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Technical Memorandum

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Subject: **Rideau River Flood Risk Mapping from Kars to Burritts Rapids**

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Executive Summary

This report provides a summary of the analytical methods used and underlying assumptions applied in the preparation of flood plain mapping for the Rideau River from Kars to Burritts Rapids. The project has been completed in accordance with the technical guidelines set out under the Canada-Ontario Flood Damage Reduction Program (FDRP) (MNR, 1986), and the technical guide for the flood hazard delineation in Ontario (MNR, 2002) as laid out by the Ontario Ministry of Natural Resources. The 1:100 year flood lines delineated here are suitable for use in the RVCA's regulation limits mapping (as per Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

Contents

1. Introduction

In 2012, The City of Ottawa and three conservation authorities (Mississippi, Rideau and South Nation) initiated a program for flood risk mapping within the boundary of the City. A five-year plan for mapping a number of high priority rivers and streams was made. As part of this program, the RVCA has identified 12 stream reaches, where the existing mapping would be updated or mapping will be created for the first time.

Historically, the Rideau River from Poonamalie Dam to the Rideau Falls has been segmented in to five reaches for flood mapping studies:

1) Rideau River (Hogs Back to Rideau Falls)
2) Rideau River (Hogs Back to Kars)
3) Rideau River (Kars to Burritts Rapids) *[this study]*
4) Rideau River (Burritts Rapids to Smiths Falls)
5) Rideau River (Smiths Falls to Poonamalie Dam)

The first three reaches are within the City of Ottawa and were therefore identified for updating during this program. Updating of the first reach (Hogs Back to Rideau Falls) has already been completed (RVCA, 2016). Work on the second reach is nearing completion and a project completion report is being produced concurrently (RVCA, 2017b). This report deals with the third reach (Kars to Burritts Rapids).

The middle three reaches are in need of updating and it was decided that a single, comprehensive hydrological analysis done for the entire Rideau River will be a logical approach. This single hydrological study has now been completed (RVCA, 2017a), which should be read along with the present report. The flood quantiles derived from the hydrology report have been used here (and will be used elsewhere) for flood mapping purposes along the Rideau River.

This report deals with the flood risk mapping of the third reach of the Rideau River (Kars to Burritts Rapids).

The last mapping study (Robinson, 2003) of this reach is now 14 years old. Changes in the landscape have taken place along the shoreline and floodplain, such that the plotted flood limits in some locations may no longer accurately depict areas that are presently flood prone under regulatory flood conditions. It has been deemed desirable and necessary by the City of Ottawa to produce updated flood line mapping, to facilitate the implementation of the natural hazards policies of its Official Plan and the associated zoning by-laws. A funding contribution from the City has enabled the RVCA to prioritize this project within its ongoing, watershed-wide program of flood risk assessment and flood plain delineation.

This report provides a summary of the analytical methods used and underlying assumptions applied in the preparation of flood plain mapping for the Rideau River from Kars to Burritts Rapids (Figure 1). The project has been done in accordance with the technical guidelines set out under the Canada-Ontario Flood Damage Reduction Program (FDRP) (MNR, 1986), and the technical guide for the flood hazard delineation in Ontario (MNR, 2002) as laid out by the Ontario Ministry of Natural Resources. It also conforms to the 'generic regulation' guidelines of Conservation Ontario (2005). The 1:100 year flood lines delineated here are suitable for use in the RVCA's regulation limits mapping (as per Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

The Robinson (2003) mapping has been used by RVCA for regulatory purposes since 2003. The present mapping, when endorsed by RVCA's Board of Directors, will supersede the 2003 Robinson mapping.

2. Study Area

The Rideau River, from Kars to Burritts Rapids, has no branches and is thus the only stream reach mapped during this study. This 32 km reach extends from the upstream side of Regional Road 6 or Roger Stevens Drive at Kars to the downstream side of the Burritts Rapids Dam (Figure 1). The area mapped is located mostly within the City of Ottawa. However, a 26 km reach separates the City from the County of North Grenville; thus mapping of this part also affects North Grenville. The river goes through sparsely populated rural areas. There are a few flood vulnerable areas such as those near the Village of Kars, Lorne Bridge Road, Fenell Lane, Baxter Conservation Area, Fairmile Drive, Hilly Lane and Becketts Landing.

