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Technical Memorandum

Date: February 14, 2012

Subject: **Analysis of Regulatory Flood Level on the Shoreline of Big/Lower Rideau Lake, for the purposes of administering Ontario Regulation 174/06**

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Abstract

This memo provides a summary of the background information, simplifying assumptions and hydrologic and hydraulic analysis methods used to generate a reasonable estimate of the Regulatory (1:100 year) Flood Level for Big/Lower Rideau Lake[1] (herein referred to as Big Rideau Lake). As found earlier for other lakes, it was not possible to identify the approximate extent of lands that may be inundated under that water level, due to the limitations of available topographical information. This study supports the plotting of Regulation Limits Mapping for the lake whenever topographic mapping of suitable scale and accuracy becomes available. Until then, the regulatory flood determination herein should be used in conjunction with site specific surveys and site visits to determine the extent of regulated areas, on a site-by-site, as-needed basis. The study area, consisting of the Big Rideau Lake watershed is depicted in Figures 1 and 2.

The completed analysis meets or exceeds the standards for "approximate methods for estimating flood plains" as provided for in "Guidelines for Developing Schedules of Regulated Areas" (Conservation Ontario, 2005).

[1] Big and Lower Rideau Lakes are hydraulically connected, having the same water surface elevation, and are commonly referred to as Big Rideau Lake.

Introduction

The development and site alteration control provisions of Ontario Regulation 174/06 apply in all areas within the RVCA area of jurisdiction meeting criteria set out in Ontario Regulation 97/04 (the so-called "generic regulation"), including areas that are adjacent to inland lakes and could be affected by flooding under 1:100 year flood conditions, or by erosion and slope failure processes. Over time, and as resources enable it, RVCA is working to complete its inventory of regulation limits mapping to explicitly delineate the areas that are subject to the regulation. Doing so will better inform the general public, landowners and RVCA staff as to where the regulations are in effect and are to be enforced.

There are numerous inland lakes in the RVCA area of jurisdiction for which there has been no previous attempt to define regulatory (1:100 year) flood levels and corresponding estimated flood lines. Big Rideau Lake is one of the lakes that are subjected to artificial flow regulation and water storage function, and where the historical record of outflow discharge or annual maximum water level is insufficient for the use of statistical methods (single station frequency analysis). A three step process has been developed:

Step 1 – estimation of the 1:100 year flow at the lake's outlet (Poonamalie Dam). Initially, flood flows at the outlets of all the lakes in the RVCA's area of jurisdiction were estimated using a number of methods (RVCA, 2010b). Various methods, borrowed from scientific research papers, handbooks and guideline documents, were applied and compared with a view to identifying a probable range of values for the 1:100 year discharge for each lake. The selection of a recommended 1:100 year discharge value for any particular lake (e.g., Big Rideau Lake) would then be made through closer examination of all of the available streamflow and water level information that is available for that lake and its receiving stream, any site-specific analysis, and consideration of its natural runoff storage and release function (which depends on the lake's area and the physical characteristics of its outlet).

Step 2 – computation of the lake level that corresponds with the 1:100 year flow at the lake's outlet, using information about the physical characteristics of the lake's outlet that determine it’s hydraulic (flow) capacity, as well as the lake’s runoff storage capacity. For Big Rideau Lake, design drawings of the Poonamalie Dam were available.

Step 3 – estimated flood lines corresponding to the 1:100 year water surface elevation are then plotted using available topography of the shorelines around the lake. For most of the lakes in the RVCA area of jurisdiction, the best available topographic information is available in two formats:

- 1:10,000 scale OBM (Ontario Base Mapping) with a 5 m contour interval
- 10 m x 10 m Digital Elevation Model (DEM) compiled by MNR in 2006

Floodline plotting can be automated using computer programs and the DEM, or done manually by interpolating between the 5 metre contours. The two methods may yield differing results (in terms of the plotted position of the flood line in plan view), but neither line would be considered to more accurately reflect the true position of the flood line on the ground than the other. As found earlier for other lakes, plotting the flood line using the DEM was not possible due to the limitations of available data. The resolution of the DEM (10x10m) is such that local topographic features at the scale of typical shoreline properties may not be accurately reflected in the DEM. Also, the stated vertical accuracy of the DEM is ±2.5 metres. Accordingly the flood lines estimated this way would only be a crude approximation, compared to the accuracy that has in the past been required for engineered flood line mapping. They may therefore not be suitable for RVCA regulation limits mapping purposes or for use in designating hazard lands for municipal zoning purposes.

This report supersedes an earlier version dated October 18, 2011 and approved by the RVCA Board of Directors on October 27, 2011.

Study Area

Big Rideau Lake has a surface area of 5790 hectares and a shoreline length of 275.1 km. The catchment area draining to the lake is 1250.9 km^2. Approximately 13% of the catchment area is covered by numerous lakes.

The study area includes the watershed of Big Rideau Lake as shown in Figure 1 (aerial photo base) and Figure 2 (DEM base). Ideally, regulation limits are to be produced for the entire shoreline of Big Rideau Lake and adjacent low-lying areas based (in part) on the estimated flood lines for the 1:100 year water surface elevation. Poonamalie Dam obviously acts as the “hydraulic control” for lake levels during extreme runoff events and is therefore the downstream boundary of the study area. The Narrows Dam is the upper limit of the study area.

The entire study area is within the townships of Rideau Lakes, Tay Valley and Drummonds-North Elmsley. There are a few, small clusters of settlement around the lake, as well as numerous lakeside cottages and rural residences. From the year 2004 to 2008 there were 161 development applications on Big Rideau Lake.

Hydrological Analysis

There are historical streamflow records on the Rideau River just downstream of Poonamalie Dam (02LA005) collected by Parks Canada since 1970. However the data is seasonal and has many gaps; moreover there is speculation about the effect of downstream dams on the rating curve. This data is therefore not suitable for performing a statistical analysis to derive reliable design floods. Continuous water level data of the lake at Rideau Ferry (02AL014) since 1977 is available from Parks Canada, and is of satisfactory quality. However, since the water level data is influenced by the dam operation, it is not suitable for deriving design flows without first converting them to a natural flow series, which appears to be cumbersome due to time-varying dam operation. Standard statistical analysis methods (frequency analysis) can not be used because of these limitations in the historical records.

As described in RVCA (2010b), flood flows for Big Rideau Lake outlet were previously computed using a number of methods, as follows (Table 1, Figure 3):

- FDRP regression (Ontario)
- FDRP regression (Eastern Ontario)
- FDRP regression (Northern Ontario)

- Gingras et al.’s equation (Region 2)
- Gingras et al.’s equation (Region 6)
- Gingras et al.’s equation (Region 7)
- Gingras et al.’s equation (Ontario/Quebec)
- Mike11 long term simulation (1940 to 2007)
- Area-prorating using Rideau River flow at Carleton

Details of these methods and their computation are described in RVCA (2010b), and are not repeated here. That analysis concluded that in general, and in the absence of more rigorous hydrologic analysis for any given lake, the 1:100 year discharge should be selected from amongst the range of values derived from the three “FDRP” regression equations, based on local considerations. In this examination of the Big Rideau Lake situation, three site-specific estimates are available:

- MacLaren (1979) – based on statistical analysis of 40 years of flow data at Poonamalie
- Genivar (2008) – based on data transposition from Merrickville
- RVCA (2007) – based on long term watershed simulation (Mike11)

Compared to the FDRP and Gingras et al’s regression methods, these three studies are based on more site-specific information and are therefore considered more representative. The regression and area pro-rating methods are therefore not considered any further.

MacLaren’s 1:100 year flood value of 143 cms was derived from a frequency analysis performed on the Poonamalie Dam flow data for the period from 1945 to 1975[2].

The Mike11 model is currently the best tool available to RVCA. This kind of continuous modeling has many advantages as documented by various authors (e.g., Boughton and Droop, 2003; DEFRA, 2005). Advantages of this method over the traditional event-based methods are numerous and varied. The main advantage is the

[2] The actual data was neither included in MacLaren (1979) nor could be found elsewhere.

automatic accounting of antecedent moisture condition at every time step, which is taken into account in event based designs but in a rather arbitrary and/or conservative way. Integrated watershed models, like Mike11, can also account for the heterogeneity of basins, river and lake attenuation, varied response time of basins, water control structures and their operation policy. With the development of sophisticated watershed modeling techniques and increasing computer power, this method is now being increasingly used to estimate flows at ungauged basins where long-term climatic data is available.

The Mike11 model yields 160 cms when the Wakeby distribution[3] is fitted (Figure 4); however a manually fitted curve yields 140 cms – a value very close to MacLaren's estimate. Therefore, these two analyses lead to almost the same design flows.

From a standard frequency analysis of the measured flow data at Poonamalie for the period from 1970 to 2010, we get a value of 123 cms. It should be noted that this data contains many gaps and is suspect due to possible backwater effects from downstream dams. So one cannot have too much confidence in this estimate; nonetheless it confirms that the design flow cannot possibly be lower than 123 cms[4]. Considering all, we conclude that the MacLarens's estimate of 143 cms is the most appropriate value for the purposes of flood mapping. The value was used in the hydraulic analysis to determine the corresponding computed water level, or the Regulatory Flood Level (RFL).

