropriate through spillways but consideration must be given to downstream impacts.

A letter to the owner in 1998 advised of the Ministry's intention to "ground truth" (collection of on location information) water intakes for inclusion in a broad survey. The Ministry requested the owner to advise of any changes or abandonment of the structure.

Findings:

It is difficult to compile a comprehensive history of the Testalinden Dam without complete records but there was sufficient evidence to see a consistent pattern of concerns and warnings about the state of the structure dating back to the 1960's. There is also no indication that actions had been taken to remedy the situation that has persisted for decades. The investigation by the Commercial Environmental Investigations Unit into the activities and responsibilities of the current and past owners/licensees is still underway. A further review of the dam safety regulation and its enforcement is included later in the report.

Recommendation 1: The Ministry of Environment should review its record keeping practices to ensure that proper and complete files are kept and archived on all dam structures, including details of water licenses, transfers of appurtenancy, and correspondence with owners.

Recommendation 2: The Ministry of Environment should review the historical warnings about the conditions of the dam and any actions taken to hold the owner(s) responsible for inspection and maintenance as per the Dam Safety Regulation.

THE LEAD UP TO THE DAM BREACH



Testalinden Lake and Dam, June 2009

The days leading up to the breach of Testalinden Dam saw heavy rains in the area. On June 11, 2010, a hiker noticed that Testalinden Lake was full of water and that the water was overflowing the lake onto the road. The water flow was enough to carve a twelve inch channel across the roadway. He commented that he could usually see a culvert there but that the culvert was now under water. He added that normally the culvert was flowing all year round. He reported the overflow to the Osoyoos Tourist Information Booth.

The individual at the Osoyoos Tourist Information Booth contacted the local RCMP detachment via a non-emergency number and conveyed the same information. The RCMP dispatcher contacted the District Office of the Ministry of Forests and Range, Vernon, and spoke with an engineering technician who then relayed the request to a Ministry of Forests Compliance and Enforcement Technician, leaving a voice message which was not retrieved until after the breach of the dam. The information relayed concerned a road washout on a “non-status road” (as opposed to a forest service road), so it was not described as an urgent priority.

Findings:

In reviewing the flow of information and the actions taken by the individuals involved, it appears that each acted on the best information they had available. Most importantly, the connection of the road washout to an earthen dam structure was not relayed or it may have prompted a higher priority response. In addition, dozens of reports of road washouts, most of no major consequence, come into local officials and regional offices after major rainstorms, so without specific local knowledge of the structure involved it is understandable to see why the issue was not escalated. Emergency Management BC was not contacted until after the debris torrent and mudslide were reported.

Recommendation 3: The Ministry of Environment should consider implementing signage at all dam locations to make it clear to passersby that the structure is a dam and to provide direction and emergency contact information, including contact information for the owner, to report any issues observed.

Recommendation 4: Emergency Management BC should work with local officials, local and provincial policing and first response agencies, and ministry provincial and regional offices to provide a quick reference list of key contact numbers, focused on “who to call when,” and develop an alert matrix to quickly escalate priority issues.

Recommendation 5: The Ministries of Forests and Range and Environment should review their call-out procedures to ensure that compliance and enforcement personnel are familiar with the issues escalation process noted in Recommendation 4, as they are often among the first individuals aware of local incidents.

THE DAM BREACH AND THE ENSUING RESPONSE AND RECOVERY

At approximately 2:15pm on June 13, 2010, the Testalinden Dam breached, causing a debris torrent that travelled five kilometers downstream. The mudslide destroyed or badly damaged five homes and caused significant damage to crops and farm equipment, covering 200 meters of Highway 97 and blocking several secondary roads. The technical reasons for the dam failure are still being investigated by hydrological and geophysical engineers, but it is likely that the combination of heavy water load (due to recent heavy rains and clear cuts in the area), over-topping of the roadway and dam, and blockage of the spillway and drainage sluices were all contributing factors.

Residents in the impacted area either saw or heard the debris torrent coming and began to self-evacuate. The Oliver Fire Chief was in the area at the time and immediately called emergency services, including police, fire, ambulance and search and rescue. The Oliver Fire Department led a tactical evacuation of approximately 25 home and established a unified command structure with local emergency response agencies.



