



THE CITY OF NANAIMO

OPERATION, MAINTENANCE AND SURVEILLANCE (OMS) MANUAL for CHASE RIVER DAMS

- Upper Chase River Dam
- Middle Chase River Dam
- Lower Chase River Dams

<i>Revision</i>	<i>Date</i>	<i>Remarks</i>
0	Nov/03	Draft for review
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(Revision 1 only)

PREFACE

This Operation Maintenance and Surveillance Manuals (OMS) has been prepared to establish in one central reference document (with associated supporting documents) comprehensive, accurate, current, structure-oriented operating instructions for each dam and reservoir and related structures.

The purpose of the OMS manual is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The Manual is prepared primarily for the use of the person or persons (**Watershed Inspectors**) located at or nearest to the dam, and immediate supervisors, who are assigned responsibility for the physical operation and maintenance of the dam.

THIS OPERATION, MAINTENANCE AND SURVEILLANCE MANUAL (OMS) CONTAINS, AS A MINIMUM, ALL INFORMATION AND INSTRUCTIONS NECESSARY FOR THE WATERSHED INSPECTORS TO PERFORM THEIR DUTIES. In addition, the instructions will permit responsible persons who are knowledgeable in reservoir operation but are unfamiliar with the conditions at a particular dam to operate the dam and reservoir during emergency situations and at such other times when the regular operator cannot perform his normal duties.

Because the Upper, Middle, and Lower Chase Dams occupy one single watershed and spill water from one to another they are treated as a single entity from an operations standpoint.

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1.0 GENERAL INFORMATION

1.1 Purpose

This Operations, Maintenance and Surveillance (OMS) Manual provides a central reference document to be used by personnel responsible for the operation and maintenance of the Chase River Dams owned by The City of Nanaimo. This manual contains background information on the dams and provides basic guidelines, procedures and instructions for the operation, maintenance and inspection of the facilities.

This manual is prepared for the use of operating personnel who are assigned the direct responsibility for operation and maintenance of the system.

1.2 Overview

The City of Nanaimo owns and operates the Chase River Dams as part of the City's Colliery Dams Park. The dams are located on the south part of the City of Nanaimo (see Figure 1) southwest of Nanaimo on the Chase River and are accessed by way of either Wakesiah Avenue or Nanaimo Lakes Road. There are three dams on the system:

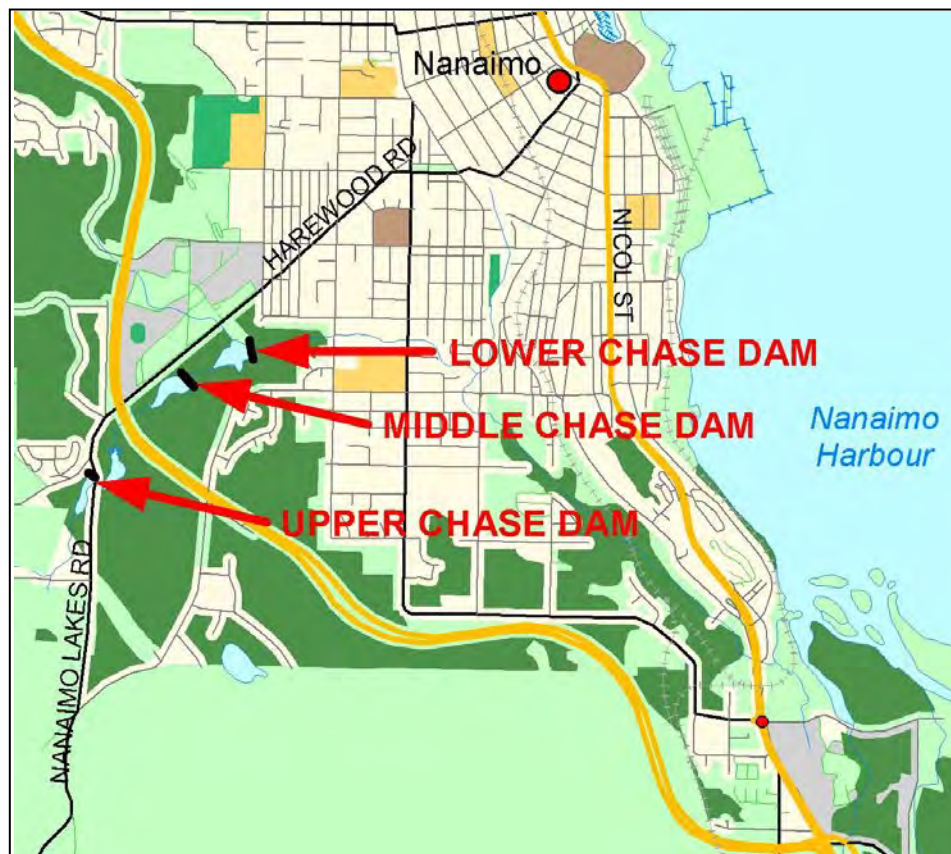


Figure 1: Site Location Plan

- **Lower Chase River Dam** (former names include *Lower Harewood Dam* and *Lower Colliery Dam*);
- **Middle Chase River Dam** (former names include *Upper Harewood Dam*, *Upper Colliery Dam*, and “*Howard # 3*” dam); and
- **Upper Chase River Dam** (former name No2 Reservoir Dam).

The reservoirs no longer store water for consumption and are only used for recreation activities such as swimming, fishing and enhancing the nature walks in the park.

The three dams are located in the same watershed, which is shown on Figure 2. Flows in the Chase River show a quick response to rainfall and with only minimal base flow in the dry summer months. There are no spillway gates or other valves/controls. Water flows through each dam in turn, using passive spillways that require no attention other than ensuring they do not become blocked.

All three dams were inherited by the City and date back to the early part of the 20th Century when coal mining was important. A description of some aspects of this era can be found in Bowen (2002). The Lower and Middle Chase dams were constructed around 1910 for water supply to Harewood Colliery. The Upper Chase Dam is thought to have been constructed in the period between 1911 and 1930, but both the actual date and the reason for its construction is unknown.

A consequence of the historic nature of all three dams is that there are no records of the original construction of the dams, nor of their design. The absence of this information makes ongoing inspection a most important role to the continued safety of these dams.

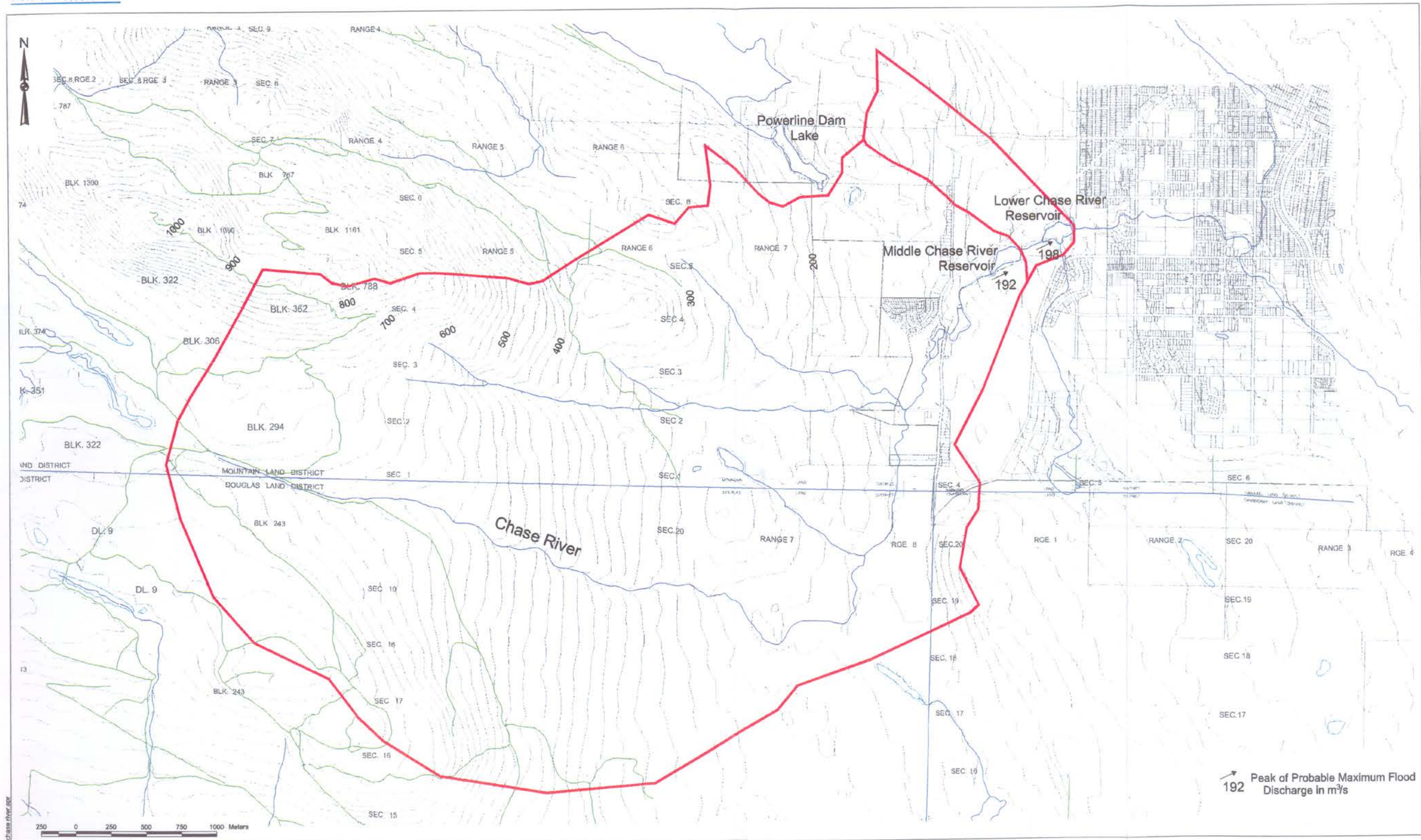


Figure 2 – Chase River Watershed

The principal structures at each of the dams are as follows:

- Lower Chase River Dam
 - Embankment dam
 - Concrete spillway structure
 - Upstream concrete retaining wall
 - Footbridge for recreational trail

- Middle Chase Dam
 - Embankment dam
 - Upstream concrete retaining wall
 - Spillway on rock with concrete training wall
 - Footbridge for recreational trail

- Upper Chase Dam
 - Embankment dam
 - Upstream concrete retaining wall
 - Concrete spillway channel with 2 corrugated steel culverts under the roadway
 - 450 mm dia offtake pipe with gate valve

Both Lower and Middle Chase dams have had engineered stability enhancement or other remediation since being taken over by the City. The Upper Chase Dam had an engineered water offtake constructed in 1999.

All three dams have been subject to periodic safety review (in 1978, 1992 and 2003). There are no known *actual deficiencies* with the dams. The only known *potential deficiencies* with the dams relate to earthquakes or extreme storms, and are discussed later in this manual. It is anticipated that these potential deficiencies will be addressed over the next five years.

Key dam and reservoir statistics are summarized on Table 1.

Record drawings, showing the best estimate of the configuration of the dams and their internal details based on reconstruction of available records and 2003 survey data, are presented in Appendices 1 – 3 for Upper, Middle and Lower Chase dams respectively.