Data Used

<u>Aerial Photo</u>: The available DRAPE aerial photo was collected in May and June of 2008 for the entire RVCA area of jurisdiction. This high quality colored photo (Figure 1) clearly shows the rivers, creeks, land use, houses, buildings, roads, infrastructure, vegetation and other details.

[3] This is one of the four theoretical distributions available in CFA (Pilon and Harvey, 1993).
[4] This statement should be qualified by pointing out the doubt cast on the flow measurements at Poonamalie due to possible backwater effect. Until such time as this issue is resolved, we would not know for sure if 123 cms defines the lower limit of the 1:100 year flow or not. In the mean time, it seems prudent to assume that it does.

Historic Aerial Photo: As shown in Figure 5, historical photos in this vicinity since the 1950s are available. These photos show lakeshore, watercourses and road layouts. These photos were helpful in gaining insight into the lake outlet, creek, the road crossing, and the surroundings.

DEM: The 10 x 10 m grid DEM was provided by MNR in 2006 (Figure 2). It has an accuracy of 1.5 m horizontally and 2.5 m vertically. Ideally, given a high enough quality of DEM, contour lines at 1 m intervals, and also corresponding to any specified elevation (e.g., 1:100 year flood elevation), can be generated from this DEM using GIS software to enable automated plotting of the flood line instead of more labour intensive interpolation between the 5 metre contours of the OBM maps.

Poonamalie Dam: This dam is situated at the downstream end of Big Rideau Lake and is used to control the lake level and the outflow from the lake (Figures 6 and 7). This dam is operated by Parks Canada's Rideau Canal Office – with the view to achieve an optimum balance between different and often conflicting demands on the water. The 1970 as-built drawing of this dam, prepared by the Department of Transportation, was obtained from Parks Canada and was used in our analysis. The main bay is 15.20 m wide and fitted with a radial gate (Figure 6) and a sill level at 121.80 m. It also has a 22 m overflow weir for passing the flood flows, with the concrete top at 123.67 m and a flashboard at 123.90 m. Concrete wing walls extend to the north and south at elevations of 124.70 m or higher to high grades on the natural river banks. Fully opening up the bay by lifting the radial gate during extreme flood events and thereby keeping the lake level within the 'flood control zone' (Figure 8) as described in Acres (1977, 1994) report is desirable; and it is our understanding that Parks Canada strives to do that. Recently, Parks Canada officials confirmed that the flashboard is not usually removed during flood events. Therefore, in our hydraulic computation for flood events, we have assumed a fully open radial gate and flashboards in place.

Dam Operation Data: By operating the Poonamalie Dam, Parks Canada strives to keep the lake water level as close as possible to the 'rule curve' (Figure 9). However, given the variability of the hydrologic regime and water demands, this is not always possible; and the actual water level deviates from the rule curve. Records of the dam operation are kept by Parks Canada. Ten years of such data was used in the calibration and validation of our Mike11 model (RVCA, 2007).

Water Level Data: Since 1978, continuous water level measurements of Big Rideau Lake at Rideau Ferry (station 02LA014), just downstream of Rideau Ferry Road bridge, have been taken by Parks Canada. This information (Figure 8) has been utilized in the present study.

Flow Data: Since 1998, flow data of the Rideau River below Poonamalie Dam (station 02LA005) is being collected by Parks Canada. However this data has gaps (Figure 10). With appropriate caution, we have used this data in this study. Moreover, this data was used in the calibration and verification of the Mike11 model.

Hydraulic Calculations

For a given estimate of the discharge, the headwater level is determined by the tailwater level (i.e. the water level downstream of the structure), and the hydraulic head required to overcome the energy losses associated with expansion and contraction of the flow and turbulent energy dissipation (see Figure 6).

The tail water must generally be estimated beforehand. In this case, the 1:100 year flood level of 123.16 m downstream of the dam, calculated in a recent study (RVCA, 2010a), was used.

The physical dimensions of the dam were taken from the 1970 as-built drawings obtained from Parks Canada (Figure 6).

The rating curve of the dam, i.e., the relationship between the upstream water level and the flow passing through the dam, was constructed using the physical dimensions of the dam and the standard broad-crested weir flow equation (Bos, 1990):

$$Q = \frac{2}{3} C_d C_v \sqrt{\frac{2}{3} g} b h^{1.5}$$

where C_d and C_v are the discharge and approach velocity coefficients; g is the acceleration due to gravity (9.81 m^2/s); b is the width of the weir; and h is the height of the upstream water level above the weir crest level. This equation applies to the central bay (when the radial gate is fully opened) as well as to the north overflow weir section of the Poonamalie Dam.

For the main 15.20 m wide bay, C_d and C_v were estimated to be 0.98 (from structure configuration) and 1.0 (assuming negligible velocity head). For the 22 m north overflow weir and 45 m south wing wall, C_d was 0.97 and 0.95 respectively and C_v was 1.0 for both cases. The 1:100 year flood level of 123.16 m downstream of the dam, calculated in a recent study (RVCA, 2010a), was used. Using both the methods of Bos et al. (1980) and Lakshmana Rao (1975), we verified that this tail water does not cause submerged condition for the weir flow.

Figure 11 shows the rating curves for the entire structure as well as for the central bay and side sections. In these calculations, it was assumed that the radial gate is fully opened, the flash board is in place, and a tail water of 123.16 m.

The hydraulic calculations using the free flow weir equations indicate that an upstream head at 124.51 m will be necessary to pass the design flow of 143 cms, which is the same level as the lower chord of the structure (Figure 8). This means that the head water can occasionally rise above the lower chord (due to wave action, etc.) creating a pressure flow more akin to sluice gate flow.

Therefore, we applied the sluice gate equations for the main bay to estimate the headwater required to pass 143 cms. We used a recent equation proposed by Habibzadeh et al. (2011) for free flow through a sluice gate, which reads:

$$q = C_d H_{sluice} \sqrt{2gy_1}$$

where:

$$C_d = C_c \sqrt{(1 - 1/\beta)/(1 + k - 1/\beta^2)}$$

$$\beta = y_1 / y_2 = y_1 / (C_c H_{sluice})$$

The following shows the relation for the distinguishing condition (free-flow or submerged):

$$\frac{(y_3)_{\max}}{H_{sluice}} = \frac{1}{2} C_c \left[\sqrt{1 + 16(\beta - 1)/(1 + k - 1/\beta^2)} - 1 \right]$$

Where q is the discharge per unit width of the rectangular channel; C_d and C_c are the discharge and contraction coefficients; g is the acceleration due to gravity (9.81 m^2/s); H_{sluice} is the height of the sluice gate opening; y_1 is the height of the upstream water level above the weir crest level; y_3 is the tailwater depth above the weir crest level; and k is the energy loss factor. C_c and k were empirically found to be 0.61 and 0.062. It was also confirmed that the sluice gate flow would be above the modular limit, i.e., not subjected to submerged condition.

The rating curves derived form the sluice gate equations are also shown in Figure 11. The calculations reveal that a head water of 124.51 m will be necessary to pass 143 cms through under sluice gate condition. This headwater is the same as the one calculated using the weir equations and is at the same level as the lower chord (Figure 8).

There appears to be some uncertainty about which condition – free weir flow or sluice gate – would prevail; it is conceivable that the flow will oscillate between the two. What is certain is that both conditions will require the same head water (at 124.51 m) to pass the design flow of 143 cms.

124.51 m can therefore be taken as the Regulatory Flood Level (RFL) for the Big Rideau Lake for a design flow of 143 cms.

The calculations above are based on the assumption that the flash boards on the north overflow weir will remain in place during flood events. This is our understanding of Park Canada's current practice. However, we have also looked at the alternate scenario where the 0.23 m high flash boards are taken out during flood events and the water flows over the concrete surface of the weir (Figure 12). We found that the 1:100 year water level under such circumstances would be 124.42 m, 9 cm below the RFL. In future, if

Parks Canada adopts the practice of removing the flash boards during flood events, the RVCA will be in a position to revise the RFL accordingly.

The recent Guidelines for Developing Schedules of Regulated Areas (Conservation Ontario, 2005) do not require accounting for wave rush-up on lakes that are less than 100 km^2 in surface area. Therefore such calculations were not performed for Big Rideau Lake.

Summary of Conclusions from Hydrologic and Hydraulic Analyses

As mentioned earlier, Parks Canada strives to keep the dam fully opened during extreme flood events, and thus to keep the water level within the ‘flood control zone’ (123.16 to 124.00 m) as described in Acres (1994).

The regulatory flood level for Big Rideau Lake is 124.51 metres above sea level (Figure 8), and is associated with a discharge of 143 cms at Poonamalie Dam, the present configuration of the dam and downstream channel, and the assumption that the radial gate is fully opened.

The RFL is coincident with the lower chord of the platform and is 0.61 m (24 inches) above the north overflow weir level. It is below the south wing wall, which remains dry during the 1:100 year flood.

We also observe that the RFL is within the 1.0 m ‘spill zone’ defined by Acres (1994), about 0.51 m (20 inches) above the ‘flood control zone’, but well below (0.49 m or 19⅓ inches) the higher limit of the spill zone (Figure 8). During large flood events including and up to the 1:100 year flood, Parks Canada strives to keep the water level within the ‘flood control zone’ with an upper limit of 124.00 m. For larger flood (greater than the 1:100 year flood), the water level may be allowed to rise within the ‘spill zone’ with an upper limit of 125.00 m (surcharge level). Exactly how these zones were determined by Acres (1994) is not clear.