Within the hour, the incident was reported to Emergency Management BC through the Oliver fire dispatch, the local authority’s emergency program coordinator (EPC) was briefed and an emergency operations center (EOC) was activated by the Regional District of Okanagan-Similkameen with support from the Town of Oliver. The Regional District of Okanagan-Similkameen promptly issued a formal evacuation order impacting approximately 25 homes in addition to a verbal declaration of local emergency, and emergency social services (ESS) volunteers established a reception centre at the Oliver Community Center to provide services to impacted residents. An Elks hall was subsequently opened as a group lodging facility in order to support a group of migrant farm workers.

By that evening, Emergency Management BC’s central region office had activated a Provincial Regional Emergency Operations Centre (PREOC), officials at the Ministry of Transportation and Infrastructure and Ministry of Environment had been briefed and a multi-agency coordination call was held at 7:00pm. On this call, officials confirm that all residents and workers are accounted for and that no injuries or fatalities had occurred. Officials also confirm that power was cut, irrigation lines were turned off and engineers had conducted an initial overflight of the impacted area. A Declaration of Local State of Emergency was received by EMBC at 11:14pm.

In the following days, the EOC ramped up further, with critical positions being filled, and the PREOC arranged a series of coordination calls involving all agencies. In addition, the Province’s central coordinating group (CCG), including senior leaders from various ministries, was activated and maintained throughout the week. ESS volunteers held meetings and

information sessions with residents and the Ministry of Transportation and Infrastructure began work on debris removal and clean up along Highway 97, which was reopened on June 15. The Interior Health Authority was also involved very early on in the response, issuing water quality advisories.

On June 14 the Ministry of Environment assigned its Commercial Environmental Investigation Unit to review the context of the dam and its licensees over time and initiates a priority review of all similar dam structures starting June 15.

By June 16 the Integrated Recovery Team (IRAD) of Emergency Management BC was in place to assist with the transition from response to recovery. A resiliency center was established for the community to provide a one-stop shop for ESS, disaster financial assistance (DFA), psycho-social support and Integrated Disaster Council of BC (includes the Red Cross, Salvation Army and other non-profit organizations) contacts. The Ministry of Agriculture and Lands was also actively meeting with Oliver growers and toured the impacted area with residents, outlining the supports available through BC Production Insurance, AgriRecovery and AgriStability programs. As well, the Province released a fact sheet titled “Government Assistance Available for Oliver Residents.”

By June 18, the Regional District of Okanagan-Similkameen downgraded the evacuation order to an alert. Recovery efforts continue to the date of this report and DFA claims are being processed.

Findings:

In reviewing the extensive activities of personnel involved in the response and recovery efforts since the breach of the dam, it is clear that the activation of emergency services occurred in a timely and organized manner. Indeed, the community and regional district stepped up to provide support to those impacted and worked well with provincial agencies to ensure effective delivery of support services.

Recommendation 6: Building on Recommendation 4, Emergency Management BC should continue to coordinate awareness and encourage training and orientation for local emergency response agencies, local government officials, and provincial government agency personnel to prepare for emergency situations. Local governments are required to have emergency plans in place, per the Emergency Program Act, and Emergency Management BC can assist with the development and testing of these plans.

THE DAM SAFETY OVERSIGHT MODEL IN BRITISH COLUMBIA

The British Columbia Dam Safety Regulation (B.C. Reg. 44/2000), *Water Act* RSBC 1996, was brought into force on February 10, 2000 (Appendix B). The regulation provides specific direction to owners of dams as to their responsibilities with respect to inspection, maintenance and reporting. The regulation spells out the expectations around hazardous conditions of a dam and requirements for the notification of a suspension of normal operation or removal of a dam. In addition, the regulation provides two schedules, the first respecting the downstream consequence classification of dam structures, ranging from very high to very low consequences for loss of life, economic and social loss and environmental and cultural losses. The second relates to the minimum inspection frequency and dam safety review requirements.

British Columbia is one of only four provinces in Canada with a formalized dam safety program which provides oversight to nearly 2000 dams in the province including some of the largest structures in Canada. In a province with very diverse geologic, hydrologic and seismic conditions, along with a variety of dam owners and operators, regulation of these structures can pose significant challenges.

