# 2023 Formal Annual Dam Inspections – Recreational Dams

# Final Report

## H366322-0000-220-230-0005



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| **2024-11-07** | **0** | **Approved For Use** | **M. Mehrbakhsh** | **J. Walker<br>P. Ashayer** | **J. Walker** | **N/A** |
| **DATE** | **REV.** | **STATUS** | **PREPARED BY** | **CHECKED BY** | **APPROVED BY** | **APPROVED BY** |
| | | | | **Discipline Lead** | **Functional Manager** | **Client** |

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## Disclaimer

This report has been prepared by Hatch for the sole and exclusive use of the City of Nanaimo (the "Client") for the purpose of assisting the management of the Client in making decisions with respect to the management of the ten City-owned recreational dams (Westwood Lake Dam, Harewood Dam, Old Reservoir No. 1, Upper Chase Dam, Middle Chase Dam, Lower Chase Dam, Witchcraft Lake Dam, and McGregor Creek Dam) and shall not be (a) used for any other purpose, or (b) provided to, relied upon or used by any third party.

This report contains opinions, conclusions and recommendations made by Hatch using its professional judgment and reasonable care. Use of, or reliance upon this report by Client, is subject to the following conditions:

(a) the report being read in the context of and subject to the terms of Consulting Agreement 2821 Dam Inspections and Concrete Condition Assessment between Hatch and the Client dated July 22, 2021 (the "Agreement"), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions that were specified or agreed therein.

(b) the report being read, with sections or parts hereof read or relied upon in context.

(c) the conditions of the ten dams may change over time or may have already changed due to natural forces or human intervention, and Hatch takes no responsibility for the impact that such changes may have on the accuracy or validity or the observations, conclusions and recommendations set out in this report.

(d) the report is based on information made available to Hatch by the Client or by certain third parties, and unless stated otherwise in the Agreement, Hatch has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

# 1. Introduction

The City of Nanaimo (the "City") retained Hatch Ltd. ("Hatch") to conduct Formal Annual Dam Inspections (FADI) for 10 City dams as per the BC Dam Safety Regulations. This report summarizes the results of the 2023 FADIs for the recreational dams which were undertaken by Hatch on September 26 to 28, 2023.

The City's Water and Resources and Water Supply Operations staff are responsible for the management and maintenance of 10 dams. The recreational dams are in the southwest end of the City. See **Figure B1** in **Appendix B**.

The majority of the recreational dams are a legacy of early coal mines or power generating operations and the water bodies created by these remaining dams are within the City of Nanaimo or the Regional District of Nanaimo park areas and are used for recreational purposes. McGregor Creek (Linley Valley) Dam was constructed as part of a housing development. The water license and ownership of the McGregor Creek Dam was transferred to the City of Nanaimo on June 10, 2022.

Old Reservoir No. 1 was previously used for the City's potable water supply but was shut down in early 2014 and drained in January 2020. The future of the reservoir is still to be determined; Hatch understands that the City of Nanaimo's goal is to declassify and decommission the Old Reservoir No. 1 Dam.

The scope of the inspection work included:

- Review of background information, including as-built drawings, rehabilitation records/drawings, previous FADI and dam safety review (DSR) reports, operation, maintenance and surveillance (OMS) manuals, and any available instrumentation records.
- Meet with City Waterworks Dam Inspectors who perform the daily operation, maintenance and surveillance on the dams and discuss the various issues they have observed since the 2022 FADI.
- Visit the sites and undertake visual inspections of the dams and compile a photographic record.
- Review of dam safety management strategies including:
  - consequence classification;
  - operation, maintenance and surveillance;
  - recommendations for dam safety improvements; and
  - review and update of the dam safety issues database assembled from previous FADI.

The eight recreational dams inspected are listed below with acronyms to identify the dams and maintain consistency with previous FADI reports:

- WWL - Westwood Lake
- UCR - Upper Chase River Dam
- MCR - Middle Chase River Dam
- LCR - Lower Chase River Dam
- HAW - Harewood Dam
- WCL - Witchcraft Lake Dam
- No1 - Old Reservoir No. 1 Dam
- MGC - McGregor Creek Dam.

A list of the documentation reviewed is provided in **Appendix A**, figures are presented in **Appendix B**, photographs are included in **Appendix C**, and the Mobile Dam Inspection Database forms from September 2023 are included in **Appendix D**. The following sections of this report document the results of the FADI.

# 2. Regional Geology

The general geological conditions of the inspected dam sites are based on the review of geological mapping of Vancouver Island (Ministry of Environment BC). **Table 2-1** is a summary of the surficial and bedrock geology.

**Table 2-1: Summary of Regional Geology of the Inspected Dam Sites**

| Dam | Regional Surficial Geology | Regional Bedrock Geology |
|---|---|---|
| Westwood Lake Dam<br>Old Reservoir No. 1 Dam<br>Harewood Lake Dam<br>Upper Chase River Dam<br>Middle Chase River Dam<br>Lower Chase River Dam<br>Witchcraft Lake Dam<br>McGregor Creek Dam | Surficial sediments comprise marine veneers of gravel and sand up to 1.5 m thick. Surficial sediments are underlain by moraine tills with lenses of gravel, sand and silt. | Bedrock belonging to the Nanaimo and Vancouver Groups. Consists of boulders, cobble and pebble conglomerate, coarse to fine sandstone, siltstone, shale, and coal. |

# 3. Dam Safety Program

## 3.1 Dam Failure Consequence Classification

The Dam Failure Consequence Classifications (DFCC) of the City's dams are determined in accordance with the B.C. Water Sustainability Act Dam Safety Regulation [B.C. Reg 44/2016]. The current classifications of the 8 recreational dams included in this FADI are summarized in **Table 3-1** below. Hatch is currently working on the Middle Chase River Dam IDF study, which may result in a change is dam classification for Middle Chase and Lower Chase Dams. This will be revisited as part of the 2024 DSRs for these sites.

**Table 3-1: Dam Consequence Classification Ratings**

| Dam | Dam Failure Consequence Classification |
|---|---|
| Westwood Lake Dam | High |
| Upper Chase River Dam | Significant |
| Middle Chase River Dam | High |
| Lower Chase River Dam | Very High |
| Harewood Dam | Significant |
| Witchcraft Lake Dam | Significant |
| Old Reservoir No. 1 Dam | Low |
| McGregor Creek Dam | Significant |

### *3.1.1 Westwood Lake Dam*

The current dam classification for Westwood Lake Dam is ‘High’. This was assessed as part of the 2004 DSR. A review of several sets of aerial photography available shows that significant development along the downstream reach has occurred since 2003. This has mostly been concentrated in the area between the dam itself and Cathers Lake. The 2014 DSR identified the current classification as being outdated for various reasons but also indicated that the outflow capacity is adequate to pass the PMF (the highest potential IDF). It is recommended that given the increasing downstream development and public use of the site that the dam classification be re-confirmed using a dam breach and inundation study approach. The reason for this recommendation it two-fold: first, it would provide information for emergency preparedness plans and evacuation procedures. Secondly, it would possibly impact the dam safety management requirements for the structure should the classification increase.

### *3.1.2 Upper Chase River Dam*

The current dam classification for Upper Chase River Dam is ‘Significant’. A spillway capacity assessment and a damage assessment were completed in 2002. In addition, it appears that dam breach flood inundation study was completed for the Chase River Dams in 2012. The very small size of the reservoir combined with a review of historic aerial photography series in the downstream reach does not appear to show significant changes in development in the

recent past. The small size of the reservoir also indicates that the current dam classification is appropriate provided failure of the structure does not trigger a cascade failure of the downstream structures (Old Reservoir No. 1 Dam, Middle Chase River Dam and Lower Chase River Dam). As in the last several FADI reports, it is recommended that, checks be performed to determine the potential for a cascade failure caused by the failure of Upper Chase River Dam. If it is found that the downstream structures can safely absorb such a failure, then this should be documented, and no additional assessment need be considered. If it does cause a cascade failure, then additional study is required.

### *3.1.3 Middle Chase River Dam*

The current dam classification for Middle Chase River Dam is 'High' as determined from the Colliery Dams Consequence Classification report from November 2014 and presented by the Provincial Dam Safety Section. This reduced the dam classification defined in the most recent DSR (2014) and a Dam Breach and Inundation study (2012) that recommended that a dam classification of 'Extreme' be adopted. A cursory review of the most recent aerial photography of the downstream reach indicates that no significant additional development has occurred within the floodplain since these studies were performed. However, an additional audit of the 2014 study has revealed that it does not clearly state whether or not the failure of the Middle Chase River Dam causes an incremental failure of the Lower Chase River Dam. The B.C. Dam Safety Regulation states that if the failure of an upstream dam (i.e., Middle Chase River Dam) would cause the failure of the downstream dam (i.e., Lower Chase River Dam), the classification of the upstream dam must be as high or higher than the downstream dam. In this case, the Lower Chase River Dam is classified as 'Very High'. The two dams were considered together in the 2014 study, with the Lower Dam classified higher due to the presence of contaminated soils within it, and the proximity of the dam to the residential population downstream. It is recommended that checks be performed to determine the potential for a cascade failure caused by the failure of Middle Chase River Dam. If a cascade is not expected, then this should be documented, and further analysis may not be required. However, if it does cause a cascade failure further study is likely warranted.

### *3.1.4 Lower Chase River Dam*

The current dam classification for Lower Chase River Dam is 'Very High' as determined from the Colliery Dams Consequence Classification report from November 2014 and presented by the Provincial Dam Safety Section. This reduced the dam classification defined in the most recent DSR (2014) and a Dam Breach and Inundation study (2012) that recommended that a dam classification of 'Extreme' be adopted. No significant additional downstream development was identified, and additional analyses are not required at this time.

### *3.1.5 Harewood Dam*

The current dam classification for Harewood Dam is 'Significant'. Documentation of how this classification was established was not found; however, given the small size of the structure and impoundment as well as a lack of surrounding development, it is expected that this was established through simple inspection and a simplified screening evaluation which is

acceptable for a Low or Significant consequence structure. A review of available aerial photography of surrounding area shows that significant development has occurred over the last 10 years to the east of HWY 19, Nanaimo Parkway that could impact the classification of the dam. A 'Significant' DFCC is reserved for dams with a temporary population at risk only, and so the presence of an increasing permanent population downstream of the dam warrants further investigation to determine if there is a permanent population at risk. The outflow from Harewood Dam appears to enter downstream of the Lower Chase River Dam (therefore potentially includes some of the same PAR). It is recommended that further investigation and analysis be considered.

### *3.1.6 Witchcraft Lake Dam*

The current dam classification for the Witchcraft Lake Dam is 'Significant'. As with Harewood Dam it is assumed that a simplified screening level analysis was used to establish this classification. A review of available aerial photography shows that significant development has occurred since 2003 but not within the last 5 years. In last year's report it was stated that the significant classification was consistent with the size of the dam and reservoir. However, upon further review this year and with our dam classification expert attending the site, that opinion has evolved. Visiting the site showed that the dam as it stands is largely missing and in an advanced state of decay. Its definition as a dam is questionable at best. Currently the dam is not impounding water or impeding flow out of Witchcraft Lake and is unlikely to significantly impound water during a large flood event. The hydraulic control is provided by the channel and the lake itself is largely in a natural condition. For this reason, it is recommended that these observations be discussed with the BC Provincial Dam Safety Section to have the dam downgraded to a 'Low' consequence classification or struck from the registry all together, as the dam has essentially been 'decommissioned by nature'. Hatch has provided a memo recommendation to the City of Nanaimo for this item.

### *3.1.7 Old Reservoir No. 1 Dam*

The current dam classification for the Old Reservoir No. 1 Dam is 'Low'. When this reservoir was filled in the past, there is potential (as with the Upper Chase River Dam) that a failure of this structure could cause a cascade failure of the Middle and Lower Chase River Dams. However, now that the reservoir has been drained, there is no risk for a cascade failure. This classification rating was approved by BC Dam Safety on February 3, 2021.

There are two possible options for this structure moving forward. Given that the reservoir has been dewatered and that the intention is to leave the low-level outlet open going forward, this structure does not meet the CDA definition of a dam, which requires that the structure retain at least 30,000 $m^3$ of water, water containing any other substance, fluid waste or tailings. While the structure remains in this state, there is justification for removing it from the City of Nanaimo portfolio of dams.

Should the long-term plan for the structure entail re-filling the reservoir, it may be prudent to leave it in the portfolio but, lower the classification to reflect the consequences (or lack thereof) of its failure. Given that the dam does not contain water and would have very minimal

consequences if it were to fail, it is recommended that the classification of the structure can be modified to 'Low.'

#### *3.1.8 McGregor Creek Dam*

The current classification for the McGregor Creek Dam is 'Significant' as per the Consequence Rating Review performed by Lewkowich Engineering Associates Ltd. (LEA) in August 2019, which maintains the consequence classification established at the time of original construction in 2011. Documentation of how this classification was established was not found; however, given the small size of the structure and impoundment, it is expected that this was established through simple inspection and a simplified screening evaluation which is acceptable for a 'Low' or 'Significant' consequence structure. Once the water license has been transferred to the City of Nanaimo this classification should be confirmed with an independent analysis. A full dam breach inundation study is likely not warranted for this.

## 3.2 Operating, Maintenance and Surveillance Manuals

The City has prepared Operating, Maintenance and Surveillance (OMS) manuals for each of their 10 dams. A high-level review of the manuals was performed as part of the FADI and appear to contain the relevant information that is expected in an OMS manual. Copies of the manuals are kept in the City of Nanaimo Public Works and City Engineering libraries. These copies have been distributed to key City personnel and are available electronically for the City Dam Inspectors to access during routine inspections if required. The manuals are updated periodically as required. The Dam Inspection Database (updated records of weekly dam inspections) were provided as part of the 2023 FADI.

## 3.3 Dam Emergency Plan

The City of Nanaimo has a comprehensive Dam Emergency Plan (DEP) which was last updated in 2019. The DEP should be updated to include the McGregor Creek Dam for which the water license and ownership was recently transferred to the City of Nanaimo.

## 3.4 Dam Safety Management

The City of Nanaimo updated their Dam Safety Management Program document in July 2020. Key updates to this document include the additions of McGregor Creek Dam, the change in operation of the Old Reservoir No. 1 Dam, and the current state of the Witchcraft Lake Dam. The most recent FADI recommendations should continue to be updated annually.

## 3.5 Surveillance

#### *3.5.1 General*

The Very High consequence classification Lower Chase River Dam, and High consequence classification Westwood Lake Dam and Middle Chase Dam, are inspected on a weekly basis. The significant consequence classification Harewood Dam, Upper Chase River Dam, and Witchcraft Dam and Low consequence classification Old Reservoir No. 1 are inspected monthly. Additional site surveillance occurs after storm events and earthquakes. A more comprehensive inspection is carried out monthly which includes taking instrumentation readings.

The inspectors are equipped with a heavy-duty laptop computer for outdoor use and the information collected during the weekly and monthly inspections is entered directly into the City's Mobile Dam Inspection Database. The most recent weekly and monthly checklists from the database were reviewed by Hatch and have been included in **Appendix D**. It should be noted that the City was not able to maintain the usual inspection frequency during part of 2023 (including September and October) due to lack of available inspectors.

The City of Nanaimo surveillance and instrumentation reading frequencies were compared against the BC Dam Safety Regulation. The monthly inspection frequency is appropriate for the Significant consequence classification dams as well as the weekly surveillance frequency for the High and Very High consequence classification dams.

### *3.5.2 Piezometers and Weirs*

As part of the routine inspections, the seepage elevation over the 'V' notch weirs are recorded by measuring the flow elevation above the base of the 'V' notch. This data is plotted on graphs to help identify trends. It is recommended that the seepage elevations be converted to flow to produce more informative plots that would track better with lake levels and rainfall records and significant changes will be more readily apparent.

Due to the low flow at the weirs, the drawdown is expected to be minimal and the seepage measurements at the weirs are effective at identifying trends.

## 3.6 Items from Previous FADI and DSR

The outstanding dam safety and maintenance issues/recommendations are updated annually in the FADIs. These items are listed in **Table 5-1** and **Table 5-2** of the report for outstanding Inspection and Surveillance and Dam Safety Issues, respectively.

# 4. Formal Annual Dam Inspections

Visual inspections of the dams were carried out by Mehdi Mehrbakhsh, P. Eng. (Structural Engineer) and Laura Paquet, P. Eng. (Geotechnical Engineer) from Hatch on September 26 to 28, 2023. The Hatch inspectors were accompanied by City of Nanaimo staff:

- Jaymie Miller – Lead Supervisor – Waterworks
- Brent Martin – Waterworks Dam Inspector
- Euan Wilson – Water Resources Section

The daily inspection activities and weather conditions are summarized in **Table 4-1**.

**Table 4-1: FADI Activity Summary**

| Date (2023) | Weather | Summary of Inspection Activities |
|---|---|---|
| September 26 | Temperature: 22°C - 29°C<br>Conditions: Rainy (5-10 mm) and windy | 3:45 PM: Old Reservoir No.1 |
| September 27 | Temperature: 22°C - 32°C<br>Conditions: Rainy (1-3 mm) and Cloudy | 8:30 AM: Harewood Dam<br>9:45 AM: Upper Chase Dam<br>10:45 AM: Middle Chase Dam<br>1:00 PM: Lower Chase Dam<br>3:15 PM: McGregor Creek Dam |
| September 28 | Temperature: 23°C - 30°C<br>Conditions: Cloudy | 8:30 AM: Witchcraft Lake Dam<br>9:30 AM: Westwood Lake Dam<br>12:00 PM: Dam Inspections Complete |

It should be noted that heavy rain (> 20 mm) happened in the area in the days preceding the site inspections.

As part of the review, the main dam structures were inspected as well as the areas immediately upstream and downstream of the dams that were accessible or clearly visible from the dams. Observations from these inspections are documented for each dam in the sections which follow. For the purpose of this report, all location descriptions are oriented in a downstream facing direction. A photographic record of the inspections is included in **Appendix C**.

Prior to entering the dam sites, Hatch filled out field visit safety forms to identify potential hazards and City staff provided additional safety information as required for working in the watershed. The condition rating of the various components of the City's dam structures shown in this document will be consistent with the following:

- Satisfactory: Minimal wear or deterioration; like new condition. No repairs required.
- Fair: Normal material wear or deterioration. Functionally adequate for all intended uses.
- Poor: Abnormal material wear, deterioration, or local defects. Components may not fulfill intended uses. Major maintenance or repairs advisable to restore component to a satisfactory condition. If maintenance or repairs are not carried out, the design life of the component may be severely limited, and the component may become unsafe.
- Unsatisfactory: Severe material wear, deterioration, or local defects. Components will not fulfill intended uses. Immediate repair or replacement required. Present situation threatens the structural integrity of the project and represents an unsafe condition.

The major recommendations of this FADI are summarized at the end of this report in **Table 5-1** and **Table 5-2** and have been ranked using a priority rating system described in **Section 5**, which was established independent of the CDA Guidelines.

## 4.1 Westwood Lake (WWL)

### *4.1.1 Dam Description*

The Westwood Lake Dam is comprised of a Main Dam and Saddle Dam. The Main Dam was constructed in 1907 for electricity generation and consists of an earth fill structure approximately 12 m high and over 100 m long. The dam is currently only used for recreation. Although no construction records exist of the original structure, site investigations have indicated the dam has a puddled clay core with loose sandy silt fill forming the upstream and downstream shells. The upstream face is completed with a concrete face, with facing stone embedded into the concrete over some sections and is sloped at 1.6H:1V. The downstream slope is approximately 2.3H:1V. See **Figures WWL2, WWL3** and **WWL4** in **Appendix B**.

Rehabilitation works in 1978 and 1980 included installation of a seepage collection and filter system, as well as backfilling of the low-level outlet pipes through the dam. A seismic upgrade was also completed in 2007 by means of adding buttress fill on the downstream side.

The Saddle Dam is a 2 m high by 130 m long earthen embankment dam located 250 m east of the main dam and is founded on dense glacial till. The dam was reconstructed in 1992. The original dam was stripped, and the downstream core was removed to expose adequate foundation and core. A compacted sand and gravel downstream shell and cap were placed over the old core and the upstream face was upgraded with cobble and boulder erosion protection. The upstream and downstream slopes are 2H:1V (**Figure WWL5** in **Appendix B**).

The dam outlet channel consists of an excavated trapezoidal channel from the northwest end of the lake connecting McNeil Creek. The channel capacity is 40 $m^3/s$ and due to the low velocity of flow, no erosion protection is present at this time. The lake level is controlled by a broad-crested weir with a 0.3 m wide concrete sill, constructed of grouted boulders and concrete.

The Westwood Lake Dam and Saddle Dam data is provided in **Table 4-2** and **Table 4-3** respectively.

**Table 4-2: Data for Westwood Lake Dam and Appurtenant Structures**

| Structure | Details |
|---|---|
| Type of Dam | Earth fill with concrete facing and central low permeable core |
| Maximum Height | 12.3 m |
| Crest Length | 104 m |
| Crest Width | 5 m (approx.) |
| Crest Elevation | 164.4 m. |
| Catchment Area | 835 ha (approx.) |
| Upstream Slope | 1.6H:1V |
| Downstream Slope | 2.3H:1V |
| Retained Water | 2,714,000 $m^3$ |
| Spillway | No spillway at dam; lake level controlled by unregulated outlet channel: base width 7 m, side slopes 1V:1H, sill elevation 162.7 m, outflow capacity about 40 $m^3/s$ at dam crest elevation. |
| Hazard Rating | High |

**Table 4-3: Data for Westwood Lake Saddle Dam**

| Structure | Details |
|---|---|
| Type of Dam | Earth fill (homogeneous with downstream pit run shell) |
| Maximum Height | 2 m |
| Crest Length | 130 m |
| Crest Width | 3 m (approx.) |
| Crest Elevation | 164.2 m |
| Catchment Area | See main dam |
| Upstream Slope | 2H:1V |
| Downstream Slope | 2H:1V |
| Retained Water | See main dam |
| Spillway | See main dam |
| Hazard Rating | Significant |

### *4.1.2 Instrumentation*

Piezometers were reportedly installed in the main dam in 1978 but are no longer functional. A 'V' notch weir is located downstream of the toe of the dam (**Photograph WWL 9**) as well as an adjacent weir located inside a concrete housing for a fisheries siphon. Water levels are measured at this weir as part of City's scheduled routine inspections. Water flow of about 2 cm was observed at the weir during the site inspection, and a measurement of approximately 14 cm was measured at the fisheries weir (**Photograph WWL 10**).

### *4.1.3 Formal Inspection*

The Westwood Lake Dam was in similar condition to that reported during the 2022 FADI. Visual inspections were performed by inspecting upstream face of Main Dam, walking the crest of the Main Dam and Saddle Dam and then walking on downstream face of the Main Dam. The following observations were made during the Westwood Dam inspection:

#### *4.1.3.1 Main Dam*

4.1.3.1.1 Upstream face

- The upstream face of the dam that is comprised of grouted stones was in fair condition. Some erosion of the mortar between stones and minor stone dislodgment is apparent. It is recommended that this item be documented as a routine monitoring and maintenance activity to be included in the OMS manual.

- The upstream face of the dam that is comprised of concrete panels was in fair condition. Some concrete cracking and spalling were observed near concrete panel joints and along the waterline (**Photograph WWL 4**). Some localized grouting repairs were performed, but these repairs have not remained intact in most cases. The concrete panels are not relied upon for impoundment; therefore, repairs are considered a maintenance item and should be undertaken if erosion of the slope occurs.

- The concrete lined upstream face of the dam exhibits a few long persistent cracks along the face above the waterline over almost all the concrete panels with a width of 2-5 mm (**Photograph WWL 3**). This could be due to the dam settlement; however, the width of cracks did not change from the 2020 FADI. Since the concrete facing is not part of the water barrier system, this is not considered a dam safety concern. Nevertheless, the cracks in the upstream concrete face should continue to be monitored for signs for potential seepage or piping. Since these are facing elements, repairs are considered a maintenance item to prevent acceleration of the deterioration and are not affecting the performance or safety of the earth dam at this time.

4.1.3.1.2 Crest and Abutments

- The dam crest is a gravelled surface and was found in good condition during the inspection. There was no signs of cracks, settlement, or sinkholes on the dam crest (**Photograph WWL 6**). No signs of erosion or unusual conditions were observed at the abutments of the dam during the site visit.

- Medium to large sized trees exist at both the left and right abutments **(Photograph WWL 2)**. Tree roots propagating towards the upstream face could introduce seepage paths through the embankment. Tree removal is likely to encounter public resistance. In the interim, the downstream dam face in the vicinity of existing trees should be monitored for signs of bulging, zones of dense vegetation, and visible seepage.

4.1.3.1.3 Downstream Face and Toe

- The downstream face of the dam was observed to be in satisfactory condition and is overlain by a surficial layer of gravel and cobbles up to 300 mm maximum nominal diameter. Tree and brush growth was noted near the crest at the left and right abutments.
- A water level of approximately 2 cm was measured through the 'V' notch weir at the toe of the dam. It should be noted that this 'V' notch weir is used for monitoring flows through the Westwood Lake Syphon and does not measure dam seepage. Water was flowing through this weir during the site inspection, which is not typical as per previous annual inspections, and can be explained by heavy rain fall prior to the 2023 inspection. As first indicated in the 2020 FADI, no flow is usually found at the weir and ponded water noted along the crest of the weir wingwalls is likely attributed to dam seepage. This seepage likely occurs through the Type 1 fill material from the 2009 As-Construction drawings [EBA, 2009] which serves as the downstream blanket drain and terminates behind the weir wingwalls. This area should continue to be monitored as part of routine inspections.
- As previously noted, large and medium sized trees are located on the downstream face near the right and left abutments. Large tree roots can cause serious stability and seepage issues in the dam as well as form a preferential flow path that could lead to piping. It is recommended that these trees be removed for this reason. Trees were also noted close to the interface of the dam and abutments, including a large tree with overhanging roots at the left side of the downstream toe. Vegetation control measures should include clearing any trees and other vegetation a minimum of 3 m beyond the abutment and dam toe.
- The City personnel noted that a section of the buried Department of Fisheries pipe that runs through the embankment dam to discharge water downstream of the dam's toe had been exposed due to heavy mountain bike use in the area (**Photograph WWL 7**). It is recommended that this area be backfilled and reinforced to protect the pipe from damage by the public.

*4.1.3.2 Saddle Dam*

4.1.3.2.1 Upstream Face

- The upstream slope of the Saddle Dam was in satisfactory condition at the time of the inspection and was covered with overgrown grass and vegetation. Some surficial riprap was observed; however, riprap could not be properly inspected due to vegetation as the riprap is covered with grass. A vegetation clearing program at the upstream and downstream slopes and toe is in place and performed regularly. Wood debris had accumulated along the upstream face at the waterline (**Photographs WWL 13 and 14**) and is understood to be removed annually by the City.
- Some light furrowing due to surface runoff was observed on the upstream slope in areas where the public also seems to have accessed the reservoir from the crest (**Photograph WWL 14**). These areas should be monitored as part of the routine inspections.

4.1.3.2.2 Crest and Abutments

- The crest of the Saddle Dam is a gravelled surface and was found to be in satisfactory condition at the time of inspection (**Photographs WWL 11 and WWL 13**). There were no signs of cracks, settlement, or sinkholes on the majority of the dam crest.
- The right and left abutments are in satisfactory condition. Tree and brush vegetation overgrowth was observed. Trees along the upstream crest and within 3 m of the downstream crest should be removed. No signs of erosion or unusual conditions were observed near the abutments of the dam.

4.1.3.2.3 Downstream Face and Toe

- The downstream slope of the Saddle Dam was in fair condition at the time of the inspection and was covered with grass and some rounded gravel and cobbles (**Photograph WWL 12**). No holes, cracking, slumps, wet spots, or signs of instability were observed on the downstream face or toe.

*4.1.3.3 Reservoir*

- An active public trail system runs around the perimeter of the lake which provides access to view the reservoir. The reservoir is also used by the public for recreation (swimming, kayaking, etc.).
- The reservoir level is currently measured using the concrete steps of the main dam. The City is considering the installation of a level gauge in the reservoir which should allow for more precise measurements and facilitate measurement in windy conditions.