Table 1: Key Statistics for Chase River Watershed and Dams

Upper Chase Dam <i>License N^o22586 (4-Jul-1955)</i>	<ul style="list-style-type: none"> • Part concrete with granular downstream shell • Part earthfill with unknown zonation
Maximum Height	<ul style="list-style-type: none"> • Concrete section: about 6 m • Earthfill section: about 3 m
Length along Crest	<ul style="list-style-type: none"> • Concrete section: 64 m • Earthfill section : 33m
Catchment Area	<ul style="list-style-type: none"> • 2200 Ha approximately
Retained water (normal pool)	<ul style="list-style-type: none"> • 62,000 m³
Offtake works	Pipe attached to concrete section and with valve in road. Discharges to No 1 Reservoir
Spillway	<ul style="list-style-type: none"> • Unregulated spillway designed to discharge under normal operating conditions • Concrete walled channel with twin culverts under road
Hazard rating	<ul style="list-style-type: none"> • HIGH

Middle Chase Dam <i>License N^o61424 (27-Sept-1985)</i>	<ul style="list-style-type: none"> • Concrete core, rockfill/granular shell • 1 filter zone on downstream side
Maximum Height	<ul style="list-style-type: none"> • 13 m
Length along Crest	<ul style="list-style-type: none"> • 50 m
Catchment Area	<ul style="list-style-type: none"> • 2600 Ha approximately
Retained Water (normal pool)	<ul style="list-style-type: none"> • 110,000 m³
Offtake works	<ul style="list-style-type: none"> • None working; historical system may be under right part of dam and unplugged
Type of Spillway	<ul style="list-style-type: none"> • Unregulated spillway designed to discharge under normal operating conditions • Concrete walled channel on exposed bedrock
Hazard rating	<ul style="list-style-type: none"> • HIGH

Lower Chase Dam <i>License N^o61423 (27-Sept-1985)</i>	<ul style="list-style-type: none"> • Concrete core, rockfill/granular shell • 1 filter zone on downstream toe
Maximum Height	<ul style="list-style-type: none"> • 24 m
Length along Crest	<ul style="list-style-type: none"> • 77 m
Catchment Area	<ul style="list-style-type: none"> • 2600 Ha approximately
Retained Water (normal pool)	<ul style="list-style-type: none"> • 122,000 m³
Offtake works	<ul style="list-style-type: none"> • None working; decommissioned and backfilled with concrete in 1980.
Type of Spillway	<ul style="list-style-type: none"> • Unregulated spillway designed to discharge under normal operating conditions • Concrete channel
Hazard rating	<ul style="list-style-type: none"> • HIGH

1.3 Dam Access and Communications

The Chase River Dams are located off Nanaimo Lake Road, and all three are readily accessed using passenger cars. Parking is provided at both Lower and Middle Chase dams. Cars can pull in off Nanaimo Lakes Road adjacent to Upper Chase Dam.

In an emergency, if access via Nanaimo Lakes Road is blocked, helicopter service is available from:

- | | | |
|----|-------------------------|----------------|
| 1) | West Coast Helicopters | 250-754-5448 |
| 2) | Trans North Helicopters | 1-250-723-1622 |
| 3) | Canadian Helicopters | 1-604-278-5502 |
| 4) | Vancouver Helicopters | 1-604-688-4646 |

Helicopters can be landed on the Ministry of Defense ground adjacent to Lower and Middle Chase dams, or on the road upstream of Upper Chase dam. The dams can also be accessed from the Nanaimo Parkway by walking through GNWD property.

There are no communication facilities at the Lower and Middle Chase River Dams, but cellular phones will work in the area.

There is a phone in the Morell Sanctuary Office at 1050 Nanaimo Lakes Road across the road from the Upper Chase Dam.

1.4 Assignment of Responsibility

The City Of Nanaimo Engineering (755-4409) or 758-5222 (operations) can be contacted regarding maintenance of the Chase River Dams. The administrator responsible for the operation and maintenance of these dams is: Mac MacKenzie, Chief Commissioner (756-5301). Operational responsibility is delegated to: Scott Crane, Manager of Utilities (756-5305) and Wayne Hansen, Superintendent, Water Supply (755-4409).

The City of Nanaimo employee responsible for the day-to-day maintenance and the inspections of the dam is referred to as the **Watershed Inspector**.

The dam **Watershed Inspector** works under the supervision of the **Water Supply Foreman**, Ritchie Fulla (756-5324).

1.5 Distribution and Revision of OMS Manual

The City of Nanaimo is responsible for the update, distribution, and maintenance of each copy of the Manual. The distributions are shown inside the front cover. Revisions will be distributed as they are issued and each copy of the manual must show the date of its latest revision.

Formal procedures are established for revising the Manual every 5 years or sooner if deemed necessary by the City of Nanaimo. However, all users should note any significant departures in either the operating and maintenance practice and notify Engineering of such instances (contact Scott Pamminger). These notifications will be reviewed and either practice revised to conform to the instructions or the instructions in this manual revised to agree with the changed practice.

1.6 Reference Documents

Reference documents and reports on the Chase River Dams are given in the References at the end of this document.

2.0 DESCRIPTION OF CHASE RIVER DAMS

2.1 History of Chase River Dams

2.1.1 Lower Chase River Dam

The history of the dam is obscured by the lack of records and documentation before 1977. Important dates are:

- ~ 1910: constructed by Harewood Colliery;
- ~ 1945: taken out of service with Colliery;
- 1975 ownership passed to City of Nanaimo (Parks & Recreation);
- 1977 Inspection by Province leading to requirement for licensing;
- 1978 Investigation of dam's condition and design of remedial work (Willis, Cunliffe & Tait and Golder Associates);
- 1980 Remediation of dam (directed by Willis, Cunliffe & Tait). Remediation comprised in particular the removal of offtake valves and their replacement with concrete together with construction of a toe berm to increase dam stability;
- 1981 Remediation of concentrated seepage/washout from left abutment;
- 1987 Dayton & Knight produced dam "data file";
- 1992 Inspection by EBA and development of "data book";
- 1993 Responsibility for the dam transferred to Engineering from Parks & Recreation;
- 2003 Vegetation clearance and installation of seepage monitoring weir;
- 2003 Inspection and Dam Safety Review (DSR) by Golder Associates; and
- 2003 Underwater survey of reservoir and dam face by AquaCoustic.

2.1.2 Middle Chase River Dam

The history of the dam is obscured by the lack of records and documentation before 1977. Important dates are:

- ~ 1910: constructed by Harewood Colliery;
- ~ 1945: taken out of service with Colliery;
- 1975 ownership passed to City of Nanaimo (Parks & Recreation);
- 1977 Inspection by Province leading to requirement for licensing;
- 1978 Investigation of dam's condition and design of remedial work (Willis, Cunliffe & Tait + Golder Associates);
- 1980 Remediation of dam (directed by Willis, Cunliffe & Tait). Remediation involved substantial reconstruction of the downstream shell;
- 1987 Dayton & Knight produced dam "data file";
- 1992 Inspection by EBA and development of "data book";

- 1993 Remediation of concentrated seepage from right abutment;
- 1995 Extension of concrete spillway wall and installation of seepage monitoring weir;
- 1993 Responsibility for the dam transferred to Engineering from Parks & Recreation;
- 2003 Inspection and Dam Safety Review (DSR) by Golder Associates; and
- 2003 Underwater survey of reservoir and dam face by AquaCoustic.

2.1.3 Upper Chase River Dam

The history of the dam is obscured by the lack of records and documentation before 1955, and even the original purpose of the dam is unclear. Important dates are:

- 1911-30: Dam constructed within this period and probably as a supporting abutment for road rather than as a dam;
- 1955 ownership passed from Canadian Collieries Ltd to Greater Nanaimo Water District;
- 1978 Inspection by Golder Associates found dam in excellent condition, with clearly adequate stability;
- 1992 Inspection by EBA found dam in good condition but with some concrete spalling;
- 1998 Construction of offtake pipe to act as emergency water supply to Reservoir #1, engineered by Reid Crowther; and
- 2003 Inspection and Dam Safety Review (DSR) by Golder Associates.

2.2 Dam Details

2.2.1 Upper Chase Dam

Upper Chase dam is believed to be about seventy years old having been constructed somewhere in the period 1911 to 1930. Little is known of its history or even, surprisingly, the reason for its construction. A map from 1911 (Department of Mines Geological Survey, Map 160A) shows a natural small lake where Reservoir #2 exists today but does not show any dam and does show water flowing to Reservoir #1. No photographs have been found of the dam during its construction or in its early years.

The dam is “L” shaped in plan. One section comprises a mass concrete wall supported by earthfill downstream and is some 64 m long and with a maximum height of about 6m. The other section is an earthfill dam that leads to the spillway in the left abutment. The earthfill section is both lower, 2.5m, and shorter, 33m.

The eastern concrete section of the dam has no design or construction drawings, nor have any cores of the concrete or tests for rebar been carried out. It appears directly founded on bedrock.

The southern earthfill embankment section also has no available details on how it was built, nor has any subsequent testing been carried out. However, it only retains water when the spillway has about a 0.3m depth at the entrance.

The spillway channel is concrete and parallel sided with near horizontal base. It leads to two culverts passing under the road, with a drop from the channel to the culvert entrance.

The dam is evidently an engineered structure from the carefully formed buttresses and care in the finishing of the concrete. However, the buttresses are on the upstream side of the dam and give the impression that the dam was first engineered to act as a retaining wall for the fill bringing Nanaimo Lakes Road to its current level.

The District constructed a pipe through the dam in 1998 to divert water to the No 1 Reservoir that is just the other side of the road. This diversion is used as an emergency water source.

Appendix 1 provides plan and section information for Upper Chase dam, based on surveys carried out in 2003 and a synthesis of available data. This synthesis is partly based on the As-Built drawing from construction of the offtake pipe to Reservoir #1 in 1998 (Reid Crowther project 37065-00/ Dwg 12940-1-98).

2.2.2 Middle Chase Dam

The Middle Chase Dam is an historic structure nearly 100 years old. No records appear to have survived from when it was constructed, and the understanding of the dam is based on work carried out over the past twenty five years as now documented.

Middle Chase dam is a mixed earthfill and concrete structure. A thin concrete core provides the impervious barrier, and also forms the front face of the dam at normal pool level in the reservoir. This concrete wall is supported by fill both upstream and downstream.

The concrete core wall is 0.6m thick at the top. There is no data or test results to show whether or not the concrete wall is reinforced, although the rebar found in the old spillway crest suggests that it might be. There are no expansion or other movement joints apparent in the concrete wall, although these might have been covered by the 1 ft crest raise concrete placed in 1980. It is unclear whether the wall thickens with depth. The

concrete core wall is presumed to extend to full depth and be founded on bedrock. Evidence for this presumption comes from the rather large excavation in 1980 as part of the dams remediation. Nothing is known about the construction detail at the concrete contact with bedrock.

On the upstream side, the core wall is supported by fill with an average slope of 1.5V:1H. This upstream shell is believed to be rockfill based on the slope; however a photograph taken while the reservoir was low in 1980 indicates a more silt-like material on the surface. There are no boreholes extending through the upstream shell. The top of this upstream fill is below the normal reservoir surface, with a metre or so of water at the core wall with normal pool conditions.

The downstream shell has a nominal 2H:1V slope and was extensively rebuilt in 1980. No grading curves of the shell material are available but the inspector from the engineer (Willis, Cunliffe & Tait) directed placement of acceptable fill. It is presumed that this was a sandy gravel pit run material. It was compacted. The slope is covered with grass.

A gravel filter drain to intercept seepage through the dam and abutment was installed in the 1980 remediation. This gravel was topped with a layer of shot-rock.

Concentrated seepage was reported in the right abutment at about mid-slope during the 1992 inspection, and this was channeled to the filter drain (EBA, 1993).