3. Previous Studies

Two flood plain mapping studies that included the reach from Kars to Burritts Rapids have been carried out in the past (James F. MacLaren, 1976; Robinson, 2003).

The first study was conducted by James F. MacLaren (1976), with a focus on the reach from Kars to Smiths Falls. Flood frequency analysis was done using available streamflow data at Long Island (1949-1975; 27 years), Merrickville (1942-1975; 34 years) and Poonamalie (1944-1975; 32 years). The 1:100 year floods at these three locations were estimated at 14400, 5300 and 5000 cfs (407.8, 150.1 and 141.6 cms) respectively. Flows at other locations were computed by interpolating flows as a linear function of drainage area. The contribution of Kemptville Creek was estimated as 8600 cfs (243.5 cms) and was added at the confluence. The determination of the 1:100 year flood profile was based on two components. First, the headwaters upstream of water control structures were computed using the information provided by Park Canada's Rideau Canal Office. Second, the channel profiles upstream were computed using the RBACK computer model (developed by James F. MacLaren and based on the standard step method). Flood lines were then plotted on photo-mosaic sheets.

The second attempt to map the Rideau River from Kars to Burritts Rapids was made in early 1990s. This project was commissioned in 1992 and the final report by Robinson (2003) was preceded by a number of interim reports. Different methodologies were tried and many challenges faced; but at the end, the approach based on flood frequency analysis at gauge locations and flow transposition – first advocated by Robinson (1984) – was adopted. A frequency analysis of the streamflow data from 1948 through 1989 at Below Manotick gauge was done, and the three parameter log-normal (3PLN) distribution was selected for conservatism and also for consistency with past studies. It is not clear if the data at the Ottawa gauge was revised. However, it appears that the flood quantiles at Ottawa and Below Manotick were used for estimating the flows at upstream locations by area pro-rating (thus making it an extrapolation rather than interpolation). The details of the hydrological calculations are scattered in various interim reports, but a 1993 report (Robinson, 1993) contains the summary. At the end, however, design flows from Dillon (1989), which were really taken from Robinson (1984), were finally chosen for flood mapping purposes. The estimated flows were then used in the

HEC-2 model for water profile computation. Flood lines were plotted on 1:2000 and 1:5000 scale topographical maps.

It is noted here that the James F. MacLaren's (1976) mapping work was extended in 1983 to include major tributaries and is documented in James F. MacLaren (1983) report. Spring floods of nine tributaries were estimated. And the spring floods were used to calculate the flood levels along the tributaries. The hydraulic computation was done using the HEC-2 model, and the floodplain plotted on phot-mosaic sheets. Updating the mapping along these tributaries is not within the scope of the current study, and therefore, the present study has no impact on them.

4. Topographical Mapping

LIDAR: High quality topography is the key to high quality flood risk mapping. Digital elevation models were derived from LIDAR data procured by the City of Ottawa. The LIDAR was flown in April 2007 and August 2012. This data set has a density of about 7 to 8 points per square meter, and an estimated vertical accuracy of 0.10 m (Airborne Imagery, 2013). The City also provided 0.25 m contour lines that were derived from LIDAR data. However, we only used the LIDAR points (spot heights) directly for this study, and the contour lines were never used.

In some places, the LIDAR data was missing along the water line or were obscured by trees and shrubs. RVCA staff carried out ground surveys during 2014 and 2015 to collect data to augment the LIDAR data for the purposes of flood line delineation.

The accuracy of the LIDAR data was checked in the field by RVCA staff in April-May 2015. The true elevations of features on the ground that are identifiable on the mapping were determined using RVCA's survey grade GPS equipment (Trimble R8), and compared with the elevations indicated by the LIDAR spot heights, to determine that any differences between mapped and true elevations were within the accuracy prescribed by the FDRP standards.

In total, 300 spot heights were verified (see Table B.1 and Figure B.1 in Appendix B). As described in the FDRP guidelines (MNR 1986), the spot height checks are considered satisfactory when 90% of the data points are within 0.33 m of the field measurement. As shown in Table B.1, this criterion has been adequately met[1]. On average, the spot heights are within 4.9 cm (Figure B.2).

At the few locations where these criteria are not met, changes to the landscape since the date of air photo have been identified as the probable cause of the discrepancy. Data at these locations were disregarded in the DTM verification.