*4.1.3.4 Miscellaneous*

- The concrete sill at the outlet channel was viewed from a public walking trail bridge and from the floor of the channel (**Photograph WWL 15**). No water was flowing over the weir during the inspection. The channel floor was observed to be large rockfill overlain by a concrete apron extending upstream and downstream of the bridge. Cobbles line the channel downstream of the bridge where the rock/concrete lip terminates.
- The left and right abutment of the outlet concrete sill was visible and appeared to be on overburden. Some minor wood debris accumulation was noted.
- The left abutment of the pedestrian bridge over the outlet channel was observed to have adequate erosion protection and consist of a veneer of soil over bedrock, covered by a thin coat of concrete. The right abutment of the pedestrian bridge consists of organic soils, and bedrock was not visible in the inspection. There is potential for this soil to erode if flow increases through this channel. Slope protection is recommended at this abutment if erosion increases.
- The inlet channel is cobble and boulder lined with steep soil banks and a pedestrian bridge. Stacked bags of concrete (dam sacks) were observed under each bridge abutment. A large tree was observed directly at the left abutment of the pedestrian bridge

which should be monitored as it may cause dam sack displacement and increase scour susceptibility **(Photograph WWL 16)**.

- Minor undermining/erosion was observed beneath and downstream of the dam sacks under the left bridge abutment, up to 0.2 m to 0.3 m beneath and up to 1 m around the downstream edge **(Photograph WWL 16)**. The current level of monitoring is considered sufficient. Consideration for additional grouting and scour protection should be considered if undermining continues.
- Minor undermining/erosion was observed in the outlet channel downstream of the channel step beneath the dam sacks **(Photograph WWL 17)**. Riprap which seemed to be placed along the channel step to protect the dam sacks, was found to be partly dispersed. It is recommended to repair the riprap along the outlet channel step to protect the dam sacks from further undermining.

#### *4.1.3.5 Public Safety*

- The Westwood Lake Dam and Appurtenant structures are located within the Westwood Lake Park public trail system. The area is well used by hundreds of walkers and runners daily while the reservoir is also used for recreation by the public.
- There were no significant public safety risks observed at the Main Dam or the Saddle Dam.
- Recommendations to protect against erosion and undermining at the pedestrian bridge abutments in the inlet and outlet locations are summarized in **Section 4.1.3.4**.

### *4.1.4 Recommendations*

The following surveillance/rehabilitation work is recommended for Westwood Lake Dam as shown in **Table 4-4**. Some of these items are carried over from previous FADIs.

**Table 4-4: Westwood Lake Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| WWL 1.01 | Replace missing hardware at 'V' notch weir. | 2020 FADI |
| WWL 1.02 | Repair erosional damage at the left bridge abutment at inlet channel. Extend the length of dam sacks downstream and backfill the erosional scarp behind the dam sacks. | 2021 FADI |
| WWL 1.03 | Vegetation control measures should include clearing any trees and other vegetation a minimum of 3 m beyond the abutment and dam toe for both main dam and saddle dam. | 2023 FADI |
| WWL 1.04 | Backfill the area where the buried Department of Fisheries pipe is exposed due to mountain biking and hiking activities to protect the pipe from damage by the public. | 2023 FADI |
| WWL 1.05 | Repair the riprap along the outlet channel step to protect the dam sacks from further undermining. | 2023 FADI |

## 4.2 Old Reservoir No. 1 (R01) Dam

### *4.2.1 Dam Description*

Old Reservoir No. 1 is separated from the Upper Chase River Dam by the Nanaimo Lakes Road. The only significant inflow into the reservoir was via a raw water piped inflow from South Fork Dam that was shut down in January 2014 and the reservoir is no longer used as a potable drinking water source. A new, above ground closed concrete reservoir was recently built and commissioned in 2014 to replace the open concrete-lined Old Reservoir No. 1.

The reservoir was permanently dewatered in January 2020 and was recently downgraded to a consequence classification of “Low”, but the future use of the reservoir is still to be determined. A plan is required to address the long-term future of the dam. As noted previously, the dam could be removed from the fleet of dams if there are no plans to refill the reservoir.

The dam that previously retained the reservoir is a mass concrete gravity dam originally built around 1910. It has a maximum height of approximately 11.5 m at its lowest foundation level and is 40 m long with a near vertical upstream face and a downstream face sloping at about 0.45H:1V. The dam location is shown in **Figures B6** and **B7** and the details are shown in **Figure B8** in **Appendix B**.

Nominal steel reinforcement is embedded in both faces. The dam was substantially remediated in 1996, including a new reinforced dam crest (utilized as a high strength beam) and the installation of 21 – 36 mm diameter Dywidag thread bar anchors grouted into bedrock to provide the required factor of safety for earthquake stability.

At the same time as the dam was remediated, stabilization of the right bank rock slope immediately downstream of the spillway was performed. The rock face is friable sandstone interbedded with shale, siltstone, and shale/siltstone with coal seams dipping into the abutment at about 10-20 degrees. The rock slope was anchored with a pattern of 25 mm diameter, 3.5 m long passive dowels and covered with a layer of shotcrete and steel mesh.

The spillway is located close to the right abutment of the dam and is constructed as an integral part of the dam. The spillway section comprises a 2.8 m wide broad crested weir with the sill set at 1.2 m below the dam crest. The spillway chute is stepped to provide some energy dissipation before reaching a flip bucket at the base of the chute. The capacity of the spillway has been estimated at approximately 6.5 $m^3/s$ at the onset of overtopping. A 250 mm diameter pipe is permanently open to release any rainfall the accumulates in the reservoir. Refer to **Table 4-5** for more detail regarding the dam.

**Table 4-5: Data for Old Reservoir No. 1 Dam**

| Structure | Details |
|---|---|
| Type of Dam | Concrete Gravity Dam |
| Maximum Height | 11.5 m (approx.) |
| Crest Length | 40 m |
| Crest Width | 1.5 m (approx.) |
| Catchment Area | Local catchment area only (64,000 $m^3$ storage volume) |
| Upstream Slope | Varies, but near vertical |
| Downstream Slope | Varies (vertical at crest to about 0.45H:1V below) |
| Inlet and Outlet Works | Inlet pipes have been decommissioned and fills only by local catchment<br>Outlet pipes through main body of dam |
| Spillway | Unregulated cascading concrete spillway controlled by filling from local catchment area |
| Hazard Rating | Low |

### *4.2.2 Instrumentation*

Instrumentation at Old Reservoir No. 1 is limited to an ultrasonic water level transducer located on the upstream side of the dam. There is also a 'V' notch weir located beyond the downstream toe of the dam used to measure dam seepage (**Photograph R01 6**). The weir was dry during the inspection.

### *4.2.3 Formal Inspection*

The Old Reservoir No. 1 was visually inspected by walking along the crest of the dam, downstream of the dam, and within the drained reservoir on the upstream side of the dam. No significant changes were noted compared to the 2022 FADI. The following site inspection observations were made:

#### *4.2.3.1 Concrete Dam*

- The dam was reviewed from the walkway along the crest to the overflow spillway, the drained reservoir, and the downstream toe. The concrete was generally in good condition. Delamination of the mortar parget coating along the spillway walls was apparent.
- The downstream face of the dam has some leaching stains, minor spalling and cracking; however, the cracks are minor and are not a dam safety concern at this time. Moss growth was noted on the downstream face which might have indicated minor seepage, however as the reservoir is dry no active seepage was observed (**Photograph R01 4**).
- A shotcrete type material appears to have been applied on the lower portions of the upstream face and showed mild erosion. In some areas where the deterioration is greatest, an embedded welded-wire fabric type of material is exposed and showing signs of corrosion **(Photograph R01 3)**.

- The mechanical equipment for the old intake system is heavily corroded (**Photograph R01 5**); however, this would only become an issue if the dam was to return to service and the existing intake was to be re-used.

*4.2.3.2 Spillway*

- The spillway has been coated with a shotcrete material, which appears to be intact with minimal deterioration and is in fair condition **(Photograph R01 4)**.
- A 250 mm diameter, low-level drainage pipe is used to drain any precipitation that accumulates in the reservoir. The low-level drainage pipe sump should be cleaned annually to avoid a build up of debris and ensure water is flowing. Water was flowing through this pipe at the time of the site visit due to recent rain fall.
- The spillway discharge channel includes a steel culvert embedded in a concrete headwall. The concrete headwall is experiencing some cracking, but this does not pose any immediate concerns given the uncertain future function of the reservoir.

*4.2.3.3 Abutments*

- The right abutment is a rock wall covered with a layer of shotcrete and topped with vegetation (**Photographs R01 7 and R01 8**). Weep holes were observed in the downstream right abutment wall, and City personnel indicated that prior to draining the reservoir, significant drainage would occur out of these drainage locations. A discontinuity was observed in the exposed rock outcrop at the top of the upstream right abutment wall of about 1 m long with a 15-20 mm aperture (**Photograph R01 8**). This new observation should be monitored as part of the annual inspection. The condition of the right abutment is considered satisfactory given the potential for decommissioning of the reservoir and limited access to the dewatered reservoir.
- The left abutment is a grassy slope (**Photograph R01 11**) in good condition.

*4.2.3.4 Downstream Face and Toe*

- No settlement, displacement, sinkholes, boils, or slope movement was observed on the downstream side of the dam. The surface on either side of the downstream channel is graded with gravel.
- Clear water flow was observed coming out through the 1.2 m-diameter culvert. The pipe rests on bedrock and appears in satisfactory condition, with minor undermining noted on the left side but in similar condition as observed in 2022 FADI. The culvert is shown in **Photograph R01 9**. The outflow channel is protected by sparse rockfill. A more robust protection system would be required for greater flows; however, is not considered necessary at this time given the drained state of the reservoir and potential for future decommissioning.
- The ‘V’ notch weir was dry at the time of the site visit (**Photograph R01 6**). The catchment area for this weir is likely not sufficient to capture all drainage from the rock

wall drains. This is not considered necessary for improvement at this time considering the drained state of the reservoir and potential for future decommissioning.

#### *4.2.3.5 Reservoir*

- Minor concrete delamination of the reservoir floor and slopes is occurring. Some cracking of the concrete slope and floor cover with vegetation growth was noted.
- The southeast portion of the reservoir consists of subvertical slopes with surficial shotcrete facing. The shotcrete was observed to be in fair condition.
- Rockslide debris was observed at the right south end of the reservoir coming from an exposed rock outcrop located above the shotcrete (**Photograph R01 12**). No significant damage due to the rock debris was observed to the shotcrete or to the reservoir floor. At this time, there is no need to remove the rock debris or to scale of the upper rock face considering the drained state of the reservoir and potential for future decommissioning. Any similar instabilities should be logged as part of the annual inspection and addressed only if the dam is to return to service.

#### *4.2.3.6 Public Safety*

- In general, this site has a low level of public interaction as it is a private area and it is monitored by CCTV cameras.
- Old Reservoir No. 1 is secured by a fence around the perimeter of the reservoir which restricts public access to the area. Vehicle access to the area requires passing through a gate which also restricts access.
- The downstream side of the dam is protected by fencing, but the fence can be circumvented, and public presence has occurred periodically, including minor vandalism in the past. During the site visit, domestic garbage such as cans were observed downstream of the dam suggesting public presence in the area.
- The dewatered nature of the reservoir makes falling from the dam a more serious safety issue, but given the small public presence, it is recommended this public usage be monitored before any control measures are added/upgraded.
- Some damages were observed in wooden handrail and access stairs at the downstream side of the dam **(Photograph R01 11)**. It is presumed the repair is not necessary considering potential decommissioning of the dam in future. These are more worker safety deficiencies, as the public is not supposed to be within this area.

### *4.2.4 Recommendations*

The BC DS Regulator has recommended that a plan be produced to determine the long-term future of the dam.

It is recommended that this dam be removed from the fleet of dams if there are no plans to refill the reservoir. The structure can then be eventually decommissioned or re-purposed as required. In general, no surveillance/rehabilitation work is recommended for Old Reservoir

No. 1 Dam in its current dewatered state. Until the dam is decommissioned, it is recommended to continue the annual cleaning of the low-level drainage pipe sump to avoid a build up of debris and ensure water is flowing. In addition, CCTV camera surveillance should continue to monitor any public access.

## 4.3 Harewood Dam (HAW)

### *4.3.1 Dam Description*

Harewood Dam is located to the southeast of the Chase River system and discharges into the Chase River downstream of the Lower Chase River Dam. The dam is a concrete gravity structure constructed in 1911 to store water for the coal mining industry in the City. The dam is about 34 m long, approximately 3.4 m high, with a crest width of 0.9 m. The dam consists of a vertical upstream face and a downstream face inclined at 72 degrees. A shallow sloping, earth fill bench approximately 11.7 m wide extends downstream from the concrete dam to a 1.9 m high rock wall. A low-level outlet is set into this wall and the bench appears to provide backfill over the outlet. The low-level outlet pipes are capped with the upper outlet containing a small valve for fisheries purposes. The outlet was once controlled by an upstream sluice gate, but the gate stem is bent and distorted and is inoperable. The LLO consists of two capped pipes that are exposed through a small concrete wall downstream of the downstream toe. A steeply sloped, approximately 1.8 m high stacked rock buttress retaining wall flanks the outlet pipes.

A two-bay spillway is incorporated into the crest of the dam near the right abutment. The inlet bays measure approximately 1.2 m wide by 1.3 m high and are separated by a 0.6 m thick centre wall. Stoplogs, which had been fastened into the base of the bays, have been permanently removed. Discharge through the spillway is contained within a concrete chute measuring 1.36 m wide, 10.6 m long and 0.6 m wall height. Beyond the chute, there is a small discharge channel. The spillway capacity has not been determined. See **Figures B9** and **B10** in **Appendix B** for the details of the dam and **Table 4-6** for the dam data.

**Table 4-6: Data for Harewood Dam**

| Structure | Details |
|---|---|
| Type of Dam | Concrete Gravity Dam |
| Maximum Height | 3.4 m (approx.) |
| Crest Length | 34 m (approx.) |
| Crest Width | 0.9 m (approx.) |
| Retained Water (Normal) | 32,000 $m^3$ (based upon water license) |
| Spillway Capacity | Unknown |
| Upstream Slope | Vertical |
| Downstream Slope | Near vertical |
| Outlet Works | Low level outlet (not operated)<br>Uncontrolled open channel concrete spillway (formerly controlled by stop logs) |

| Structure | Details |
|---|---|
| Spillway | Unregulated spillway controlled by filling from local catchment area |
| Hazard Rating | Significant |

### 4.3.2 *Instrumentation*

The only instrumentation at Harewood Dam is a 'V' notch weir that is located downstream of the LLO and rock wall to record monthly seepage measurements through the dam (**Photograph HAW 9**). Clear water was ponding behind the weir at the time of the inspection as the water level did not exceed the bottom of the 'V' notch weir.

### 4.3.3 *Formal Inspection*

The Harewood Dam was in similar condition to that reported during the 2022 FADI. Visual inspections were performed by walking the crest of the dam, abutments, and areas downstream of the dam. The spillway was not spilling water and was dry and free of debris. The following observations were made during the inspection:

#### 4.3.3.1 *Concrete Dam*

- The upstream vertical face of the concrete dam was in poor condition but was only visible above the waterline. Cracking and calcite staining were observed along the entire length of the dam (**Photograph HAW 3**). However, due to the low reservoir level that the dam operates under, these cracks are not considered a major dam safety concern at this time.
- The sloping downstream face of the concrete dam was found to be in similar condition to the upstream side (**Photograph HAW 7**). Several locations showed crack widths between 5 and 10 mm. It is recommended that the crack propagation continued to be monitored and that any observed seepage be documented, particularly at the lower sections of the dam (**Photograph HAW 8**).
- The downstream face of concrete dam was pressure washed and cleaned prior to the inspection. This should continue as part of the annual maintenance program.
- No seepage was observed on the downstream side of the concrete dam.

#### 4.3.3.2 *Spillway*

During the inspection, the concrete overflow spillway was observed to be in poor condition.

- The crest of the dam has several areas of severe delamination of the concrete surface in the top 50 mm of the concrete in the area surrounding the spillway; this was noted in particular at the suspended slab spanning over the spillway in previous FADIs. However, new concrete was placed in this location to prevent further erosion in concrete deck at the left spillway bay (**Photograph HAW 4**). It is noted that most of this cracking is above the maximum water level, and it is not a major dam safety issue at this time. It is recommended that all heavy equipment be prevented from crossing the spillway bridge. It should be noted that a guardrail with signage was installed on the dam crest at both

abutments to limit heavy load crossing of the bridge and allows only for pedestrian traffic but no vehicles **(Photograph HAW 2)**.

- The spillway piers are experiencing some cracking and the spillway walls have developed some vertical cracks and opening of joints (**Photographs HAW 12**). At the time of this inspection, the water level was below the spillway sill elevation and the spillway concrete chute was dry. The City should seal a vertical construction joint on the left side of the chute wall where some water seepage was observed during the 2019 FADI. Seepage from the spillway walls continues to be monitored as part of routine inspections.
- At the time of the inspection, the base of the spillway slab concrete slab was exposed after recent rain and pressure wash maintenance. The concrete slab was in fair condition (**Photographs HAW 5 and HAW 6**).
- It is noted that City staff repaired the downstream end of the spillway chute to prevent further undermining and soil erosion in 2020 **(Photograph HAW 6)**.
- There is minimal rock at the end of the spillway chute to dissipate the energy and prevent further scour under the slab and downstream of the spillway. It was recommended in the FADI 2021 report that 300 mm diameter riprap be installed for channel protection downstream of the spillway chute. The riprap should extend the width of the spillway plus 0.5 meters on each side, and extend approximately 10 m downstream, at a minimum (**Photographs HAW 11**).

#### *4.3.3.3 Abutments*

- The left abutment is on overburden and the right abutment is on bedrock. No seepage, cracking, or signs of movement were observed at the left and right abutments.
- The exposed rock at the right abutment appears competent and the contact is strong.
- At the left abutment, a fir tree near the crest was recently removed by the City. Vegetation should continue to be cleared within three meters of dam crest, abutments, and toes.

#### *4.3.3.4 Downstream Face and Toe*

- The downstream toe of the concrete dam is buttressed by an overburden bench supported by a rockfill retaining wall. During the 2021 FADI, a small depression was observed on the bench approximately one meter to the left of the spillway channel wall approximately two meters downstream of the concrete dam toe. The depression was measured to be 0.35 m in diameter and 0.15 m deep. City personnel indicated that it was from a rotten cedar stump removal. It is recommended to monitor this depression and, if the depression changes or worsens, rehabilitate it by excavating and backfilling with compacted granular filter material. City personnel mentioned during the site visit that there has not been any change observed at this depression.

- Several trees are located on the downstream bench between the concrete dam and the rock wall. The composition of the bench or its contribution to dam stability are not fully understood; therefore, it is not recommended to remove these trees at this time.

#### *4.3.3.5 Low Level Outlet and Rock Wall*

- The retaining wall flanking the LLO was observed to be in poor to satisfactory condition (**Photographs HAW 13** and **HAW 14**) with some loose unstable rocks and moss covering the face of the wall.
- A wet, spongy area with some pooled water was observed in previous inspection, approximately two to five meters from the left abutment (**Photograph HAW 15**). Continual monitoring of flow through the weir and the extent of this wet area is considered sufficient for surveillance.
- City personnel mentioned the LLO structure was not used during the unprecedented amount of rain in November 2021 and is generally not in use.

#### *4.3.3.6 Reservoir*

- At the time of the inspection, no water was flowing over the spillway and the reservoir level was slightly below the spillway invert concrete slab. A visual review of the reservoir and surrounding basin area was made from the crest of the dam.
- Numerous trees and vegetation surrounding the reservoir edge and minor erosion along the left shoreline, but in general, it was clear of debris and there were no signs of landslide scars or undercutting along its slopes.

#### *4.3.3.7 Public Safety*

- Harewood Dam is accessible from a residential development and has a public presence in the area of the dam. Gates with “Danger - Keep Out” signs have been installed at either side of the dam crest to deter pedestrians and cyclists from crossing the concrete crest of the dam. The crest is exposed to water on the upstream side and drops off 3.5 m on the downstream side.
- The remnants of handrail sleeves on the upstream face of the dam were observed, but there has not been any type of handrail system in place in recent years.
- There are some public safety hazards that should be assessed at this site. These include fall hazards along the top of the main dam and fall/trip hazards from the spillway bridge.

### *4.3.4 Recommendations*

The following surveillance/rehabilitation work is recommended for Harewood Dam as shown in **Table 4-7**. Some of these items are carried over from previous FADIs.

**Table 4-7: Harewood Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| HAW 1.01 | Address identified public safety issues (i.e., missing handrail and fall hazards around dam). The City should also consider moving towards a more Formal Public Safety around Dams program based on the recommendations in the 2011 Canadian Dam Association Guidelines for Public Safety Around Dams. This would involve performing a public safety risk assessment and developing a formal public safety management plan for each site that is open to the public. This would help the city to understand public safety risks in a systematic priority-based process that will allow an overall reduction of liability and is defensible to the public. Observations at the site indicate that the public presence is relatively light and overall hazards are relatively low; therefore, this process does not have to be an immediate priority and should be considered as part of future initiatives. | 2017/2018 FADI |
| HAW 1.02 | Scour protection should be placed at the exit side of the spillway chute.<br>It is recommended that a 300 mm diameter rock (riprap) blanket that is 3 m wide by 8 m long by 0.6 m high be placed downstream of the spillway chute, underlain by a minimum 400 gr/m$^2$ non-woven geotextile.<br>2022 Revision: Place 300 mm median diameter riprap blanket with underlying filter which extends 0.5 m beyond the spillway wingwalls and is minimum 10 m long. | 2015 FADI/ 2018 FADI (Modified 2022) |
| HAW 1.03 | Perform detailed concrete condition assessment of dam and spillway structures and subsequent repairs.<br>2021 Revision: This condition assessment should also provide recommendations on what repairs would need to be made to maintain long term operability of the dam given the reduced maximum operating level compared to original design. | 2015 FADI |
| HAW 1.04 | Repair the stacked rock wall and remove moss. | 2018 FADI |
| HAW 1.05 | Seal cracks along the bottom portions of spillway wall and slab to prevent seepage. | 2019/2021 FADI (Updated 2023) |
| HAW 1.06 | Clear vegetation and debris from channel downstream of rock wall. | 2020 FADI |
| **Recommendations to close** | | |
| | A young tree was removed from left abutment to limit vegetation growth on the abutments. | 2020 FADI |
| | A vertical joint down the left side of the spillway chute wall was sealed to prevent water seepage through the wall. | 2019/2021 FADI |

## 4.4 Upper Chase River Dam (UCR)

### *4.4.1 Dam Description*

The Upper Chase River Dam is the furthest upstream dam in a series of three cascading dams along the Chase River. The Upper Chase River Dam is believed to have been

constructed between 1911 and 1930. The spillway and twin culverts underneath Nanaimo Lakes Road divert the Chase River around the Old Reservoir No.1. The Upper Chase River Dam is comprised of two types of water retaining structures. The main (right) dam is a reinforced concrete upstream retaining wall (buttressed on the upstream side) and a downstream supporting earth fill embankment. This structure is 5.5 m high and 64 m long. The embankment (left) dam is a low earth fill embankment approximately 2.5 m high and 33 m long and retains approximately 0.3 m of water above the spillway invert. Together, these structures impound a small reservoir of about 60,000 $m^3$ of water.

The spillway is located within the left (embankment) dam and includes a free overflow rectangular concrete flume that discharges into two 1.8 m diameter corrugated steel pipe culverts buried beneath Nanaimo Lakes Road. The spillway is under capacity due to the restricted capacity of the flume but also due to the throttling effect of the culverts. See **Figures B11** and **B12** in **Appendix B** and **Table 4-8** for the Upper Chase River Dam data.

**Table 4-8: Data for Upper Chase River Dam**

| Structure | Details |
|---|---|
| Type of Dam | Earth filled dam with impervious homogeneous materials with upstream concrete cut-off wall |
| Maximum Height | 5.5 m (earth fill) to 2.5 m (concrete) |
| Crest Length | 64 m (earth fill) to 33 m (concrete) |
| Storage Volume | 60,000 $m^{3.}$ |
| Spillway Capacity | Unknown |
| Outlet Works | Low level outlet into Old Reservoir No. 1 |
| Spillway | Unregulated open channel concrete spillway |
| Hazard Rating | Significant |

### *4.4.2 Instrumentation*

There is a level sensor installed at the Upper Chase Dam from which readings are transferred into the SCADA system and monitored at the Public Works Department. As part of the Chase River flood warning system, a level sensor is installed at a tributary creek at a bridge on Lincoln Road upstream of the dam. An instrument to measure flow (“FlowDar”) is installed in the spillway channel (**Photographs UCR 4**). There is no instrumentation installed in this dam to record seepage.

### *4.4.3 Formal Inspection*

The Upper Chase Dam was in similar condition to that reported during the 2022 FADI. Visual inspections were performed by walking the crest of the buttress dam, spillway slab and chute walls, upstream slopes, and discharge culverts. The spillway invert was wet with some water flowing inside chute and it was free of major debris at the time on inspection. The following observations were made during the inspection:

#### *4.4.3.1 Spillway*

- At the time of the inspection, there was some small debris and a few millimeters clear water flowing over the base of the spillway slab (**Photographs UCR 4**) and the concrete slab was visible. The concrete slab in the spillway chute invert was in fair condition without any major erosion and cracks. It is recommended to keep this area clean for the annual inspection.
- The concrete spillway was generally in fair condition with several cracks noted along each spillway wall. The cracks range in size from 1.5 mm to 4 mm maximum width. Two of these wider cracks are found along construction joints respectively close to the spillway level gauge and close to a culvert. These cracks should continue to be monitored to see if they increase in length or size over time.
- Some vegetation and grass growth was observed at the upstream side of the spillway structure and it is recommended that this vegetation be cleared (**Photograph UCR 9**).
- The culverts at the exit end of the spillway (at Nanaimo Lakes Road) were free and clear of debris except for the presence minor branches in the left culvert.
- The downstream end of the culverts were not assessed during the 2023 FADI, however, the 2021 FADI noted some undermining of the culverts on the downstream side of Nanaimo Lakes Road. It is recommended that this area continue to be monitored to see if the erosion of the supporting material continues to advance. If it continues, then the area under the culvert should be backfilled to try to seal off the seepage path and to support the end of the culvert.
- During the 2021 FADI, one of the joints in the left culvert was noted to be separating, leaving a gap between the adjacent culvert sections. This could in part be due to the downstream section of the culvert settling faster than the upstream section due to the undermining issue at the downstream end. It is recommended that this separation continue to be monitored and if it continues to increase, reinforcing of the material under the culvert on the downstream side may be required.
- Minor erosion was noted at the base of the culvert wingwalls which should continue to be monitored to ensure a seepage path is not opening up underneath the culverts in this area **(Photograph UCR 10)**.
- The slopes above the spillway wingwalls exhibit signs of erosion and slope movement due to poor runoff control and protection (**Photograph UCR 11 and UCR 12**). Additionally, a void beneath the spillway headwall where it interfaces with the right spillway abutment (**Photograph UCR 5**) was observed. The slope should be regraded and hydroseeded. A temporary coir-mesh should be utilized to provide temporary erosion protection until vegetation is established. The void between the headwall and supporting soil should be backfilled. Specialized high-density foams may be required for this application.

- The wingwalls on the upstream side of the spillway were noted to be in fair condition with only minor calcite staining and cracking. It is recommended that this continue to be monitored to determine if the cracks are advancing over time.

*4.4.3.2 Main (Right) Dam – Upstream Concrete Buttress Wall*

- At the time of the inspection, the concrete buttress wall was in similar condition to that reported in previous FADIs except for the recently installed fence along the wall.
- The concrete walls of the dam have experienced extensive damage from freezing and thawing and were observed to be in poor condition. The freeze thaw damage was covered with a mortar parging that has failed and it is debonding over large areas (**Photograph UCR 3**).
- There was a large crack (caused by tree root damage) observed in the wall near the south end which has been there for a long time according to City staff. The tree that caused this damage has since been removed. but it is recommended the crack continue to be monitored. A depression in the ground adjacent to the old tree trunk behind the concrete wall was also noted during the site visit which could indicate that its roots are rotten. This depression had a depth of about 0.25 m and length of up to 1 m. It is recommended to level the ground surface behind the wall to avoid water accumulation at the location of this depression and facilitate surface runoff away from the wall.
- Large vertical and horizontal cracks were observed along the buttress portion of the wall. Some vegetation growth was noted at the base of the vertical crack. It is recommended this vegetation be removed.
- Routine inspections should be performed to ensure the wall condition does not deteriorate rapidly and a detailed condition assessment and subsequent repairs should be undertaken. It is recommended that heavy vehicles and trucks be prevented from driving directly adjacent to the concrete wall to limit the surcharge on the concrete. Parking blocks currently separates the adjacent road from the concrete wall area (**Photograph UCR 13**).
- Vegetation growth was noted at various areas around the abutments of the dam. Clearing of this vegetation should be included as part of routine maintenance for the dam and completed on a continuous basis.