The regulatory flood level (124.51 m) can also be expressed relative to the range of water levels (122.55 to 124.10) observed over the last 33 years (Figure 8). According to the measurements, the annual high water levels were mostly below the upper limit of the flood control zone (124.00 m) and always about 0.5 m (20 inches) lower than the RFL computed here. In theory, the dam can be manipulated to maintain different water levels for the same flow. Therefore, high water level incidents (approaching or exceeding of the RFL) could be avoided by keeping them under the RFL by opening up the radial gate. From the observed data, it appears that Parks Canada has been doing a good job of keeping the water level down and therefore the lake free of flood risk.

Flood Line Delineation and Regulation Limits

Ideally, once the Regulatory Flood Level is established, the plotting of 1:100 year flood lines or flood risk limits around the lake is a relatively straightforward matter. As previously noted, limitations of the available topographical information (the 10 x 10 m DEM received from MNR in 2006) did not allow accurate plotting of contour lines at 1 metre intervals or the estimated flood lines. If this were not the case, the Regulation Limit line would then be plotted the prescribed 15 metres upland of the estimated flood line, wherever the extent of the flood hazard area limit is greater than the extent of wetlands or erosion and slope stability hazards.

However, because of the low horizontal resolution and stated vertical accuracy of the digital elevation model, it does not accurately represent the actual topography of shoreline properties, and the resulting estimated flood lines do not accurately identify areas that are affected by flooding under regulatory flood conditions and are, therefore, subject to the regulations.

Until topographic mapping or digital elevation models of better accuracy and resolution becomes available, identifying the boundaries of hazardous lands with reasonable confidence will require on-site inspections and/or aerial photograph interpretation if suitable imagery is available.

The Regulatory Flood Level (124.51 metres above sea level) should be used when assessing the safe access/egress and flood proofing aspects of development applications in the regulated area.

Regulation Policy Recommendations

Because of the large surface area (about 5%) of Big Rideau Lake relative to its catchment area and the presence of many other lakes (about 13% of the basin is made up of lakes), the lake has a considerable flow attenuating effect during major runoff events. The runoff storage volume associated with inundated low-lying lakeshore properties is insignificant compared with the storage volume on the lake itself. It follows that the flood hydrograph attenuating function of the lake will not be significantly diminished by the minor loss of storage capacity that would be associated with typical shoreline development.

In general, therefore, development of shoreline properties will not have an adverse effect on the control of flooding provided the design of the development meets the following requirements:

1. The estimated regulatory flood level of 124.51 m.a.s.l. should be used in the design of any structures in the regulated area around Big Rideau Lake. Any new structure (or addition to an existing structure) within the regulated area should be flood-proofed to prevent damage to the structure or its contents under 1:100 year flood conditions. The design of flood-proofing measures should include a minimum 30 cm freeboard above the regulatory flood level to provide an additional margin of safety, in consideration of uncertainties in the derivation of the regulatory flood level. The drawings submitted with the application should identify the proposed geodetic elevation of the structure and its foundation elements, and the flood proofing provisions in the design will be determined by the structure's relationship to the regulatory flood level.

2. Applications for approval of new residential buildings or additions that would enable an increase in the occupancy of existing residential buildings, in the regulated area will need to be accompanied by information on the access route to the building. Safe access to and egress from the site will be required under 1:100 year conditions. 30 cm (or less) of flood waters on access roads has typically been accepted as meeting

safe access requirements, where flow velocities are not significant. Topographic surveys of access routes may be required.

3. In general, lot grading and site alteration should be designed to minimize the need for importation fill from off-site, and in all cases shall be designed so as to ensure no degradation – and enhancement where possible – of the ecological integrity and water quality protection functions of the shoreline and riparian zone.

Closure

The hydrotechnical procedures used in this study to determine a regulatory flood level for Big Rideau Lake conform to present day standards for flood hazard delineation, as set out in the MNR Natural Hazards Technical Guide (MNR, 2002). The computed flood elevations will be useful in the evaluation of applications for approval of development or site alteration in the regulated area and will also be of value in the flood forecasting and warning services of the RVCA.

The 1:100 year flood limits could not be drawn due to the limitations of the available topographical information. In the absence of topographic mapping or digital elevation models of better accuracy and resolution, identifying the boundaries of hazardous lands with reasonable confidence will require on-site inspections and/or aerial photograph interpretation if suitable imagery is available.

It would be prudent for Parks Canada to continue to keep the water level as low as possible within the 'flood control zone' by appropriate dam operation during severe flood events (to the extent possible considering various demands on water management both upstream and downstream). This will ensure that the lake experiences only the lowest possible flood level associated with a 1:100 year flood event under a particular set of circumstances.

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17. RVCA (2010a). Rideau River Flood Risk Mapping – Poonamalie Dam to Smith Falls. Technical Memo, Rideau Valley Conservation Authority, Manotick, Ontario, February 2010.

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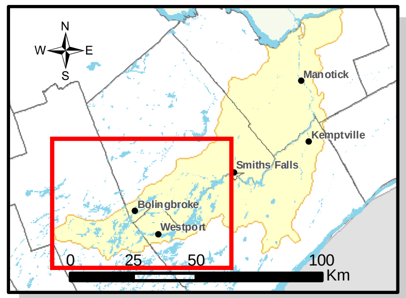
Table 1: Estimated Flood Flows upstream of Poonamalie Dam

Return Period (years)	METHOD/SOURCE												
	Frequency Analysis of Flow at Poonamalie Dam [9]	Mike11[1]		FDRP[2]			Gingras et al.[3]				Area Pro-rating[4]	Genivar (2008)[5]	MacLaren (1979)[8]
		Wakeby	Manually Fitted Curve	Northern Ontario	Eastern Ontario	Ontario	Region: 7	Region: ON/QC	Region: 2	Region: 6			
	Flow (cms)												
2	57.6	54.5	53	65.9	164.1	67.5	203.7	126.2	173.4	30.9		69	
5	77	84.6	100	92.5	183	93.7						80.4	
10	89.1	105	117	110.5	193.7	111.2						86.7	
20	100	123	128	128	203	128.1	402.7	232.7	280.2	56.6		91.8	
50	114	145	135	156.1	219.3	154.8						97.5	
100	123	160	140	178.3	230.9	175.6	469.8	277.7	314.8	69.4	282.6	101	143
200	132	174	145										
500	144	190	150									125	
1000 [5]												128	
10000 [5]												138	
Summer/Fall PMF[6]												181	
Spring PMF[7]												221	

1. Mike11 output, using a Wakeby Frequency Distribution and a manually fitted curve.
2. MNR (1986). Flood Plain Management in Ontario – Technical Guidelines. Ontario Ministry of Natural Resources, Conservation Authorities and Water Management Branch, Toronto.
3. Gingras, D., Adamowski, K., and Pilon, P.J. (1994) Regional Flood Equations for the Provinces of Ontario and Quebec. Water Resources Bulletin 30(1):55-67.
4. Area Pro-rating method using streamflow measurements from the gauge: Rideau River at Carleton University (Station ID 02AL004; drainage area 3830 km2).
5. Frequency analysis with data based on hydrometric station 02LA011 (Merickville) -- Caution: limited time series used in analysis. Values from 500 to 10,000 use with caution.
6. Summer/Fall Probable Maximum Flood, generated by the summer/fall Probable Maximum Precipitation (PMP).
7. Spring Probable Maximum Flood, the maximum of either:
   a) PMF computer with the spring PMP and 1:100 yr snow accumulation, or
   b) PMF computed with the Probable Maximum Snow Accumulation and a 1:100 yr rainstorm.
8. Based on frequency analysis of daily discharge records collected at Poonamalie Dam from 1944 to 1975.
9. CFA Analysis (Generalized Extreme Value Distribution) of raw/unverified flow data d/s of Poonamalie Dam (02LA005) -- Caution: Data gaps from May to Oct due to the backwater effect from Dam 17 in Smith Falls during the navigation period for which the stage-discharge curve has not been calculated.