There are no presently working offtake works, the dam only being used for recreation. However, the dam was built for water supply and a disused low-level outlet valve structure existed upstream of the dam in 1978. At that time the offtake pipe was thought to be a woodstave extending through the body of the dam from the upstream control valve. Excavations were undertaken to find the offtake pipe in the dam during 1980 and fill it with concrete. However, despite extensive excavations that exposed a substantial amount of the core wall, the pipe was not found. The underwater slope of the upstream shell was imaged using a sidescan sonar in November 2003, and no pipe or other offtake works were seen. The evidence is therefore that the offtake pipe had been removed at some time in the past.

Appendix 2 provides plan and section information for Middle Chase dam, based on surveys carried out in 2003 and a synthesis of available data to give the best estimate of the internal configuration of the dam.

2.2.3 Lower Chase Dam

Lower Chase Dam is also a historic structure nearly 100 years old, being apparently built near the same time as Middle Chase dam and by the same company. In many respects, both dams are similar, Lower Chase also having a concrete core wall as its impervious barrier and with this wall supported by earthfill upstream and downstream.

Also like the Middle Chase dam, no records on Lower Chase dam appear to have survived from when it was constructed. The understanding of the dam is based on work carried out over the past twenty five years as now documented.

A concrete wall provides the impervious barrier, and also forms the front face of the dam at normal pool level in the reservoir. This wall is 0.3m thick at the top and extends at this thickness to 0.6m below the crest. It then thickens to a reported 1.2m (EBA, 1992), and a horizontal construction joint is evident. It is unclear whether the wall thickens further with depth. There is no data or test results to show whether or not the concrete wall is reinforced, although this would be likely. There are no expansion or other movement joints apparent in the concrete wall.

The concrete core wall is presumed to extend to full depth and be founded in dense till or on bedrock. Evidence for this presumption comes from the concrete valve tower on the front face of the dam that extended to a measured depth of 15m, which ought to be original valley bottom as estimated from the depth to dense material found in the nearby Borehole #9 (put down as part of the 1978 investigation).

There have apparently been no concrete cores taken over the years and the strength of the concrete is unknown. However, the concrete is weathering well and there are no apparent signs of deterioration.

On the upstream side, the core wall support is unknown. The upstream shell has a slope of 2H:1V but the nature of the fill is uncertain. There are no boreholes extending through the upstream shell. Earlier drawings of the dam have indicated a rockfill upstream shell, and it is thought that this is an assumption based on rockfill being found in the downstream shell. The downstream fill extends to the base of the concrete tower that is freestanding in the reservoir upstream of the dam.

The downstream shell comprises loose sand and gravel placed over rockfill. A compacted sand and gravel toe berm was added in 1980 to stabilize the downstream slope. However, the upper slope above the berm was left in place at an average slope of about 1.5 H:1V and has experienced ongoing creep settlements.

A gravel filter drain to intercept seepage through the dam and abutment was installed in the 1980 remediation.

The dam is not straight in plan at present, with what appear to be non-structural extension of the dam upstream in both abutments. These are seemingly only to provide better recreational access.

According to photographs taken during a 1981 inspection there was washout/erosion incident in the contact of the dam with the Left Abutment. There were no notes about the remediation of this area, but it was found in good condition with no sign of further washout during the 2003 DSR.

There are no presently working offtake works or other low-level outlet. Lower Chase Dam was built for water supply and this was achieved using two woodstave pipes that went from an upstream inlet through the body of the dam. The control valves were located in a valve tower on the front face of the dam. This offtake arrangement was remediated in 1980 by: removing the control valves; filling the woodstave pipes with concrete; and, backfilling the valve access tower.

Appendix 3 provides plan and section information for Lower Chase dam, based on surveys carried out in 2003 and a synthesis of available data to give the best estimate of the internal configuration of the dam.

2.3 Stored Water

Estimated retained water volume versus water level curves were developed for both the Lower and Middle Chase dams some fifteen years ago (Dayton & Knight, 1987). These stored water curves were based on available contour drawings at the time. The estimates of stored water were updated by the recent bathymetric survey (Aquacoustics Remote Technologies, 2003) of the two reservoirs. The computed capacities are shown on Figure 3a and 3b for the Middle and Lower Chase dams respectively. The recent surveys show rather more stored water in the Middle Chase Reservoir than thought in 1987, and comparable storage at Lower Chase. The 2003 estimates are likely the most reliable; the 1987 data is shown for continuity with past documentation of the dams.

There is no available retained volume versus water level curve for the Upper Chase Dam. Prior reports suggest a maximum retained volume of 62,000 m³ but the origin of this estimate is unknown.

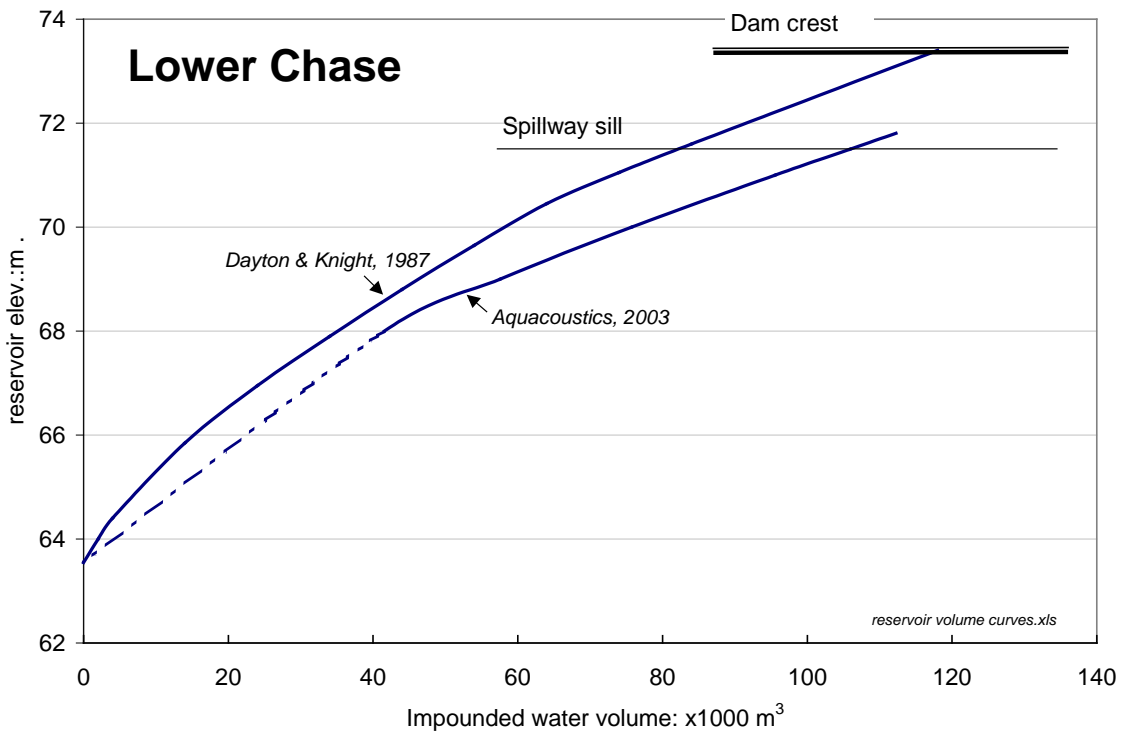
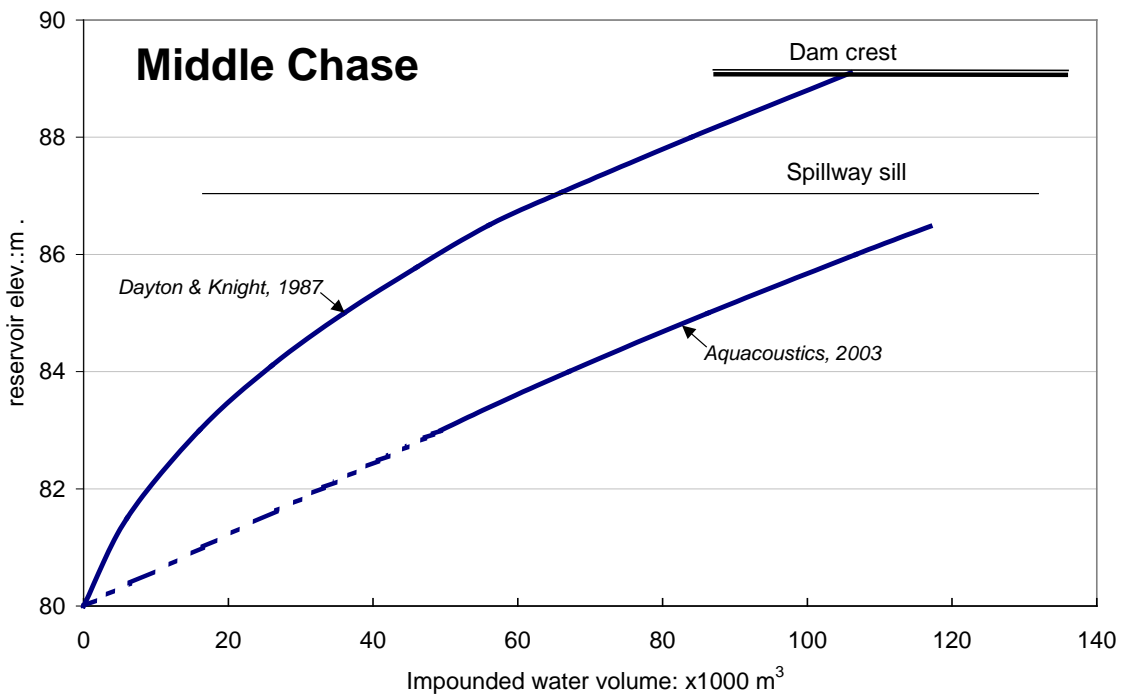


Figure 3: Stored Water Volume versus Reservoir Elevation

2.4 Chase Watershed Hydrology

The Chase River has most of its catchment to the west of the City, as shown on Figure 2. The upper part of the watershed is at about elevation 1000m on the slopes of Mount Benson, with the river flowing east and entering the sea south of the city centre. The extent of the watershed above the Chase River dams is shown on Figure 1 and comprises about 20 km², with only minor reductions in tributary area when moving upstream from the Lower to Middle and then Upper Chase dams. Most of the watershed is forested.

The hydrology of the watershed has been estimated in three studies carried out since the Chase river dams were taken over by the City:

- 1978: by Willis, Cunliffe & Tait in connection with the 1980 dam;
- 1987: by Dayton & Knight in connection with the dam's *Data File*; and
- 2002: by Water Management Consultants who looked at the Chase River basin.

The results of these studies have been plotted as storm flow versus the associated estimated return period on Figure 4 for the Lower Chase dam. Also shown on this figure is the Probable Maximum Flood (PMF) and which is only quoted by Water Management Consultants. The PMF corresponds to about 230 mm precipitation in 24 hours within the catchment.

There is some difference between the 1978 study and the other two. A trend line has been drawn through the results of these studies, weighted to the 1987/2002 results, to indicate a present best-estimate of how the flood increases with increasing return period. A 3000 year return period event corresponds to about an 80 m³/sec flow at the Lower Chase Dam. The PMF, which is 198 m³/sec, represents markedly in excess of a 10,000 year event (which is quite extreme).

Figure 5 compares the trend lines for flood flow versus return period for all three of the Chase river dams. There is not a great deal of difference from one dam to the next because most of the catchment lies above the Upper Chase dam. There has been no systematic measurement of weir flows over the life of the dams, and thus no measured data to improve the hydrological estimates shown on Figures 3 and 4.