The Ministry of Environment adopted the current approach to dam safety following a review by Semmens and Adams “An Evaluation of the Dam Safety Program” (1996), which focused on a results-based approach with considerable reliance on professionals, particularly engineers, and the specific accountability of dam owners who are fully responsible for the maintenance and inspection of their dams. The Semmens and Adams review was instigated following a significant dam failure on Cannon Creek, and the Ministry has since implemented all of the recommendations.

In reviewing similar dam safety oversight models in other jurisdictions¹, it is clear that the self-regulating owner responsibility model is common across key jurisdictions. The model used in British Columbia is consistent with other well developed models when it comes to including:

- clear accountabilities on the part of owners for inspections, maintenance, reporting and responsibility for consequence impact costs;
- well defined powers for licensing and outlining qualifications of inspectors; and
- consequence impact classification and inspection frequency schedules.

Some notable differences include:

- existence of an independent regulatory authority responsible for dam safety (as in Alberta);
- authority to set norms and standards for dam conditions, typically under a regulator - BC’s regulation outlines what conditions are considered hazardous as opposed to establishing proactive standards;

¹ Bradlow, D., Palmeiri, A., Salman, S.: “Regulatory Frameworks for Dam Safety – A Comparative Study,” World Bank, Law Justice and Development Series, 2002.

- authority to monitor inspections and reports – BC’s regulation requires inspections and reports to be submitted but it is not clear what powers the dam safety officers have once these reports are received; and
- inclusion of a specific requirement on the part of owners to develop and maintain an emergency preparedness plan (EPP) for consequence management – this requirement would enable a key linkage with local emergency planning efforts as well as enhancing downstream consequence classification assessments.

The Canadian Dam Association (CDA) published guidelines in 2007² to enhance public safety around dams and to ensure proper inspection and maintenance. Many of the guidelines are consistent with the dam safety program in British Columbia with a notable exception that the CDA moved to a five category consequence classification system (versus four in BC). This system now risk rates dams according to incident likelihood, from very frequent down to remote, and for incident consequence, from fatality to insignificant. It is clear that the more precision that can be applied in a risk rating analysis, the more relevant the respective rating will be. The CDA also recommends a periodic re-assessment of risk ratings, ideally tied to scheduled dam safety reviews.

Findings:

The Testalinden Dam was rated as “Low” on the BC Dam Safety Regulation Downstream Consequence Classification schedule. A “Low” classification describes a low potential for multiple loss of life, low economic loss and cost, and loss or significant deterioration of regionally important environmental or cultural habitats that may recover overtime without restoration. A “Low” rating would imply an audit every 10 years.

In hindsight, it appears that a “Low” rating for the Testalinden Dam was likely inappropriate, although the technical and engineering review of the exact cause and the resulting debris torrent and mudslide are still underway. As a result of this dam breach, the Ministry of Environment initiated a rapid assessment of similar dam structures starting on June 15. Over the following two weeks, a total of 628 dams were assessed and the Ministry is currently reviewing the results.

This review noted the importance of clear communication and information sharing between the Ministries of Environment and Transportation and Infrastructure with respect to downstream developments (e.g., subdivisions, re-zoning applications) near dams and the potential impact that this information could have on the consequence rating. This linkage needs to be strengthened to ensure that all relevant information is considered in assigning an appropriate consequence rating. The same is true for initiatives and activities of other ministries, including Forests and Range and Energy Mines and Petroleum Resources.

² A draft discussion paper is currently available at http://www.cda.ca/cda_new_en/main%20index.html, providing updates to the Canadian Dam Association 2007 guidelines.

In addition, this review revealed that a number of other water related structures are not monitored by the Dam Safety Program. These include mine tailing dams, dikes, and other authorized works like high pressure water conveyance systems. Mine tailing dams are monitored by the Ministry of Energy Mines and Petroleum Resources through a memorandum of understanding with the Ministry of Environment. Because these types of structures are indistinguishable from other types of dams and have similar potential for consequential damage, it is important that a consistent approach to licensing and standards be in place for both. In the case of dikes, the Ministry of Environment is working with Emergency Management BC on addressing key priority requirements through the Flood Protection Program.