Sources: RVCA (2010), ***Estimation of Design Flows for RVCA Lakes***
GENIVAR (2008), ***Hydrotechnical Study of the Rideau River Watershed***
JF MacLaren Ltd. (1979), ***Rideau River Floodline Mapping (Smiths Falls to Poonamalie)***

Figure 1: Location Map



Legend

Lower/Big Rideau Lake Basin

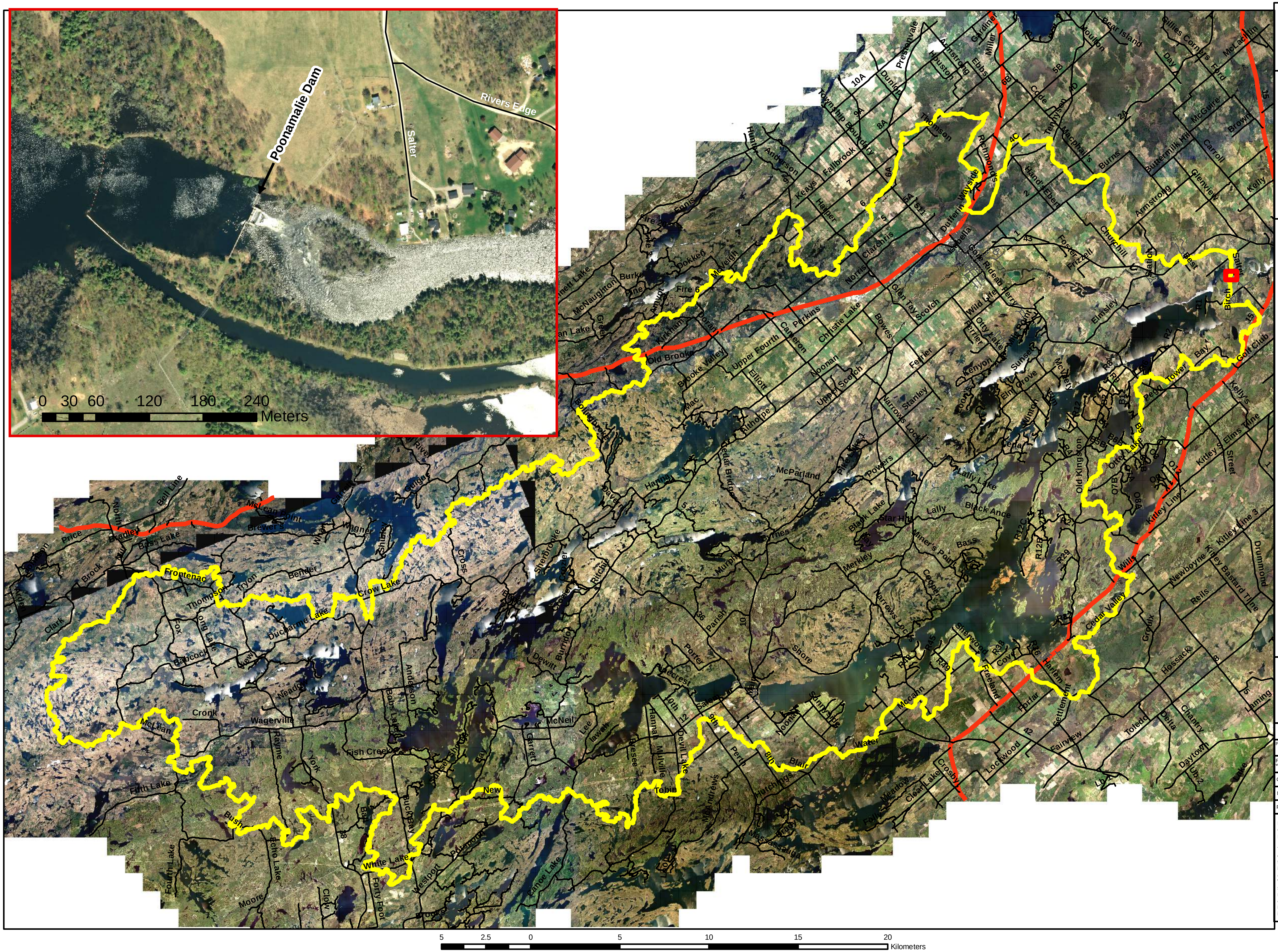
Transportation

Freeway

Expressway / Highway

Collector

Local / Street



RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:200,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

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Modified by: aahmed	Date Modified: 9/22/2011 2:23:27 PM
Published by: sschreiner	Date Published: 9/26/2011