In the southeast portion of the study area, floodplains extended beyond the 2012 LIDAR coverage, which extended only about 500 m south of the Rideau River. High

[1] FDRP (1986) Manual also specifies criteria for checking contour crossings. However, in this study we used only LIDAR spot heights, not contour lines. Therefore, we did not check the accuracy of contour lines supplied by the City of Ottawa.

quality DTM based on 2001 aerial photography, which met FDRP (1986) specifications, was used in this area.

Drape Imagery: The Drape imagery was collected in April-June 2014 with a horizontal accuracy of ±0.5 metre. This high quality colored photo clearly shows the rivers, creeks, land use, houses, buildings, roads, infrastructure, vegetation and other details.

2011 Aerial photo: The 2011 aerial photo was also available from the City of Ottawa. It is accurate, sharp and in colour, and shows various natural and man-made features clearly.

Building footprint: The 'building footprint' layer was provided by the City of Ottawa for the area inside the urban boundary. It enables us to accurately draw flood lines around buildings. This data layer contained information collected over a number of years.

5. Hydrological Analysis

The hydrological analyses to support this study have been documented in an accompanying report (RVCA, 2017a), and are not repeated here. Suffice it to say that the methodology was based on a thorough review of past studies.

Our current methodology for estimating flood quantiles along the Rideau River consists of the following components:

- Estimating and using instantaneous flows
- Converting ‘regulated flows’ to ‘naturalized flows’ by using the Robinson (1984) methodology
- Testing streamflow data for suitability for flood frequency analysis (homogeneity, independence, randomness, and trend)
- Using standard flood frequency analysis where long enough streamflow record is available (gauge locations) to estimate flood quantiles
- Using area pro-rating to transpose flood quantiles from gauge locations to other locations
- Using the hydraulic model (HEC-RAS) to determine the flow split where multiple branches are present

Once we settled on this approach, the available streamflow data and watershed characteristics determined to a large extent the eventual outcome of this analysis, i.e., the flood quantiles. Table 1, taken from RVCA (2017a), shows the flood quantiles that were computed for flood mapping purposes along the Rideau River. Table 2 lists the exponents which were determined from streamflow data and were used in computing flows at ungauged locations. Table 3 shows the flows that were used for hydraulic computation (HEC-RAS modeling). Figures 2 and 3 illustrate the spatial distribution of flood quantiles and their relative magnitude.

6. Hydraulic Computations

6.1 HEC-RAS Model

Following standard procedures (MNR, 1986; USACE, 1990, 2010), a steady-state hydraulic model of the Rideau River was built. The steady state HEC-2 model developed by Robinson (2003) was converted to HEC-RAS and updated to present conditions. The HEC-RAS software (version 4.1.0) developed by the US Army Corps of Engineers (USACE, 2010) was used. It uses the same back water calculation procedure as HEC-2 (USACE, 1990), which has been the industry standard since the 1970s, but with improved data processing and graphical capabilities.

Cross-Sections: The cross-sections used in the modeling were imported from Robinson's (2003) HEC-2 model files. These cross-sections (95 in total) were based on the original 1970 bathymetry generated by sounding technique by Canadian Hydrometric Service (CHS). The above-water part of the cross-sections was extracted from 1:2000 scale topographical mapping generated from aerial photography collected on 26th April 1985. This data was supplemented by field data collected by Robinson (2003) and RVCA staff at that time. The above-water portion of cross-sections matched well with recent LIDAR data and was deemed to be suitable for the current study. Survey work to verify the representativeness of the below-water portions of the cross-sections was considered to be beyond the scope of the current project.

In total, 95 cross-sections were used in our HEC-RAS model. Figure 4 shows a schematic of the HEC-RAS model. Figures 9(a-e) show the cross-sections in greater detail, along with the computed Regulatory Flood Levels (RFLs) and flood risk limits. The spacing between and the alignment of river cross-sections within the model were reviewed and adjusted as necessary.

Channel Roughness: These values were directly taken from Robinson's (2003) calibrated HEC-2 model. The Manning's roughness coefficient was generally between 0.030 and 0.035 in the main channel, and was 0.08 for most of the overbank areas (a tabular listing is included in Appendix A). These values were consistent with standard values, such as those recommended by Chow (1959). As will be seen later in this report, these values were found satisfactory and no further adjustment was necessary.