*4.4.3.3 Left (Embankment) Dam*

- The embankment between the spillway and main (right) dam consists of vegetated slopes (**Photograph UCR 8**). Minor shoreline erosion was observed. The waterline is partially covered by bulrushes.
- During the site visit, on the downstream side of the concrete spillway's left wrap-around wingwall, the soil backfill showed some signs of settlement and displacement as previously reported in the 2021 FADI. The soil behind the spillway wall has settled up to 0.11 m in places extending from approximately 6 m upstream of the FlowDar instrument, out to the

concrete wingwall. Against the downstream face of the concrete wingwall, settlement increases up to 0.3 m.

- Sign of undermining was noted in camera pole foundation at left abutment of the main dam. The void underneath the foundation should be backfilled and slope erosion in this area should be monitored **(Photograph UCR 14)**.

#### *4.4.3.4 Reservoir*

- The reservoir area upstream of the dam and spillway is relatively small.
- A low-level outlet valve is operational if the City ever needs to drain the Upper Chase River reservoir.

#### *4.4.3.5 Public Safety*

- Upper Chase Dam is located at the south end of Colliery Dam Park adjacent to Nanaimo Lakes Road. This park has a very high public presence with many daily users which are engaged in activities such as fishing, walking or dog walking. The lake is stocked with fish, which encourages fishing from the shoreline.
- A fence was installed along the headwall adjacent to the culverts and down both sides of the spillway chute walls to address the public safety hazards (**Photograph UCR 4**).
- Following the site visit, the City installed chain link fencing (approximately 1m high) along the concrete buttress dam to further enhance public safety at the site while still allowing for fishing activities from behind the fencing (**Photograph UCR 13**).
- Parking blocks were installed along the length of the dam access to prevent cars from driving from the shoulder pull-out and fully into the dam area (**Photograph UCR 13**).

### *4.4.4 Recommendations*

The following surveillance/rehabilitation work, as noted in **Table 4-9**, is recommended for Upper Chase River Dam. Some of these items are carried over from previous FADIs.

**Table 4-9: Upper Chase River Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| UCR 1.01 | Address identified public safety hazards (i.e., fall hazards along buttress wall and spillway chute walls). Consider developing a public safety management plan for this structure in accordance with the 2011 Canadian Dam Association Guidelines for Public Safety Around Dams. It is expected given site observations that such a plan would not require a large number of additional control measures be installed but would help the City better understand public safety risk at the site and reduce overall liability. As with HAW 1.01 this process does not have to be an immediate priority and should be considered as part of future initiatives. See HAW 1.01 for more detail. | 2017/2018 FADI |
| UCR 1.02 | Perform detailed concrete condition assessment of dam and spillway structures and provide subsequent repair details. | 2015 FADI |

| Item | Description | Reference |
|---|---|---|
| UCR 1.03 | Install pins on either side of major buttress wall crack to monitor crack width.<br>Clear the vegetation at the base of the vertical crack along the buttress wall. | 2017/2021 FADI |
| UCR 1.04 | Reinstate eroded material under the downstream end of the culverts and protect eroding slope at culvert outlet with geotextile and riprap after vegetation removal and regrading. | 2020/2021 FADI |
| UCR 1.05 | Regrade slopes around the spillway wingwalls and provide coir-mesh and hydroseed to establish protective vegetation. Construct drainage swales along the crest of the wingwalls to collect and discharge runoff. Fill the void beneath the spillway headwall on the right abutment. | 2022 FADI |
| UCR 1.06 | It is recommended that the ground surface behind the right dam wall be leveled to avoid water accumulation at the location of the observed depression to facilitate surface runoff away from the wall. | 2023 FADI |
| UCR 1.07 | Backfill the area of camera pole foundation to prevent further undermining and slope erosion. | 2023 FADI |

## 4.5 Middle Chase River Dam (MCR)

### *4.5.1 Dam Description*

The Middle Chase River Dam is in the southern part of the City and was originally constructed around 1910 to provide water for coal washing operations in the City. The dam is about 50 m long and 12.5 m high and is comprised of a 0.6 m thick concrete cut-off wall close to the upstream side. The upstream concrete cut-off wall is supported by earth fill shells situated both upstream and downstream of the core. The upstream shell (upstream of the cut-off wall) has a slope of 1.5V:1H, initiating approximately 2 m below the concrete wall crest, and likely consists of rock fill. The downstream shell has a nominal 2H:1V slope that was rebuilt in 1980. During rehabilitation in 1980, the crest was raised 0.3 m by adding a 0.3 m thick extension, and a gravel filter drain was installed to intercept seepage. An additional drain was installed near the right abutment in 1992 to intercept concentrated seepage observed. A 'V' notch weir located at the downstream toe is used to monitor seepage. See **Figures B13** and **B14** in **Appendix B** for general layout and cross section of the MCR Dam.

The spillway is located on the left abutment and is separated from the dam by a concrete wall. The spillway entrance is split with a central pier. The spillway is a free-overflow rectangular concrete structure that discharges over bedrock and into an unlined channel situated along the left groin of the dam. The spillway capacity is approximately 60 $m^3/s$ with lake level at the dam crest (no freeboard), but no field measurements have been taken to confirm this capacity. The spillway crest flows are very uneven across the spillway entrance weir at low flows. In 2002, the total spillway capacity required to accommodate the Probable Maximum Flood (PMF) was estimated to be about 192 $m^3/s$. The current dam classification of High requires that the spill capacity be able to pass a flood 1/3 between the 1,000-year flood and the PMF with adequate freeboard protection. This capacity was not confirmed as part of

this project but given the 192 $m^3/s$ PMF level compared to the 60 $m^3/s$ spill capacity it is unlikely that the dam could safely pass an IDF size flood event without overtopping.

Middle Chase River Dam data is provided in **Table 4-10.**

**Table 4-10: Data for Middle Chase River Dam**

| Structure | Details |
|---|---|
| Type of Dam | Rock/Earth fill dam comprised of rockfill on the upstream face and semi-impervious materials on the downstream side with upstream concrete cut-off wall. |
| Maximum Height | 12.5 m |
| Crest Length | 50 m |
| Crest Elevation | 88 m |
| Top of Concrete Core El. | 88 m |
| Upstream Slope | 1.5H:1V (initiating approximately 2 m below the top of the wall) |
| Downstream Slope | 2H:1V |
| Spillway Invert Elevation | 86.04 m |
| Storage Volume | 111,000 $m^3$ |
| Low Level Outlet | N/A (the existing woodstave LLO has been abandoned) |
| Spillway | Unregulated open channel concrete spillway |
| Hazard Rating | High |

### *4.5.2 Instrumentation*

Instrumentation consists of ultrasonic sensors to measure water levels at the crest of the spillway. The instrumentation is relayed back to the City's SCADA system where a high-water level alarm has been created.

Additional instrumentation includes a 'V' notch weir located at the downstream toe to measure seepage through the toe of the dam during routine monitoring by City staff. In past years, there has been seepage observed downstream of the weir which appears to be circumventing the weir. At the time of inspection, there was no water flow over the 'V' notch weir at the toe of the dam.

### *4.5.3 Formal Inspection*

The Middle Chase Dam was in similar condition to that reported during the 2022 FADI. The following observations were made during the inspection.

#### *4.5.3.1 Upstream Face*

- The concrete dam wall on the upstream face above the water level has experienced extensive surface erosion and was in poor condition during the site visit.
- The portion of the concrete wall exposed to wet/dry cycles had major concrete deterioration estimated at up to 100 mm in depth in some areas. The bottom portion of

the concrete dam wall was below the waterline and appeared to be in similar condition to the deteriorated concrete surface above (**Photograph MCR 1**).

- Several cracks were identified along the upstream face during the condition assessment. It is recommended that these cracks be monitored regularly and that pins be installed to measure the growth of the crack over time.
- Though the eroded face of the concrete is up to 100 mm deep in some areas, the surface erosion at this stage is not considered to be a major dam safety issue. It is recommended that the surface be monitored and if further erosion is observed in the future, then the entire surface should be patched with a repair mortar to limit the deterioration.

#### *4.5.3.2 Crest and Abutments*

- The crest was in satisfactory condition at the time of inspection. There were no signs of cracks, settlements, or sinkholes on the dam crest.
- Bedrock was exposed on both right and left abutments (**Photographs MCR 9** and **MCR 11**). No signs of unusual conditions could be observed at this time at the abutments of the dam. Vegetation should continue to be cleared within 3 m of the abutments.
- The left abutment under the spillway bridge (adjacent to the level gauge) shows erosion and degradation of the concrete pier, resulting in a concrete-rock contact that appears partially unbonded and in poor condition (**Photograph MCR 5**).
- At the upstream side of the right abutment, some deterioration of the concrete was observed in the upstream face and where it bonds to the bedrock. The contact was in fair condition. Under the bridge, some minor cavitation was observed similar to that observed on the left side of the bridge. It is recommended to patch both the left and right abutment areas.

#### *4.5.3.3 Downstream Face and Toe*

- The downstream toe of the dam was vegetated with grass and was in good condition during the inspection with no signs of sinkholes and piping. Cobbles and boulders corresponding to the downstream shot rock blanket were present near the slope toe.
- Seepage from the embankment is collected and monitored by one ‘V’ notch weir located in the concrete housing at the toe of the dam (**Photographs MCR 13 and MCR 14**).
- In the 2019 FADI, it was recommended that the foundation surrounding the ‘V’ notch weir be sealed using low pressure grout to cut-off seepage flows coming from under the ‘V’ notch weir. No significant seepage has been observed through this righthand channel during the inspection. A review of the weir monitoring data completed as part of 2022 FADI indicates that the weir is responsive to changes in the reservoir elevation. If possible, weir measurements should be obtained during or immediately after precipitation events to confirm the influence of runoff on weir measurements. The existing automatic data acquisition system was not functional at the time of the site visit and should be

repaired. Consideration could be given to grouting the foundation if it is determined that weir measurements are due to runoff and not dam seepage.

*4.5.3.4 Spillway*

- The reservoir level was below the crest of the spillway at the time of the inspection and the spillway slab was primarily dry. A wet area was observed during the 2022 FADI in the downstream section of the spillway while no flowing water was noted in the rest of the spillway. During this site visit, due to recent rain, water was flowing in part of the spillway, however the same wet area was observed.
- The underside of the spillway bridge deck (particularly on the left bay) was observed to have extensive concrete deterioration and heavily corroded reinforcing bars were exposed in a large area of the concrete slab (**Photograph MCR 4**). The load rating of the bridge in its current condition is unknown, therefore it is recommended that the City prevent any vehicles from travelling over the bridge until a detailed assessment and repairs are completed. A sign was installed to inform the public of the vehicle restriction. A bridge engineer from the City Roads Section inspected the bridge and he was in agreement that no vehicles should use the bridge until repairs are performed.
- A 45° crack was observed at the top corners of the centre spillway pier on the downstream edge, likely due to bearing stresses from the spillway bridge. This crack should continue to be monitored to document any increase in the length or size (**Photograph MCR 18**).
- Some undermining was noticeable at the base of the upstream pier nose. This area should be filled with repair concrete or low-pressure grout to eliminate the undermining of the pier and to prevent further advancement of the deterioration.
- Extensive cracking and spalling was observed at the right spillway pier underneath the bridge deck on the upstream side. Some undermining of the wall in this area was evident as a wet zone was noted downstream of the sill and major concrete deterioration was noted at the base of the wall. It is recommended that this area be repaired with a low-pressure grout to fill the voids between the upstream dam face and the spillway wall and sill.
- Cracks were observed at several locations along each of the two spillway walls. It is recommended that these cracks be sealed to prevent any seepage through the concrete. The majority of the wall sections downstream of the bridge were otherwise noted to be in fair condition, with minor erosion noted in some areas at the base of the walls where they are subjected to flowing water. However, this erosion is not considered to be a major dam safety concern at this time and only needs to be monitored to ensure the concrete does not deteriorate further.
- The concrete wall on the left side of the spillway chute does not extend to the end of spillway chute. As reported in previous 2015 FADI, this has resulted in significant erosion

of natural soils from the left embankment at the lower portion of the spillway channel. A riprap protection and some geotextile were placed on the left soil slope of the spillway to protect it from future high flows (**Photograph MCR 15**). This new protection should be monitored as part of routine inspections to confirm it is functioning adequately.

- The staff gauge and SCADA system is on the right side of the spillway, but there is a "lip" preventing water from flowing over the spillway invert in this area – instead, it flows through the left side where the invert is slightly lower.

#### *4.5.3.5 Reservoir*

- A visual review of the reservoir and surrounding basin area was made from the crest of the dam.
- In general, no signs of landslide scars or near reservoir logging operations were observed that could impact the operation of the dam.
- There is no safety or debris boom upstream of the spillway structure.

#### *4.5.3.6 Public Safety*

- Middle Chase Dam is the located near the centre of Colliery Dam Park. This park has a very high public presence with hundreds of daily users. Recreational activities include swimming, walking/jogging, dog walking (off-leash area), picnicking, and fishing. The lake is stocked with fish, which encourages fishing from the shoreline.
- Fencing was erected along the dam crest since the previous inspection; however, the fence line needs to be extended further down the left side of the chute wall immediately downstream of the bridge to restrict access to the edge of the chute wall (**Photograph MCR 16**). The City completed this work in late 2023 after the site visit.
- The rock outcrop on the left shore immediately upstream of the spillway also provides access to the potentially dangerous spillway. There is minimal signage warning the public of the hazards. It is understood that the public may be resistant to additional public safety control measures such as signage and fencing and therefore this should be considered in the design to minimize the impact to park users while mitigating the identified hazards. New signage was erected recently prohibiting vehicles from using the spillway bridge.

### *4.5.4 Recommendations*

The following surveillance/rehabilitation work, as summarized in **Table 4-11**, is recommended for Middle Chase River Dam. Some of these items are carried over from previous FADIs.

**Table 4-11: Middle Chase River Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| MCR 1.01 | Address identified public safety issues (i.e., fall hazards along chute walls, consider adding some signage). Consider developing a public safety management plan for this structure in accordance with the 2011 Canadian Dam Association Guidelines for Public Safety Around Dams. Given the site observations, this dam and Lower Chase Dam are likely the most critical candidates for this type of assessment. Public presence and interaction is high, there are several identifiable unmitigated public safety hazards, and there is a high degree of public concern that will complicate any further public safety controls put in place. For these reasons, having a formal public safety assessment completed would allow the City to understand their risk as well as identify the key low impact/publicly palatable control measures to effectively mitigate this risk. | 2017/2018 FADI |
| MCR 1.02 | Complete a detailed assessment and repair/replace the spillway bridge to enable continued long-term use. | 2021 FADI (Updated in 2023) |
| MCR 1.03 | Repair the area surrounding the 'V' notch weir by low pressure grouting of the bedrock to capture seepage flows.<br>2022 Revision: Repair the automatic data acquisition system for the weir and monitor weir measurements in response to precipitation events. Consideration could be given to grouting the foundation if it is determined that weir measurements are due to runoff and do not capture dam seepage. | 2018 FADI (Modified 2022) |
| MCR 1.04 | All undermining and cavitation at interface of concrete bedrock/soil should be repaired by low-pressure grout/concrete fill. This includes the spillway bridge pier upstream nose at the base and the right and left spillway walls at the upstream end. | 2020 FADI |
| MCR 1.05 | Seal the smaller concrete cracks in the spillway walls using Xypex concrete waterproofing or other equivalent materials depending on the severity of damage. | 2021 FADI |
| MCR 1.06 | Install pins at major cracks on the upstream dam face to monitor movement of the cracks over time. Continue to monitor upstream face of concrete as part of annual inspections and consider repaired if deterioration advances significantly. | 2021 FADI |
| MCR 1.07 | Repair the spalled concrete areas along the spillway walls and pier that have been identified in the condition assessment. Chip away loose and delaminated surfaces prior to repairing with a patching mortar. | 2021 FADI |
| MCR 1.08 | Install public safety boom. | 2023 FADI |
| **Recommendations to close** | | |
| | A sign prohibiting vehicles from using the spillway bridge was added. | 2021 FADI |
| | Riprap protection was added to protect the left slope of spillway chute from erosion. | 2015/2021 FADI |

## 4.6 Lower Chase River Dam (LCR)

### *4.6.1 Dam Description*

The Lower Chase River Dam is the farthest downstream of the series of dams on the Chase River cascade system. The Lower Chase River Dam was constructed in 1910 to supply water for the nearby Harewood Colliery during production which commenced around 1945. The dam is now part of the recreational area called Colliery Dam Park.

The dam is an earth/rock fill structure about 77 m long and 23.3 m high with about a 10 m wide crest. The Lower Chase Dam is considered as a Large Dam as it is higher than 15 m. The dam is comprised of an upstream concrete cut-off wall supported by upstream and downstream earth fill shells. The 300 mm-thick concrete cut-off wall forms the upstream face at normal lake level. The upstream shell has a slope of 1.8H:1V and is likely composed of a coarse granular material, but the nature of the fill is unconfirmed. The downstream shell, comprised of loose cinders, slag, or sand and gravel over rock fill, has a nominal slope of 1.6H:1V and has experienced some minor slumping and settlements. In 1930, a stabilizing berm comprised of gravelly sand was added on the downstream slope at a slope of 2H:1V. An extended apron area is located immediately to the left of the spillway, where members of the public can enter the reservoir via an installed set of steps. See **Figure B15** in **Appendix B** for plan and cross sections of the LCR dam.

In 1980, a gravel filter drain was installed below the downstream shell to intercept seepage through the dam and abutments. Construction included a stabilization berm for the lower downstream slope and backfilling of the low-level outlet pipes through the dam.

The original (main) spillway is located on the right abutment and is separated from the dam by a concrete wall which forms the left side of the concrete spillway. The spillway is a rectangular, concrete lined channel that is split at the upstream end and converges into a single channel downstream. The spillway is a free overflow structure that discharges downstream over a steep bedrock slope. The spillway capacity is approximately 44 $m^3/s$.

An auxiliary spillway was constructed in 2016 to increase the flood routing capacity of the reservoir. The auxiliary spillway is located south of the main spillway and consists of a labyrinth weir that discharges to Harewood Creek before reaching the Chase River. The main spillway remains in place and serves as the primary spillway, while the auxiliary spillway crest overtops during storm events and associated high water levels within the reservoir. The auxiliary spillway has a capacity of 100 $m^3/s$ during Inflow Design Flood (IDF) conditions. Both spillways are required to pass the IDF event.

The auxiliary spillway also includes a secant pile wall and pedestrian bridge. The secant wall is approximately 29.4 m long and consists of a row of concrete piles with steel ‘I’ beam reinforcement that forms a continuous retaining structure. The core of the secant wall is approximately 900 mm thick covered with riprap on the upstream face. Details of the auxiliary spillway are shown on **Figures B16** and **B17** in **Appendix B**. LCR Dam data is summarized in **Table 4-12**.

A Worthington TuffBoom consisting of 14-3.05 m (10 ft.) long boom sticks connected with a 5/16-inch diameter chain was installed as part of the 2016 auxiliary spillway installation. The boom initially was installed to span across the entrances of both the main and auxiliary spillways and was anchored to the concrete facing of the original dam structure on the left and a soil anchor on the right. The left anchor location was relocated to the right wall of the main spillway, so the boom now only protects the auxiliary spillway and not the main spillway.

**Table 4-12: Data for Lower Chase River Dam**

| Structure | Details |
|---|---|
| Type of Dam | Earth fill dam with upstream concrete cut-off wall face |
| Maximum Height | 23.3 m |
| Crest Length | 77 m |
| Crest Elevation | 72.5 – 75.5 m |
| Top of Concrete Core El. | Same as crest |
| Upstream Slope | 1.5H:1V |
| Downstream Slope | Upper part: 1.6H:1V and lower part: 2H:1V |
| Main Spillway | Unregulated open channel concrete spillway |
| Spillway Invert El. | 71.65 m |
| Auxiliary Spillway | Labyrinth weir concrete spillway regulated with sluice gate and stoplogs |
| Auxiliary Spillway El. | 72.10 m |
| Storage Volume | 121,640 $m^3$ |
| Low Level Outlet | N/A (the existing woodstave LLO has been abandoned) |
| Hazard Rating | Very High |

### *4.6.2 Instrumentation*

Instrumentation consists of ultrasonic sensors to measure water levels at the crest of the spillway. The instrumentation is relayed back to the City's SCADA system where a high-water level alarm has been created. Additional instrumentation includes a 'V' notch weir located at the downstream toe of the dam to measure seepage through the toe of the dam during routine monitoring by City staff. At the time of inspection, the water flow over the 'V' notch weir at the toe of the dam was about 3 cm of clear flow.

### *4.6.3 Formal Inspection*

The Lower Chase River Dam was in similar condition to that reported during the 2022 FADI. Visual inspection was performed by walking the crest of dam, abutments, and areas downstream of dam.

#### *4.6.3.1 Main Dam*

##### 4.6.3.1.1 Upstream Face

- The concrete walls on the upstream face of the dam have experienced damage in some areas and were found to be in poor condition overall.
- The concrete face of the upstream wall adjacent to the spillway in the area where the steps are located was found to be in fair condition except at the vertical wall joints, where significant cracks were found, and the wall was noted to be tilting away from the dam towards the reservoir (**Photographs LCR 7 & LCR 8**). It is recommended that the vertical cracks have pins installed to measure the movement of the wall over time and the angle of inclination of the wall should also be documented. If the wall continues to tilt further upstream, reinforcing measures would need to be installed to prevent the wall from experiencing a failure and releasing the embankment material into the reservoir. Significant undermining of the wall at the base was noted in previous FADIs, with one void measured up to 2 m deep directly adjacent to the spillway. This area was underwater at the time of the inspection.
- In the upstream wall area to the left of the main spillway, the soil has generally settled up to 0.25 m below the top of the concrete upstream face (**Photograph LCR 7**).
- The left section of the upstream face was observed to have areas of minor spalling up to 50 mm in depth as well as some minor cracking observed in several locations. Calcite deposits were noted along the entire length of the concrete surface. It is recommended that the spalls and cracking continue to be monitored in this area, though it is not considered a major dam safety concern at this time. Undermining of the wall in this area did not appear to be overly extensive, though much of the wall was underwater at the time of the inspection, making it difficult to confirm.
- The upper concrete retaining wall that runs from the left abutment to the spillway on top of the main cut-off wall was found to be in fair condition with some minor erosion and spalling observed along the top portion of the concrete **(Photograph LCR 1)**. No remediation work is required at this time.
- The aesthetic rock retaining wall on the left abutment was noted to have eroded and been undermined at the base of the large tree on the left abutment of the concrete wall (0.3 m tall, 0.3 m deep, and 1.2 m wide). A second eroded zone was observed approximately 3 m to the left of this area and was 3 m long, 0.5 m high, and 0.5 m deep (**Photograph LCR 23**).
- Three depressions were noted near the upstream face during the 2020 FADI, however those depressions were determined to remain from previously removed concrete signage foundations.

4.6.3.1.2 Crest and Abutments

- The crest was observed to be in satisfactory condition at the time of inspection. The crest of the dam is composed of an asphalt surfaced pedestrian pathway and grass surfacing.
- There was no significant signs of cracks, settlements, or sinkholes on the dam crest, except for a reported borehole at the crest of the dam from a geotechnical investigation that was surface patched with asphalt. As noted in the 2019 FADI, Hatch believes that the borehole was backfilled with excessive bentonite materials which swells when it absorbs moisture. This should continue to be monitored through routine inspections, no significant movement was noted during the inspection.
- As noted in **Section 4.6.3.1.1**, undermining of the aesthetic retaining wall at the left abutment was observed.
- The upstream side of the right abutment, to the right of the auxiliary spillway, was loosely armored with riprap ranging from 0.1 to 0.3 m in size, extending for at least 10 m from the walkway towards the log boom anchor point. For notes on the downstream side of the right abutment, refer to **Section 4.6.3.2**.
- No other signs of erosion or unusual conditions were observed at the abutments of the dam.
- The City is removing the vegetation annually as part of their maintenance program.

*4.6.3.2 Downstream Face and Toe*

- The downstream face and toe of the dam was cleared of vegetation at the time of inspection (**Photograph LCR 18 and LCR 19**). No significant settlement, cracking, or slope instability was able to be observed.
- The right abutment of the earthfill section (left abutment of the spillway) consists of a steep, vegetated slope (**Photograph LCR 18)**. Wet spots were observed during the inspection. The formation of a head scarp at the slope crest suggests that some minor slope movement and deterioration has likely occurred due to wet slope conditions and poor runoff control. City personnel previously indicated that wet spots diminished when the reservoir level was decreased 1 m below operating level several years ago. No visible seepage (i.e., trickling water) was noted. The installation of a weir may not suitably intercept this seepage. The source of this seepage has not been confirmed, however, could be occurring through joints in the spillway. The condition of the slope should be continuously monitored and cracks/joints along the spillway should be sealed. Consideration should be given to the removal of vegetation, regrading of the slope, and installation of a reverse filter.
- The LCR dam is considered a large dam and has a significantly high downstream slope. Currently no survey monuments (or pins) exist on the dam crest or the downstream slope. It is recommended to install a few survey pins along two cross sections for

deformation monitoring purpose. The monuments should be installed at the dam crest as well as at the top of stabilizer berm.

- Water seepage from the embankment was observed at the toe of the dam (but not monitored remotely) by one 'V' notch weir located in the concrete housing at the toe of the dam as mentioned in **Section 4.6.2** (**Photograph LCR 19**). No major signs of slope distress or instability were found at the downstream slope.

*4.6.3.3 Main Spillway*

- At the time of the inspection, there was some small amount of water flowing over the spillway at the left bay. The spillway chute right bay was dry. Some small debris was observed at the base of the chute. The moss on the walls of the spillway was cleared off to aide with the inspection. The City also attempted to clear off areas of the spillway slab to facilitate the inspection of the concrete slab.
- The upstream end of the spillway was observed to have been undermined, similar to the adjacent upstream concrete wall. The central pier nose at the upstream end has heavily deteriorated, spalled with a corroded reinforcing bar exposed and also allowed grass to grow within the concrete cracks (**Photograph LCR 6**). It is recommended that this area be repaired to protect the existing rebar from any further corrosion and prevent advancement of the concrete deterioration.
- Cracking was noted in multiple locations along the central concrete pier, particularly on the left side where a tree stump is located (the tree was cut down previously by the City) and at the location around the old stoplog slot upstream of the spillway bridge. It is recommended that these cracks be sealed to prevent any seepage through the concrete.
- The condition of the spillway bridge was fair with only minor concrete staining and cracking observed. It was noted that the bolts on the underside of the bridge deck securing the handrail posts to the bridge were corroded. It is recommended that the City monitor the condition of the bolts and consider replacing them if further deterioration is observed.
- Several areas at the base along the left spillway wall downstream of the spillway bridge are showing signs of cavitation and erosion with some local pockets measuring depths of up to 110 mm **(Photograph LCR 9)**. There was also suspicion that these pockets are providing a seepage path for water to travel from the spillway through to the right seepage channel noted on the downstream face of the dam (though this cannot be confirmed by the visual inspection as there was not significant water flow in the spillway chute). It is recommended that these pockets be filled with low-pressure grout to prevent seepage through the concrete structure.
- Another area of erosion was noted at the base of the left spillway wall at the downstream jog in the spillway. City staff confirmed that the flow path of the water in the spillway causes a constriction at this location and it is subjected to higher energy flows compared

to the surrounding concrete. It is recommended that a steel plate be installed on the face of the wall to provide increased erosion protection to the concrete in this localized area.

- Additional cracks were observed in the left and right walls at multiple locations. These cracks should be sealed to help prevent any seepage flow through the concrete. The concrete at the base of each wall has experienced minor erosion along the full length of the spillway with small pockets showing more major spalling. These majorly spalled areas should be repaired in conjunction with the repairs being made to the base of the left spillway wall at the suspected seepage path location.
- Several cracks, some of which were capped and sealed in 2022, and erosion at the concrete surface were noted along the spillway slab. The spillway slab overall looked to be in fair condition, and it was noted from the existing reference drawings that a number of cracks had been repaired previously. Some of these repaired areas were located during the inspection and the repairs appeared to still be in satisfactory condition **(Photograph LCR 11)**.
- At the steeply plunging bedrock portion of the main spillway chute, a cavity was observed downstream of the concrete chute due to scouring of the bedrock. The cavity was observed to be filled up to 2 m deep with debris consisting of logs and assorted vegetation (**Photograph LCR 12**). The cavity should be monitored in the long-term to ensure it does not begin to undermine the surrounding slopes.
- There was a large tree on the left abutment immediately downstream of the pedestrian bridge that requires removal so that its root system does not impact the spillway chute wall **(Photograph LCR 5)**. Large trees with branches overhang top of the spillway chute were observed at the time of this visit and it is recommended to cut the overhanging branches as part of the vegetation control plan.