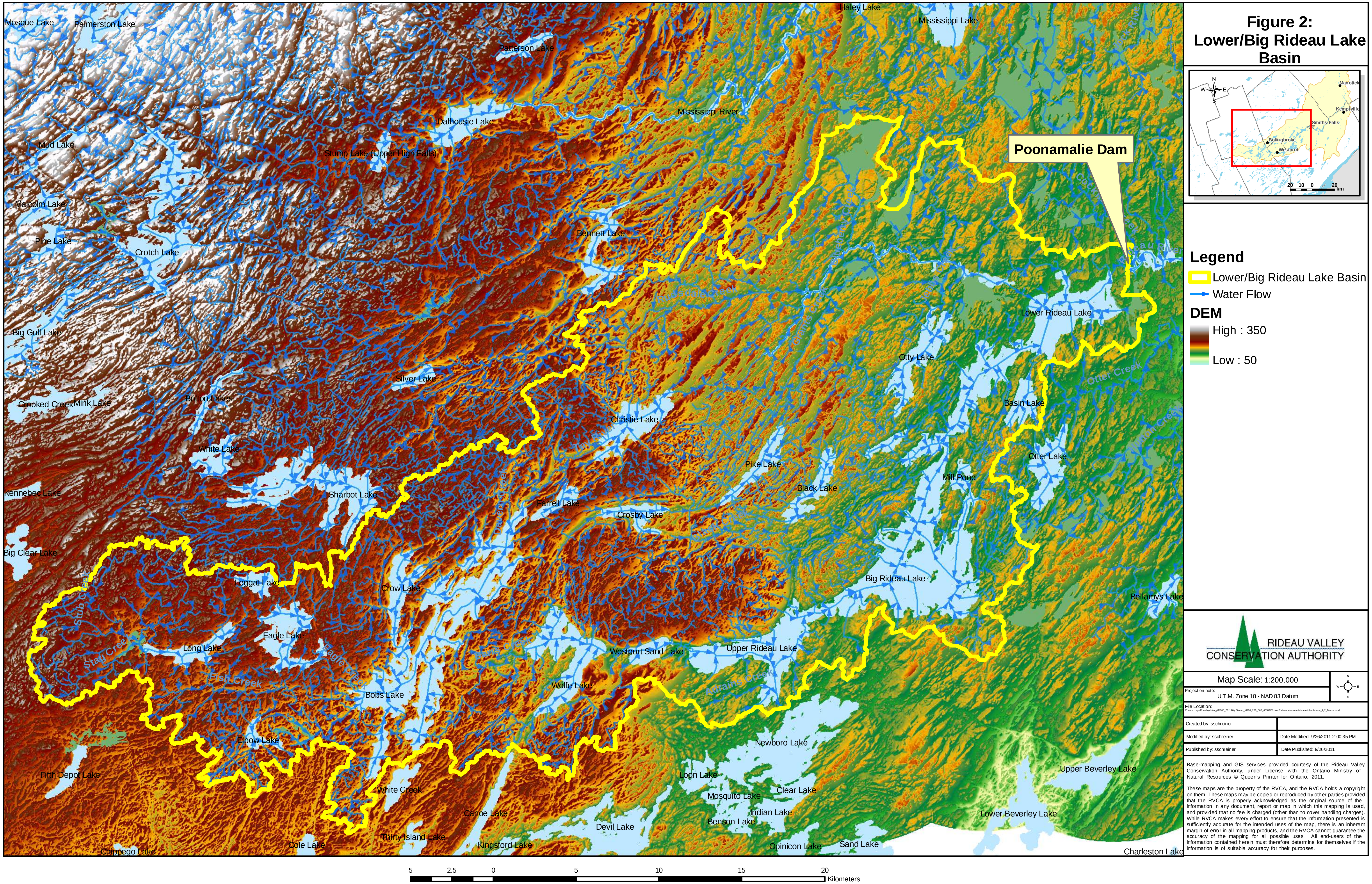


Figure 2: Lower/Big Rideau Lake Basin

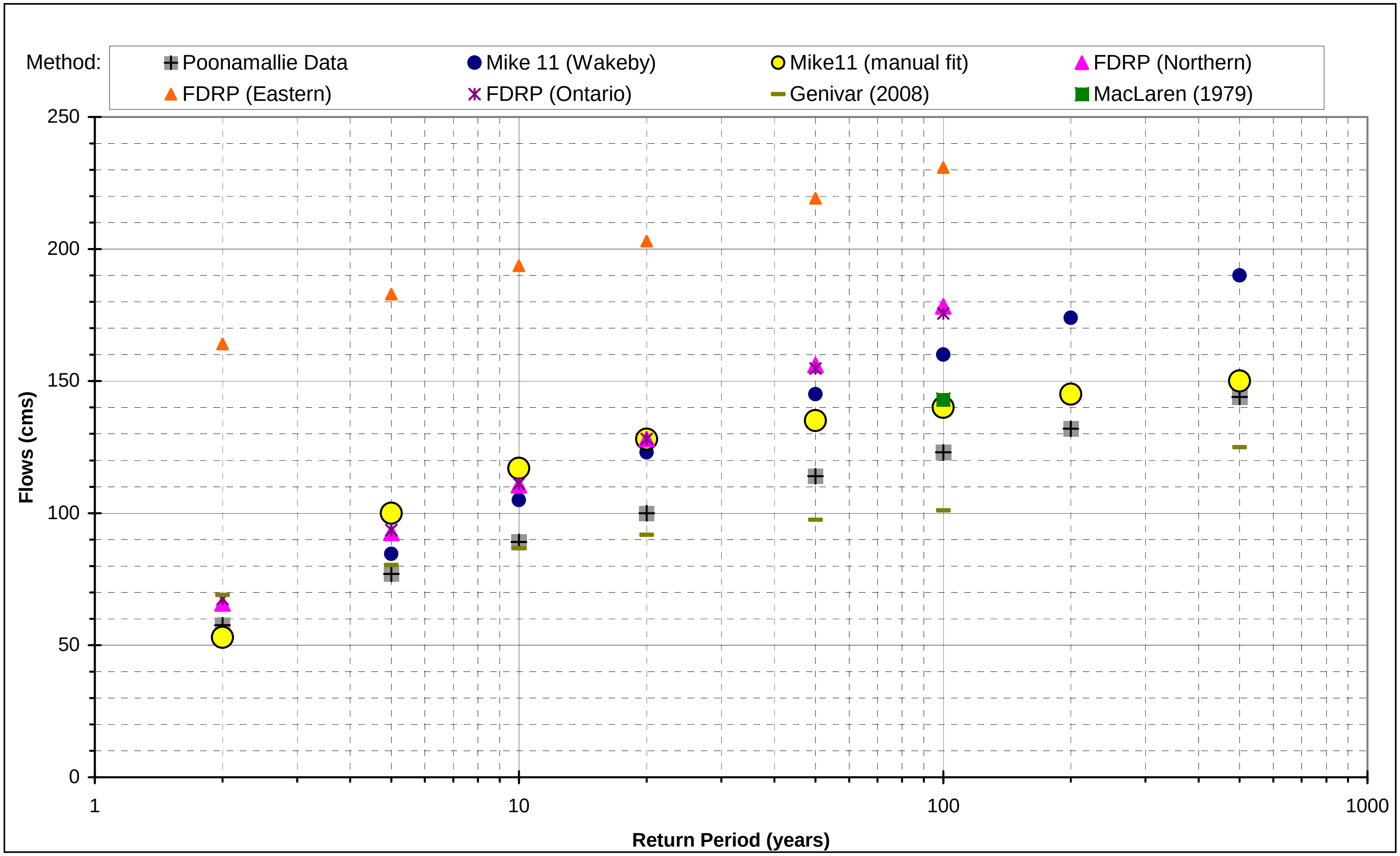


Figure 3 - Estimated flood flows at Poonamalie Dam

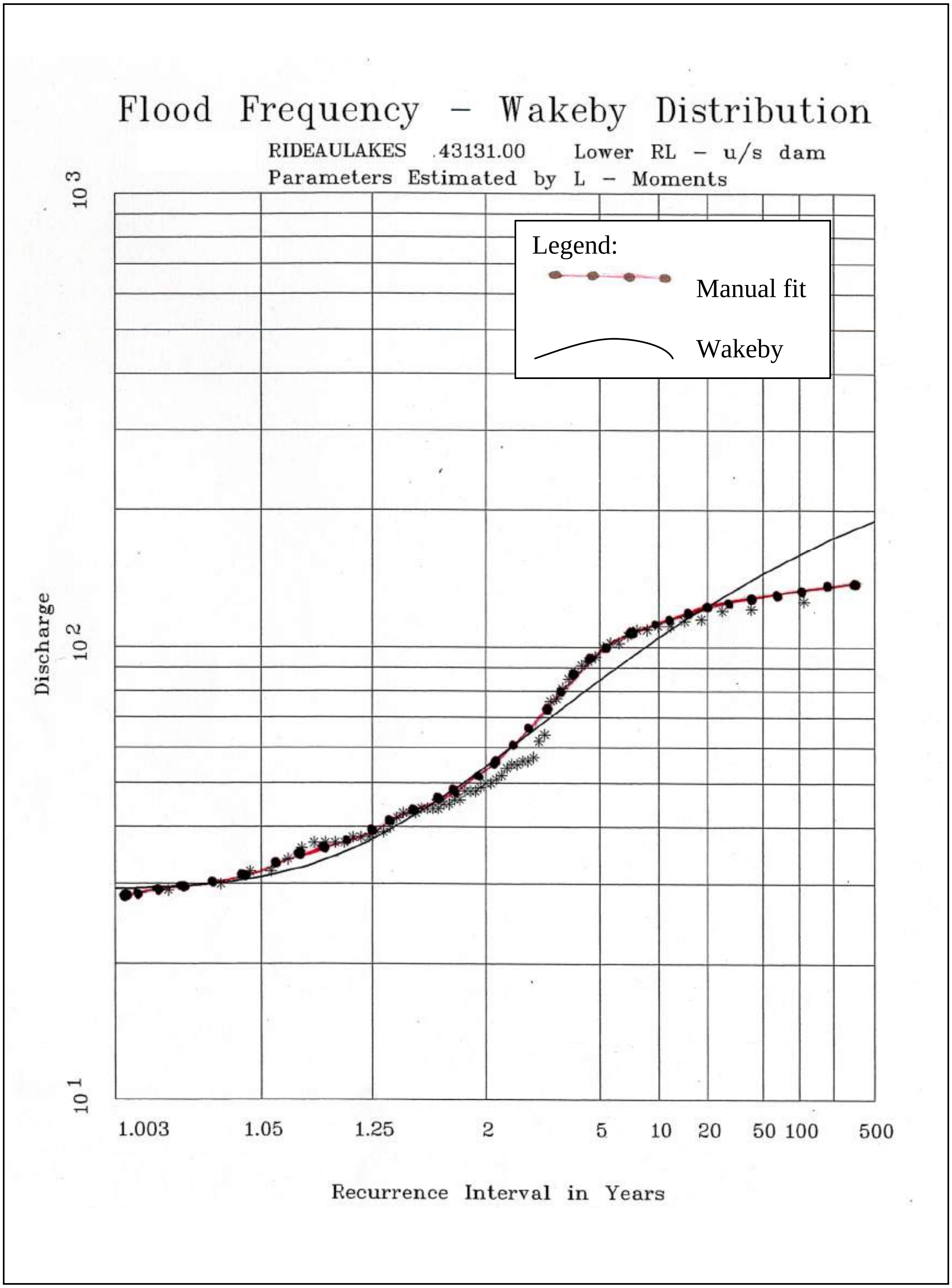
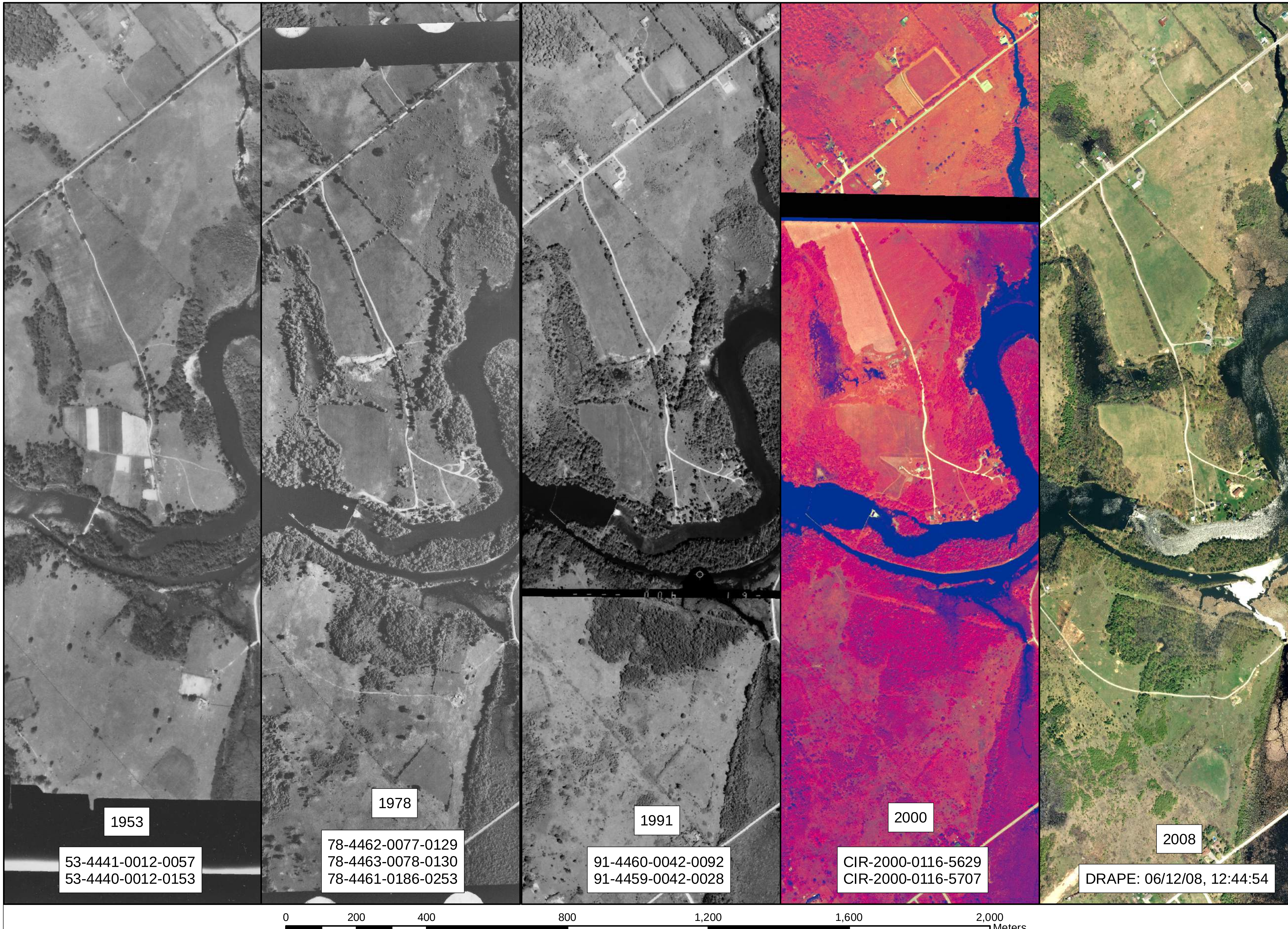