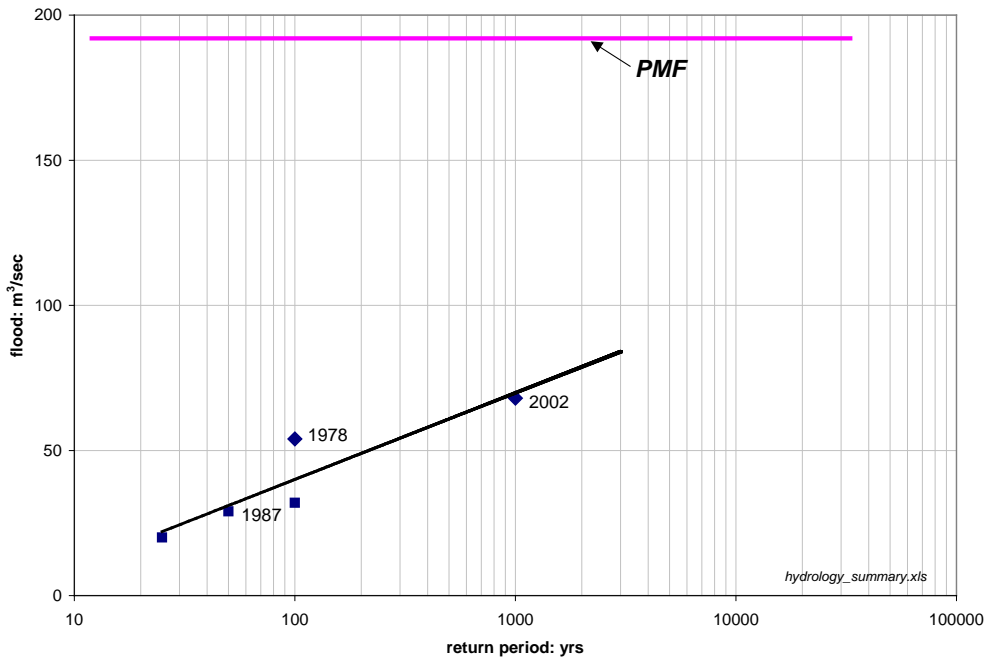


Figure 4: Summary of Studies of Flood Flow versus Return Period at Lower Chase Dam

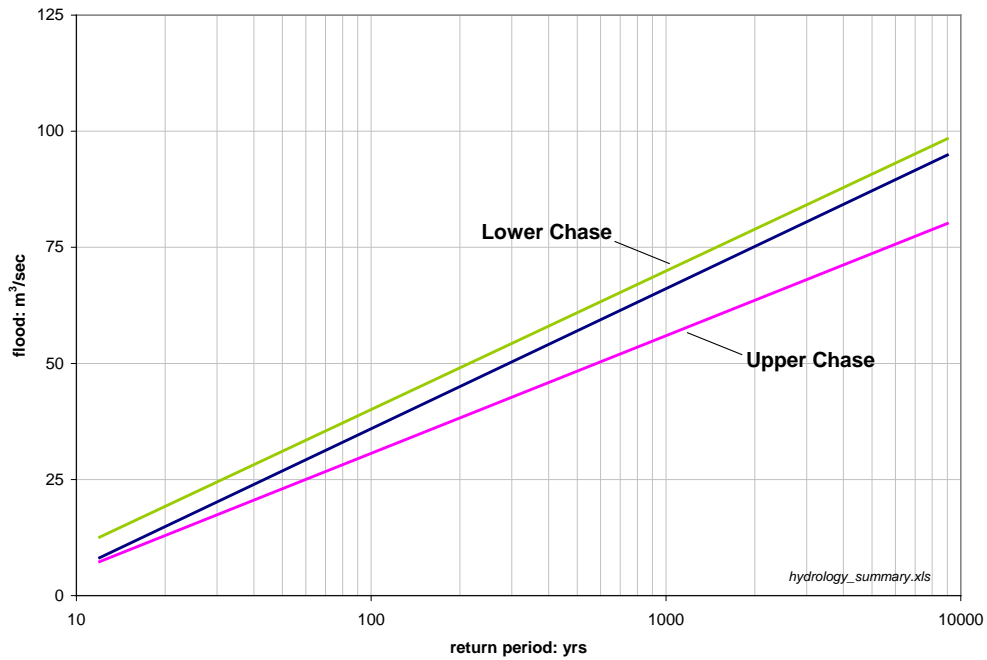


Figure 5: Comparison of Estimated Flood Flows for Chase River Dams

2.5 Spillway Structures

2.5.1 Upper Chase Dam

The spillway comprises a rectangular concrete channel with a horizontal base, leading to a pair of 1800 mm diameter (6ft) culverts in a headwall. These culverts pass under the road and discharge into the Chase River.

There are no water depth versus flow capacity curves developed in prior work for the Upper Chase spillway. Figure 6 shows the estimated hydraulic capacity of the Upper Chase spillway as limited inlet conditions to the corrugated steel culverts.

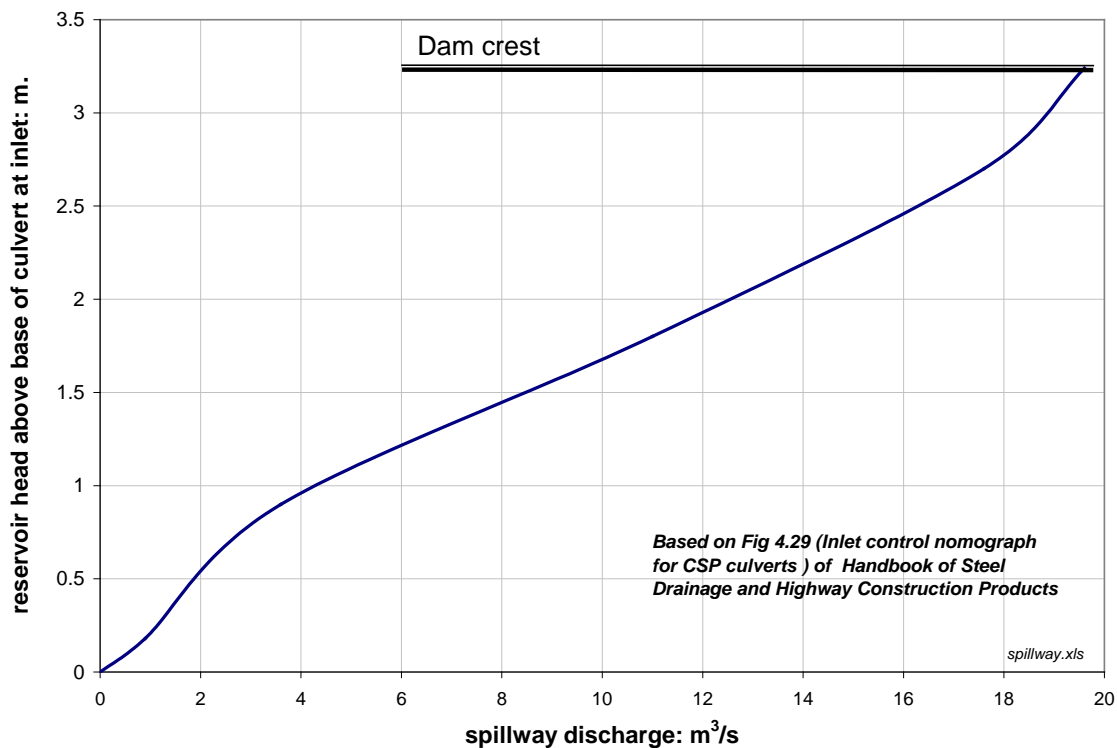


Fig 6: Estimated Hydraulic Performance of Upper Chase Spillway

The depth shown on Figure 6 is the depth above the base of the culverts, which is about 0.6m below the base of the upstream concrete channel. There is a short inclined section of the concrete channel immediately upstream of the culverts and, while this accelerates the water at low flows, its effect on the hydraulic capacity of the culverts has not been determined. Thus, Figure 6 is only a first estimate of hydraulic capacity and could usefully be updated by field calibration as storm events present themselves.

2.5.2 Middle Chase Dam

The spillway is a channel comprising concrete retaining walls in the upper part and using the natural bedrock of the left abutment as the base. The original inlet works comprised a concrete weir section standing some 350 mm above bedrock and with steel channel section for stop-logs. The weir has now been removed in part, so that lake level is largely controlled by natural rock elevation without a weir as such. Stop logs are not used and there is no mechanical gate or the like to regulate water level.

The capacity of the spillway has been estimated by both Dayton & Knight (1987) as part of developing the then “Data File” and most recently by Water Management Consultants (2002) as part of a study into the Chase River hydrology. The two estimated hydraulic performance curves are shown on Figure 7.

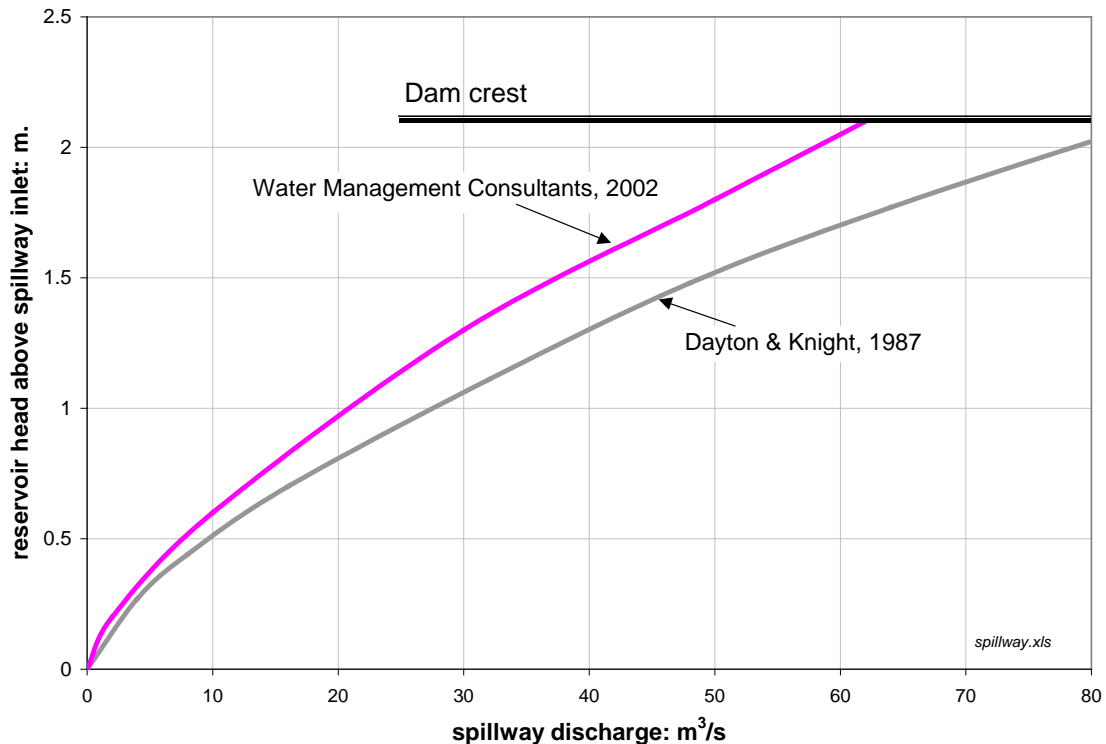


Figure 7: Estimated Hydraulic Performance Curves For Middle Chase Spillway

The reason for the difference between the two estimates of the Middle Chase spillway capacity are not known, and there are no known field calibrations to resolve the discrepancy.

2.5.3 Lower Chase Dam

The spillway is concrete sided and floored channel, split into two channels near the entrance and which are spanned by the footbridge. Water level is controlled by the spillway inlet lip elevation, stop logs not being used by the City. There are no gates or other mechanical means of water level control.