#### *4.6.3.4 Auxiliary Spillway*

- Water in the reservoir was below the crest of the auxiliary spillway at the time of the inspection and some debris had collected either upstream or downstream of the spillway.
- The auxiliary spillway was constructed in 2016 and as expected the exposed concrete was generally in satisfactory condition. As noted in the 2016 FADI, there were some vertical cracks present in the walls with some of these showing minor seepage. Two wet areas were identified during this inspection at the upstream corners of the spillway on the left and right sides, though no flowing water could visually be confirmed (**Photograph LCR 15**). There are no immediate concerns and the City should continue to monitor with routine inspections. The spillway concrete slab at downstream side of the walls was in satisfactory condition with no sign of deterioration.
- The riprap downstream of the auxiliary spillway was in good condition (**Photograph LCR 22**). City personnel indicated that water flow here is minimal and never fully covers the riprap.

*4.6.3.5 Safety Boom*

- The safety boom was observed to be in good condition with no significant issues observed.
- At the time of the inspection, no debris was present in front of the log boom.
- The boom was originally designed to span across both the main spillway and the new auxiliary spillway; however, the left boom anchor was relocated to the right wall of the main spillway, so the boom does not provide protection for the main spillway. The City is currently planning a log boom expansion project to ensure the main spillway is also protected from debris.

*4.6.3.6 Reservoir*

- The reservoir level was measured at 0.2 m based on the reservoir gauge located by the upstream staircase.
- There are numerous trees and vegetation surrounding the reservoir edge, but in general the reservoir was clear of debris and there were no signs of landslide scars or undercutting along its slopes.

*4.6.3.7 Public Safety*

- Lower Chase Dam is located at the north end of Colliery Dam Park. This park has a very high public presence with hundreds of daily users. Recreational activities include swimming, walking/running, dog walking, picnicking, beach users, and fishing. The lake is stocked with fish and recreational fishing is encouraged.
- During the summer of 2016, a security guard was stationed at the new auxiliary spillway to prevent the public from jumping off the concrete walls into the water immediately upstream of the spillway. This was required as the guardrail and signage “DANGER – NO TRESPASSING, Stay Back From Dam, Do Not Climb Fence” was not an effective deterrent for park users.
- There was also extensive graffiti on the walls of the auxiliary spillway demonstrating the high public presence at the site **(Photograph LCR 14)**. The City has removed the vegetation on both side of the bridge crossing the auxiliary spillway to facilitate inspections and to discourage trespassers with the improved visibility of the area.
- Fencing was recently erected along the right chute wall of the main spillway.
- The log boom does not currently protect the main spillway (**Photograph LCR 2**) and there is limited signage warning the public of the hazards. Although there were some obvious unmitigated hazards, there are also many control measures in place that provide a good basis for a formal public safety management plan. A formal public safety assessment is recommended allow the City to better understand their risk and liability as well as identify if additional measures are required and if so what the key low impact/publicly palatable control measures are to effectively mitigate this risk.

- Similar to Middle Chase Dam, it is understood that the public may be resistant to additional public safety control measures such as signage and fencing and therefore this should be considered in the design to minimize the impact to park users while mitigating the identified hazards.

### *4.6.4 Recommendations*

The following surveillance/rehabilitation work is recommended for Lower Chase River Dam as shown in **Table 4-13**. Some of these items are carried over from previous FADIs.

**Table 4-13: Lower Chase River Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| LCR 1.01 | Address identified public safety issues (i.e., fall hazards along dam and chute walls). Consider developing a public safety management plan for this structure in accordance with the 2011 Canadian Dam Association Guidelines for Public Safety Around Dams. Given the site observations, this dam is likely the most critical candidate for this type of assessment. However, many control measures for an effective public safety management plan are already in place, meaning that the task of developing a plan is not likely to be very onerous. Despite the existing control measure, though, public presence and interaction is high, there are several identifiable unmitigated public safety hazards, and there is a high degree of public concern that will complicate any further public safety controls put in place. For these reasons, having a formal public safety assessment completed would allow the City to understand their risk and liability as well as identify the key low impact/publicly palatable control measures to effectively mitigate this risk. Given the amount of public interaction at this site and difficulty in addressing these issues, this may be a very good candidate to pilot the public safety risk assessment process at some point in the future. | 2017/2018 FADI |
| LCR 1.02 | Remove large tree along left side of spillway chute. | 2016 FADI |
| LCR 1.03 | Install survey monuments (pins) on two cross sections, one on the dam crest and one on the downstream slope, on the stabilizer berm. | 2018 FADI |
| LCR 1.04 | Install pins to aid in measuring changing displacement over time. Monitor tilt of upstream concrete facing wall and potential undermining of earth shell underneath. | 2020 FADI |
| LCR 1.05 | Clear vegetation and monitor wet area at downstream toe. Continually monitor for changes in the seepage pattern.<br>2022 Revision: Seepage response (from sealing cracks) along the downstream right abutment slope should be monitored for a maximum of one year. Vegetation should be removed after the monitoring period. The slope should be immediately flattened to a minimum of 2H:1V and overlain by a reverse filter and rockfill. | 2020 FADI (Modified 2022) |
| LCR 1.06 | Repair cavitation and erosion in concrete at the base of spillway chute walls. A steel plate should be installed at the left wall where the horizontal jog in the spillway constricts the flow. The remaining areas can be filled with low pressure-grout or concrete. | 2020/2021 FADI |

| Item | Description | Reference |
|---|---|---|
| LCR 1.07 | Seal cracks in the spillway walls using Xypex waterproofing concrete or approved equivalent to prevent seepage through the concrete. | 2021 FADI |
| LCR 1.08 | Repair the spillway pier nose concrete to protect the exposed reinforcing from corrosion. | 2021 FADI |
| LCR 1.09 | Repair the spalled concrete areas along the spillway walls and pier that have been identified in the condition assessment. Chip away loose and delaminated surfaces prior to repairing with a patching mortar. | 2021 FADI |

## 4.7 Witchcraft Lake Dam (WCL)

### *4.7.1 Dam Description*

Witchcraft Lake Dam is a timber crib structure built in the 1930s to supply water to Westwood Lake reservoir for the purposes of generating electricity. The power generating facility closed in the 1950s and the reservoir is now part of a popular walking trail. A floating bridge was constructed across the reservoir upstream of the dam as part of the walking trail. However, the bridge was removed in the fall of 2019. The dam can now be accessed from a walking trail further upstream. An overview of the area is shown on **Figure B18** in **Appendix B**.

The reservoir is fed from a diversion channel on McCarrigle Creek which flows from the northwest. The majority of the diversion channel has eroded for a depth of 3 m to 6 m into the slope. As a result of deposition, the reservoir has been filled up with the eroded material for 40 m to 50 m upstream of the dam.

A partial breach of the dam occurred near the right abutment in 1958, causing the top 2 m of the crib to be displaced. The remaining crib is around 1.8 m high from the base at downstream side. The dam is in a state of disrepair and could breach at any time as a result of the rotting and unstable condition of the logs. The logs in the unbreeched section of the dam are in an advanced state of deterioration. Water currently flows around and through the dam now and is largely controlled by the channel more so than by the dam. The original reservoir outflow was through an excavated ditch connected to McNeil Creek, which flows into Westwood Lake. However, most of the flow is currently through the breach in the dam. Witchcraft Lake Dam data is provided in **Table 4-14**.

**Table 4-14: Data for Witchcraft Lake Dam**

| Structure | Details |
|---|---|
| Type of Dam | Timber Crib Dam |
| Maximum Height | 1.8 m |
| Crest Length | 7.4 m |
| Storage Volume | 31,200 $m^3$ |
| Spillway | No spillway |
| Low Level Outlet | No low-level outlet |
| Hazard Rating | Significant |

### *4.7.2 Instrumentation*

There is no instrumentation at Witchcraft Lake Dam. The reservoir level gauge is located on the lake upstream of the dam and was measured to be approximately 8 cm below the zero of the level gauge during the inspection.

### *4.7.3 Formal Inspection*

The Witchcraft Dam was observed to be in a similar deteriorated state to previous years. At the time of inspection, the wood debris around the dam made observations of the timber cribbing difficult. The dam was visually inspected from the left and right abutments and downstream side and was in unsatisfactory condition. The following observations were made during the inspection:

#### *4.7.3.1 Main Dam*

- The dam was observed to be in an advanced state of deterioration. The vertical piece of rebar used to hold the timber cribbing together was visible due to the heavy rotting and deterioration of the timber. Logs and wood debris had also collected upstream of the dam, vegetation was present on both abutments, and the area is extremely overgrown (**Photographs WCL 1, WCL 2, WCL 3, WCL 4** and **WCL 5**).
- The downstream face of the dam was characterized by slumping and deteriorating horizontally-oriented logs.
- Wet areas were observed at the dam toe and throughout the dam area, and the dam was covered in dozens of logs, rocks, and fallen trees.
- Given the presence of two additional beams upstream of the timber face, both well embedded, parallel to the beam at the top of the face and the presence of nails in one of these, it is possible that the timber cribbing and any related rockfill extends back approximately 3 m from the dam face. This should be considered in any future planning for dam decommissioning or removal.
- Previous FADIs mentioned remnants of a short dyke on the left abutment of the dam with a maximum height of approximately 1.5 m. As the dyke was significantly eroded and difficult to locate, it was not observed during this visit. Additionally, significant

undermining and erosion was observed beneath a tree leaning into the channel downstream at the left abutment.

- The inlet channel, a tributary of McGarrigle Creek, was inspected near the dam and signs of significant erosion of channel walls during high flows were noted on the left side of the creek bed.
- As noted in previous inspections, the dam is currently not serving to impound water as the control has shifted to the upstream channel and inlet area. The dam as it stands is largely missing and in an advanced state of decay. Currently the dam is not impounding water or impeding flow out of Witchcraft Lake and is unlikely to significantly impede flow during a large flood event. The hydraulic control is provided by the channel and the lake itself is largely in a natural condition.
- For the above reasons, it is recommended that these observations be discussed with the BC Provincial Dam Safety Section to have the dam downgraded to a “Low” or more appropriately struck from the registry all together. The structure’s definition as a dam is highly questionable, therefore it is recommended the lingering structure be officially decommissioned because the dam has essentially been “decommissioned by nature”.

#### *4.7.3.2 Reservoir*

- The reservoir level staff gauge was measured at approximately 8 cm below the zero (-8 cm) of the level gauge during the site visit.
- There are numerous trees and heavy vegetation observed surrounding the reservoir edge in addition to some wood debris in the reservoir, but in general there were no signs of landslide scars or undercutting along the reservoir slopes.

#### *4.7.3.3 Public Safety*

- Witchcraft Lake Dam is accessible to the public; however, since the installation of a new trail access in the fall of 2019, there is less public presence and not any safety concern for this dam.

### *4.7.4 Recommendations*

The following surveillance/rehabilitation work, as summarized in **Table 4-15**, is recommended for Witchcraft Lake Dam. Some of these items are carried over from previous FADIs.

**Table 4-15: Witchcraft Lake Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| WCL 1.01 | Witchcraft Lake Dam's definition as a dam is questionable at best. Currently the dam is not impounding water or impeding flow out of Witchcraft Lake as it was designed to do and is unlikely to significantly impede flow during a large flood event. The hydraulic control is provided by the channel and the lake itself is largely in a natural condition. For this reason and the fact that the dam and reservoir have not been required for power generating facility since the 1950s, it is recommended that the City apply to the BC Provincial Dam Safety Officer to rescind the water license, as the dam has essentially been 'decommissioned by nature'.<br>2022 Revision: Provide documentation to the BC Provincial Dam Safety Officer to get the dam removed from the dam registry. Hatch will provide a memo/documentation that should assist with this process. | 2017/2018 FADI (Modified 2022) |

## 4.8 McGregor Creek Dam (MGC) (Linley Valley Dam)

### *4.8.1 Dam Description*

McGregor Creek Dam is an earth dam constructed by Lamont Land Inc. in 2011 to comply with the City of Nanaimo Development Permit requirements for the Linley Valley Subdivision. Ownership was transferred to the City of Nanaimo in January 2020. The water license was transferred by Lamont Land Inc. to the City of Nanaimo in June 2022. The dam is located at the end of a wetland pond. These wetlands and the associated habitat have been in place for many years.

The dam is approximately 3 m high, constructed of silty sand and gravel fill, with a crest width of 4 m and 2H:1V side slopes. The upstream slope is armored with riprap. The dam has a 3 m wide, uncontrolled lowered rockfill spillway that creates an outlet channel. A footbridge spans across of outlet channel for pedestrian traffic. A log boom and 250 mm diameter beaver control drain are used to prevent beavers from creating dams at the spillway location.

An overview of the dam details are shown on **Figure B19** in **Appendix B**.

McGregor Creek Dam data is provided in **Table 4-16**.

**Table 4-16: Data for McGregor Creek Dam**

| Structure | Details |
|---|---|
| Type of Dam | Impervious Earthfill Dam |
| Maximum Height | 3 m |
| Crest Length | 100 m |
| Crest Width | 4 m |
| Catchment Area | 57 Hectares |
| Storage Volume | 25,950 $m^{3.}$ |
| Spillway | Unregulated rockfill outlet channel. Low flow “Beaver Bypass” 250 mm diameter pipe with shut off valve. |
| Outlet Channel Flow Capacity | 1.64 $m^3$/sec |
| Hazard Rating | Significant |

### *4.8.2 Instrumentation*

There is no instrumentation at McGregor Creek Dam. A staff gauge is located at the site but is not properly installed, and not currently read by the City. It is recommended that the City reinstall a functional staff gauge and commence taking regular readings.

### *4.8.3 Formal Inspection*

#### *4.8.3.1 Main Dam*

McGregor Creek Dam was visually inspected from the crest of the dam and was found to be in satisfactory condition. The water level was below the spillway invert and there was no water flowing through the spillway at the time on inspection. Vegetation growth was observed in the spillway channel at the time of inspection, and it is recommended to regularly clear of vegetation **(Photograph MGC 8)**. There was no significant debris observed in the reservoir at upstream side of the dam.

#### *4.8.3.2 Upstream Face*

The upstream slope of the dam was in satisfactory condition at the time of the inspection. The upstream face was overlain by an erosion protection layer of angular cobbles up to approximately 100 mm in diameter. Vegetation growth has occurred within the void space which obscures the protection layer.

There was no sign of slope instability, cracking, sinkholes, or settlement along the upstream slope of the dam during the inspection. Some minor slumping and displacement of riprap pieces were observed.

Significant vegetation was observed up to 2 m high (**Photograph MGC 4**). It is recommended that the vegetation clearing program be performed twice-yearly instead of the current annual program. Vegetation should be removed and any voids from roots filled to the toe of the dam.

#### 4.8.3.3 *Crest and Abutments*

The crest of the dam is a gravelled surface and was in satisfactory condition at the time of inspection (**Photograph MGC 1**). There were no signs of cracks, settlement, or sinkholes on the majority of the dam crest. Minor erosion of the upstream crest line, likely due to precipitation runoff and minor slumping of riprap, was observed. This should be monitored and regraded with gravel and riprap when required (**Photograph MGC 4**).

No seepage was observed at the abutments. All vegetation should be cleared to the toe and abutment.

#### 4.8.3.4 *Downstream Face and Toe*

The downstream slope of the dam was in good condition at the time of the inspection and was covered with grasses and small trees especially at the right abutment (**Photograph MGC 9**). No wet spots were found on the downstream slope of the dam. No signs of slope distress or instability was found along the downstream slope. Vegetation was well cleared from the downstream toe at the time of the inspection. It is recommended to continue vegetation clearing approximately 2 m from the toe of the dam. It is understood that the public may be resistant to further vegetation clearing but it should be cleared at least to the toe of the dam.

#### 4.8.3.5 *Spillway*

The spillway was inspected from a public walking trail bridge which spans over the spillway channel. The spillway floor and abutments are lined with riprap of approximately 500 mm diameter. Significant vegetation growth was observed within the spillway channel which prevented proper inspection of the spillway. The spillway floor is anticipated to be lined with a 400 mm thick layer of 10 kg riprap underlain by a non-woven geotextile.

It is recommended to remove and control vegetation within the spillway; however, significant vegetation growth is likely to re-establish annually. The frequency of vegetation control works should be increased such that significant vegetation growth does not establish.

The capacity of the spillway and effects of vegetation growth should be assessed by a hydrotechnical engineer. Some level of vegetation growth may be acceptable if it is properly maintained and spillway capacity remains sufficient. Alternatives to riprap or vegetated spillways (e.g., concrete spillways) may be considered if vegetation growth is considered adverse to spillway operation.

#### 4.8.3.6 *Reservoir*

The lake level is controlled by an unregulated spillway channel and a 250 mm diameter “Beaver Bypass” pipe. The spillway was viewed from a public walking trail bridge that spans over the spillway channel. The downstream channel was too overgrown to inspect, but riprap protection was visible approximately 5 m downstream of the pedestrian bridge, protecting the channel from flow erosion (**Photograph MGC 6**). The riprap was observed to range in size up to approximately 0.5 m diameter. It is recommended to remove vegetation from the spillway channel.

Beaver activity has historically and recently, as mentioned by the City Staff, been reported in this area but was not observed during the inspection. Minimal debris was observed on the lake during the site visit.

#### *4.8.3.7 Log Boom*

There is a log boom installed immediately upstream of the spillway channel consisting of timber logs that are chained together (**Photograph MGC 7**). The boom was in good condition with minimal deterioration and the logs are sitting well above the waterline. Surficial corrosion was observed on the chains and anchors. No debris was observed upstream of the boom at the time inspection.

#### *4.8.3.8 Public Safety*

McGregor Creek Dam is accessible to the public via trail through the development and along the dam crest. However, due to the low height of the dam, there were no obvious hazards identified during the site visit. It should be noted that the pedestrian bridge sits on large (>1 m diameter) rocks that are formed into a wall approximately 2 m high (**Photograph MGC 8**). The spillway channel was covered with heavy vegetation growth at the time of the inspection that made it difficult to inspect the condition of the rock at the base of the bridge abutments. It is recommended to keep this area clear of vegetation for regular visual inspection.

### *4.8.4 Recommendations*

The following surveillance/rehabilitation work, as summarized in **Table 4-17**, is recommended for McGregor Creek Dam.

**Table 4-17: McGregor Creek Dam – Surveillance/Rehabilitation Recommendations**

| Item | Description | Reference |
|---|---|---|
| MGC 1.01 | Remove vegetation on upstream and downstream dam faces, spillway channel, and within 2 m of toe and abutments. | 2019 FADI |
| MGC 1.02 | Update OMS manual to reflect and clarify change in dam ownership. | 2019 FADI |
| MGC 1.03 | Repair/replace staff gauge and commence taking regular readings during inspections. | 2020 FADI |
| MGC 1.04 | Clear vegetation from abutments of pedestrian bridge to aid in visual inspections.<br>2022 Revision: Perform vegetation clearing twice per year. | 2020 FADI (Modified 2022) |
| MGC 1.05 | Perform a hydrotechnical assessment of the spillway to assess the impacts of vegetation growth on spillway capacity. Increase the frequency of spillway vegetation control. | 2022 FADI |

# 5. Summary

There are two types of recommendations summarized below:

1. Outstanding surveillance and rehabilitation recommendations were summarized from previous FADI and new recommendations were made. See **Table 5-1**.
2. Outstanding dam safety recommendations originating from previous DSRs that were in the City's Dam Safety Issues tracking spreadsheet were summarized. See **Table 5-2**.

Note that items in these tables are summarized and additional detail is provided in earlier sections. Additionally, Hatch has attempted to summarize all previous outstanding recommendations; however, it is the City's responsibility to ensure that all previous recommendations have been prioritized and addressed to their satisfaction.

Hatch understands that the City has limited resources. Therefore, it is extremely important to prioritize the various recommendations so the City can create a plan for addressing/resolving these deficiencies. Priority ratings have been added for each item where:

A = high priority (complete within 2 years);

B = medium priority (complete within 5 years); and

C = low priority (complete within 10 years/reassess with changing conditions).

**Table 5-1: Summary of Surveillance and Rehabilitation Recommendations**

| Item | Description | Reference | Priority |
|---|---|---|---|
| GENERAL 1.01 | Convert elevations to flow on seepage plots. | | A |
| | | | |
| WWL 1.01 | Replace missing hardware at 'V' notch weir. | 2020 FADI | B |
| WWL 1.02 | Repair erosional damage at the left bridge abutment at inlet channel. Extend the length of dam sacks downstream and backfill the erosional scarp behind the dam sacks. | 2021 FADI | B |
| WWL 1.03 | Vegetation control measures should include clearing any trees and other vegetation a minimum of 3 m beyond the abutment and dam toe. | 2023 FADI | B |
| WWL 1.04 | Backfill the area where the buried Department of Fisheries pipe is exposed due to mountain biking and hiking activities to protect the pipe from damage by the public. | 2023 FADI | A |
| WWL 1.05 | Repair the riprap along the outlet channel step to protect the dam sacks from further undermining. | 2023 FADI | A |
| | | | |
| HAW 1.01 | Address identified public safety issues (i.e., missing handrail and fall hazards around dam). The City should also consider moving towards a more Formal Public Safety around Dams | 2017/2018 FADI | B |

| Item | Description | Reference | Priority |
|---|---|---|---|
| | program based on the recommendations in the 2011 Canadian Dam Association Guidelines for Public Safety Around Dams. This would involve performing a public safety risk assessment and developing a formal public safety management plan for each site that is open to the public. This would help the city to understand public safety risks in a systematic priority-based process that will allow an overall reduction of liability and is defensible to the public. Observations at the site indicate that the public presence is relatively light and overall hazards are relatively low; therefore, this process does not have to be an immediate priority and should be considered as part of future initiatives. | | |
| HAW 1.02 | Scour protection should be placed at the exit side of the spillway chute.<br>It is recommended that a 300 mm diameter rock (riprap) blanket that is 3 m wide by 8 m long by 0.6 m high be placed downstream of the spillway chute, underlain by a minimum 400 gr/m$^2$ non-woven geotextile.<br>2022 Revision: Place 300 mm median diameter riprap blanket with underlying filter which extends 0.5 m beyond the spillway wingwalls and is minimum 10 m long. | 2015 FADI/ 2018 FADI (Modified 2022) | A |
| HAW 1.03 | Perform detailed concrete condition assessment of dam and spillway structures and subsequent repairs.<br>2021 Revision: This condition assessment should also provide recommendations on what repairs would need to be made to maintain long term operability of the dam given the reduced maximum operating level compared to original design. | 2015 FADI | A |
| HAW 1.04 | Repair the stacked rock wall and remove moss. | 2018 FADI | B |
| HAW 1.05 | Seal cracks along the bottom portions of spillway wall and slab to prevent seepage. | 2019/2021 FADI (Updated 2023) | B |
| HAW 1.06 | Clear vegetation and debris from channel downstream of rock wall. | 2020 FADI | A |
| | | | |
| UCR 1.01 | Address identified public safety hazards. Consider moving towards a more Formal Public Safety around Dams program and creating a formal Public Safety Management Plan. | 2017/2018 FADI | B |
| UCR 1.02 | Perform detailed concrete condition assessment of dam and spillway structures and provide subsequent repair details. | 2015 FADI | A |

| Item | Description | Reference | Priority |
|---|---|---|---|
| UCR 1.03 | Install pins on either side of major buttress wall crack to monitor crack width. Clear the vegetation at the base of the vertical crack along the buttress wall. | 2017/2021 FADI | A |
| UCR 1.04 | Reinstate eroded material under the downstream end of the culverts and protect eroding slope at culvert outlet with geotextile and riprap after vegetation removal and regrading. | 2020/2021 FADI | B |
| UCR 1.05 | Regrade slopes around the spillway wingwalls and provide coir-mesh and hydroseed to establish protective vegetation. Construct drainage swales along the crest of the wingwalls to collect and discharge runoff. Fill the void beneath the spillway headwall on the right abutment. | 2022 FADI | A |
| UCR 1.06 | It is recommended that the ground surface behind the right dam wall be leveled to avoid water accumulation at the location of the observed depression to facilitate surface runoff away from the wall. | 2023 FADI | A |
| UCR 1.07 | Backfill the area of camera pole foundation to prevent further undermining and slope erosion. | 2023 FADI | A |
| | | | |
| MCR 1.01 | Address identified public safety issues (i.e., fall hazards along chute walls, consider adding some signage). Consider developing a public safety management plan for this structure in accordance with the 2011 Canadian Dam Association Guidelines for Public Safety Around Dams. Given the site observations, this dam and Lower Chase Dam are likely the most critical candidates for this type of assessment. Public presence and interaction is high, there are several identifiable unmitigated public safety hazards, and there is a high degree of public concern that will complicate any further public safety controls put in place. For these reasons, having a formal public safety assessment completed would allow the City to understand their risk as well as identify the key low impact/publicly palatable control measures to effectively mitigate this risk. | 2017/2018 FADI | B |
| MCR 1.02 | Complete a detailed assessment and repair/replace the spillway bridge to enable continued long-term use. | 2021 FADI (Updated in 2023) | |
| MCR 1.03 | Repair the automatic data acquisition system and monitor weir measurements in response to reservoir elevation and precipitation events. Consider grouting of the bedrock if weir flows do not correlate with reservoir elevations. | 2018 FADI (Modified 2022) | A |
| MCR 1.04 | All undermining and cavitation at interface of concrete bedrock/soil should be repaired by grout/concrete fill. Cracks or deterioration in concrete should also be repaired. | 2020 FADI | A |

| Item | Description | Reference | Priority |
|---|---|---|---|
| MCR 1.05 | Seal the smaller concrete cracks in the spillway walls using Xypex concrete waterproofing or other equivalent materials depending on the severity of damage. | 2021 FADI | B |
| MCR 1.06 | Install pins at major cracks on the upstream dam face to monitor movement of the cracks over time. Continue to monitor the upstream face of concrete as part of annual inspections and consider repaired if deterioration advances significantly. | 2021 FADI | A |
| MCR 1.07 | Repair the spalled concrete areas along the spillway walls and pier that have been identified in the condition assessment. Chip away loose and delaminated surfaces prior to repairing with a patching mortar. | 2021 FADI | C |
| MCR 1.08 | Install public safety boom. | 2023 FADI | B |
| | | | |
| LCR 1.01 | Address identified public safety hazards. Consider moving towards a more Formal Public Safety around Dams program and creating a formal Public Safety Management Plan. Given the amount of public interaction at this site and difficulty in addressing these issues, this may be a good candidate to pilot the public safety risk assessment process. | 2017/2018 FADI | B |
| LCR 1.02 | Remove large tree along left side of spillway chute. | 2016 FADI | A |
| LCR 1.03 | Install survey monuments (pins) on two cross sections, one on the dam crest and one on the downstream slope, on the stabilizer berm. | 2018 FADI | A |
| LCR 1.04 | Install survey pins to monitor deflection of right abutment upstream wall. | 2020 FADI | A |
| LCR 1.05 | Clear vegetation and inspect depression/wet area at downstream toe. Continually monitor for changes.<br>2022 Revision: Seepage response (from sealing cracks) along the downstream right abutment slope should be monitored for a maximum of one year. Vegetation should be removed after the monitoring period. The slope should be immediately flattened to a minimum of 2H:1V and overlain by a reverse filter and rockfill. | 2020 FADI (Modified 2022) | A |
| LCR 1.06 | Repair cavitation and erosion in concrete at the base of spillway chute walls. | 2020/2021 FADI | B |
| LCR 1.07 | Seal cracks in the spillway walls using Xypex waterproofing concrete or approved equivalent to prevent seepage through the concrete. | 2021 FADI | B |
| LCR 1.08 | Repair the spillway pier nose concrete to protect the exposed reinforcing from corrosion. | 2021 FADI | A |

| Item | Description | Reference | Priority |
|---|---|---|---|
| LCR 1.09 | Repair the spalled concrete areas along the spillway walls and pier that have been identified in the condition assessment. Chip away loose and delaminated surfaces prior to repairing with a patching mortar. | 2021 FADI | C |
| | | | |
| WCL 1.01 | Witchcraft Lake Dam's definition as a dam is questionable at best. Currently the dam is not impounding water or impeding flow out of Witchcraft Lake as it was designed to do and is unlikely to significantly impede flow during a large flood event. The hydraulic control is provided by the channel and the lake itself is largely in a natural condition. For this reason and the fact that the dam and reservoir have not been required for power generating facility since the 1950s, it is recommended that the City apply to the BC Provincial Dam Safety Officer to rescind the water license, as the dam has essentially been 'decommissioned by nature'.<br>2022 Revision: Provide documentation to the BC Provincial Dam Safety Officer to get the dam removed from the dam registry. Include the Hatch memo that was prepared in 2021 providing documentation that should assist with this process. | 2017/2018 FADI (Modified 2022) | A |
| | | | |
| MGC 1.01 | Remove vegetation on upstream and downstream dam faces, spillway channel, and within 2 m of toe and abutments. | 2019 FADI | A |
| MGC 1.02 | Update OMS manual to reflect and clarify change in dam ownership. | 2019 FADI | A |
| MGC 1.03 | Repair/replace staff gauge and commence taking regular readings during inspections. | 2020 FADI | A |
| MGC 1.04 | Clear vegetation from abutments of pedestrian bridge to aid in visual inspections.<br>2022 Revision: Perform vegetation clearing twice per year. | 2020 FADI (Modified 2022) | A |
| MGC 1.05 | Perform a hydrotechnical assessment of the spillway to assess the impacts of vegetation growth on spillway capacity. Increase the frequency of spillway vegetation control. | 2022 FADI | A |

**Table 5-2: Outstanding Dam Safety Issues**

| Item | Description | Reference | Priority |
|---|---|---|---|
| WWL 2.01 | Review hydraulics and hydrology to determine if outlet channel width needs to be increased to accommodate debris in channel to satisfy fish habitat requirements. | 2013 DSR | A |
| WWL 2.02 | Update inundation mapping. | 2013 DSR | A |
| | | | |
| R01 2.01 | Test post-tensioned anchors.<br>*Note: On hold. | 2013 DSR | On Hold |
| R01 2.02 | Perform stability analysis/seismic review (including special inspection of the upstream face by emptying the reservoir). This should include stability against PMF flooding from Upper Chase River into Old Reservoir No. 1.<br>*Note: Permanently dewatered. Recommendation put on hold. | 2013 DSR | On Hold |
| R01 2.03 | Perform hydrology/hydraulic study (inundation study) including consequence category.<br>*Note: Permanently dewatered. Recommendation put on hold. | 2013 DSR | On Hold |
| R01 2.04 | Produce a plan to determine the long-term future of the dam. | BC DS Regulator Recommendation (2020) | A |
| | | | |
| HAW 2.01 | Hydrology/hydraulic study to determine to determine capacity of spillway. | 2013 DSR | B |
| HAW 2.02 | Update inundation mapping and review dam classification. | 2013 DSR/ 2017 FADI | A |
| | | | |
| UCR 2.01 | Check for potential of a cascade failure of the downstream structures caused by a failure of Upper Chase River Dam. | 2019 FADI | A |
| | | | |
| MCR 2.01 | Review and compare crest elevation for as-built drawings vs. survey information of the dam crest.<br>2022 Revision: Include a new survey in the scope of work for the next DSR which is planned for 2024. | 2009 FADI | B |
| MCR 2.02 | Check for potential of a cascade failure of the downstream structures caused by a failure of Middle Chase River Dam. | 2021 FADI | A |
| MCR 2.03 | Implement capital plan to increase the capacity of the spillway to allow for passage of an IDF event. | 2022 FADI | A |
| | | | |

| Item | Description | Reference | Priority |
|---|---|---|---|
| LCR 2.01 | Perform dam stability analysis of earth fill dam. The upper portion of downstream slope is particularly steep.<br>2022 Revision: Include this in the scope of work for the next DSR which is planned for 2024. | 2003 DSR | A |
| LCR 2.02 | Perform stability analysis of spillway walls including seismic loading.<br>2022 Revision: Include this in the scope of work for the next DSR which is planned for 2024. | 2003 DSR | A |

# 6. Cost Estimate

The cost estimate is an ASCE Class 5 (-50% to +100%) cost estimate that provides for engineering services and for maintenance/rehabilitation works where the scope of work is defined sufficiently to provide an estimate. Where an engineering study is required, the subsequent rehabilitation has not been estimated as this will be dependent on the findings the engineering report and detailed design.