Figure 4: Frequency analysis of Mike 11 – generated stream flow

Figure 5: Lower/Big Rideau Lake, Poonamalie Dam Historical Air Photos



RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:10,000	N W E S
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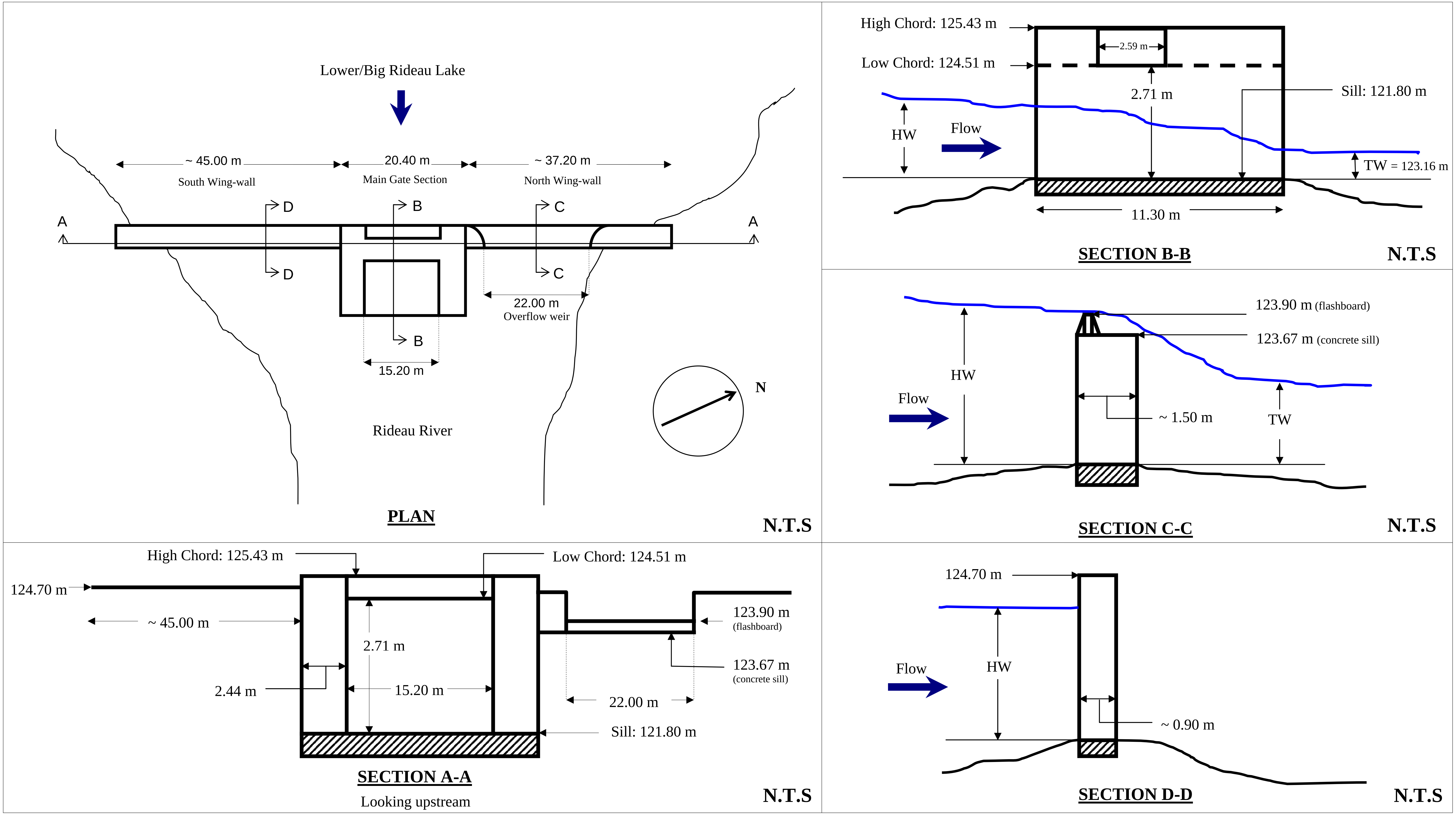

Figure 6: Poonamalie Dam, based on Drawings from the Department of Transport (1970)

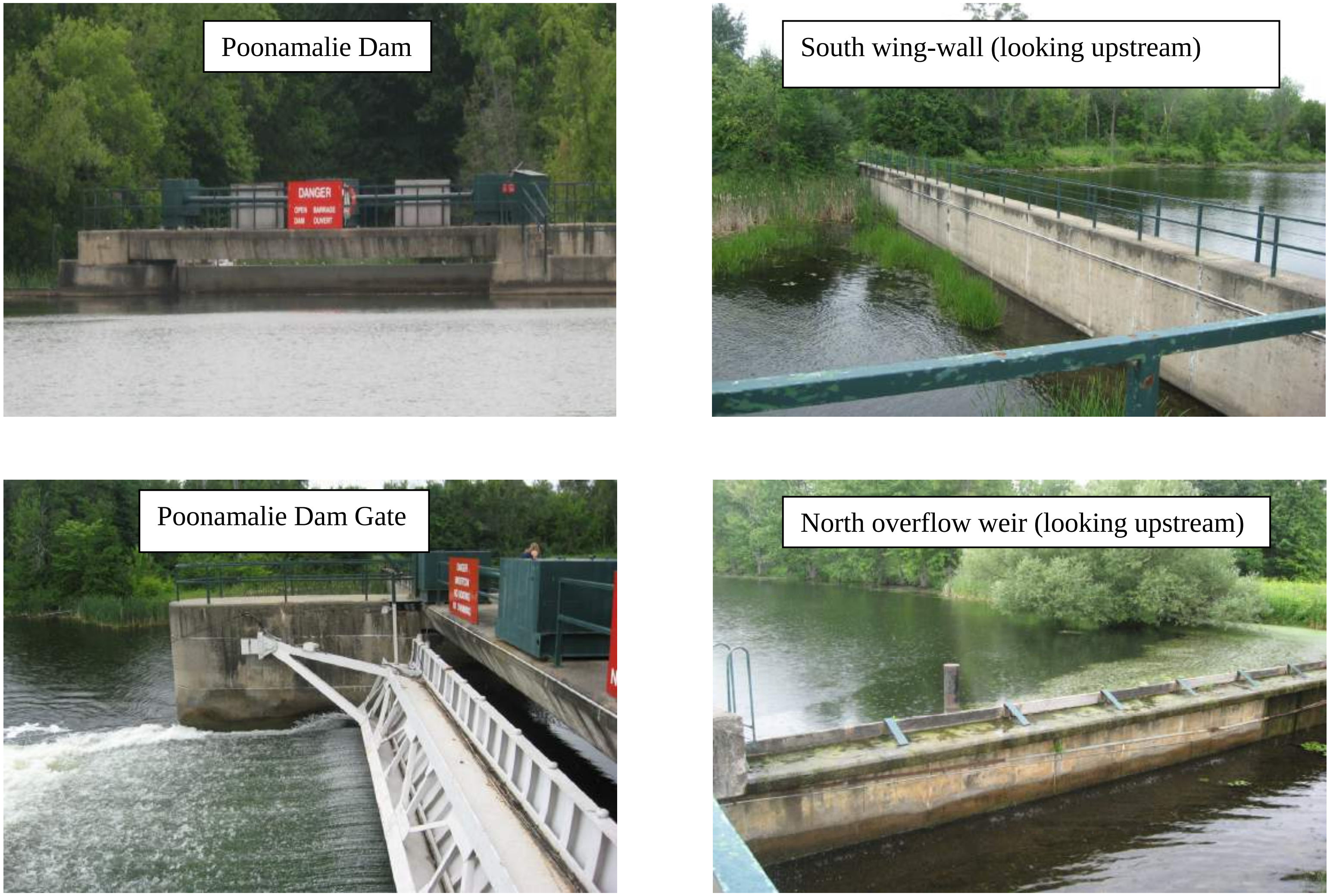

Figure 7: Pictures of Poonamalie Dam (taken July 2010)