It was noted that the Ministry of Environment has done some very good work in developing dam audit checklists and providing a significant amount of practical information for owners and the public on its website. The Ministry is also moving towards implementation of a Dam Registry. Previously, the dam database was linked to the Water Licensing Information System, but the new registry will enable more appropriate tools to track trends and performance. In addition, the Ministry has linked dam information with new tools such as Government's iMap system and Google Earth, to enable the location and geo-referencing of dams and related data for Ministry, government and local government use. This linkage will be important in assigning appropriate consequence ratings and will provide important information for Local Emergency Response Plans.

A final area of review was with respect to resources assigned to dam safety oversight. The number of staff dedicated to dam safety has fallen from 8.5 FTEs (full time equivalents) at the time of the 1996 Semmens and Adams review to 5.5 FTEs today. It was also noted that dam safety officers have many competing responsibilities, in addition to licensing and review functions. As a result, their approach has been primarily risk-based, focusing primarily on high and very high consequence dam structures. As stated above, collaborative efforts between ministries and other agencies will also complement the work of the dam safety program staff.

Recommendation 7: The Ministry of Environment should review and update the Dam Safety Regulation to incorporate best practices on dam safety found in other jurisdictions. This would include but is not limited to an update to the downstream consequence classification tool, inclusion of a requirement for the owner to develop an emergency preparedness plan for the structure, and consideration of further regulatory oversight to enhance enforcement and compliance.

Recommendation 8: The Ministry of Environment should complete its Rapid Dam Assessment Project and update its consequence rating system accordingly to determine priority areas in need of attention. The Ministry should develop an action plan to address those areas needing immediate attention and schedule appropriate follow up based on overall findings.

Recommendation 9: The Ministry of Environment should continue its work in building a robust Dam Registry, with linkages through to geo-reference tools which can be utilized by other partners.

Recommendation 10: The Ministries of Environment and Transportation and Infrastructure need to continue to ensure effective communication and information sharing of community development and transportation initiatives as they relate to downstream consequences for dam safety. This information should be periodically reviewed on a priority basis to account for any historical changes. In addition, other ministries such as Forests and Range and Energy Mines and Petroleum Resources should be linked in to any consequence review initiatives to ensure that all appropriate information is considered on a periodic basis.

Recommendation 11: The Ministry of Environment should ensure the consistent oversight and regulation of all water related structures, including licensing, standards and risk assessments, by working with the ministries that have the legislative authority. The Ministry should build a business case to rationalize the types of resources and supports that would be needed to accomplish this recommendation.

Recommendation 12: The Ministry of Environment should continue and expand its education and awareness initiatives with dam owners and should work with Emergency Management BC to ensure that dam owners are working directly with local government officials in tying together their emergency preparedness and response plans. In addition, the Ministry of Environment should publish an annual Dam Safety Program report on its public website for the information of the public.

CONCLUSION

The events leading up to the failure of the Testalinden Dam indicate that more could have been done to avert the disaster caused by the debris torrent and mudslide on June 13, 2010.

This review focused on the circumstances leading up to the failure of the privately-owned dam, the chain of events following initial reports of the dam overtopping received prior to the incident, the response and recovery efforts following the incident and a review of dam safety oversight in British Columbia.

Recommendations have been made to improve public awareness of “who to call when” someone witnesses an emerging or emergency situation and to enhance the timely sharing of emergency information among public agencies. The integrated approach to emergency management in British Columbia helped to avert the loss of life and to quickly move from response into recovery.

A review of the dam safety program indicates that the risk based approach and self-regulating owner accountability model used in British Columbia are consistent with the approach used in other jurisdictions. A number of recommendations are made to strengthen the dam safety program and to ensure appropriate enforcement and compliance. And the investigation by the Commercial Environmental Investigations Unit into the activities and responsibilities of the current and past owners/licensees is still underway.

In summary, the recommendations being made in this report are intended to enhance not only the dam safety program but also to enhance public safety initiatives in British Columbia in order to protect the public from potentially avoidable disasters.

APPENDIX A

INFORMATION BULLETIN

2010PSSG0038-000715
June 15, 2010

Ministry of Public Safety and Solicitor General

SOLICITOR GENERAL ANNOUNCES DEBRIS TORRENT REVIEW

OLIVER – Deputy Solicitor General David Morhart has been appointed to review the circumstances leading up to the debris and mud torrent that occurred June 13 south of the town of Oliver, announced Michael de Jong, Minister of Public Safety and Solicitor General.