The capacity of the spillway has been estimated by both Dayton & Knight (1987) as part of developing the then “Data File” and most recently by Water Management Consultants (2002) as part of a study into the Chase River hydrology. Figure 8 compares the two computed performance curves for the spillway. Very similar estimated performance is evident from the two studies.

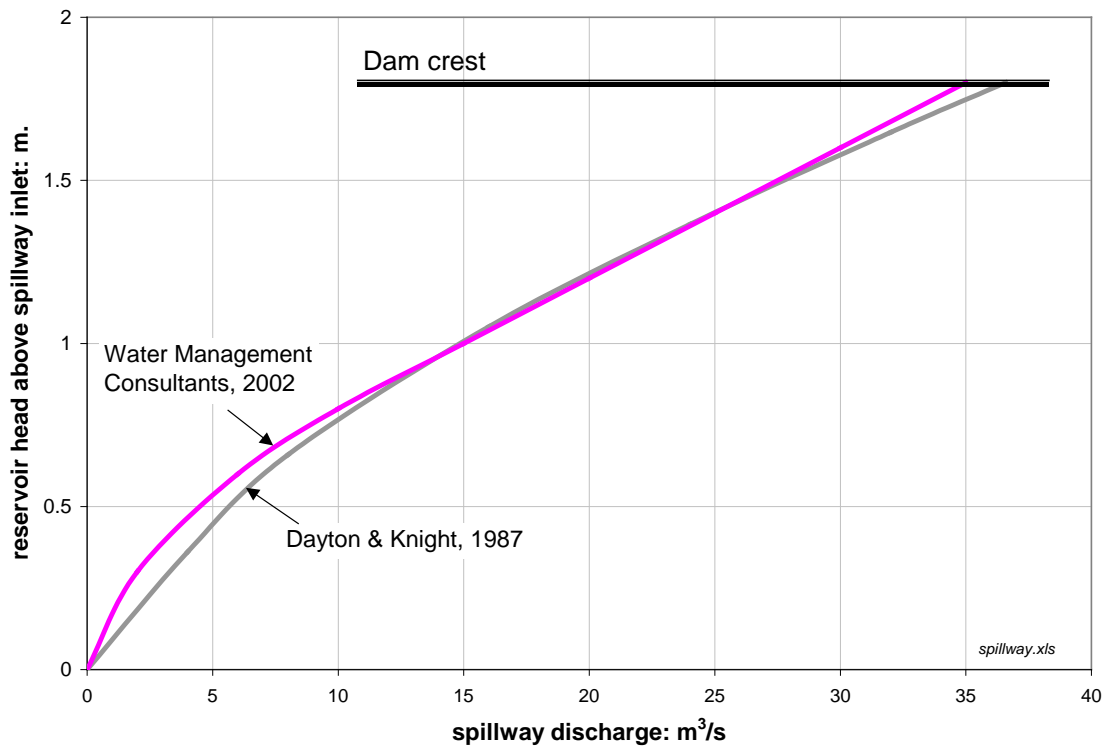


Figure 8: Estimated Hydraulic Performance Curves For Lower Chase Spillway

Broadly, both estimates indicate the spillway can pass 35 m³/sec at the onset of overtopping the crest of the dam. However, Water Management Consultants (2002) note that flows above 25 m³/s would overtop the channel walls downstream of the spillway inlet and might cause some erosion of part of the downstream shell. The estimated capacity of Lower Chase spillway is about half that of the immediately upstream Middle Chase spillway.

2.6 Hazard Classification and Criteria

The hazard classification of the dams and appurtenant structures is based on the consequences of failure and increases with each incremental increase in the potential for loss of life, economic social and environmental losses.

The Canadian Dam Association (CDA) guidelines are used by the Water Management Branch of Land and Water British Columbia Inc. in assessing the required standards of dams. Determination of the required safety level and appropriate engineering standards are based on the consequence classification of the dam.

Table 3.1 shows the classification of dams in terms of loss categories. The highest consequence category of the three considerations is the governing rating for the dam. The dams are currently classified as HIGH hazard dams; however, the recent 2003 DSR has recommended that Upper Chase be reduced to a LOW hazard rating.

**Table 3-1: Classification of Dams in Terms of Consequences of Failure
(after Table 1.1 – CDA Guidelines)**

CONSEQUENCE CATEGORY	POTENTIAL INCREMENTAL CONSEQUENCES OF FAILURE ^[a]	
	LIFE SAFETY ^[b]	SOCIOECONOMIC FINANCIAL & ENVIRONMENTAL ^{[b][c]}
Very High	Large number of fatalities	Extreme damages
High	Some fatalities	Large damages
Low	No fatalities anticipated	Moderate damages
Very Low	No fatalities	Minor damages beyond owner's property

[a] Incremental to the impacts which would occur under the same natural conditions (flood, earthquake or other event) but without failure of the dam. The consequence (i.e. loss of life or economic losses) with the higher rating determines which category is assigned to the structure. In the case of tailings dams, consequence categories should be assigned for each stage in the life cycle of the dam.

[b] The criteria which define the Consequence Categories should be established between the Owner and regulatory authorities, consistent with societal expectations. Where regulatory authorities do not exist, or do not provide guidance, the criteria should be set by the Owner to be consistent with societal expectations. The criteria may be based on the levels of risk which are acceptable or tolerable to society.

[c] The Owner may wish to establish separate corporate financial criteria which reflect their ability to absorb or otherwise manage the direct financial loss to their business and their liability for damage to others.

2.7 Required Safety Criteria

The required design/assessment criteria for dam safety depend on the consequence category. Tables 3.2 and 3.3 show the safety criteria published by the CDA for flood situations and earthquake respectively.

**Table 3.2: Usual Minimum Criteria For Design Inflow Floods
(After Table 6.1-Cda Guidelines)**

CONSEQUENCE CATEGORY	INFLOW DESIGN FLOOD (IDF)
Very High	Probable Maximum Flood (PMF)
High	Annual exceedance probability between 1/1000 and the PMF (depends on consequences)
Low	Annual exceedance probability between 1/100 and 1/1000

**Table 3.3: Usual Minimum Criteria For Design Earthquakes
(After Table 5.1-Cda Guidelines)**

CONSEQUENCE CATEGORY	MAXIMUM DESIGN EARTHQUAKE (MDE)	
	<i>DETERMINISTICALLY DERIVED</i>	<i>PROBABILISTICALLY DERIVED</i>
Very High	MCE	1/10,000
High	50% to 100% MCE	1/1000 to 1/10,000
Low	Building Code	1/100 to 1/1000

3.0 OPERATION OF CHASE RIVER DAMS

3.1 Operating Log

The Watershed Inspector shall maintain an operating log for the Chase River Dams at all times. The purpose for the operating log is to have readily accessible a chronological report on the status of the dam as reported per site visit. This log book shall consist of a three ring binder with each entry being separate sheets. The log book shall be kept in the Public Works Yard in an appropriate designated place.

3.2 Normal Conditions

The Upper Chase dam is primarily a back-up facility for emergency water diversion to Reservoir #1, and would be used when there is a loss of supply from the watershed. **Diversion of water is controlled by Public Works Operations.**

Neither Middle and Lower Chase dams have any operational offtake works nor do they have regulated spillways. Correspondingly there are no normal operations for these dams.

3.3 Extreme Storms

The hazard rating of the Chase River dams is such that they should be able to pass a 3000 year return period flood, which is about 80 m³/sec. Only the Middle Chase spillway has this approximate capacity, with both Upper and Lower Chase being markedly less.

The hydrological studies on which the above statement is based are believed to be very conservative, as it is known that the spillways have passed significant storms without damage and most recently in 2003. The actions and descriptions given below are based on the existing hydrological studies. However, the City is facing potentially large costs in upgrading the spillways and wants to determine actual flows in large storm over the next few years. This will ensure future costs to the City for these recreation area dams are as small as possible while ensuring appropriate protection of the public from risk. Accordingly:

- An important task for the Watershed Inspector is gathering data on actual spillway flows during storms. This will require attending the dams, recording water levels, and taking photographs. Details of observations and measurements required are given later in this section.

The Upper Chase spillway is expected to reach its hydraulic capacity at a flow of about 20 m³/sec. This flow corresponds to about a thirty year return period event, which is something that should be expected to arise within the experience of present people involved with the dam. **In terms of rainfall, this corresponds to about 25 mm precipitation falling in the watershed in a 24 hour period.** Flows in excess of 20 m³/s are expected to lead to overtopping of the dam, with erosion of the Nanaimo Lakes road and with likely debris entering Reservoir #1.

The Lower Chase spillway has a capacity of about 35 m³/sec, although there will be erosion of the dam shoulder for flows above 25 m³/sec. This flow corresponds to about a seventy year return period event for the dam, or **35 mm of rainfall falling within the watershed within a 24 hour period.**

Based on the above, when a **warning of 24 hour precipitation exceeding 25mm is issued**, the **Watershed Inspector** shall:

- Immediately visit Lower, Middle and Upper Chase dams in that order to verify that each spillway is clear of debris;
- If any spillway is blocked, arrange for immediate clearing of the blocked spillway(s); and
- Arrange for signs warning of road washout to be placed on high ground both above and below the Upper Chase dam on Nanaimo Lakes road.

During the passage of the storm the Watershed Inspector shall:

1. Attend the Lower Chase spillway once per hour and record water level retained by the dam. If the retained water rises to within 150mm of the dam crest, take action as defined in the ***Emergency Protection Plan (EPP)***;
2. While at Lower Chase Dam, record the depth of water in the spillway at the inlet and take photographs of the flows at the spillway inlet and in the spillway channel downstream of the footbridge. Keep taking these measurements and photographs at one-hour intervals when returning to the dam to check the reservoir level. For each photograph, record the time that the photograph was taken;
3. On completion of observations at Lower Chase, go up the Nanaimo Lakes dam to the Upper Chase dam. Record the depth of water in the spillway channel and take a photograph of flow in the rectangular section and a photograph of flow at the upstream end of the culverts beneath the road. Record the time of each photograph;

4. Return to Lower Chase dam for the next set of hourly observations and inspections;
5. Continuing inspecting the dams and taking observations until the water levels in both spillways start decreasing. If it appears that the storm flows will last longer than can be covered with normal overtime arrangements, contact the Water Supply Foreman (Richie Fulla) to arrange additional cover so that observations are made 24 hours per day during passage of the storm; and
6. Once the storm is over, provide a record of the water levels and photographs to Engineering.

The 25 mm per day storm criterion for action by the Watershed Inspector will likely be changed (increased) as experience with smaller storms is documented. These changes will be notified by issuing a revision of this manual.

3.4 Earthquakes

The Upper Chase dam is not thought vulnerable to extreme earthquakes anticipated for the Nanaimo area.

Both Lower and Middle Chase dams may be vulnerable to earthquake induced damage (this aspect has been identified as a potential deficiency in dam safety, and possible remediation has been planned in the 2004-2009 period). Broadly, although the downstream stability of each dam is likely satisfactory, the central concrete wall at either dam may topple forward into the reservoir and expose the dam crest to erosion and washout, followed by possible breaching.

Pending further remediation, in the event of a felt earthquake in the Nanaimo area, the Watershed Inspector shall:

- Immediately go to Lower Chase dam and inspect the dam crest for signs of incipient slip;
- Inspect the downstream slope for any springs or other signs of increased erosion or seepage; and
- On completion of the Lower Chase inspection, go to Middle Chase and similarly inspect Middle Chase dam for incipient slip, seepage and erosion.

In the event of any sign of distress to either dam, take action as defined in the *Emergency Protection Plan (EPP)*.