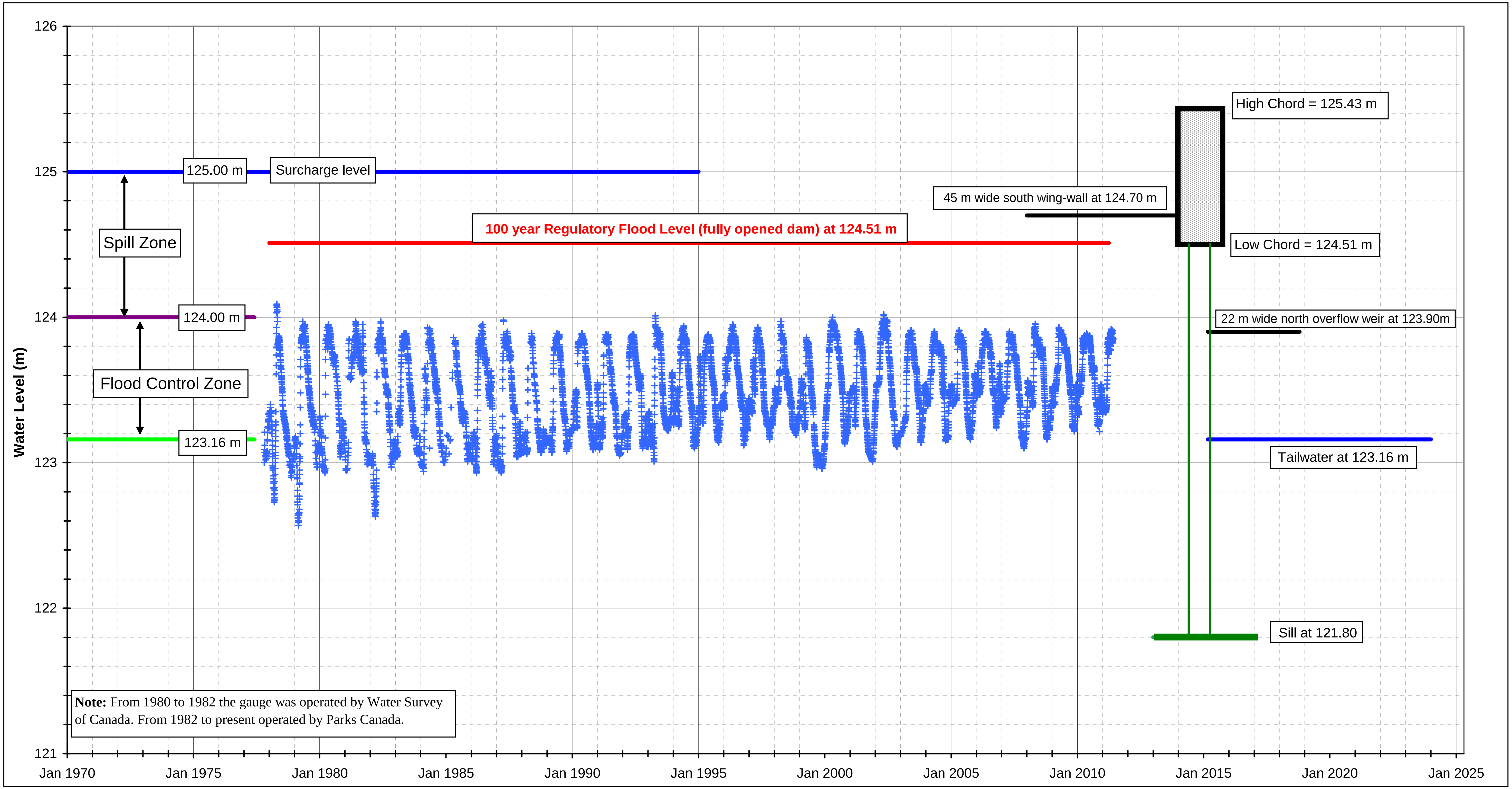

Figure 8: Observed Water Level at Rideau Ferry (Station ID: 02LA014)