**Table 6-1: Cost Estimate – Outstanding Surveillance and Rehabilitation Issues**

| Item | Description | Estimated Cost | Notes |
|---|---|---|---|
| GENERAL 1.01 | Convert elevations to flow on seepage plots. | N/A | By City staff |
| | | | |
| WWL 1.01 | Replace missing hardware at 'V' notch weir. | $ 200 | Labour by City staff |
| WWL 1.02 | Repair erosion at the inlet channel left bridge abutment. | $ 5,000 | Labour by City staff |
| WWL 1.03 | Vegetation control measures should include clearing any trees and other vegetation a minimum of 3 m beyond the abutment and dam toe. | $ 7,000 | Labour by City staff |
| WWL 1.04 | Backfill the area where the buried Department of Fisheries pipe is exposed due to mountain biking and hiking activities to protect the pipe from damage by the public. | $ 2,000 | Labour by City staff |
| WWL 1.05 | Repair the riprap along the outlet channel step to protect the dam sacks from further undermining. | $ 5,000 | Labour by City staff |
| | | | |
| HAW 1.01 | Address identified public safety hazards. Consider moving towards a more Formal Public Safety around Dams program and creating a formal Public Safety Management Plan. | $ 15,000 | Site visit combined with other dams PSMPs. |
| HAW 1.02 | Place scour protection at the exit side of the spillway chute. | $ 10,000 | |

| Item | Description | Estimated Cost | Notes |
|---|---|---|---|
| | 2022 Revision: Place 300 mm median diameter riprap blanket which extends 0.5 m beyond the spillway wingwalls and is minimum 10 m long. | | |
| HAW 1.03 | Perform detailed concrete condition assessment of dam and spillway structures and subsequent repairs.<br>2021 Revision: This condition assessment should also provide recommendations on what repairs would need to be made to maintain long term operability of the dam given the reduced maximum operating level compared to original design. | $ 40,000 | From City estimate with added cost for repair details. |
| HAW 1.04 | Repair the stacked rock wall and remove moss. | N/A | By City staff |
| HAW 1.05 | Seal other cracks along the bottom portions of spillway wall and slab to prevent seepage. | $ 200 | Labour by City staff |
| HAW 1.06 | Clear vegetation and debris from channel downstream of rock wall. | N/A | By City staff |
| | | | |
| UCR 1.01 | Address identified public safety hazards. Consider moving towards a more Formal Public Safety around Dams program and creating a formal Public Safety Management Plan. | $ 15,000 | Site visit combined with other dams PSMPs. |
| UCR 1.02 | Perform detailed concrete condition assessment of dam and spillway structures and provide subsequent repair details. | $ 30,000 | From City estimate |
| UCR 1.03 | Install pins on either side of major buttress wall crack to monitor crack width. Clear the vegetation at the base of the vertical crack along the buttress wall. | N/A | By City staff |
| UCR 1.04 | Reinstate eroded material under the downstream end of the culverts and protect eroding slope at culvert outlet with geotextile and riprap after vegetation removal and regrading. | $ 10,000 | |
| UCR 1.05 | Regrade slopes around the spillway wingwalls and provide coir-mesh and hydroseed to establish protective vegetation. Construct drainage swales along the crest of the wingwalls to collect and discharge runoff. Fill the void beneath the spillway headwall on the right abutment. | $ 25,000 | |
| UCR 1.06 | It is recommended that the ground surface behind the right dam wall be leveled to avoid water accumulation at the location of the observed depression to facilitate surface runoff away from the wall. | N/A | By City staff |
| UCR 1.07 | Backfill the area of camera pole foundation to prevent further undermining and slope erosion. | N/A | By City staff |

| Item | Description | Estimated Cost | Notes |
|---|---|---|---|
| | | | |
| MCR 1.01 | Address identified public safety hazards. Consider moving towards a more Formal Public Safety around Dams program and creating a formal Public Safety Management Plan. | $ 20,000 | Site visit combined with other dams PSMPs. |
| MCR 1.02 | Complete a detailed assessment and repair/replace the spillway bridge to enable continued long-term use. | $ 15,000<br><br>$ 40,000 | Repair cost is an allowance as it will be dependent on findings of condition assessment. |
| MCR 1.03 | Repair the automatic data acquisition system and monitor weir measurements in response to reservoir elevation and precipitation events. Consider grouting of the bedrock if weir flows do not correlate with reservoir elevations. | $ 2,000 | Allowance |
| MCR 1.04 | All undermining and cavitation at interface of concrete bedrock/soil should be repaired by grout/concrete fill. Cracks or deterioration in concrete should also be repaired. | $ 2,000 | Labour by City staff |
| MCR 1.05 | Seal the smaller concrete cracks in the spillway walls using Xypex concrete waterproofing or other equivalent materials depending on the severity of damage. | $ 1,000 | Labour by City staff |
| MCR 1.06 | Install pins at major cracks on the upstream dam face to monitor movement of the cracks over time. Continue to monitor the upstream face of concrete as part of annual inspections and consider repaired if deterioration advances significantly. | $ 500 | Labour by City staff |
| MCR 1.07 | Repair the spalled concrete areas along the spillway walls and pier that have been identified in the condition assessment. Chip away loose and delaminated surfaces prior to repairing with a patching mortar. | $ 40,000 | Allowance for major repairs to upstream face and minor repairs to the chute walls and bridge pier. |
| MCR 1.08 | Install public safety boom. | $ 25,000 | Allowance |
| | | | |
| LCR 1.01 | Address identified public safety hazards. Consider moving towards a more Formal Public Safety around Dams program and creating a formal Public Safety Management Plan. Given the amount of public interaction at this site and difficulty in addressing these issues, this may be a good candidate to pilot the public safety risk assessment process. | $ 25,000 | Site visit combined with other dams PSMPs. |
| LCR 1.02 | Remove large tree along left side of spillway chute. | $ 5,000 | |

| Item | Description | Estimated Cost | Notes |
|---|---|---|---|
| LCR 1.03 | Install survey monuments (pins) on two cross sections, one on the dam crest and one on the downstream slope, on the stabilizer berm. | $ 1,000 | |
| LCR 1.04 | Install survey pins to monitor deflection of right abutment upstream wall. | N/A | By City staff |
| LCR 1.05 | Clear vegetation and inspect depression/wet area at downstream toe. Continually monitor for changes.<br>2022 Revision: Joints and cracks in the original spillway should be sealed and the seepage response along the downstream right abutment slope should be monitored for a maximum of one year. Vegetation should be removed after the monitoring period. The slope should be immediately flattened to a minimum of 2H:1V and overlain by a reverse filter and rockfill. | $ 30,000 | Allowance for design and construction. |
| LCR 1.06 | Repair cavitation and erosion in concrete at the base of spillway chute walls. | $ 3,000 | Labour by City staff |
| LCR 1.07 | Seal cracks in the spillway walls using Xypex waterproofing concrete or approved equivalent to prevent seepage through the concrete. | $ 1,000 | Labour by City staff |
| LCR 1.08 | Repair the spillway pier nose concrete to protect the exposed reinforcing from corrosion. | $ 5,000 | |
| LCR 1.09 | Repair the spalled concrete areas along the spillway walls and pier that have been identified in the condition assessment. Chip away loose and delaminated surfaces prior to repairing with a patching mortar. | $ 100,000 | Allowance for major repairs to upstream wall that's titling and undermined and local repairs to spillway chute walls, piers and slab. |
| | | | |
| WCL 1.01 | Given the advanced state of deterioration of the dam structure, consideration should be given to partially or fully decommissioning the structure and/or replacing it with a simple rockfill overflow structure to preserve the upstream lake level and reduce/eliminate the potential risk of failure. Given its current state, it could potentially be abandoned and struck from the registry since it is no longer acting as a water retaining structure.<br>2022 Revision: Provide documentation to the BC Provincial Dam Safety Officer to get the dam removed from the dam registry. Include the Hatch memo that was prepared in 2021 providing documentation that should assist with this process. | N/A | |

| Item | Description | Estimated Cost | Notes |
|---|---|---|---|
| | | | |
| MGC 1.01 | Remove vegetation on upstream and downstream dam faces, spillway channel, and within 2 m of toe and abutments. | N/A | By City staff |
| MGC 1.02 | Update OMS manual to reflect and clarify change in dam ownership. | N/A | By City staff |
| MGC 1.03 | Repair/replace staff gauge and commence taking regular readings during inspections. | $ 500 | By City staff |
| MGC 1.04 | Clear vegetation from abutments of pedestrian bridge to aid in visual inspections.<br>2022 Revision: Perform vegetation clearing twice per year. | N/A | By City staff |
| MGC 1.05 | Perform a hydrotechnical assessment of the spillway to assess the impacts of vegetation growth on spillway capacity. Increase the frequency of spillway vegetation control. | $ 25,000 | Engineering fees |

**Table 6-2: Cost Estimate – Outstanding Dam Safety Issues**

| Item | Description | Estimated Cost | Comments |
|---|---|---|---|
| WWL 2.01 | Review hydraulics and hydrology to determine if outlet channel wide needs to be increased. | $ 20,000 | Does not include survey |
| | | | |
| R01 2.01 | Test post-tensioned anchors. | $ 20,000 | Allowance |
| R01 2.02 | Perform stability analysis/seismic review (including special inspection of the upstream face by emptying the reservoir). This should include stability against PMF flooding from Upper Chase River into Old Reservoir No. 1. | $ 30,000 | Can be removed if Old Reservoir No. 1 is permanently dewatered and no longer classified as a dam. Dam plan required (see item N01 2.04). |
| R01 2.03 | Check for potential of a cascade failure of the downstream structures caused by the failure of Old Reservoir No. 1. | $ 5,000 | Simple volume/capacity assessment of sunny day failure. |
| R01 2.04 | Produce a plan to determine the long-term future of the dam. | $ 20,000 | |
| R01 2.05 | Reduce consequence classification to Low or remove from fleet of dams if there is no plan to re-fill the reservoir. | N/A | By City staff with BC Dam Regulator. |
| | | | |
| HAW 2.01 | Hydraulic study to determine to determine capacity of spillway. | $ 10,000 | Using existing drawings, not including additional survey acquisition if needed. |
| HAW 2.02 | Review dam classification by assessing the potential for downstream damages. | $ 25,000 | Very simplified assessment, full assessment $40K plus LiDAR acquisition. |
| | | | |
| UCR 2.01 | Check for potential of a cascade failure of the downstream structures caused by a failure of Upper Chase River Dam. | $ 5,000 | Simple volume/capacity assessment of sunny day failure. |
| | | | |
| MCR 2.01 | Review and compare crest elevation for as-built drawings vs. survey information of the dam crest. | N/A | *By City staff |
| MCR 2.02 | Check for potential of a cascade failure of the downstream structures caused by a failure of Middle Chase River Dam. | N/A | Study currently underway |
| MCR 2.03 | Implement capital plan to increase the capacity of the spillway to allow for passage of an IDF event. | | Cost can be estimated once MCR 2.02 is completed. |
| | | | |
| LCR 2.01 | Perform dam stability and seepage analysis of earth fill dam. | $ 30,000 | |
| LCR 2.02 | Perform stability analysis of spillway walls including seismic loading. | $ 25,000 | |

# Appendix A
# Summary of Information Reviewed

| Item | Document Name | Date |
|---|---|---|
| 1 | Dam Mobile Database (pdf files from most recent routine inspections) | September 2023 |
| 2 | Reservoir No. 1 OMS Manual | May 2020 |
| 3 | Westwood Lake Dam OMS Manual | February 2017 |
| 4 | Upper Chase River Dam OMS Manual | June 2020 |
| 5 | Middle Chase River Dam OMS Manual | March 2020 |
| 6 | Lower Chase River Dam OMS Manual | October 2017 |
| 7 | Harewood Lake Dam OMS Manual | November 2016 |
| 8 | Witchcraft Lake Dam OMS Manual | 2017 |
| 9 | McGregor Creek Dam OMS Manual | January 2020 |
| 10 | 2022 Formal Annual Dam Inspections | April 2023 |
| 11 | 2021 Formal Annual Dam Inspections | June 2022 |
| 12 | 2020 Formal Annual Dam Inspections | February 2021 |
| 13 | City of Nanaimo – Dam Safety Management Program | July 2020 |
| 14 | City of Nanaimo – Dam Emergency Plan | November 2019 |
| 15 | Dam Safety Reviews for Jump Creek Dam & Saddle Dam, South Fork Dam, Reservoir No. 1 Dam, Westwood Lake & Saddle Dam | 2014 |
| 16 | Dam Safety Reviews for the Middle & Lower Chase River Dams | 2014 |
| 17 | City of Nanaimo – Dam Emergency Plan for Jump Creek, South Fork, Westwood, Upper Chase, Middle Chase, Lower Chase, Reservoir No. 1. Harewood, Witchcraft | November 2019 |
| 18 | Dam Emergency Plan (DEP) – McGregor Creek Dam, D720163 | January 2020 |
| 19 | Water Licence Amendment 114478 | June 2022 |

# Appendix B
# Figures

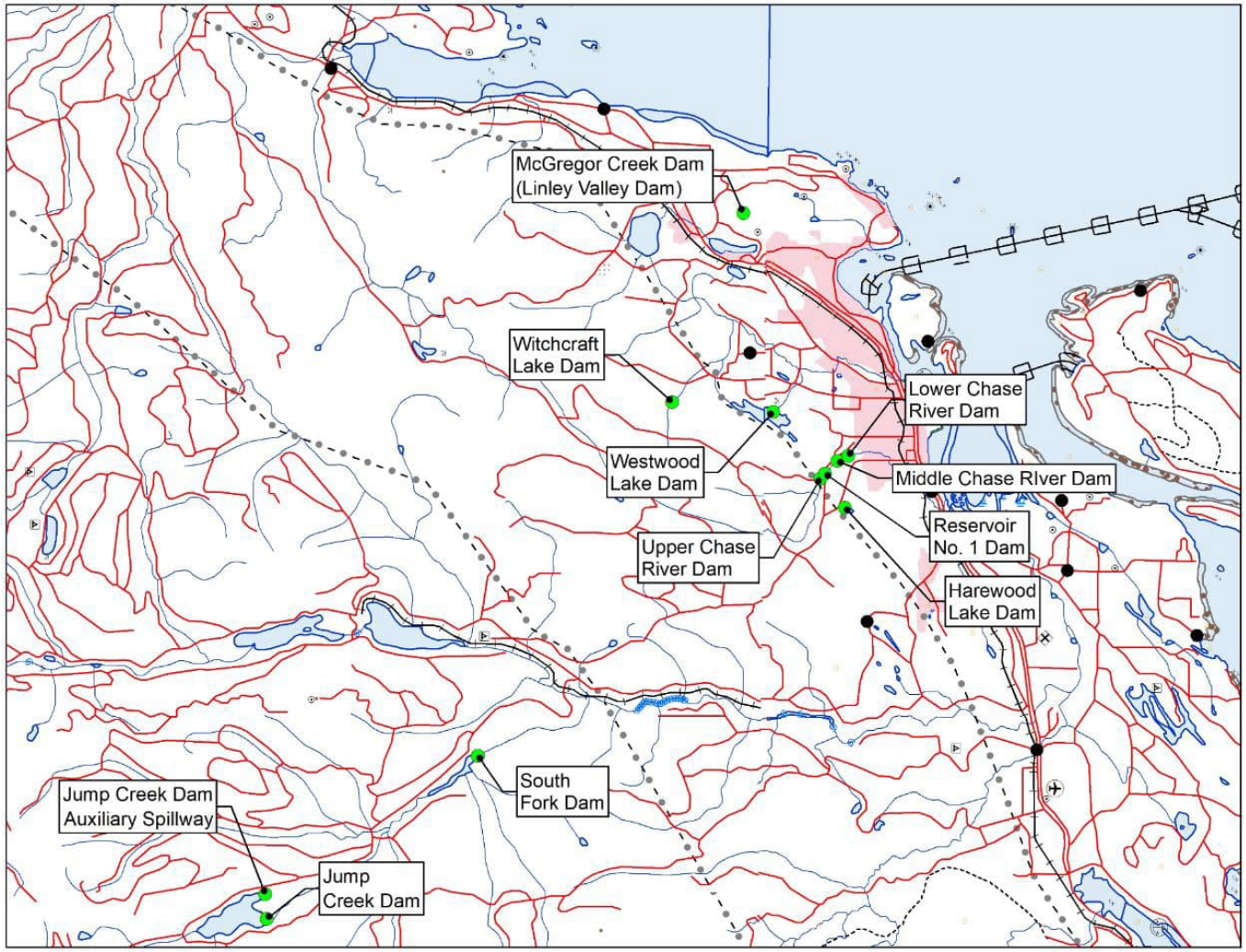



**Figure B1: Dam Locations**

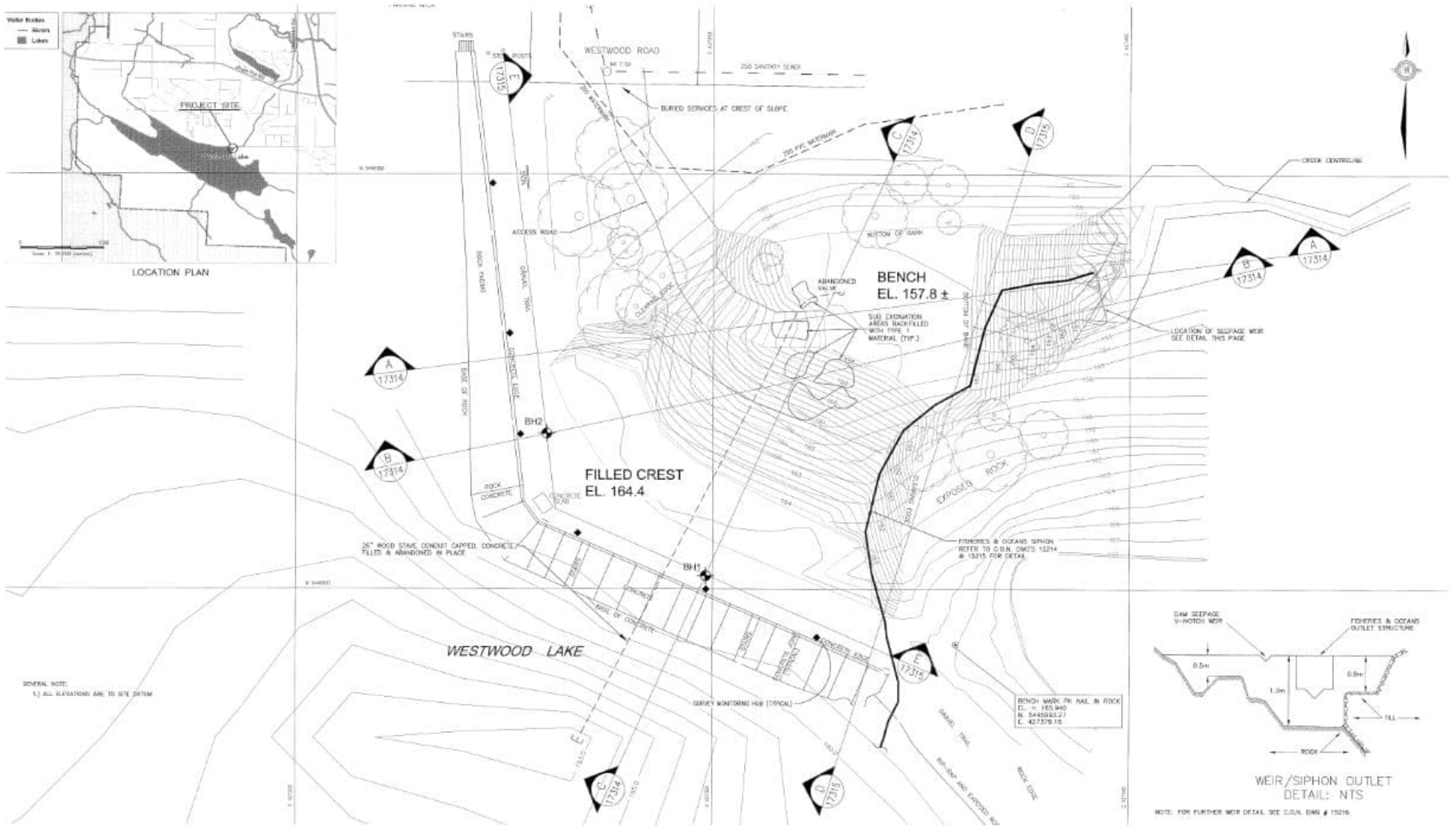
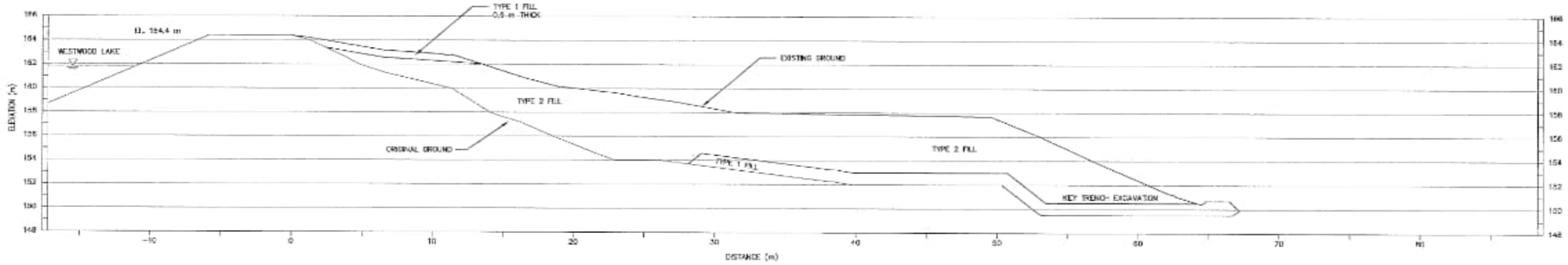
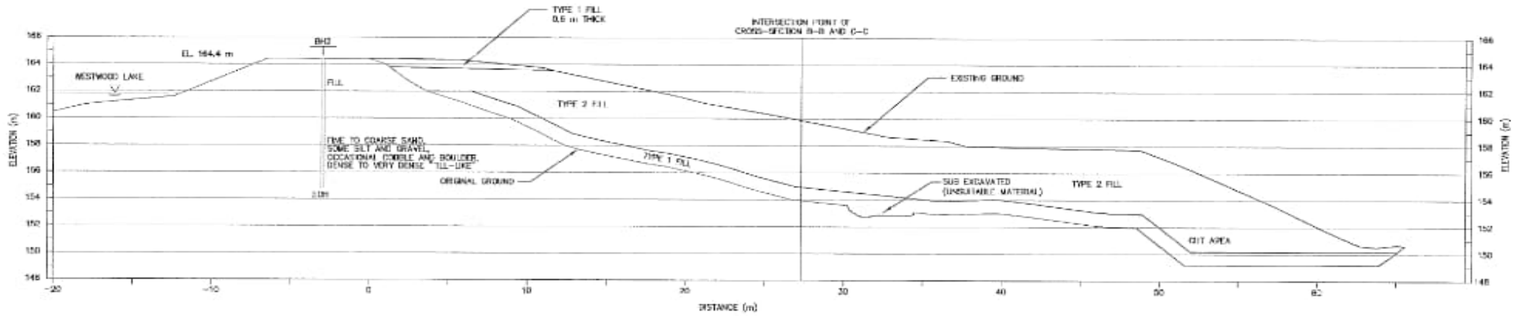