4.0 MAINTENANCE OF CHASE RIVER DAMS

Maintenance of the system is a major requirement of Operations, Maintenance and Surveillance (OMS). Keeping maintenance activities current is the keystone of successful project operation. The objectives of the maintenance program are:

- Ensuring that the facilities are in top operating condition at all times;
- Ensuring that the longest life and greatest use of the facilities are achieved; and
- Ensuring that the above are achieved at the lowest possible cost without quality loss.

The key components of the maintenance program include *Routine Maintenance* (which is expected on a semi-annual basis and *Periodic Maintenance* (every few years). However, other items may arise as a result of surveillance. These are now discussed.

4.1 Routine Maintenance

There are only two items of routine maintenance and these arise at each of the three Chase River dams:

- Keep spillway clear of debris and other materials; and
- Keeping vegetation to a minimum on the slopes and at the toe of the dams.

The first action, clearing spillways, is safety critical because the spillway capacities are marginal as described earlier. Correspondingly, if debris is observed in the spillways during a monthly inspection then it must be cleared as soon as possible and certainly before any storm in the watershed. Debris in the spillway should be expected because of the decision to not install log booms, a decision based in concern for the safety of swimmers using the lakes. **The Water Inspector shall initiate clearance of the spillways.**

Clearing vegetation is expected to be required each year for the Middle Chase and Lower Chase dams, and would normally be carried out in the fall. The purpose is to ensure that grass is kept short enough to allow easy inspection of any seepage or movements in the downstream shell of the dam, and in particular at the toe and abutment contact. Similarly vegetation must be kept away from the toe areas so that the presence of any local seepage can be readily detected if it occurs. Early and prompt detection of dam movement or toe seepage is a most important task in the safe operation of these historic dams, and the maintenance to ensure this is a safety action not a landscaping task.

No clearing of vegetation is required at Upper Chase Dam. This is because of the very low height of the earthfill part of the dam while the concrete section has a roadway downstream.

4.2 Periodic Maintenance

Periodic maintenance is not anticipated at *Upper Chase Dam* for at least the next ten years. The small amount of spalling in the concrete wall can continue without threat to the structure, there are no settlement issues, and there are no slopes to maintain. It is envisaged that the spillway will be reconstructed to provide greater flow capacity before 2014.

Periodic maintenance at *Middle Chase Dam* may arise in the lower part of the spillway on the left side. Here, there is no concrete training wall and the abutment is being undercut by the flows down the spillway. It is anticipated that the spillway may be modified for increased capacity within the next five years or so, and that may provide a convenient time to further protect the left side of the spillway by extending the existing training wall. The dam itself is showing excellent stability and the remedial works undertaken in 1980 are foreseen to need no further maintenance in at least the next ten years. The footbridge may need to be repaired, as the concrete support for the bridge beams is cracked and spalling.

Periodic maintenance of the downstream slope is required at *Lower Chase Dam*. The upper part of this slope is too steep and as a consequence is settling. There are also water erosion gullies on the slope, and these need to be filled in as they develop. It is expected that the upper part of the downstream slope will be reconstructed during the next five years, and also that the spillway will be reconstructed to provide a substantially greater flow capacity.

4.3 Other Maintenance

No other maintenance issues are expected from those identified above. If movements, localized seepage, or settlement/cracking of any dam is observed during routine surveillance these should be treated as unusual conditions, not a lack of foresight in anticipating maintenance. If such unusual conditions do arise, **Watershed Inspector** shall immediately notify Engineering and who shall immediately conduct a full dam safety review.

5.0 SURVEILLANCE OF CHASE RIVER DAMS

5.1 British Columbia Dam Safety Regulation Requirements

A surveillance program is required to ensure that the Chase River dam facilities are in a condition to function safely in the manner intended. All structures should be inspected as follows:

- To verify the physical safety of the structures and facilities;
- To disclose conditions which might cause disruption or failure;
- To determine the adequacy of structures and facilities in serving the purpose for which they were constructed; and
- To assess the extent of any deterioration requiring planned maintenance and repair.

Two of the Chase River Dams are classified as **HIGH** Consequence dams, with the third (Upper Chase Dam) being **LOW**. For the purpose of surveillance, all will be treated as **HIGH** consequence. Table 5.1 shows the minimum surveillance and inspection requirements, with those for the **HIGH** category highlighted. This table is extracted from BC Reg 44/2000, British Columbia Dam Safety Regulation, Schedule 2 and is the legally required inspection frequency.

Following Table 5.1, for the Chase River dams, the City of Nanaimo must carry out the following inspection programs:

- **Site Surveillance**, carried out by **Watershed Inspector** on a **weekly** basis throughout the life of the facility to provide for identification of problems requiring remedial action; and
- **Formal Inspection**, by **Engineering** (or their delegated representative) **annually**, of the various project components of the system to verify that the system is functioning well.

It is expected that these surveillance requirements will be changed once the monitoring weirs are automated and linked to the city's SCADA system. This manual will be revised at that time. Broadly, weekly inspection visits will change to monthly but with continuous real time monitoring of dam seepage. Annual formal inspections are likely to remain.

Table 5.1: Minimum Inspection Frequency and Dam Safety Review Requirements
From - Schedule 2: British Columbia Dam Safety Regulation (section 5 (a) and 7(1))

Item	Very High Consequence	High Consequence	Low Consequence	Very Low Consequence
Site Surveillance (a)	Weekly	Weekly	Monthly	Monthly
Formal Inspection (b)	Semi-Annually	Semi-Annually Or Annually	Annually	Annually
Instrumentation	As per OMS Manual*	As per OMS Manual*	As per OMS Manual	N/A0
Test Operation of Outlet Facilities, Spillway gates and other Mechanical Components	Annually	Annually	Annually	Annually
Emergency Preparedness Plan	Update communications directory semi-annually	Update communications directory semi-annually	Update communications directory annually	N/A
Operation, Maintenance & Surveillance Plan	Review Every 7-10 years	Review every 10 years	Review every 10 years	Review every 10 years
Dam Safety Review (c)	Every 7-10 years (d)	Every 10 Years (d)	(d)	(d)

* Operation, Maintenance, and Surveillance Manual.

- a) Site surveillance may consist of visual inspections and/or monitoring of automated data acquisition systems. Reduced frequencies of visual inspections may be determined by seasonal conditions.
- b) Formal Inspections are intended as more through inspections performed by the appropriate representative of the owner responsible for safety surveillance.
- c) A dam Safety review involves collection of all available dam records, field inspections, detailed investigations and possibly laboratory testing. It then proceeds with a check of structural stability and operational safety of the dam, beginning with a check of structural stability and operational safety of the dam, beginning with a reappraisal of basic features and assumptions. The level of detail required in a dam safety review should be commensurate with the importance and complexity of the dam, as well as the consequences of failure.

Note: Chase River Dams are High Consequence and the highlighted inspection frequency should be followed.

5.2 Surveillance Plan

5.2.1 Weekly Site Surveillance

Site surveillance forms part of the duties and responsibilities of the operating staff. For the purpose of this manual, the term “site surveillance” refers to those activities required whether any change has occurred since construction. If changes have occurred, the information should be used, as a basis to determine what action should be taken.

In the site surveillance, emphasis is placed on the word “change”. For example a sudden increase in the flow rate downstream or seepage at the toe of the dams are significant observations and must be reported so that the cause can be investigated and an assessment made as to the need for remedial action. The purpose of inspections is to identify possible deficiencies that potentially affect the integrity and safety of the dam. Embankment dams may be subject to several different types of deficiencies including (all deficiencies should be noted – some key points are included in the following):

- Seepage: Seepage may occur as wet or boggy areas, flowing water, or sand boils on the downstream face of the embankment or near the downstream toe. Leakage around the low level outlet may also be of concern. If seepage is cloudy or turbid, an emergency situation may exist.
- Cracking: Cracking may occur as desiccation cracking (random honeycomb pattern), transverse cracking (across or perpendicular to the length of the dam), or longitudinal cracking (parallel to the length of the dam). If transverse or longitudinal cracking is observed, an emergency situation may exist.
- Instability (slides, sloughing or building): If any instability is observed on either the upstream or downstream slopes of the dam, an emergency situation may exist.

There is no instrumentation at the Upper Chase Dam to assist the Watershed Inspector. The site surveillance is limited to visual inspection.

Middle Chase Dam has a V-notch seepage monitoring weir; a similar weir is under construction at *Lower Chase Dam*. These weirs, which are situated close to the downstream toes of the dams, measure seepage through any defects in the dam, seepage from the abutments, and precipitation onto the downstream shell. Flows through the V notch weir should be noted during operations, routine inspections and formal inspections. Measurements should be taken by measuring the depth of water above the

apex of the “V” notch immediately upstream of the weir. Records should include date, and reservoir level. A chart should be maintained in with the record of inspections showing how the flow is changing from week to week at each dam.

Routine inspections should be undertaken on a weekly basis with a Dam Inspection report completed and filed. Forms for reporting the results of the routine inspections are provided in **Appendix 4**. The forms are specific to each of the three dams, as there are items requiring specific attention at both Middle Chase and Lower Chase dam. These specific concern inspection items are shown on a sketch plan for each dam. Photographs can be attached to this form for record purposes.

5.2.2 Annual (Formal) Inspections

Formal inspections to be covered in this type of inspection are essentially the same as for the routine inspection. The distinction between these two types of inspection lies in the fact that the annual formal inspection is to be carried out by Engineering (or their designated representative) and who are not part of the day-to-day dam operations/maintenance. The objective of the formal inspection is to carry out a detailed review of the condition of the complete system and to check whether any changes need to be made to the regular surveillance in light of developing conditions and such like.

5.2.3 Dam Safety Review (DSR)

A **DSR** will be carried out at 10-year intervals. This review will include a systematic evaluation of the safety of the dam by means of a **Comprehensive Inspection and Review (CIR)** of the structures, assessment of the performance and review to ensure that the construction meets current standards. The last DSR was in 2003, and the next one is scheduled for 2014.

5.3 Training Schedules

Operation and maintenance personnel for the Chase River Dams should, on an annual basis, review procedures and data acquisition for dam inspections.

Training should be done on a regular basis either as new individuals arrive or bi-annually for experienced Watershed Inspectors.

The office of Land and Water British Columbia Inc. has a number of dam safety videos and training aids, which should be reviewed by all Watershed Inspectors. These include:

- 1) "Safety of Dams" - United States Corps of Engineers;
- 2) "Design and Construction of Safe Dams" - United States Corps of Engineers; and
- 3) Inspection and Maintenance of Dams - Dam Safety Guidelines.

In addition, a slide presentation by experienced inspection personnel on Dam Safety in British Columbia is available.

A record of review of these training aids should be available and signed off by the Watershed Inspectors.

6.0 EMERGENCY PROCEDURES

6.1 Introduction

In the event of an emergency, the response will follow the City of Nanaimo **Emergency Preparedness Plan (EPP)** for the operation of the city Dams. The EPP is specific for the type of emergency, and requires actions by the **Watershed Inspector**. In the event that the inspector is not available, a **Designated Alternate Inspector** may be appointed in compliance with the requirements of the EPP.

The highest priority for the **Watershed Inspector** or **Designated Alternate** is to alert the Emergency Response Authorities of the situation of the dams and reservoirs. When an emergency situation is discovered, the **Watershed Inspector** should:

- a) Contact the Manager of Utilities, Scott Crane or Water Supply Foreman, Ritchie Fulla;
- b) Establish with the supervisor who is to contact the various authorities. Follow the procedures outlined in the EPP; and
- c) Rope off the dam access and that of the downstream dam.