The debris and mud torrent occurred at approximately 2:15 p.m. in an agricultural area about eight kilometres south of Oliver. Initial reports have indicated it was caused by the failure of an earthen dam on a privately-owned, man-made reservoir situated about five kilometres from impacted homes.

Media have also reported that a citizen called a local tourism office on Friday, June 11, to report that the reservoir was overtopping the earthen dam and that the call was then relayed to the RCMP.

The Deputy Solicitor General's review will examine the circumstances leading up to the failure of the privately-owned dam, in conjunction with an investigation by the B.C. Conservation Officer Service. The Deputy Solicitor General will also examine the chain of events following any initial reports of the dam overtopping received prior to the incident. The review will establish the circumstances and provide appropriate recommendations.

In particular, and in the interest of public safety and preventing similar occurrences in the future, the review will include:

- A fact framework – a description of the incident and what was known by whom and when.
- A review of dam and water licensing policy and procedure as related to this structure.
- Analysis of the incident response and recovery effort.
- Any further issues that arise during the course of the review.

The review will be completed by mid-July, forwarded to the Minister of Public Safety and Solicitor General for review, and then released to the public in accordance with the provisions of the Freedom of Information and Protection of Privacy Act.

Highway 97 has been closed since the incident, with a detour in place for traffic. The highway is expected to be cleared and re-opened later tonight.

Interior Health Authority (IHA) has issued a water-quality advisory effective immediately for individual water licensees and shallow wells in the immediate proximity of the area south of Road 15 south to Osoyoos. The health authority recommends that persons boil their water for one minute or seek alternative sources of potable water until further notice.

Water intended for drinking, washing fruit and vegetables, making juice or ice, or brushing teeth should be boiled for one minute. IHA will notify the public when conditions change or water quality has improved.

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Media Contact: Media Relations
 Ministry of Public Safety and Solicitor General
 250 356-6961 250 356-6961

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APPENDIX B

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IMPORTANT INFORMATION

B.C. Reg. 44/2000
O.C. 131/2000

Deposited February 10, 2000

Water Act **BRITISH COLUMBIA DAM SAFETY REGULATION**

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Schedule 1

Schedule 2

Definitions

1 In this regulation:

"Act" means the *Water Act*;

"dam" means

(a) a barrier constructed across a stream, or

(b) a barrier constructed off-stream and supplied by diversion of water from a stream,

for the purpose of enabling the storage or diversion of water, and includes all works which are incidental to or necessary for the barrier;

"dam owner" means, with respect to a dam, any or all of the following:

(a) the person who holds the current licence or is required to hold a licence for the dam;

(b) the person who last held a licence for the dam, including a licence that has been suspended, cancelled, abandoned or terminated;

(c) if there is no person to whom paragraph (a) or (b) applies, the owner of the land on which the dam is located or the person who had the dam constructed;

"dam safety officer" means an engineer or officer who is designated in writing by the comptroller as a dam safety officer;

"emergency preparedness plan" means a plan prepared by a dam owner under section 3 (2) (a) that describes the actions the dam owner proposes to take in the event of an emergency at a dam;

"height" means the vertical distance to the top (crest) of a dam measured,

(a) in the case of a dam across a stream, from the natural bed of the stream at the downstream outside limit of the dam, or

(b) in the case of a dam that is not across a stream, from the lowest elevation at the outside limit of the dam;

"instrumentation" means, but is not limited to, survey monuments and stations, inclinometers, extensometers, piezometers or measuring weirs;

"maintain" or maintenance means the performance of those tasks required to keep the dam in good operating condition;

"operation, maintenance and surveillance manual" means a manual prepared by a dam owner under section 3 (2) (b) that describes the dam owner's operation, maintenance and surveillance procedures for the dam;

"professional engineer" means a person registered, and in good standing, as a professional engineer under the *Engineers and Geoscientists Act*;

"volume of water" means the total storage volume of the reservoir at full supply level measured in accordance with one of the following:

- (a) between the natural bed of the stream and the spillway crest;
- (b) between the upstream outside limit of the dam and the spillway crest;
- (c) if a low level outlet is excavated to an elevation lower than the general foundation of the dam, between the bottom of that outlet and the spillway crest.