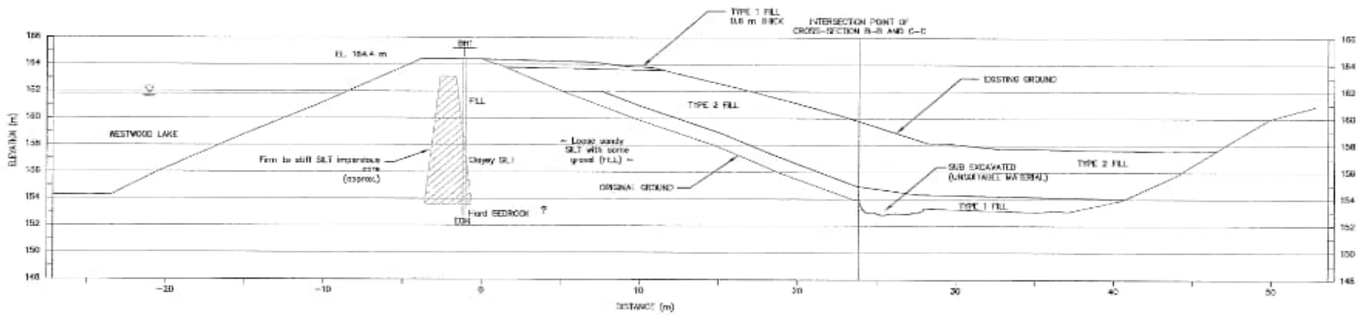

**Figure B2: General Layout and Cross Sections of Westwood Dam**
**(Provided by The City)**




SECTION A
1:200 17313




SECTION B
1:200 17313




SECTION C
1:200 17313

**Figure B3: Cross Sections of Westwood Dam (Provided by The City)**

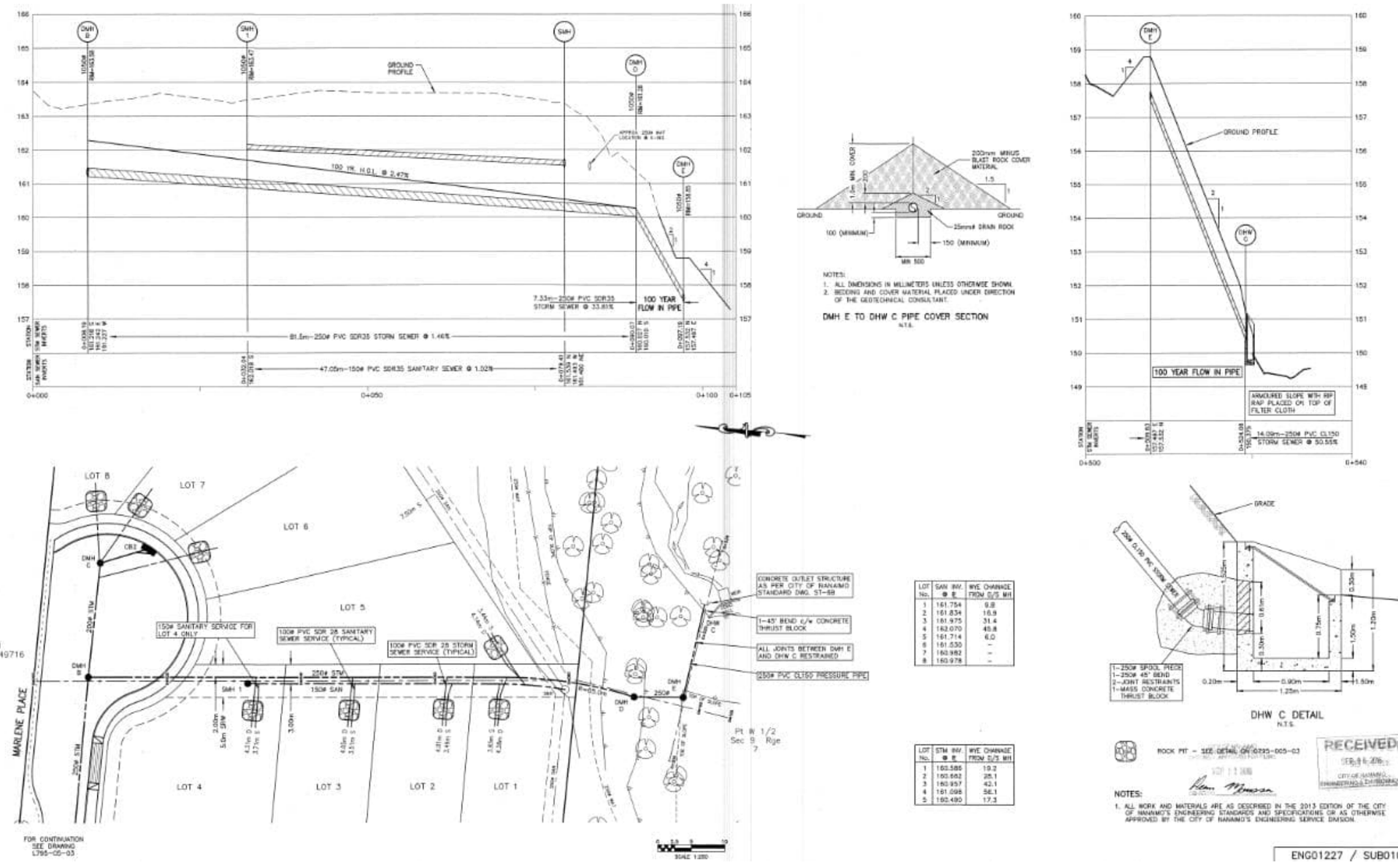



**Figure B4: Cross Sections of Storm and Sanitary Sewers at Westwood Lake Dams (Provided by The City)**

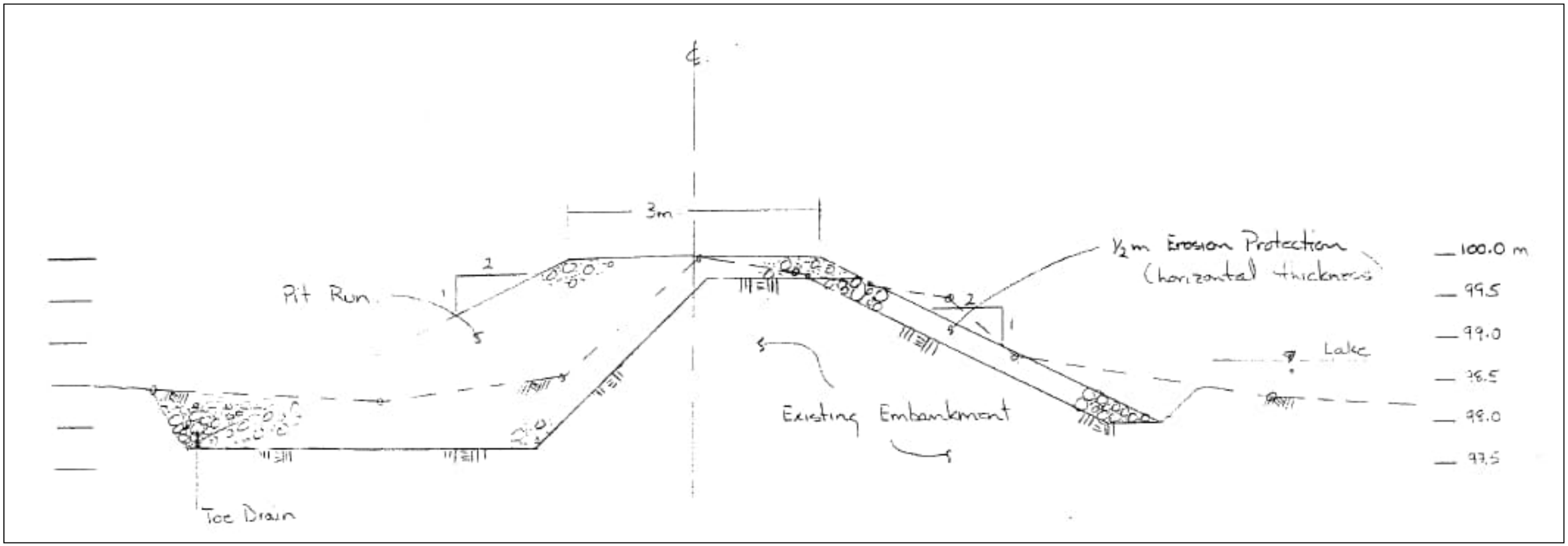



**Figure B5: Cross Sections of Saddle Dam at Westwood Lake**
**(From OMS Manual)**

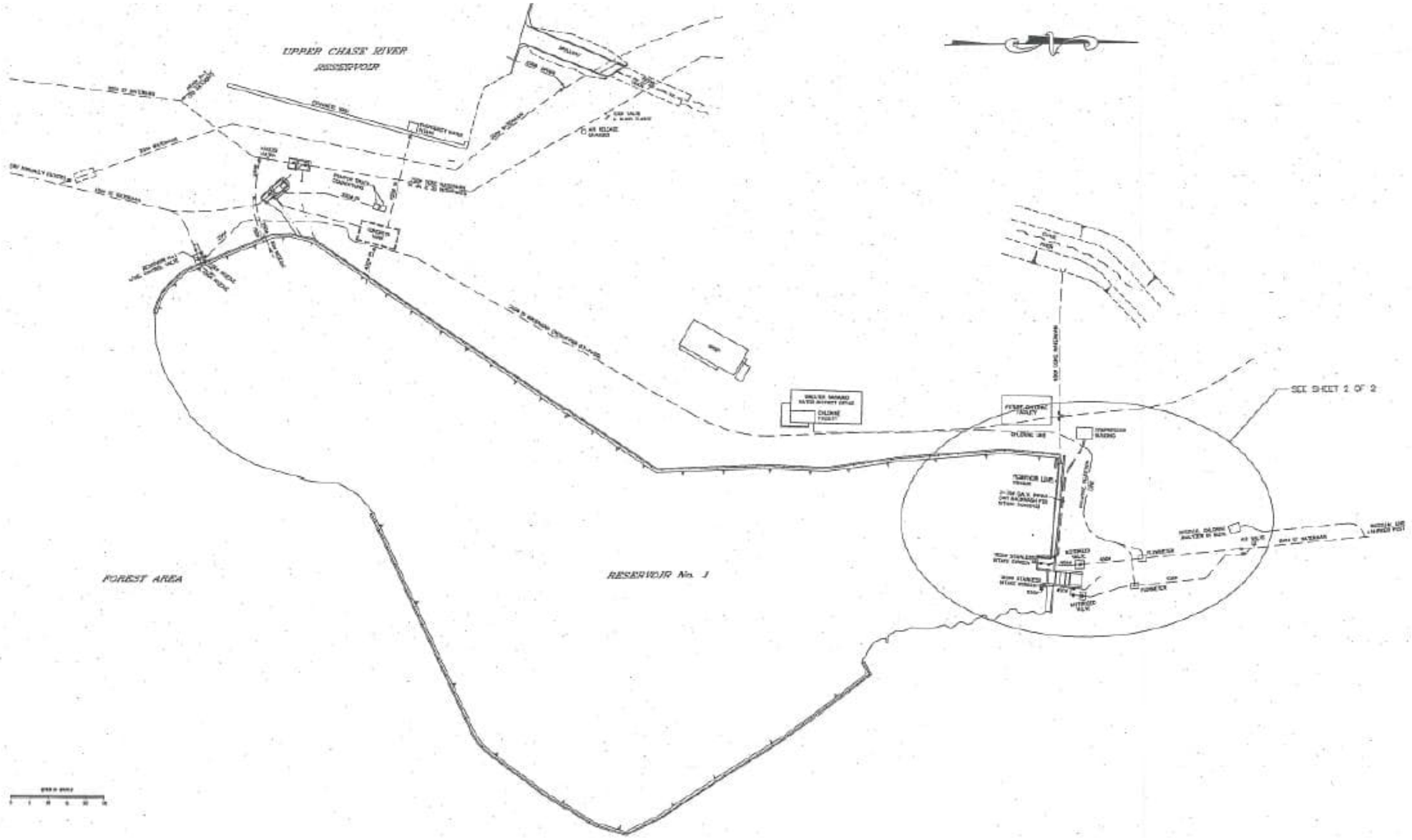



**Figure B6: Cross Sections of Old Reservoir Dam No. 1**
**(Figure taken from 2016 FADI)**

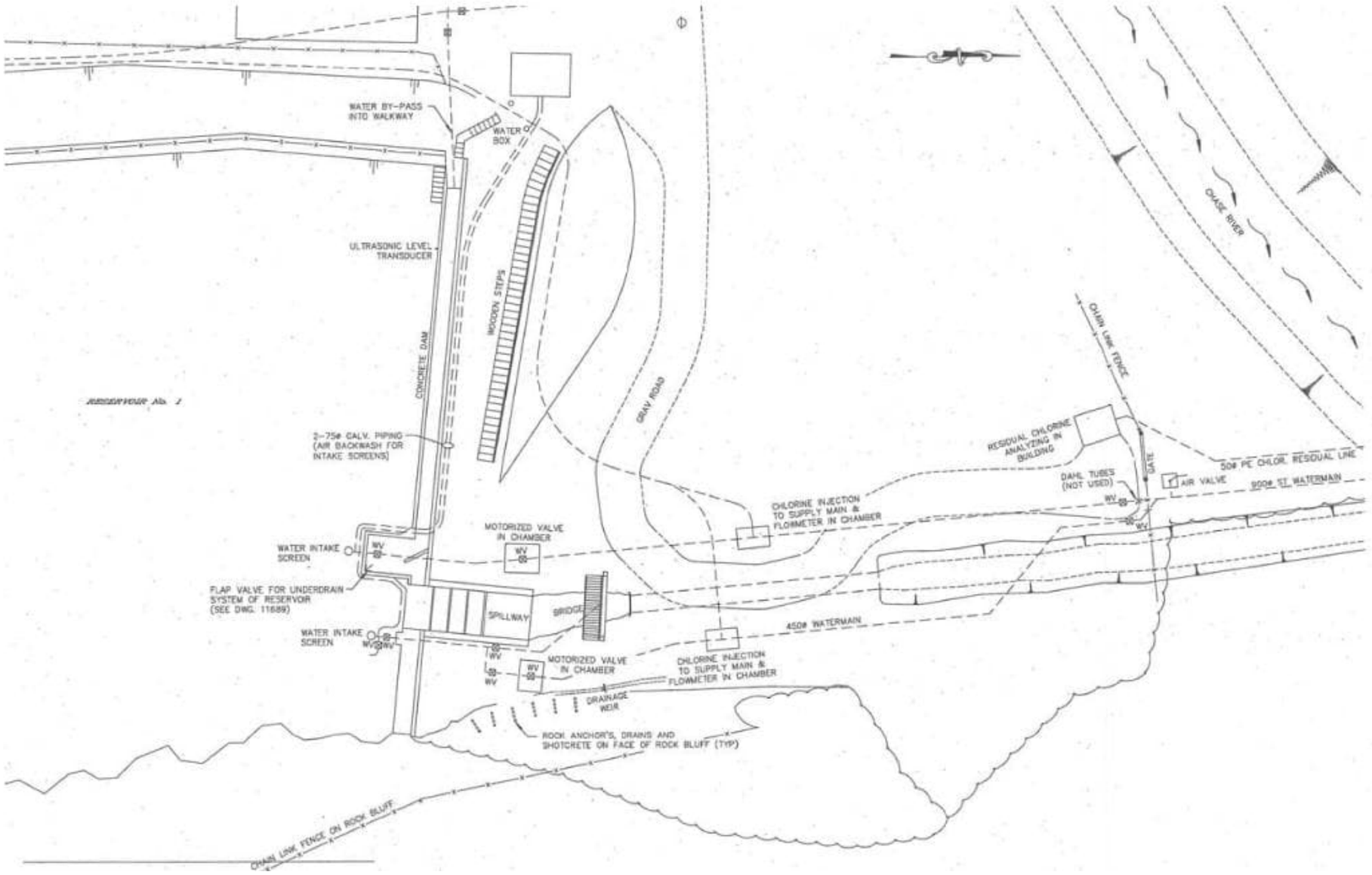



**Figure B7: General Layout of Old Reservoir Dam No. 1**
**(Figure taken from 2014 DSR)**

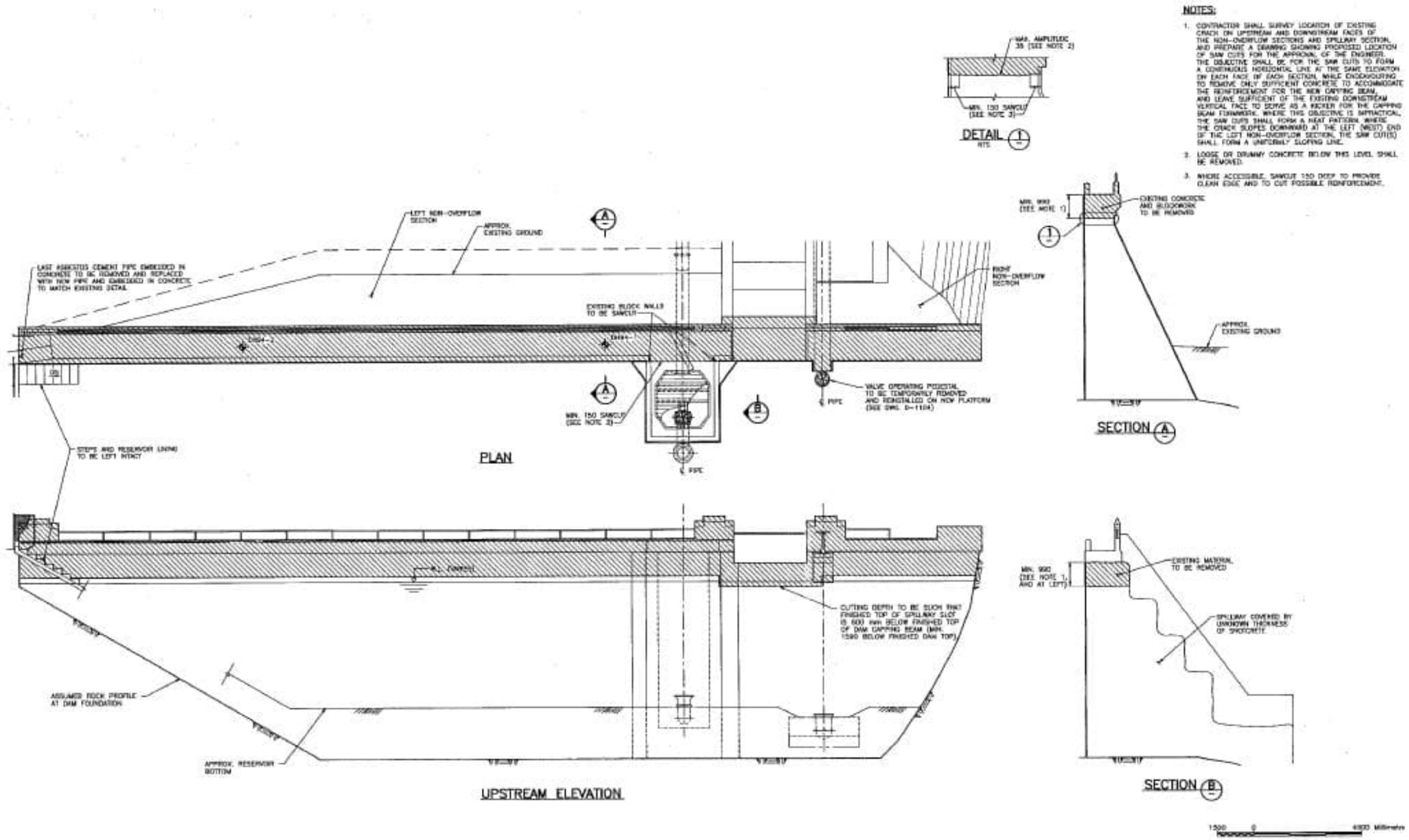



**Figure B8: Cross Sections of Old Reservoir Dam No. 1**
**(Figure taken from 2014 DSR)**

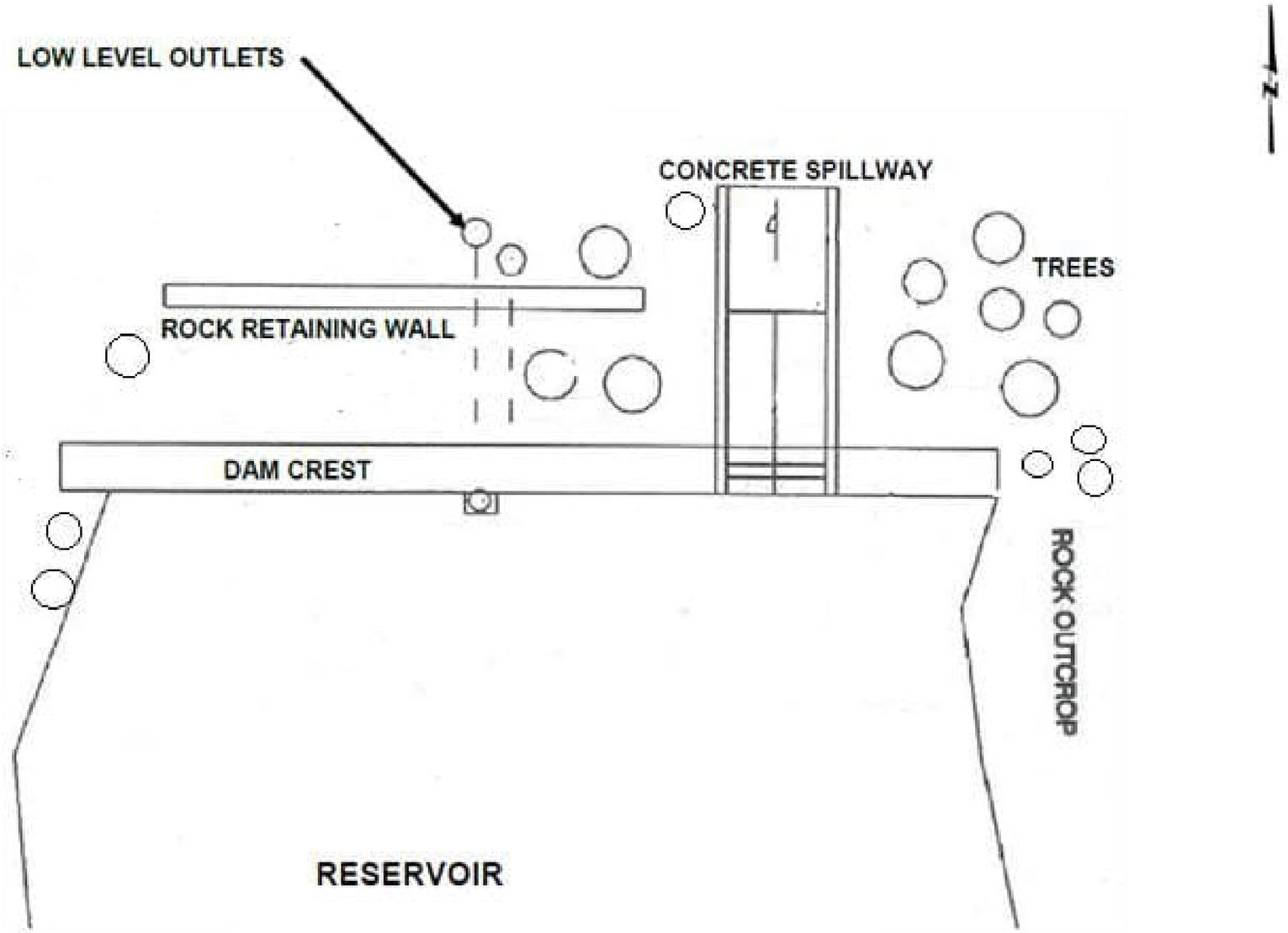



**Figure B9: General Arrangement of The Harewood Dam**
**(Adapted from 2016 FADI Figure)**

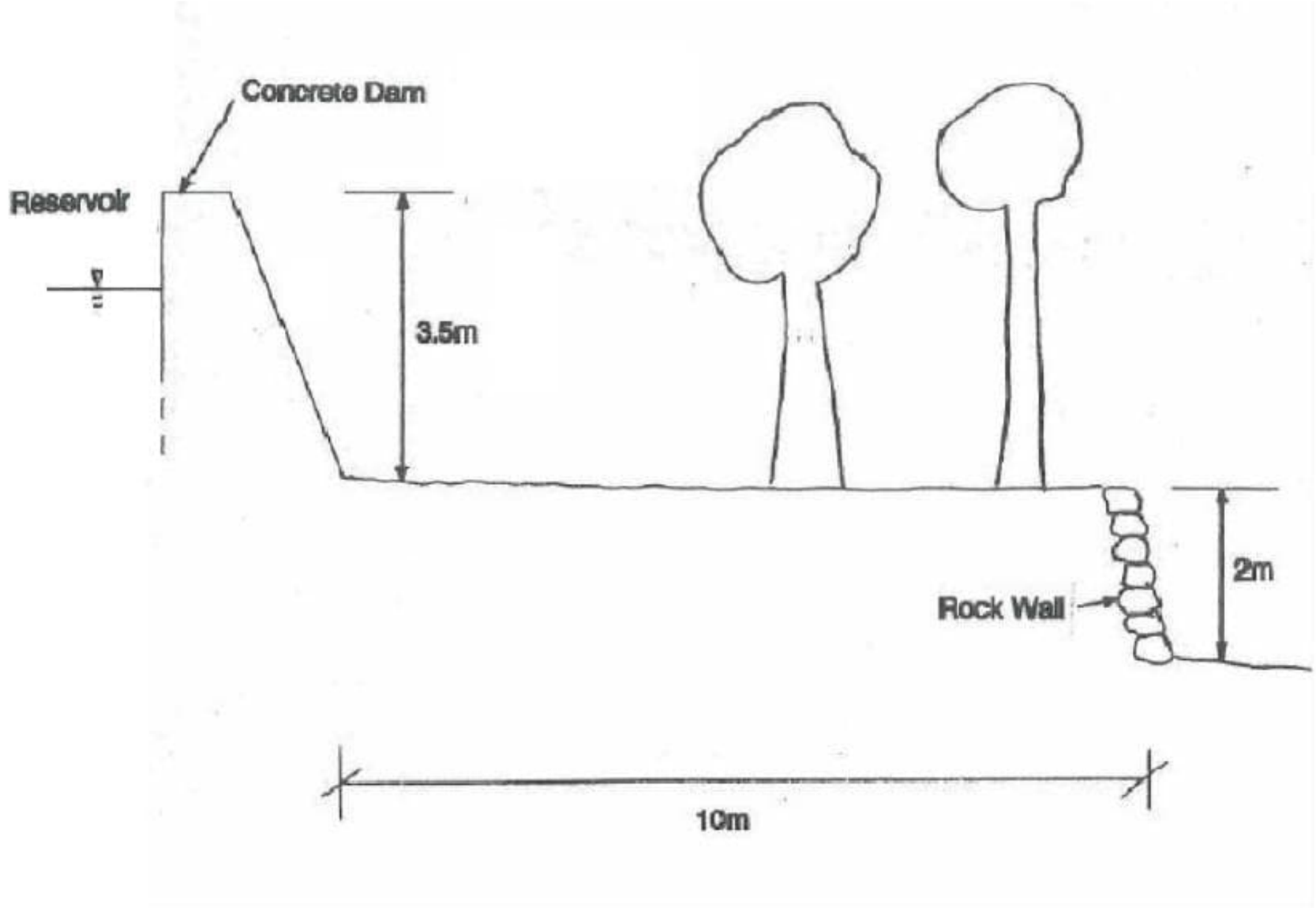



**Figure B10: General Cross Section of the Harewood Dam**
**(Figure Taken From 2016 FADI))**

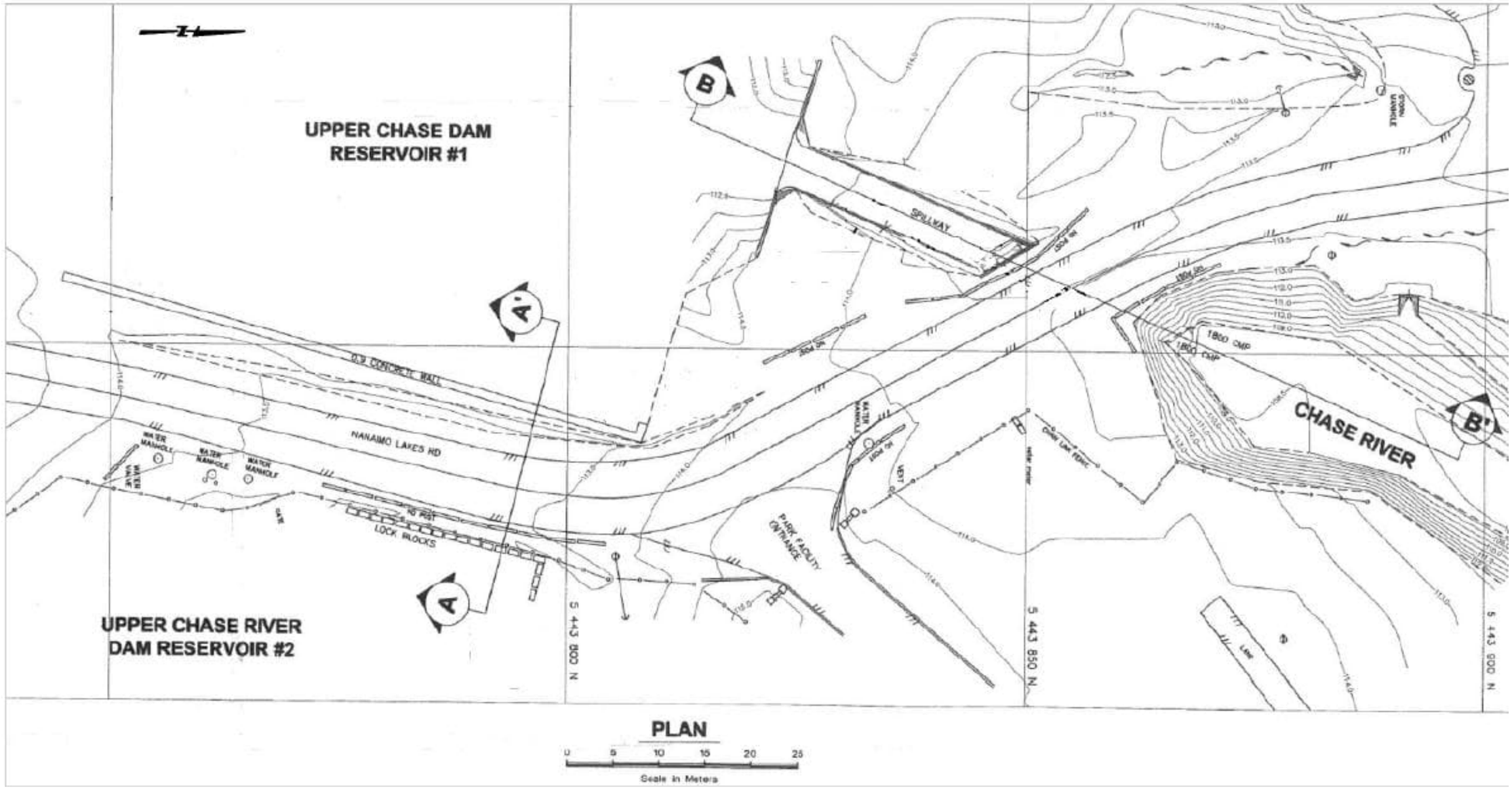



**Figure B11: General Layout of Upper Chase River Dam**
**(Figure taken from 2016 FADI)**

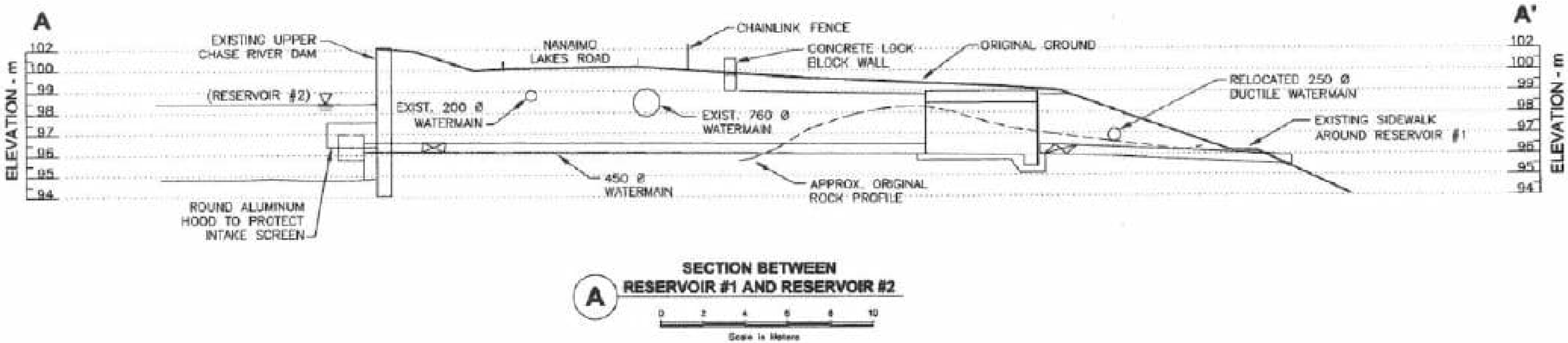



**Figure B12: General Cross Section of Upper Chase River Dam**
**(Figure taken from 2016 FADI)**

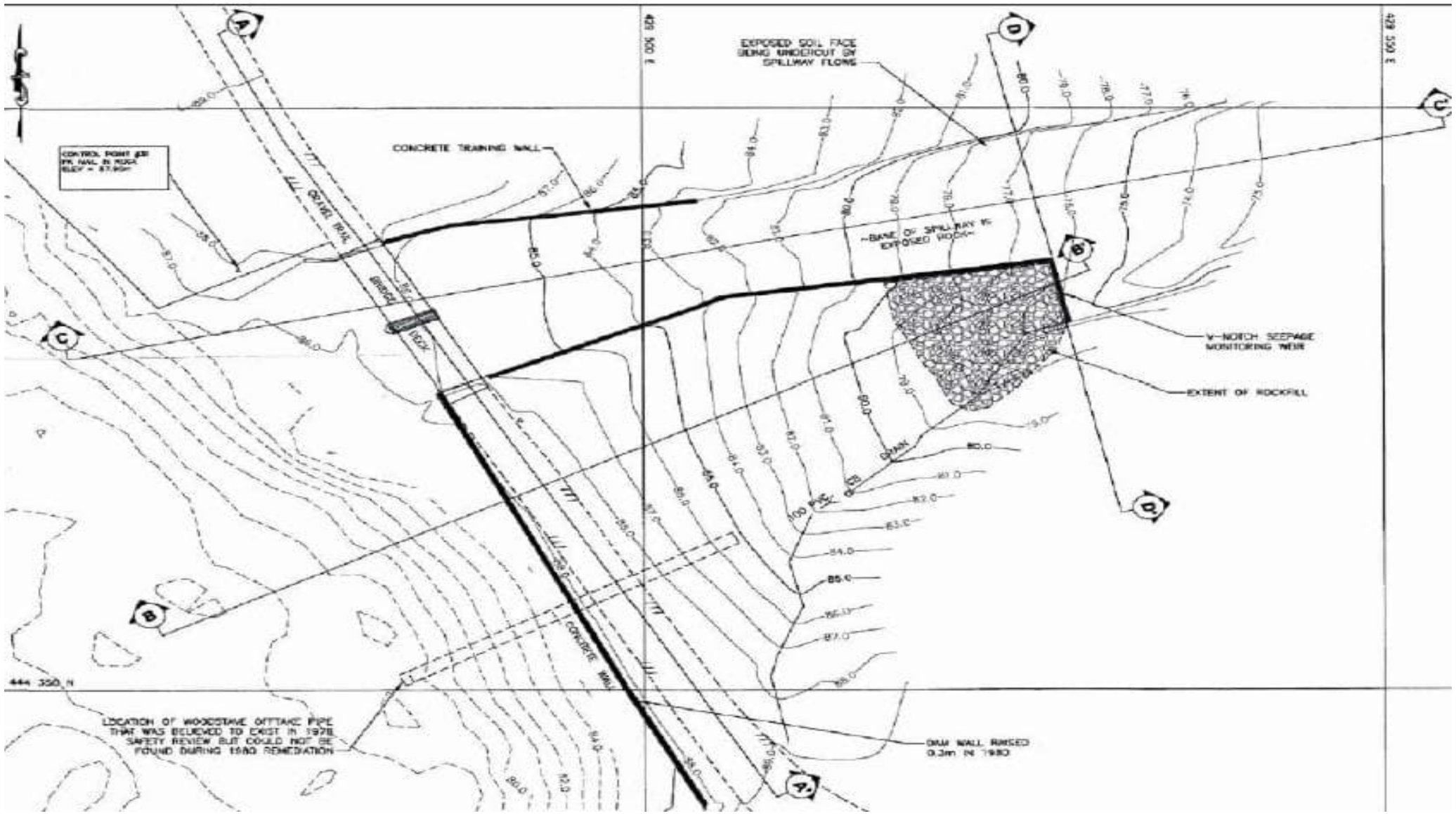



**Figure B13: General Layout of Middle Chase River Dam**
**(Figure taken from 2016 FADI)**

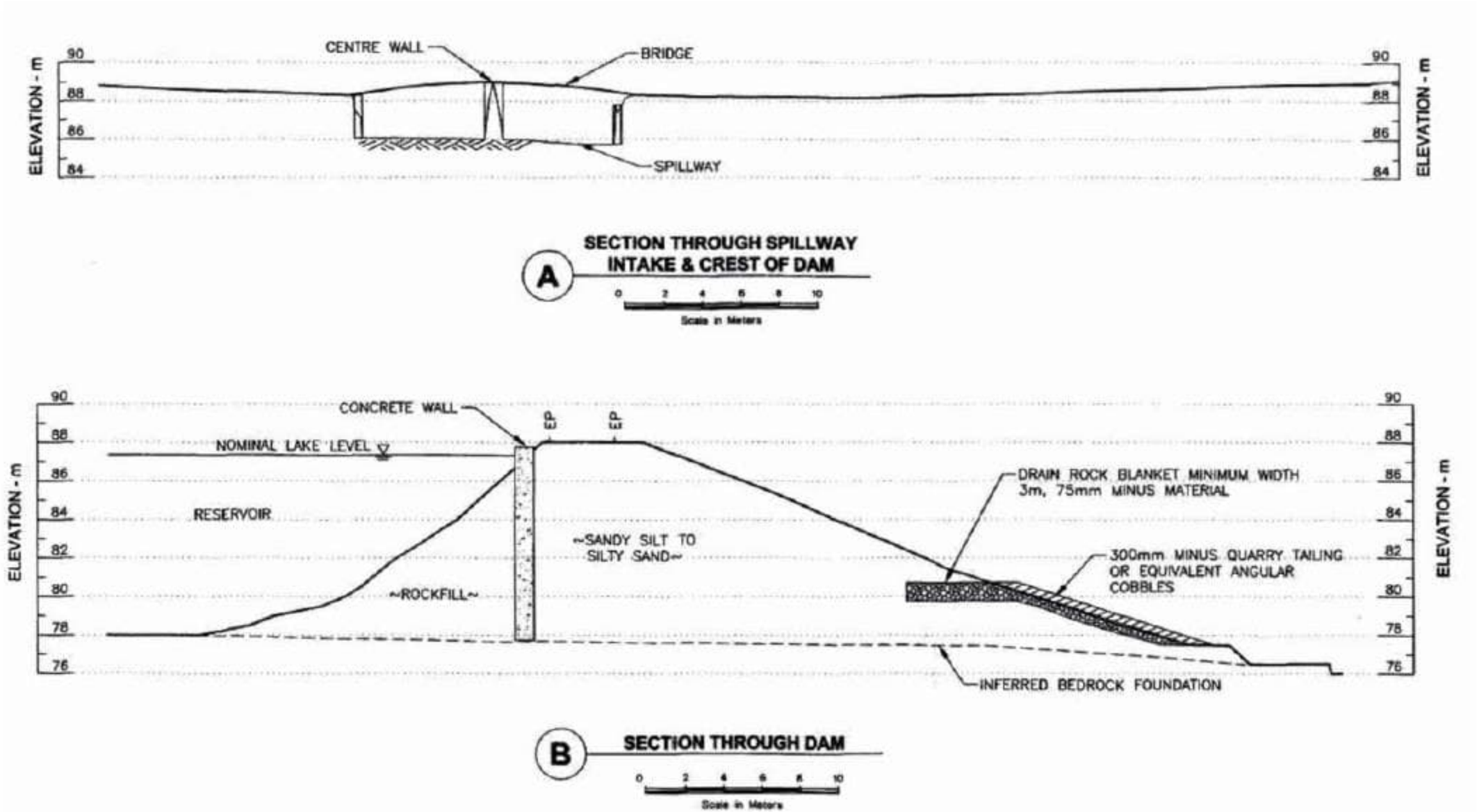



**Figure B14: Cross Sections of Middle Chase River Dam**
**(Figure taken from 2016 FADI)**

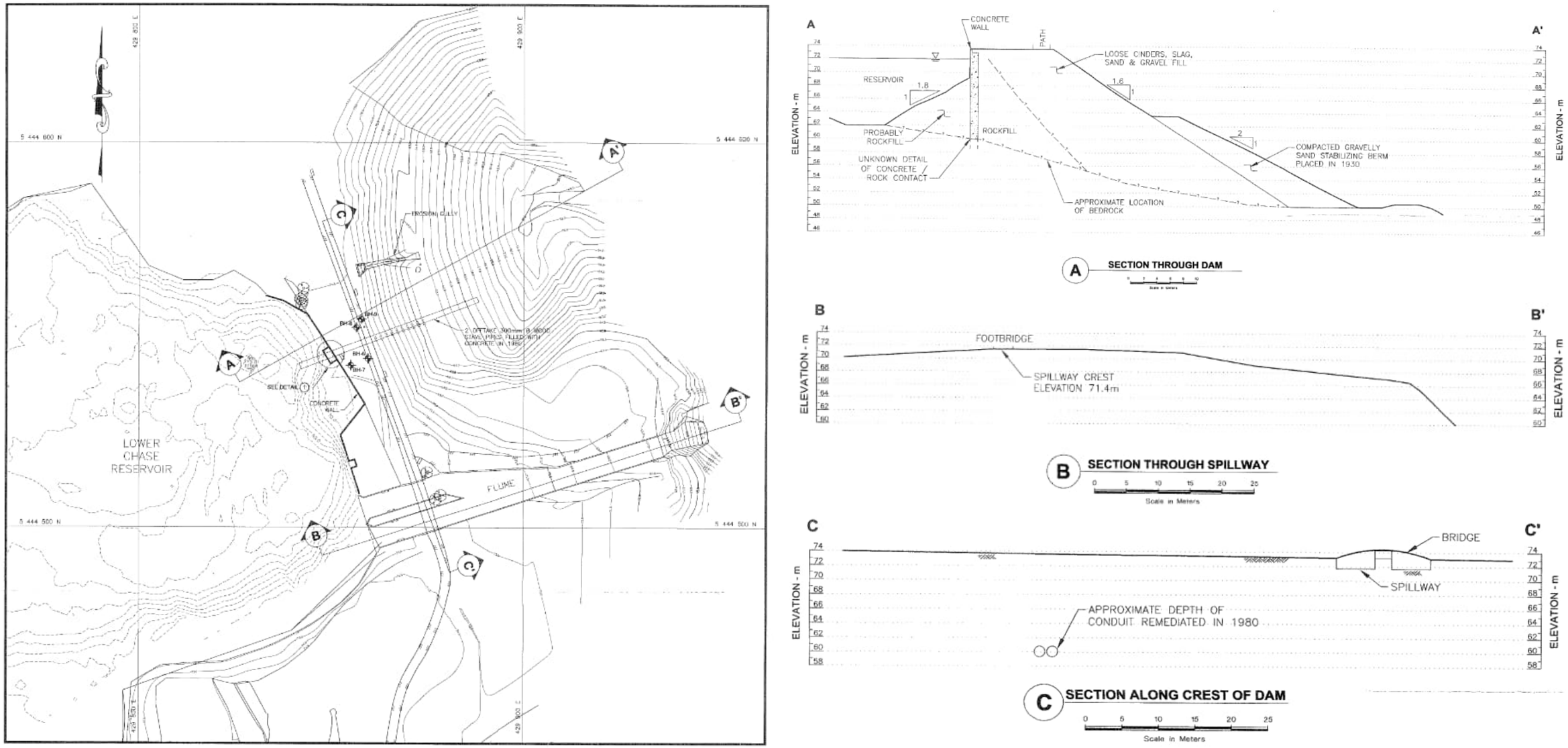



**Figure B15: Plan and Cross Sections of Lower Chase River Dam**
**(Figure taken from Drawing No. 15430)**

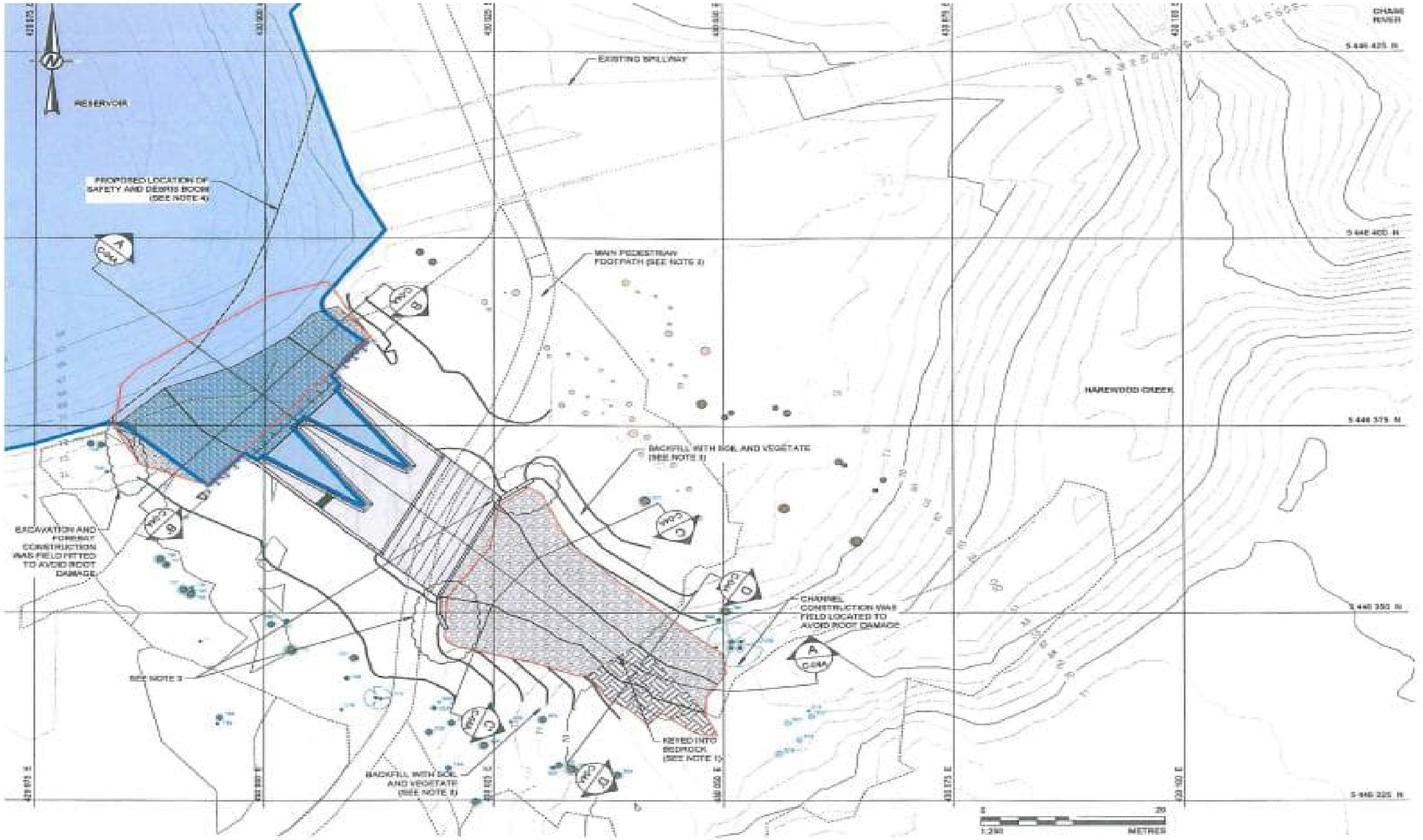



**Figure B16: General Plan of Lower Chase River Dam Auxiliary Spillway**
**(Figure taken from 2016 FADI)**

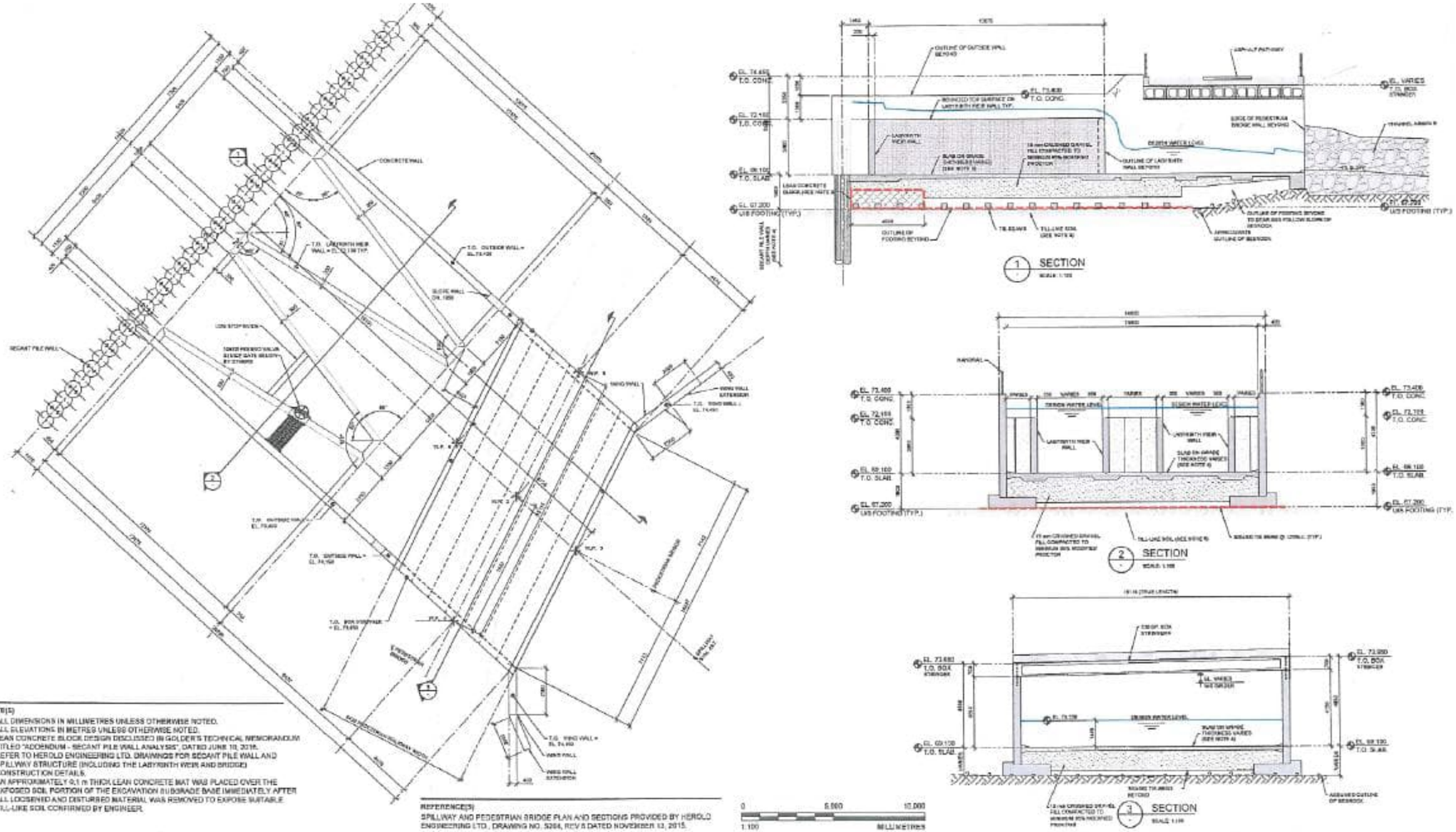