No attempts should be made to repair/remediate the dam until the EPP has been implemented to protect public safety.

A map of the potentially affected area in the event of a dam breach of any of the Chase River dams is shown on Figure 9.

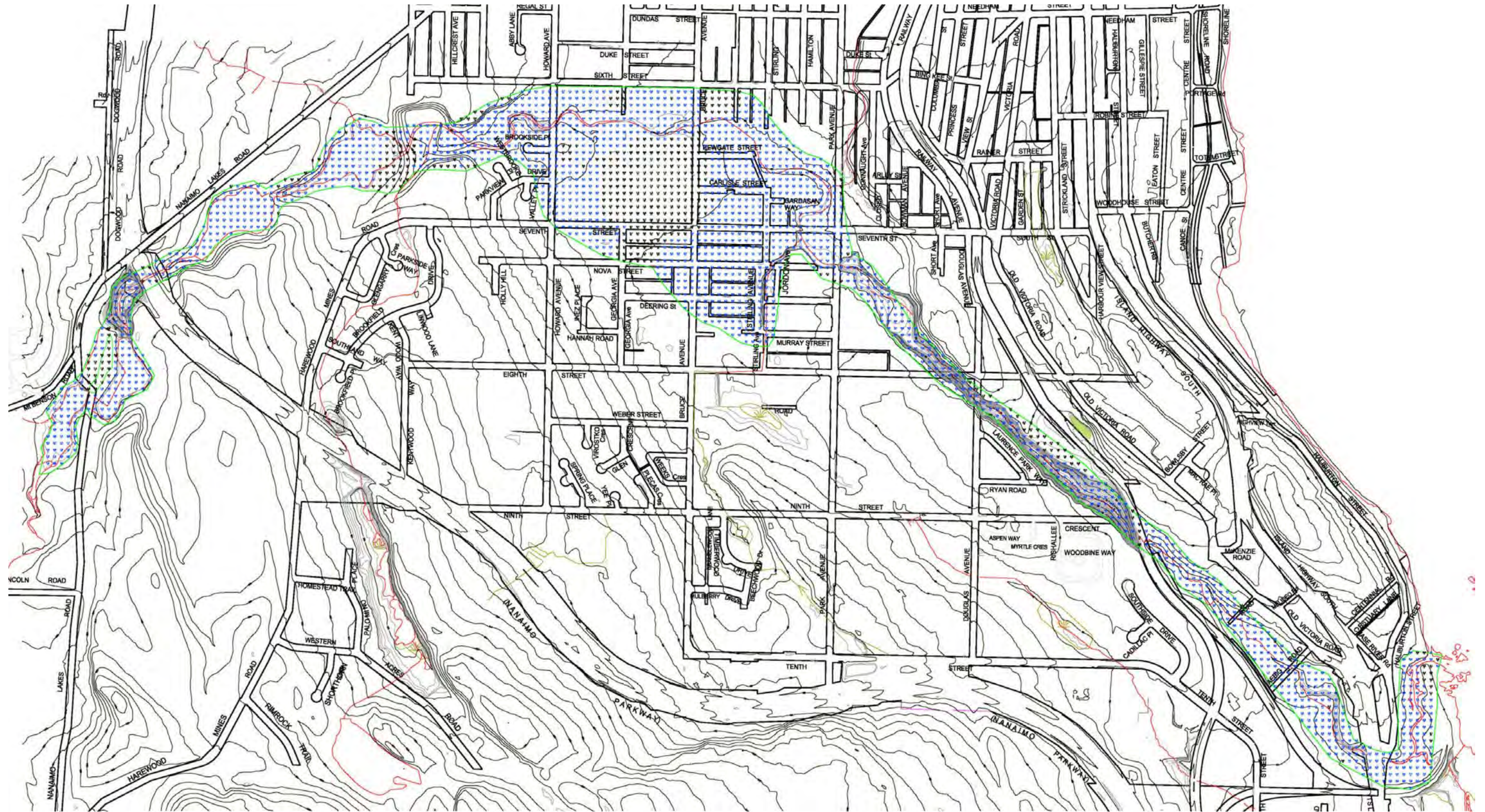


Figure 9: Preliminary Chase River Maximum Potential Flood Inundation Area

6.2 Emergency Situation

The following events constitute an emergency situation:

1. Failure or suspected incipient failure of the dam;
2. Occurrence of damaging earthquakes;
3. Overtopping or flooding above specified storage elevation and incipient overtopping the dam;
4. Slumping, cracking, or bulging of the dam or abutments;
5. Failure of appurtenant structures;
6. Damage to or movement of the spillway walls or invert;
7. Onset of new springs, seeps, or boggy areas;
8. Rapid increase or unexplained cloudy appearance of seepage from the earth dams;
9. Abnormal instrumentation readings;
10. Landslides;
11. Server storms;
12. Fire (forest, range or structural);
13. Demonstrations or sabotage;
14. Oil and hazardous substance and/or pesticide spills;
15. Large or sudden releases into downstream channel;
16. Significant fish and/or wildlife losses in reservoirs;
17. Drownings in reservoirs;
18. Major/minor accidents to persons or damage to property;
19. Any criminal activity.

6.3 Earthquake or Severe Storm

In the event of an occurrence such as an earthquake or severe storm, the **Watershed Inspector** or **Designated Alternative** shall carry out the actions defined in Section 3 for the relevant emergency condition. On completion of those actions:

- a) Formally inspect all of the dams, spillways and reservoirs to assess the conditions and identify any changes or potential problems;
- b) Contact the Manager of Utilities and agree on what action should be taken; and
- c) Follow the EPP Procedures.

6.4 Other Damage

When other damage to the dam, reservoir or spillway is noticed, the City of Nanaimo's Manager of Utilities should be notified immediately. Subsequently, the affected area

should be closely monitored and any changes noted. If the area poses a threat to the public, it should be roped off and attended for the protection of park users.

6.5 Fire

In the case of a fire the **Watershed Inspector or Designated Alternate** should:

- a) Contact the Fire Department;
- b) Contact the City of Nanaimo's Manager of Utilities; and
- c) Attempt to keep the public well clear of the area.

6.6 Drownings or Other Accidents

The **Watershed Inspector for Designated Alternate** being the City representative on the scene, should ensure that the ambulance and police are immediately summoned and that first aid is made available to those in need.

Once these measures have been taken, the City of Nanaimo's Manager of Utilities should be advised of the occurrence.

6.7 Criminal Activity

Once the RCMP and City of Nanaimo's Manager of Utilities have been notified, the affected area should be roped off and the public kept clear such that no further disturbance to the site occurs.

6.8 Hazardous Spills or Significant Fish or Wildlife Losses

Should the **Watershed Inspector or Designated Alternate** become aware of one of these conditions he should:

- Have the reservoir area cleared of people fishing or swimming;
- Contact the City of Nanaimo's Manager of Utilities and agree which agencies should be telephoned and by whom;
- Contact those agencies assigned to the tender;
- Install stoplogs at the spillway and at the upper Chase River dam spillway to delay the spread of the harmful effects; and
- Attend the dam such that the public is discouraged from entering the area.

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APPENDIX I
RECORD DRAWING
UPPER CHASE DAM

APPENDIX II
RECORD DRAWING
MIDDLE CHASE DAM

APPENDIX III

**RECORD DRAWING
LOWER CHASE DAM**

APPENDIX IV

Monthly inspection by _____ Date _____

Weather (Rain, sunshine)...

Today _____ ... Previous Week _____

INSPECTION ITEMS SPECIFIC TO THIS DAM (see Fig 1 on Page 3 for locations)	
Location 1. What is the width of cracks in the crest path ? Have the cracks opened up since last visit ? Has the slope erosion progressed as far as the path ?	
Location 2. Has the slumped area in the lower part of the dam slope moved or settled since last visit ? Is there any seepage from this area or just below it ?	
Location 3. Has the backfill placed in the decayed tree hole settled or been washed away ?	
Location 4. Has there been any concentrated seepage that has eroded the dam fill or created a gully ?	
If the answer to any of the above questions is “yes” contact Ritchie Fulla	

SPILLWAY	
a) What is the water depth at spillway ? (use staff gauge at bridge)	(mm)
b) What is the reservoir level ? (use gauge in the reservoir next to the stairs)	
c) Is spillway clear of debris and unobstructed ?	
d) Is spillway discharge clear and not undermining the spillway ?	
e) Are there any new cracks in the spillway concrete walls or base ?	
f) Has any concrete at the spillway spalled to expose reinforcing steel ?	

DAM STABILITY	
g) Are there any settlement or movement cracks in the concrete wall of the dam ?	(mm)
h) Is there any slumping or bulges in the downstream slope of the dam ?	
i) Have any sinkholes or depressions developed in the dam crest ?	
j) Have any sinkholes or depressions developed at the intersection of berm with original dam ?	
k) Has any settlement developed on the line of the old woodstave offtake pipe ? <i>(see Fig1 for location)</i>	
l) Are there any wet or spongy areas at the downstream toe?	
m) What is the water depth in the V-notch flow monitoring weir at dam toe?	(mm)

RESERVOIR	
n) What is the water quality ? <i>Comment on any suspended solids seen at spillway, oil pollution, or dead fish</i>	
o) Are any banks around the reservoir slipping or being undermined ?	
p) Are there any floating logs in the reservoir ?	

MAINTENANCE
q) What maintenance is required to keep the dam and spillway in good condition ?