Application

2 (1) This regulation applies to all of the following:

- (a) a dam 1 metre or more in height that is capable of impounding a volume of water greater than 1 000 000 m³;
- (b) a dam 2.5 metres or more in height that is capable of impounding a volume of water greater than 30 000 m³;
- (c) a dam 7.5 metres or more in height;
- (d) a dam that does not meet the criteria under paragraph (a), (b) or (c) but has a downstream consequence classification under Schedule 1 of low, high or very high.

(2) This regulation does not relieve a dam owner from any other requirements that may be imposed under the Act, the Water Regulation or any other applicable enactment.

Operation and maintenance of a dam

3 (1) A dam owner must operate and maintain a dam in accordance with all of the following:

- (a) this regulation;
- (b) any applicable licence or approval;
- (c) any order that is made under the Act;
- (d) the emergency preparedness plan that has been prepared and accepted in accordance with subsection (2) (a);
- (e) the operation, maintenance and surveillance manual that has been prepared and accepted in accordance with subsection (2) (b).

(2) A dam owner must, in the form and manner and within the time period specified by the comptroller or regional water manager, prepare and submit to a dam safety officer, for acceptance by the dam safety officer, the following:

- (a) if the downstream consequence classification under Schedule 1 is high or very high, an emergency preparedness plan;

(b) if the downstream consequence classification under Schedule 1 is low, high or very high, an operation, maintenance and surveillance manual.

(3) Subsection (2) applies whether or not there is a term or condition in an approval granted or licence issued that requires the preparation of such a plan or manual for the dam.

(4) A dam owner must ensure that the dam is adequately safeguarded to prevent unauthorized operation of the dam by someone other than the dam owner or an agent of the dam owner.

Alteration of a dam

4 (1) Any alteration, improvement or replacement to all or any part of a dam must be authorized by an approval, licence or order.

(2) Subsection (1) does not apply to an alteration, improvement or replacement for the purpose of

(a) maintaining the dam as authorized under section 3, or

(b) addressing a hazardous condition under section 8.

(3) A dam owner must submit to a dam safety officer, on completion of the alteration, improvement or replacement, a report on the work and the manner in which any such alteration, improvement or replacement to all or any part of the dam was performed.

Inspection

5 A dam owner must do all of the following:

(a) carry out an inspection of a dam on the frequency applicable to the downstream consequence classification for the dam as set out in Schedule 2 in order to assess the condition of the dam during the construction, operation or alteration of the dam;

(b) record the results of every inspection performed under paragraph (a);

(c) repair any safety hazard revealed by an inspection, if authorized to do so by an approval, licence or order or as authorized under this regulation.

Reporting

6 (1) A dam owner must, when an inspection is carried out under section 5 or when any other inspection is carried out with respect to a dam,

(a) submit to a dam safety officer, in the form and manner and within the time period specified by the dam safety officer,

(i) the record of inspection required by section 5 (b), and

(ii) the results and analysis of any test or measurement taken including, but not limited to,

(A) instrumentation readings and analysis,

(B) visual records or observations,

(C) drawings,

(D) soil, aggregate and concrete test results, and

(E) any other test results, and

(b) promptly submit to a dam safety officer the record of inspection required by section 5 (b) if the inspection reveals a potential safety hazard.

(2) A dam owner must submit to a dam safety officer, if requested by the dam safety officer, the original or clear copies of the following documentation required for the design, construction or alteration of the dam:

(a) all design notes, drawings and specifications;

(b) hydraulic, hydrologic, geological and geotechnical data;

(c) reports and other similar documentation.

Dam safety review

7 (1) If required by Schedule 2, a dam owner must have a professional engineer, experienced in dam safety analysis, do a dam safety review and prepare, in the form and manner and within the time period specified by the comptroller or regional water manager, a dam safety report.

(2) The dam owner must submit to a dam safety officer a copy of the dam safety report prepared by the professional engineer who carried out the dam safety review under subsection (1).