**Figure B17: General Cross Sections of Lower Chase River Dam Auxiliary Spillway**
**(Figure taken from 2016 FADI)**

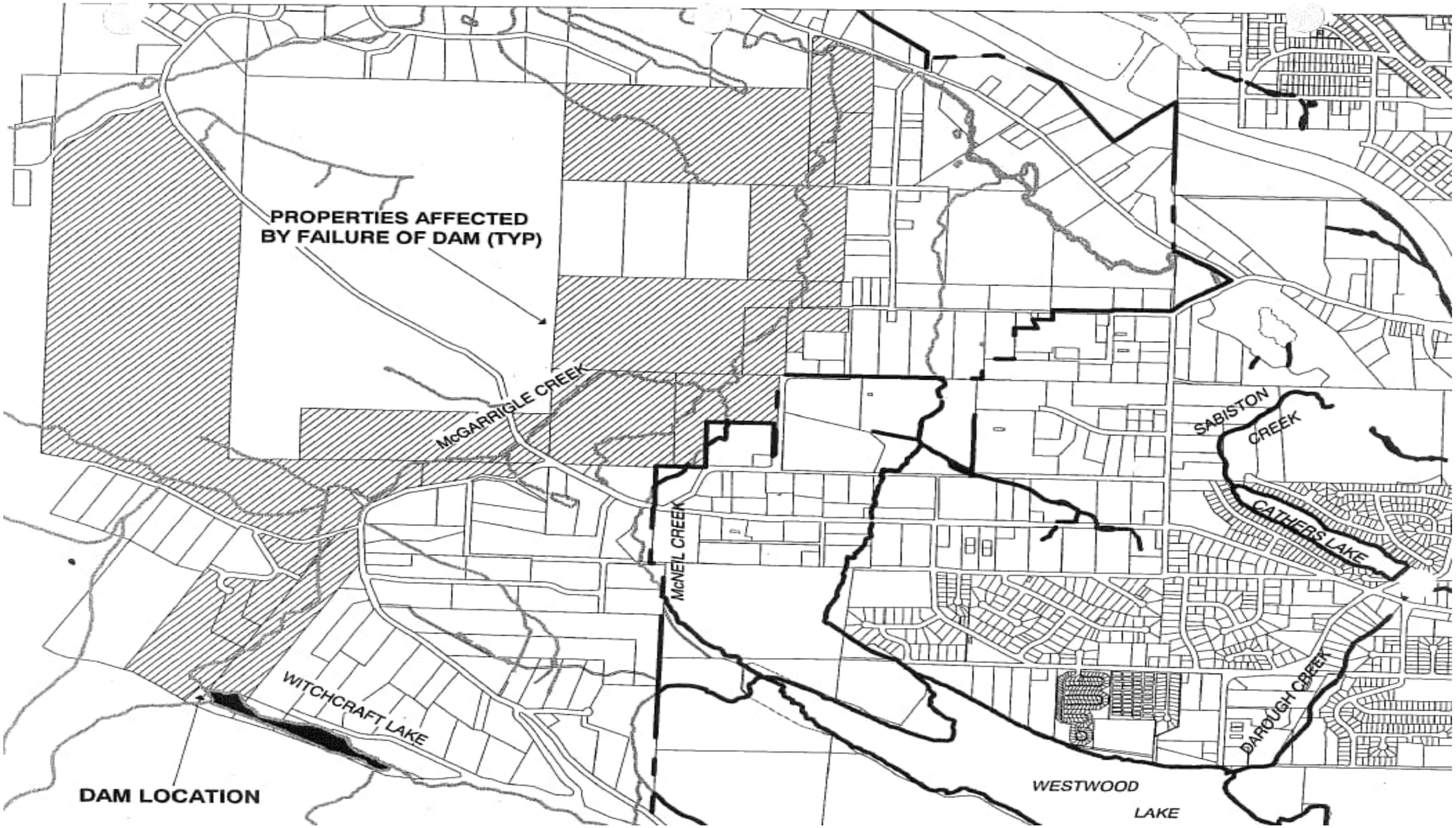



**Figure B18: Location of Witchcraft Lake Dam**

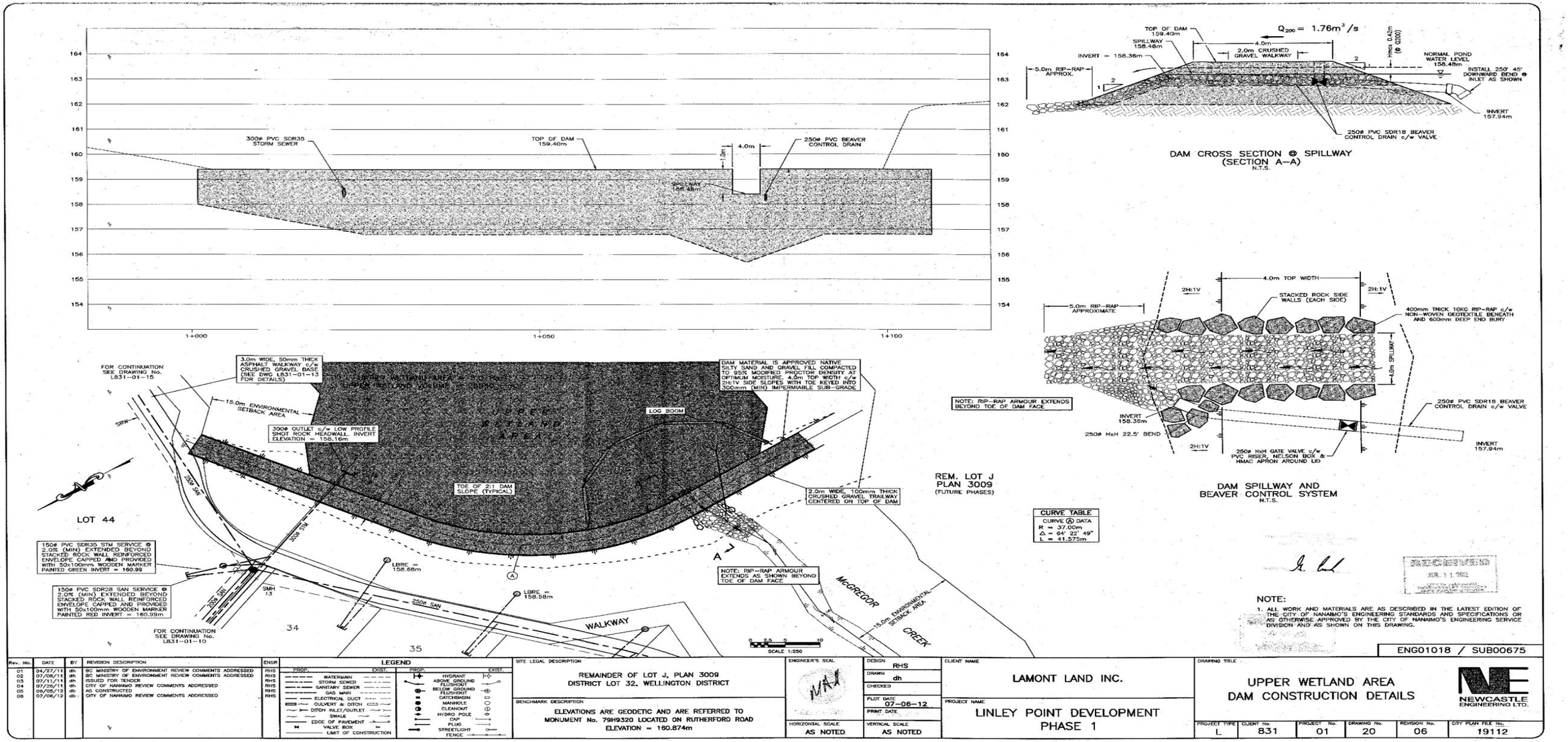



**Figure B19: McGregor Creek Dam – Details**

# Appendix C
# Inspection Photographs


**WWL 1: Reservoir, Crest of Main Dam and Upstream Stone Face of Main Dam**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 2: Trees at Crest of Main Dam and Downstream Slope**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 3: Upstream Concrete Face of Main Dam with Horizontal Cracking**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 4: Upstream Concrete Face of Main Dam with Joint Deterioration and Cracking**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 5: Upstream Stone Face of Main Dam**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 6: Dam Crest of Main Dam (Looking towards the Right Abutment)**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 7: Downstream Face of Main Dam where Part of the Buried Department of Fisheries pipe is Exposed**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 8: Downstream Face of Main Dam**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 9: Downstream Seepage Monitoring Weir**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 10: Seepage downstream of the monitoring weir**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 11: Saddle Dam Crest**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 12: Downstream Face of Saddle Dam**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 13: Upstream Face of Saddle Dam**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 14: Debris Accumulated at Upstream Toe of Saddle Dam and Light Furrowing on the Upstream Slope**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 15: Westwood Lake Outlet Concrete Sill (Outlet Channel)**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 16: Erosion Damage on Downstream Right Abutment of Bridge (Inlet Channel)**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023