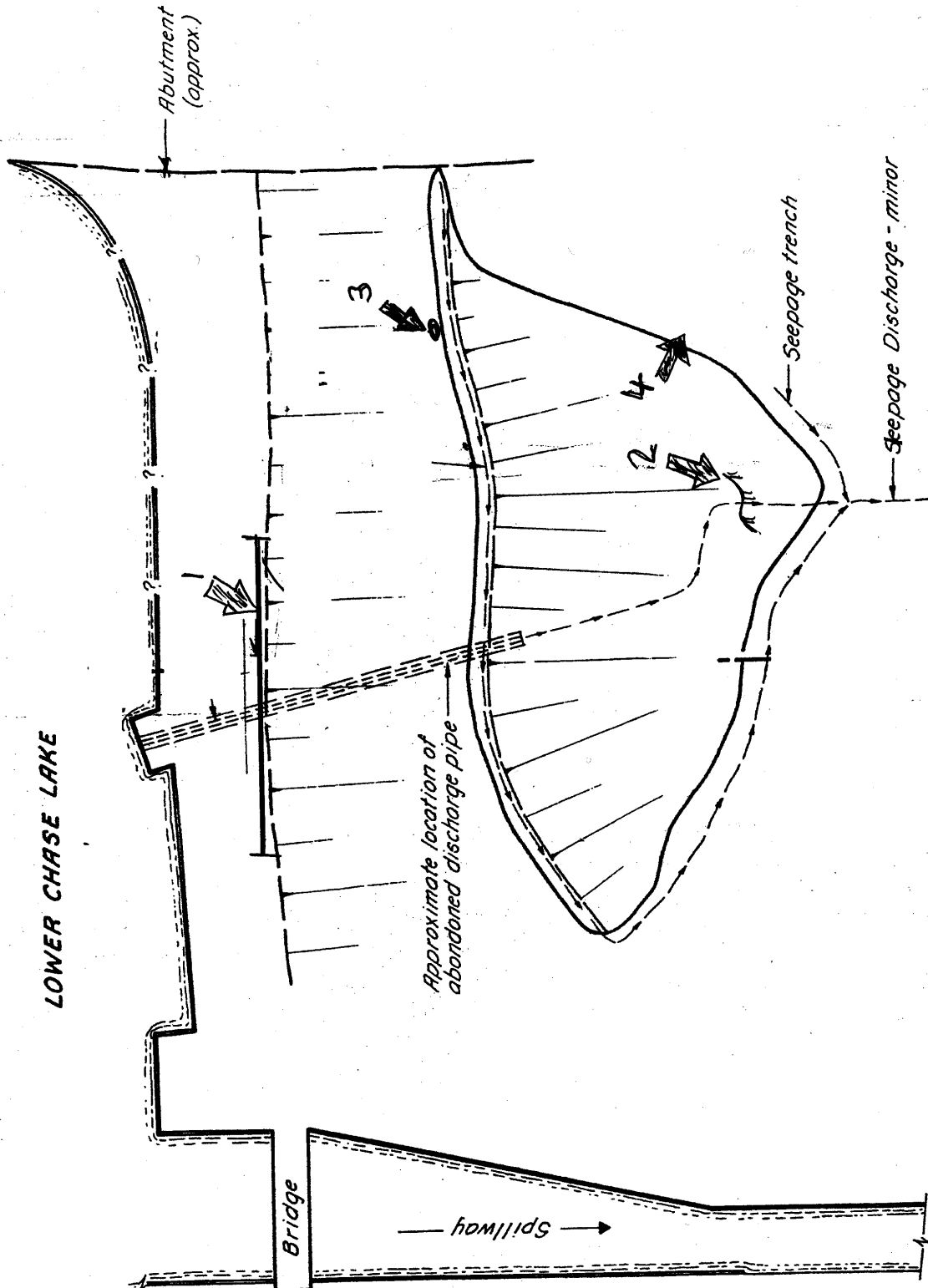


Figure 1: Location of specific inspection items for Lower Chase Dam

Monthly inspection by _____ Date _____

Weather (Rain, sunshine)...

Today _____ ... Previous Week _____

INSPECTION ITEMS SPECIFIC TO THIS DAM (see Fig 1 on Page 3 for locations)	
Location 1. Are there any trees that are in danger of toppling into the spillway because of erosion undermining the bank ?	
Location 2. Has the dam slope been eroded by water flowing over the spillway training wall ?	
Location 3. Are there any zones of seepage from the abutment or dam slope ?	
Location 4. Has the concrete supporting the footbridge beam spalled off the pier ?	
<i>If the answer to any of the above questions is "yes" contact Ritchie Fulla</i>	

SPILLWAY	
a) What is the water depth at spillway entrance (left hand open side)?	(mm)
b) Is spillway clear of debris and unobstructed ?	
c) Is lake by spillway entrance free of floating or grounded logs ?	
d) Are there any new cracks in the spillway concrete walls since last months inspection ?	
e) Has any concrete at the spillway spalled to expose reinforcing steel ?	

DAM STABILITY	
f) Are there any settlement or movement cracks in the concrete wall of the dam ?	(mm)
g) Is there any slumping or bulges in the downstream slope of the dam ?	
h) Have any sinkholes or depressions developed in the dam crest ?	
i) Have any sinkholes or depressions developed in the downstream slope ?	
j) Has any settlement developed on the line of the possibly still in place old woodstave offtake pipe (<i>see Fig1 for location</i>) ?	
k) Are there any wet or spongy areas at the downstream toe?	
l) What is the water depth in the V-notch flow monitoring weir at dam toe?	(mm)

RESERVOIR	
m) What is the water quality ? <i>Comment on any suspended solids seen at spillway, oil pollution, or dead fish</i>	
n) Are any banks around the reservoir slipping or being undermined ?	
o) Are there any floating logs in the reservoir ?	

MAINTENANCE
p) What maintenance is required to keep the dam and spillway in good condition ?

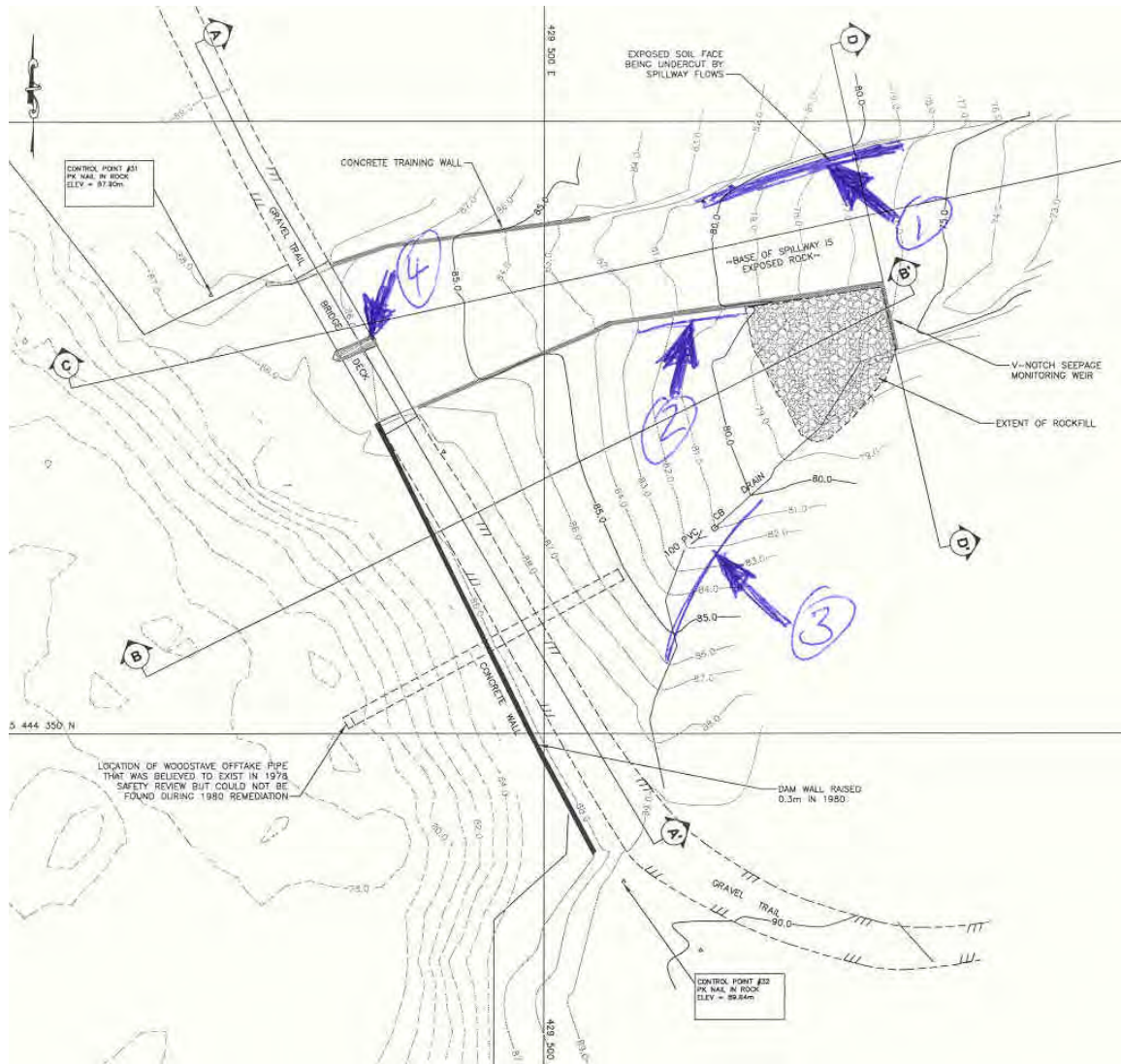


Figure 1: Location of specific inspection items for Middle Chase Dam

Monthly inspection by _____ Date _____

Weather (Rain, sunshine)...

Today _____ ... Previous Week _____

INSPECTION ITEMS SPECIFIC TO THIS DAM (see Fig 1 on Page 3 for locations)	
Location 1. Is there any damage to the underwater hood protecting the water offtake ?	
Location 2. Is the offtake control valve cover plate in good condition ?	
<i>If the answer to any of the above questions is “yes” contact Ritchie Fulla</i>	

SPILLWAY	
a) What is the water depth in the horizontal spillway channel ?	(mm)
b) Is spillway clear of debris and unobstructed ?	
c) Is spillway discharge from the corrugated steel pipes undermining road ?	
d) Are there any new cracks in the spillway concrete walls or base since last months inspection ?	
e) Has any concrete at the spillway spalled to expose reinforcing steel ?	

DAM STABILITY	
f) Are there any settlement or movement cracks in the concrete wall of the dam ?	(mm)
g) Are there any cracks or signs of settlement in the road downstream of the concrete dam ?	
h) Is there any sign of seepage from the toe of the earthfill section of the dam ?	
i) Are there any wet or spongy areas at the downstream toe?	

RESERVOIR	
k) What is the water quality ? <i>Comment on any suspended solids seen at spillway, oil pollution, or dead fish</i>	
l) Are any banks around the reservoir slipping or being undermined ?	
m) Are there any floating logs in the reservoir ?	

MAINTENANCE
n) What maintenance is required to keep the dam and spillway in good condition ?

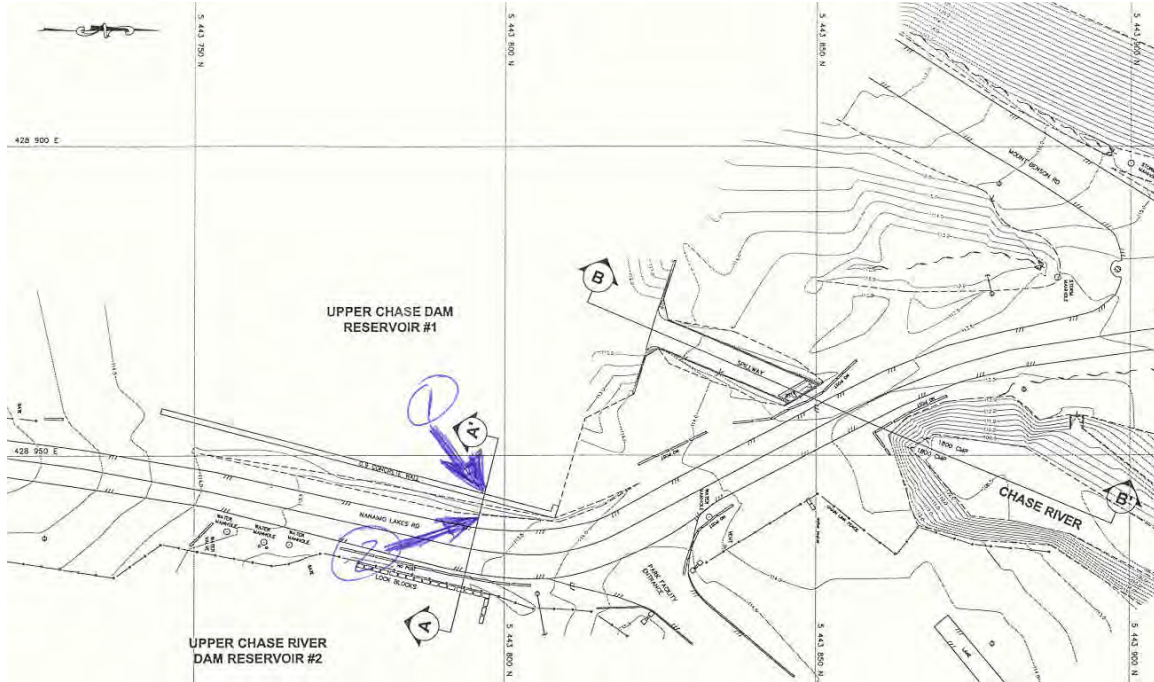


Figure 1: Location of specific inspection items for Upper Chase Dam