Hazardous conditions at a dam

8 If conditions exist which are or are likely to be hazardous to a dam, or if conditions may reasonably be anticipated to cause a dam, or any part of a dam, or any operation or action at or in connection with a dam, to be or become potentially hazardous to public safety, the infrastructure or works, other property or the environment, a dam owner must promptly do all of the following:

(a) if an emergency preparedness plan exists, modify the operation of the dam, or any part of the dam, in accordance with the emergency preparedness plan;

(b) if an emergency preparedness plan does not exist, operate the dam in a manner, and initiate any remedial actions, that will

(i) safeguard the public,

(ii) minimize damage to the infrastructure or works or to other property, including that not owned by the dam owner, and

(iii) minimize damage to the environment;

(c) contact the Provincial Emergency Program continued under the *Emergency Program Act*;

(d) notify a dam safety officer, or the comptroller or regional water manager, of

(i) the nature of the existing or anticipated conditions,

(ii) all things done by the dam owner to rectify the conditions, and

- (iii) the time and exact nature of any information or warning of existing or anticipated conditions issued to any person under this section;
- (e) inform local authorities, and persons who may be in immediate danger from the potential failure of the dam, of the nature of the existing or anticipated conditions and, if necessary, advise those persons who may be in immediate danger to vacate and remove any property from the endangered area;
- (f) modify the operation of the dam to minimize or prevent damage which may be caused by the failure of the dam, and undertake any other hazard response activity required by a dam safety officer or engineer or by the comptroller or regional water manager.

Suspension of normal operation or removal of a dam

- 9 (1) A dam owner must give the comptroller or regional water manager at least 60 days written notice before undertaking any of the following activities:
- (a) removing all or a significant part of a dam;
 - (b) decommissioning or abandoning a dam;
 - (c) stopping the normal operation of a dam for a period of time longer than one year.
- (2) The dam owner must prepare, and submit to a dam safety officer for approval,
- (a) a plan respecting an activity under subsection (1) (a) or (b), or
 - (b) if required by the dam safety officer, a plan respecting an activity under subsection (1) (c).
- (3) The dam owner must, at least 14 days before the date on which the work is expected to commence, notify a dam safety officer before commencing any work under the approved plan.
- (4) The dam owner must submit to a dam safety officer, on the completion of the work performed under the approved plan, a report on the work and the manner in which it was performed.
- (5) The dam owner must undertake any further actions that the comptroller or regional water manager requires to alleviate any adverse consequences to any person, the infrastructure or works, other property or the environment that may be affected by any work performed on the dam.
- (6) An approval under subsection (2) respecting the decommissioning of a dam is subject to the *Environmental Assessment Act* and to approvals, if any, required under that Act.

Information and evaluation

- 10 (1) A dam owner must, if requested by a dam safety officer, provide the following information in order to evaluate the condition or hazard potential of a dam:
- (a) information with respect to the dam including, but not limited to,

- (i) foundation investigation results,
- (ii) design details and as-built plans,
- (iii) construction records,
- (iv) operation manuals,
- (v) records of instrumentation,
- (vi) inspection reports,
- (vii) safety reports, and
- (viii) inundation studies and emergency preparedness plans;

(b) information with respect to the nature of the land and the stream, and the use of the land and the stream, downstream from or adjacent to the dam or reservoir, including the hydraulic, hydrologic, geological and geotechnical characteristics and the uses of the land and stream;

(c) information with respect to the watershed upstream of the dam.

(2) The information requested under subsection (1) must be submitted to a dam safety officer, in the form and manner and within the time period specified by the comptroller or regional water manager.

(3) The dam owner must conduct any inspection, investigation, survey or test that is necessary to provide the information required by subsection (1).

Instrumentation

11 A dam owner must do all of the following:

- (a) install any instrumentation necessary to adequately monitor the performance of a dam;
- (b) monitor, maintain or replace instrumentation installed at a dam to ensure continuity of readings;
- (c) submit instrumentation readings and evaluations to a dam safety officer, in the form and manner and within the time period specified by the dam safety officer;
- (d) submit, to a dam safety officer for approval by the dam safety officer,
 - (i) notice of any planned modifications to, changes to or removal of the instrumentation at least 60 days before the proposed modification, change or removal, or
 - (ii) an annual plan outlining intended changes to the instrumentation.