**WWL 17: Undermining of the Dam Sacks and Dispersed Riprap at the Downstream Step in the Inlet Channel**

Location: Westwood Lake Dam (WWL)

Date: September 28, 2023


**R01 1: Empty Reservoir Looking Upstream from the Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023

**R01 2: Dewatered Reservoir Upstream of the Dam looking Downstream**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023

**R01 3: Upstream Face of the Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023


**R01 4: Downstream Face and Spillway of the Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023


**R01 5: Mechanical Equipment at Upstream Side of the Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023

**R01 6: 'V' Notch Weir Downstream of Dam**

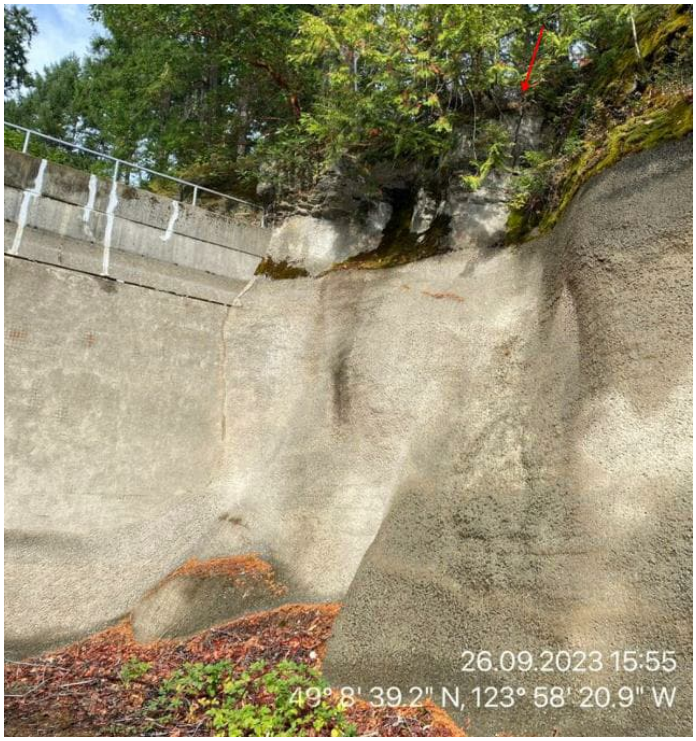
Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023

**R01 7: Right Abutment Wall Downstream of the Dam (Bedrock, Partially Covered in Shotcrete)**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023




**R01 8: Right Abutment Upstream of the Dam; Crack in the Bedrock above the Shotcrete Wall**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023


**R01 9: Drainage Pipe Downstream of Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26,2023


**R01 10: Fenced Reservoir Upstream of Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023


**R01 11: Left Abutment Slope and Wooden Access Stair and Handrail Downstream of Dam**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023


**R01 12: Right South End of the Reservoir where Rockslide Debris was Observed**

Location: Old Reservoir No. 1 Dam (N01)

Date: September 26, 2023

**HAW 1: Dam Crest from the Left Abutment**

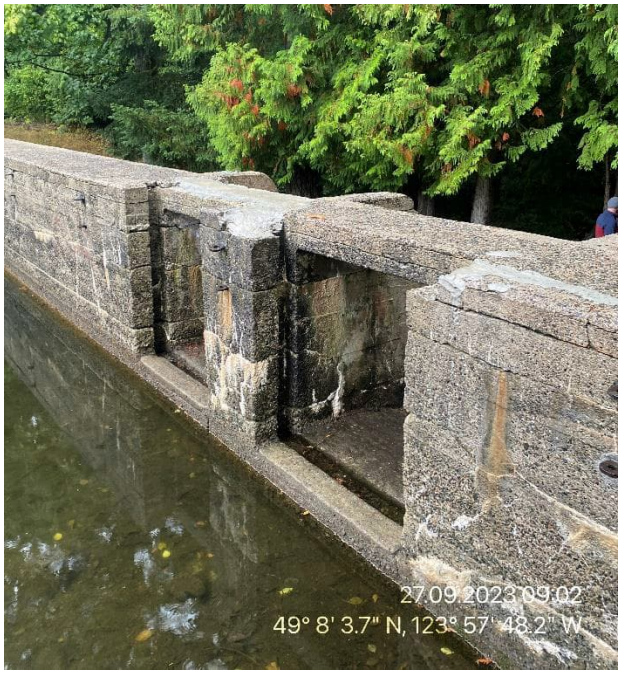
Location: Harewood Dam (HAW)

Date: September 27, 2023


**HAW 2: Dam Crest from the Right Abutment**

Location: Harewood Dam (HAW)

Date: September 27, 2023




**HAW 3: Upstream Face of the Dam and Spillway from Right Abutment**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 4: Concrete Deterioration of the Top of the Spillway Bridge**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 5: Spillway Chute looking Upstream**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 6: Spillway Slab at Downstream End**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 7: Downstream Side of the Dam**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 8: Concrete Deterioration at Downstream Face of the Dam**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 9: 'V' Notch Weir in Foreground, Stacked Rock Wall Beyond (Looking Upstream)**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 10: Spillway Chute Concrete Looking Upstream**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 11: Channel Downstream of Spillway with Minimal Riprap Protection**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 12: Gap in Joint at Top of Spillway Left Chute Wall**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**HAW 13: Right Side of Downstream Bench and Stacked Rock Wall**

Location: Harewood Dam (HAW)

Date: September 27, 2023


**HAW 14: Stacked Rock Wall**

Location: Harewood Dam (HAW)

Date: September 27, 2023


**HAW 15: Stacked Rock Wall and Wet, Spongy Area**

Location: Harewood Dam (HAW)

Date: September 27, 2023

**UCR 1: Buttressed Retaining Wall at Upstream Face of the Dam (Looking South)**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 2: Crest from Right Abutment of Concrete Face of Dam**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 3: Concrete Deterioration at Right Side of Buttress Wall of the Dam**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 4: Spillway Structure and FlowDar System (looking Downstream)**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 5: Undermining at the Base of Culvert Headwalls**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 6: Left Spillway Chute Wall with Crack at Water Gauge**

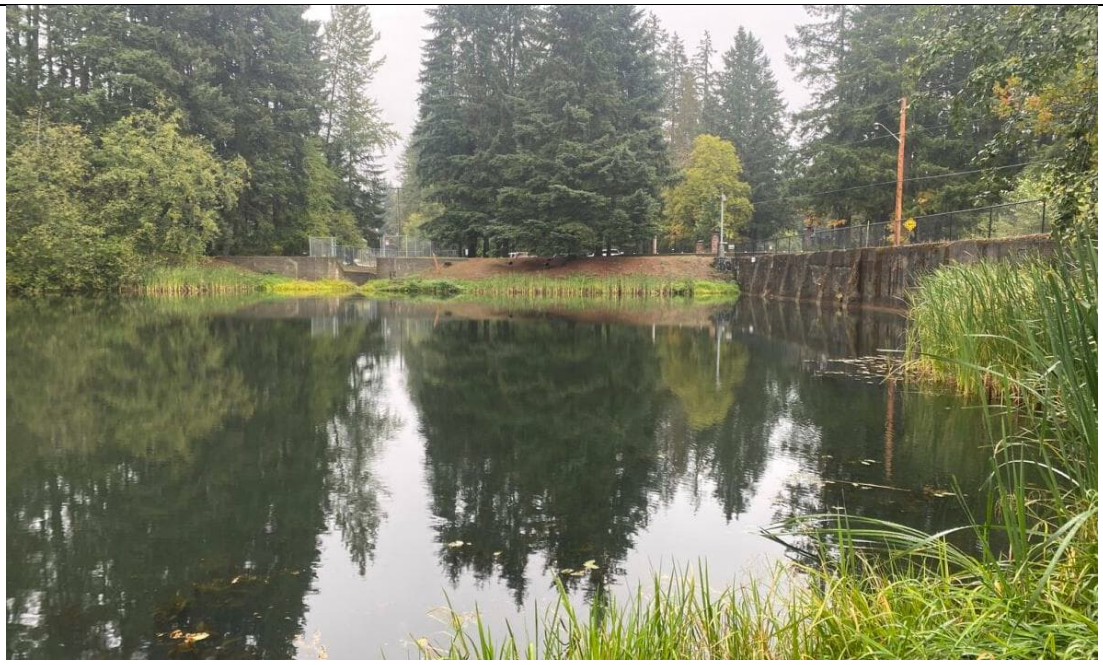
Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 7: Right Spillway Chute Wall with Crack at Drainage Pipe**

Location: Upper Chase River (UCR)

Date: September 27, 2023



**UCR 8: Embankment Dam and Vegetated Shoreline**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 9: Spillway Wingwalls from Left Abutment**

Location: Upper Chase River (UCR)

Date: September 27, 2023


**UCR 10: Spillway Wingwalls from Left Abutment**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 11: Surface Runoff Erosion Along Wingwall Slopes**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 12: Surface Runoff Erosion Along Wingwall Slopes**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 13: New Fencing Installed Along Buttress Dam**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**UCR 14: Camera Pole Foundation at Left Abutment**

Location: Upper Chase River (UCR)

Date: September 27, 2023

**MCR 1: Upstream Wall of the Dam (from Right Abutment)**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 2: Upstream Wall of the Dam and Spillway**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 3: Right Spillway Pier**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 4: Concrete Deterioration with Exposed Reinforcing Bars Underside of the Spillway Bridge Deck (Left Bay)**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 5: Concrete Erosion at Contact with Rock at Left Abutment of the Spillway Bridge Deck (Left Bay)**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 6: Spillway Chute Slab (Looking Downstream)**

Location: Middle Chase River (MCR)

Date: September 27, 2023


**MCR 7: Dam Reservoir.**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 8: Spillway Chute Structure**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 9: Bedrock at the Left Abutment.**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 10: Crest of the Dam (Looking at the Right Abutment)**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 11: Concrete/Bedrock at the Right Abutment**

Location: Middle Chase River (MCR)

Date: September 27, 2023


**MCR 12: Downstream Face of Dam**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 13: 'V' Notch Weir Housing at Downstream Toe**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 14: 'V' Notch Weir Concrete Housing (Weir Not Visible)**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 15: Newly Placed Riprap at the Left Embankment Beyond the Wing Wall**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 16: No Fence/Handrail and presence of Cobble cover at Left Side of Spillway**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 17: Upstream of Dam Looking Left Abutment**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**MCR 18: Concrete Crack at Top Corner of Centre Spillway Pier**

Location: Middle Chase River (MCR)

Date: September 27, 2023

**LCR 1: Upstream Face of the Dam with Reservoir (from Left Abutment)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 2: Safety Boom Upstream Side of Auxiliary Spillway**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 3: Spillway Structure (Downstream Side of Bridge)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 4: Spillway Chute Structure (Looking Upstream)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 5: Large Tree Downstream of the spillway Bridge on the Left Abutment**

Location: Lower Chase River (LCR)

Date: September 27, 2023


**LCR 6: Spillway Centre Pier Nose with Exposed Reinforcing Bar**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 7: Upstream Retaining Wall for Reservoir Access with Spalling Visible**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 8: Cracks at Upstream Lower Wall Corner**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 9: Erosion at the Base of the Spillway Chute Left Concrete Wall**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 10: Repair at the Base of Spillway Chute Left Wall**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 11: Spillway Chute Structure (looking Downstream)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 12: Scoured Rock Channel filled with Debris Downstream of Main Spillway Chute Slab**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 13: Auxiliary Spillway Structure Looking Upstream with Safety Boom Beyond**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 14: Downstream Face of Auxiliary Spillway Structure**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 15: Downstream Face of Auxiliary Spillway (Wet Area at Corner)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 16: Upstream Side of Auxiliary Spillway Structure and Log Boom Beyond**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 17: Large Trees at Right Abutment (Downstream)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 18: Large Trees at Left Abutment (Downstream)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 19: Wet Area at Downstream Toe of Dam**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 20: Steep Slope at Downstream Right Abutment with Vegetation, Seepage, and Wet Spots (from Downstream Face, Facing Towards Abutment and Downstream)**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 21: 'V' Notch Weir Housing at Downstream Toe**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 22: Well-Interlocked Riprap Downstream of Auxiliary Spillway Looking Downstream**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**LCR 23: Erosion at Upstream Rock Retaining Rock**

Location: Lower Chase River (LCR)

Date: September 27, 2023

**WCL 1: Left Abutment of Dam Showing High Degree of Deterioration**

Location: Witchcraft Lake Dam (WCL)

Date: September 28, 2023

**WCL 2: Left Abutment Looking Downstream**

Location: Witchcraft Lake Dam (WCL)

Date: September 28, 2023

**WCL 3: Dam Showing High Degree of Deterioration**

Location: Witchcraft Lake Dam (WCL)

Date: September 28, 2023

**WCL 4: Right Abutment of Dam**

Location: Witchcraft Lake Dam (WCL)

Date: September 28, 2023

**WCL 5: Inlet Channel Upstream of the Dam Showing Significant Erosion**

Location: Witchcraft Lake Dam (WCL)

Date: September 28, 2023

**MGC 1: Dam Crest (from Right Abutment of Spillway Bridge)**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023

**MGC 2: Upstream Slope of the Dam**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023

**MGC 3: Upstream Slope at Right Side of Spillway**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023


**MGC 4: Upstream Face (Looking towards the Right Abutment)**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023

**MGC 5: Vegetation on the Downstream and Upstream Face at Right Abutment**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023


**MGC 6: Downstream of Spillway**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023


**MGC 7: Log Boom at Upstream Side of Spillway Channel**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023

**MGC 8: Pedestrian Bridge and Spillway Channel (from Left Abutment)**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023

**MGC 9: Downstream Face of Dam**

Location: McGregor Creek Dam (MGC)

Date: September 27, 2023

# Appendix D
# City of Nanaimo – Mobile Dam Inspection Database September 2023

**City of Nanaimo Dam Inspection Database – Week Ending September 8, 2023**

Hatch undertook formal annual dam safety inspections of the City's recreational dams from September 26 to 28, 2023.

The readings of each dam from the City's dam inspectors at the closest inspection date prior to the Hatch inspection (note this inspection was 2 weeks prior to the Hatch inspection). Dam Inspector comments are included at the end of each dam inspection report.

**Upper Chase River Dam**

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Spillway Level:** | 0 cm |
| **Date:** | 30-Aug-23 | | |
| **Weather:** | Overcast | | |
| **Ground Condition:** | Wet | | |

**Weekly Inspection Checklist**

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| Reservoir | Bank Stability | Satisfactory | Add |
| | Debris | Minor | Add |
| | Tree Toppling | Minor | Add |
| | Valve Operation Completed | No | Add |
| Dam Crest | Cracking | Minor | Add |
| | Spalling | N/A | Add |
| Concrete Buttress Wall | Cracking | Moderate | Add |
| | Spalling | Major | Add |
| Spillway | Cracking | Minor | Add |
| | Debris | Minor | Add |
| | Movement | N/A | Add |
| | Spalling | Minor | Add |
| Downstream Slope | Cracking | Minor | Add |
| | Settlement | Minor | Add |
| | Vegetation Growth | Minor | Add |
| Ground Survey | Completed | No | Add |

## Middle Chase River Dam

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Weir Level:** | 0 cm |
| **Date:** | 07-Sep-23 | **Spillway Level:** | 0 cm |
| **Weather:** | Sun | | |
| **Ground Condition:** | Dry | | |

### Weekly Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| Reservoir | Bank Stability | N/A | Add |
| | Debris | N/A | Add |
| | Settlement | N/A | Add |
| Dam Crest | Cracking | N/A | Add |
| | Settlement | N/A | Add |
| Upstream Slope | Cracking | N/A | Add |
| | Settlement | N/A | Add |
| | Spalling | N/A | Add |
| Spillway | Cracking | N/A | Add |
| | Erosion | N/A | Add |
| | Movement | N/A | Add |
| | Spalling | N/A | Add |
| | Vegetation Growth | N/A | Add |
| | Tree Foliage Overhanging | N/A | Add |
| Downstream Slope | Movement | N/A | Add |
| | Spalling | N/A | Add |
| | Vegetation Growth | Minor | Add |
| Foot Bridge | Handrails | N/A | Add |
| | Deck (Underneath) | N/A | Add |
| | Abutment | N/A | Add |
| | Central Peir | N/A | Add |
| Ground Survey | Completed | No | Add |

## Lower Chase River Dam - Page 1

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Reservoir Level:** | 14 cm |
| **Date:** | 07-Sep-23 | **Weir Level:** | 1.5 cm |
| **Weather:** | Sun | **Spillway Level:** | 0 cm |
| **Ground Condition:** | Dry | **Auxiliary Spillway Seepage Weir Level:** | cm |

### Weekly Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| **Reservoir** | Bank Stability | Satisfactory | Add |
| | Debris | Minor | Add |
| **Dam Crest** | Cracking | Minor | Add |
| | Settlement | Minor | Add |
| Accelerometer Data Downloaded, Complete | | No | Add |
| **Upstream Slope** | Cracking | Minor | Add |
| | Settlement | Minor | Add |
| | Spalling | Minor | Add |
| **Spillway** | Cracking | Minor | Add |
| | Erosion | Minor | Add |
| | Movement | Minor | Add |
| | Spalling | Minor | Add |
| | Vegetation Growth | Moderate | Add |
| | Tree Foliage Overhanging | Moderate | Add |
| **Downstream Slope** | Cracking | N/A | Add |
| | Settlement | Moderate | Add |
| | Vegetation Growth | Minor | Add |
| **Tuff Boom** | East Anchor | Satisfactory | Add |
| | West Anchor | Satisfactory | Add |
| | Chain and Cable | Satisfactory | Add |
| | Logs | Satisfactory | Add |

| | | | |
|---|---|---|---|
| **Pedestrian Bridge** | Handrails | Satisfactory | Add |
| | Deck (Underneath) | Unsatisfactory | Add |
| | Abutments | Satisfactory | Add |
| | Central Pier | Satisfactory | Add |
| **Auxiliary Spillway** | | | |
| Debris Removed | | Yes | Add |
| Labyrinth Weir Condition (Leaks/Cracks) | | Satisfactory | Add |
| Log Stop (Installed) | | No | Add |
| Valve Sluice Gate Operated | | Yes | Add |
| Rip Rap | | Satisfactory | Add |
| Vegetation | | Moderate | View |
| **Harewood Creek** | Condition (Erosion) | Satisfactory | Add |
| **Auxiliary Spillway Bridge** | Handrails | Satisfactory | Add |
| | Deck (Above and Under) | Satisfactory | Add |
| | Abutments | Satisfactory | Add |
| **Ground Survey** | Completed | No | Add |

## Westwood Lake Dam

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Weir Level:** | 0 cm |
| **Date:** | 07-Sep-23 | **Siphon Gauge:** | 14.5 cm |
| **Weather:** | Sun | **Reservoir Level:** | -56 cm |
| **Ground Condition:** | Dry | | |

### Weekly Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| Reservoir | Bank Stability | Satisfactory | Add |
| | Debris | Minor | Add |
| | Tree Toppling | Minor | Add |
| Dam Crest | Cracking | N/A | Add |
| | Settlement | Minor | Add |
| Upstream Slope | Cracking | Minor | Add |
| | Settlement | N/A | Add |
| | Spalling | Minor | Add |
| | Loose Rocks in Concrete | Minor | Add |
| Downstream Slope | Cracking | N/A | Add |
| | Settlement | Minor | Add |
| | Vegetation Growth | Moderate | Add |
| Storm Sewer System | Riprap | Satisfactory | Add |
| | Energy Dissipator | Satisfactory | Add |
| **Saddle Dam** | | | |
| Saddle Dam Crest | Cracking | N/A | Add |
| | Settlement | Minor | Add |
| Saddle Dam Upstream Slope | Erosion | Minor | Add |
| | Settlement | Minor | Add |
| Saddle Dam Downstream Slope | Erosion | N/A | Add |
| | Settlement | N/A | Add |
| | Vegetation Growth | Major | Add |
| | Seepage | Minor | Add |

| Spillway at NW End of Lake | | | |
|---|---|---|---|
| **Concrete Sill** | Cracking | Minor | Add |
| | Debris | Moderate | Add |
| | Erosion | Minor | Add |
| | Spalling | N/A | Add |
| **Log Boom** | South Anchor | N/A | Add |
| | North Anchor | N/A | Add |
| | Chain and Cable | N/A | Add |
| | Logs | N/A | Add |
| **Ground Survey** | Completed | No | Add |

## Harewood Reservoir Dam

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Reservoir Level:** | -10 cm |
| **Date:** | 30-Aug-23 | **Weir Level:** | 0 cm |
| **Weather:** | Overcast | | |
| **Ground Condition:** | Wet | | |

### Monthly Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| **Reservoir** | Bank Stability | Satisfactory | Add |
| | Debris | N/A | Add |
| | Erosion | Minor | Add |
| | Tree Toppling | Minor | Add |
| **Dam Crest** | Cracking | Minor | Add |
| | Movement | N/A | Add |
| | Spalling | N/A | Add |
| **Upstream Face** | Cracking | Minor | Add |
| | Movement | N/A | Add |
| | Spalling | N/A | Add |
| **Downstream Face** | Cracking | Minor | Add |
| | Movement | N/A | Add |
| | Spalling | N/A | Add |
| **Spillway** | Debris | Minor | Add |
| | Cracking | Minor | Add |
| | Erosion | Minor | Add |
| | Movement | Minor | Add |
| | Spalling | Minor | Add |
| **Downstream Embankment** | Cracking | N/A | Add |
| | Seepage | Minor | Add |
| | Settlement | Minor | Add |
| | Vegetation Growth | Minor | Add |
| | Rock Wall Stability | Satisfactory | Add |
| | Low-Level Outlet | Deficient | Add |
| **Ground Survey** | Completed | No | Add |

## Linley Valley Dam

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Reservoir Level:** | cm |
| **Date:** | 07-Sep-23 | **Weir Level:** | cm |
| **Weather:** | Sun | | |
| **Ground Condition:** | Dry | | |

### Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| Reservoir | Debris | Minor | Add |
| | Tree Toppling | Minor | Add |
| Dam Crest | Settlement | Minor | Add |
| | Erosion | Minor | Add |
| Upstream Slope | Settlement | Minor | Add |
| | Erosion | Minor | Add |
| | Vegetation Growth | Minor | Add |
| Downstream Slope | Settlement | Minor | Add |
| | Erosion | Minor | Add |
| | Vegetation Growth | Minor | Add |
| | Seepage | Minor | Add |
| Spillway | Debris | Moderate | Add |
| | Vegetation Growth | Minor | View |
| Log Boom | South Anchor | Satisfactory | Add |
| | North Anchor | Satisfactory | Add |
| | Chain and Cable | Satisfactory | Add |
| | Logs | Satisfactory | Add |
| Beaver Control System | Pipe | Unsatisfactory | Add |
| | Control Valve | Satisfactory | Add |
| Downstream Culvert | Debris | Minor | Add |
| | Vegetation Growth | Minor | Add |
| Ground Survey | Completed | No | Add |

## No.1 Reservoir Dam

| | | | |
|---|---|---|---|
| **Inspected By:** | Troy Monsell | **Weir Level:** | 0 cm |
| **Date:** | 21-Mar-23 | **Spillway Level:** | 0 cm |
| **Weather:** | Overcast | | |
| **Ground Condition:** | Dry | | |

### Weekly Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| Reservoir | Bank Stability | Satisfactory | View |
| Dam Crest | Cracking | Minor | Add |
| | Spalling | Moderate | View |
| Upstream Slope | Cracking | Minor | Add |
| | Spalling | Minor | Add |
| Downstream Slope | Cracking | Minor | Add |
| | Seepage | Minor | Add |
| | Settlement | N/A | Add |
| | Spalling | Minor | Add |
| | Rock Slope | Satisfactory | Add |
| Spillway | Cracking | Minor | Add |
| | Erosion | Minor | Add |
| | Movement | N/A | Add |
| | Spalling | Minor | Add |
| Ground Survey | Completed | No | Add |
| Valve Operation | Completed | No | View |

**NOTE:**
The low level outlet valve should be manually operated in March and October of each year

## Witchcraft Lake Dam

| | | | |
|---|---|---|---|
| **Inspected By:** | B Martin | **Reservoir Level:** | 18 cm |
| **Date:** | 04-Jul-23 | | |
| **Weather:** | Sun | | |
| **Ground Condition:** | Dry | | |

### Monthly Inspection Checklist

| Feature | Concern | Rating | Comments |
|---|---|---|---|
| Reservoir | Flow from Diversion Creek | Moderate | View |
| Downstream Slope | Movement | Minor | Add |
| | Settlement | Minor | Add |
| | Seepage | Minor | Add |
| Dam Breach Area | Log Cribbing | Unsatisfactory | Add |
| | Waterflow Increase | Minor | Add |
| Diversion Channel | Condition | Satisfactory | Add |
| | Erosion | Moderate | Add |
| Ground Survey | Completed | No | Add |

**NOTE:**
Photos of the dam breach and diversion channel are requried in June and October.
Provide the digial images to Water Resources by uploading them to the folder:
**G:\Utilities\Water\Resources\DAMS\Witchcraft Lake Dam\Photos\<date>**