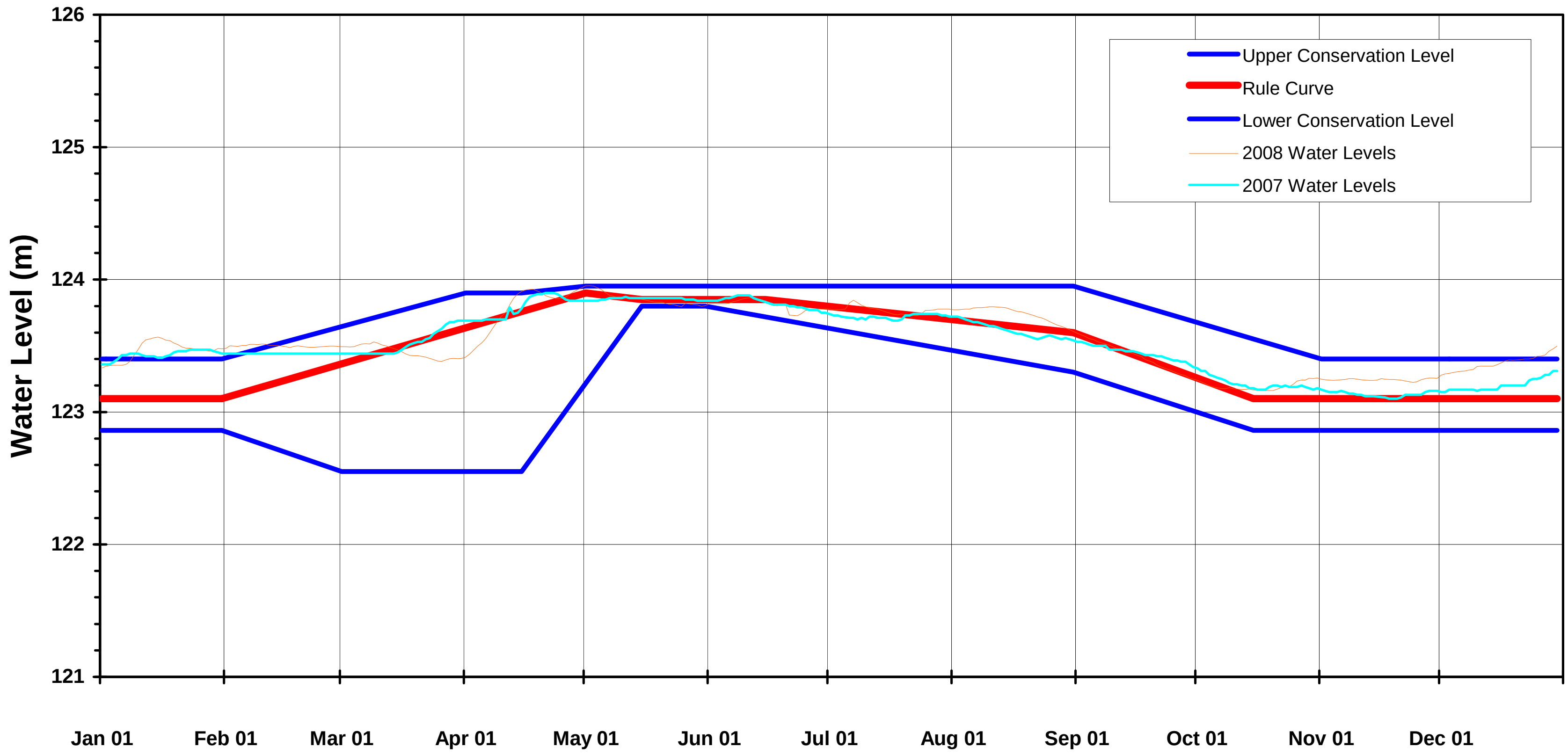

Figure 9: Rule Curve for Big Rideau Lake

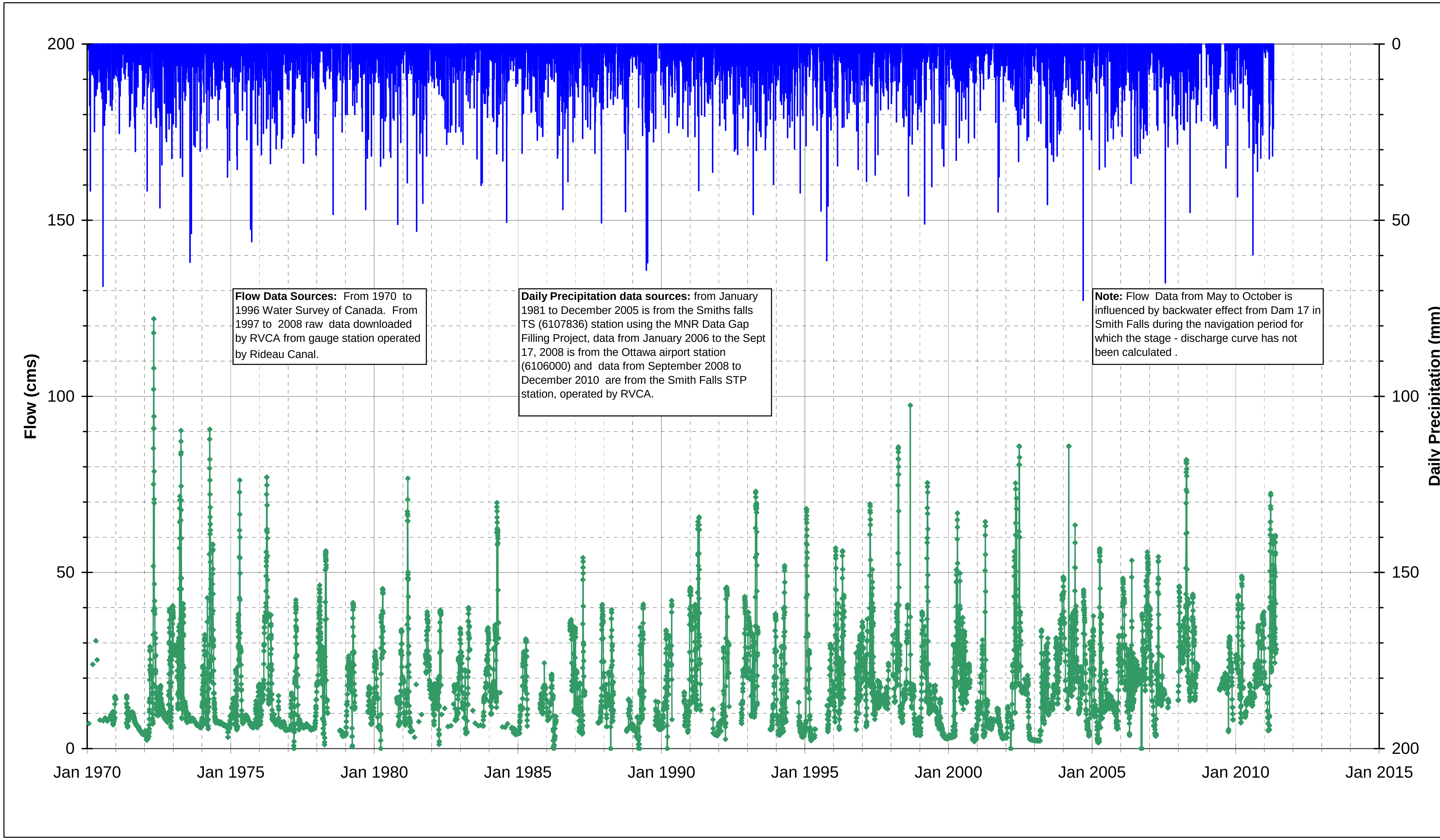

Figure 10: Observed flow downstream of Poonamalie Dam (WSC Station: 02LA005)

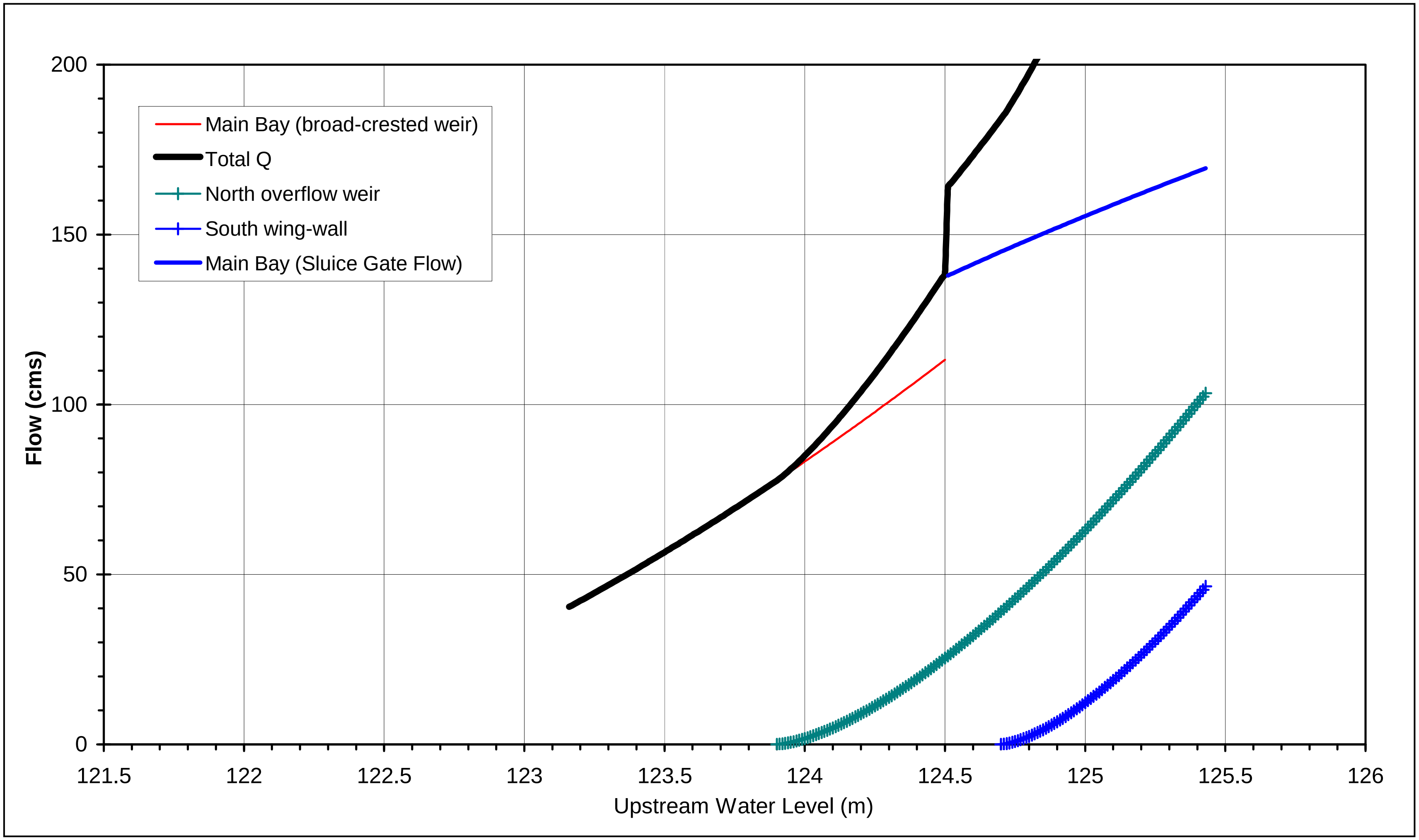

Figure 11: Stage - Discharge Relationship at Poonamalie Dam (with flashboard)

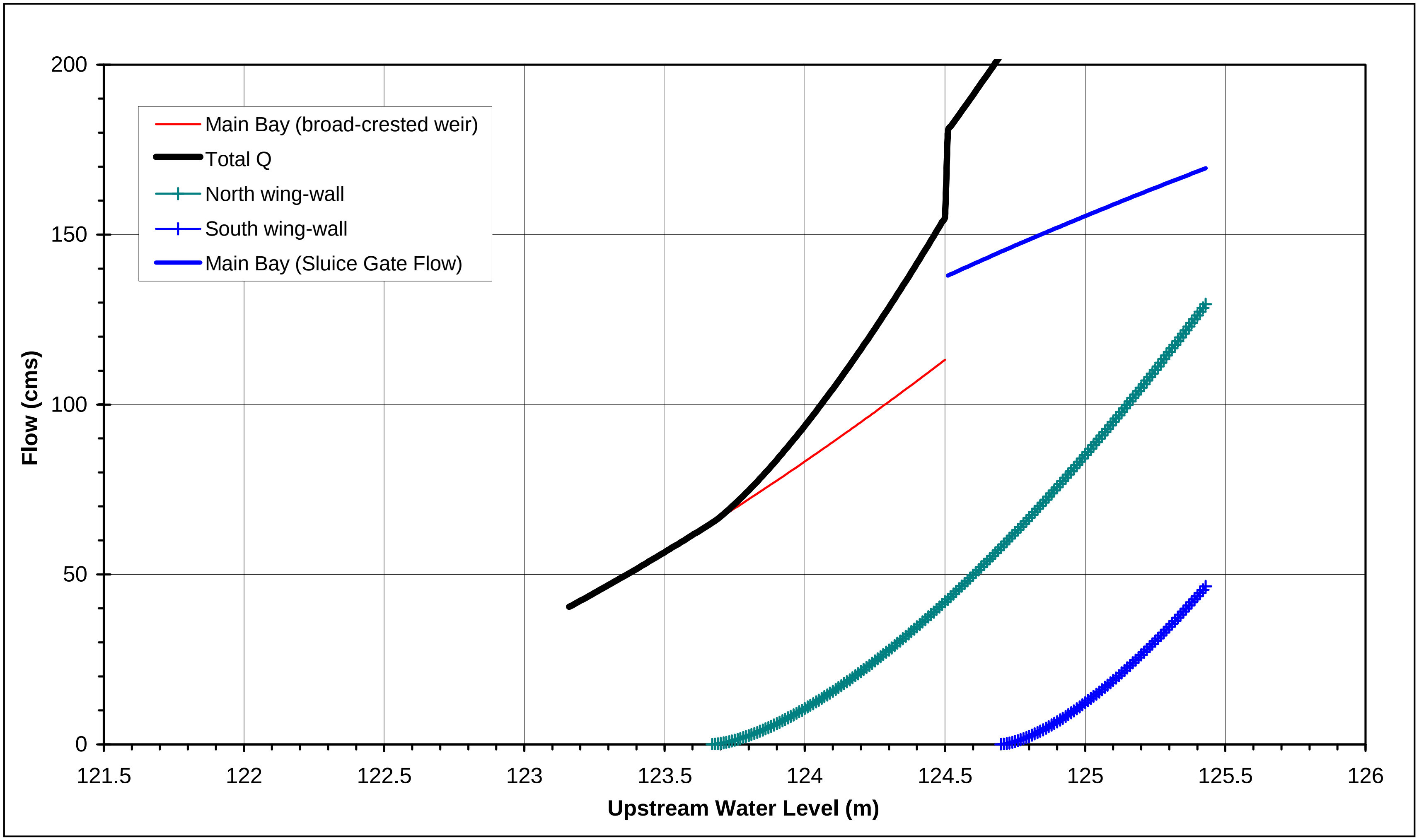

Figure 12: Stage - Discharge Relationship at Poonamalie Dam (without flashboard)