Expert opinion

12 (1) If, based on information submitted in respect of a dam or related works, the comptroller or regional water manager considers that a question has arisen as to what is proper practice for resolving an issue involving a dam or related works, the comptroller or regional water manager

may require a dam owner to retain an expert, satisfactory to the comptroller or regional water manager, with qualifications and experience as follows:

- (a) in the case of a dam, in dam design, construction and analysis;
- (b) in the case of related works, in hydraulic, hydrological, geological, geotechnical, mechanical or structural engineering or other appropriate disciplines.

(2) The expert retained under subsection (1) must provide a report to the comptroller or regional water manager on the issue.

Schedule 1

(sections 2 (1) (d) and 3 (2))

Downstream Consequence Classification Guide

Rating	Loss of Life	Economic and Social Loss	Environmental and Cultural Losses
VERY HIGH	Large potential for multiple loss of life involving residents and working, travelling and/or recreating public. Development within inundation area (the area that could be flooded if the dam fails) typically includes communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated fatalities could exceed 100.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Estimated direct and indirect (interruption of service) costs could exceed \$100 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low.

HIGH	Some potential for multiple loss of life involving residents, and working, travelling and/or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of service) costs could exceed \$1 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.
LOW	Low potential for multiple loss of life. Inundation area is typically undeveloped except for minor roads, temporarily inhabited or non- residential farms and rural activities. There must be a reliable element of natural warning if larger development exists.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect (interruption of service) costs could exceed \$100 000.	Loss or significant deterioration of regionally important fisheries habitat (including water quality), wildlife habitat, rare and endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high. Includes situations where recovery would occur with time without restoration.
VERY LOW	Minimal potential for any loss of life. The inundation area is typically undeveloped.	Minimal economic losses typically limited to owner's property not to exceed \$100 000. Virtually no potential exists for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare or endangered species, unique landscapes or sites of cultural significance.

Schedule 2

(sections 5 (a) and 7 (1))

Minimum Inspection Frequency and Dam Safety Review Requirements

Item	Very High Consequence	High Consequence	Low Consequence	Very Low Consequence
Site Surveillance (a)	WEEKLY	WEEKLY	MONTHLY	QUARTERLY
Formal Inspection (b)	SEMI- ANNUALLY	SEMI- ANNUALLY or ANNUALLY	ANNUALLY	ANNUALLY
Instrumentation	AS PER OMS * MANUAL	AS PER OMS * MANUAL	AS PER OMS * MANUAL	N/A
Test Operation of Outlet Facilities, Spillway Gates and other Mechanical Components	ANNUALLY	ANNUALLY	ANNUALLY	ANNUALLY
Emergency Preparedness Plan	UPDATE COMMUNICATIONS DIRECTORY SEMI- ANNUALLY	UPDATE COMMUNICATIONS DIRECTORY SEMI- ANNUALLY	UPDATE COMMUNICATIONS DIRECTORY ANNUALLY	N/A
Operation, Maintenance & Surveillance Plan	REVIEW EVERY 7 - 10 YEARS	REVIEW EVERY 10 YEARS	REVIEW EVERY 10 YEARS	REVIEW EVERY 10 YEARS

Dam Safety Review (c)	EVERY 7-10 YEARS (d)	EVERY 10 YEARS (d)	(d)	(d)
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* Operation, Maintenance, and Surveillance Manual.

(a) Site surveillance may consist of visual inspections and/or monitoring of automated data acquisition systems. Reduced frequencies of visual inspections may be determined by seasonal conditions.

(b) Formal Inspections are intended as more thorough inspections performed by the appropriate representative of the owner responsible for safety surveillance.

(c) A Dam Safety Review involves collection of all available dam records, field inspections, detailed investigations and possibly laboratory testing. It then proceeds with a check of structural stability and operational safety of the dam, beginning with a reappraisal of basic features and assumptions. The level of detail required in a Dam Safety Review should be commensurate with the importance and complexity of the dam, as well as the consequences of failure.

(d) Dam owners must conduct an annual review of conditions downstream of their dam and notify a dam safety officer if the downstream consequence classification level increases. The downstream consequence classification guide is shown in Schedule 1.

[Provisions of the *Water Act*, R.S.B.C. 1996, c. 483, relevant to the enactment of this regulation: section 46 (1) and (2) (d), (f), (h) and (i)]