Rating Curve: Rating curve at the Rideau River Below Merrickville gauge location was obtained from Water Survey of Canada (WSC) (Figure 5). This rating curve was outside the study reach (Kars to Burritts Rapids) and thus could not be directly used in HEC-RAS model verification. But it would be useful for mapping the next reach (Burritts Rapids to Smiths Falls).

Bridges/Structures: Within the study area there are four bridges and one dam (Tables 4 and 5). As-built drawings for all the bridges within the reach were obtained from the City of Ottawa. Bridges in the Robinson study were not directly added to the model since the structures were wide and high with no possibility of affecting the flood flow. The bridges were instead represented as cross-sections with encroachments to represent bridge abutments[2]. Only the Roger Stevens Drive Bridge was included in the hydraulic model in order to be consistent with the RVCA's (2017b) model downstream (Kars down to Hogs Back).

As-built information for the Burritts Rapids Dam was obtained from Parks Canada's Rideau Canal Office, Smith Falls and from Acres (1994) report. Tables 6 and 7 lists the cross-sections, bridges and dams that were modified from Robinson's (2003) during the course of this study, and the reasons for doing so.

The design flows from the hydrologic analysis (discussed above), with return periods ranging from 2 to 500 years (Table 1), were used in the HEC-RAS model. Table 3 shows the flows that were input to the HEC-RAS model.

At the downstream end of the HEC-RAS model, the model was extended about 1.5 km downstream of Regional Road 6 Bridge. The boundary conditions, i.e., simulated water levels at the downstream end (cross-section -1460), were taken from the recent HEC-RAS model for the downstream reach (from Hogs Back to Kars; RVCA, 2017b). Table 8 lists the boundary conditions for various flood events.

All dams were assumed to be fully open during flood conditions. This is the current policy of Parks Canada, the owner and operator of the dams[3].

[2] This was found to be an acceptable method when scrutinized. When the bridges were modelled using the bridge design editor in HEC-RAS, a water level variation of only 1 cm was found.

[3] In a meeting between RVCA and Parks Canada staff on 12 March 2015, the current operating policies for the dams along the Rideau Canal were clarified and confirmed by Parks Canada staff. During flood events, Parks Canada fully opens the dams and allows 'free flowing' condition at all structures.

Once the model was set up, the computed profiles and other parameters were scrutinized to assess the reasonableness of model outputs. Special attention was given to the computed water level and energy profiles near bridges. Adjustments of model parameters – mainly the channel resistance and contraction and expansion coefficients – were made as necessary.

6.2 Model Verification

If possible, hydraulic models are generally calibrated and validated before being accepted as representative of the river system being modeled. In this case, our HEC-RAS model is based on Robinson's (2003) HEC-2 model, which was calibrated and found satisfactory at that time. Therefore, we first tested our HEC-RAS model, without significant changes, to see if it works. We found that it works well, and conforms to available data (collected both during Robinson study and since then). By virtue of being a slightly modified version of the well calibrated Robinson's (2003) HEC-2 model, the current HEC-RAS model needed almost no adjustment to be considered calibrated. The verification was done in the following ways:

- By comparing water levels during 6 April 1999 flood event
- By comparing water levels during 11 April 2014 flood event
- By comparing water levels during 4 April 2015 flood event

The HEC-RAS model is able to match observed water level data very well for the 1999 event that were also used by Robinson (2003)[4]. Table 9a indicates that the matching was within 2-13 cm. The 6 April 1999 had a return period between 2 to 5 years.

The flood of 11 April 2014 had a return period of about 5 years. This is a well-documented large flood in recent years. The HEC-RAS model simulated the water levels within 1-10 cm (Table 9b).

These two events of 1999 and 2014 were used to verify the model and it was concluded that the model was well-calibrated. After this, however, information was also collected during 2015 spring, and we decided to utilize this additional information.

[4] This is the only event that Robinson (2003) used for calibration.

The flow on 4 April 2015 was far below of what can be considered a flood. Nonetheless, it allowed an additional check of the model. The model slightly overestimated the water levels by 16-18 cm (Table 9c). This overestimation may be attributed to the modelling of dam parameters. The dams have been modeled for free flow condition. But on 4 April 2015, not all dams were in free flow condition; and therefore, stop logs and gate openings were added to model them properly. During the verification runs, the dam settings were based on the information supplied by Parks Canada[5]. This adjustment to the dam conditions without adjusting the other dam parameters, such as contraction and expansion coefficients, may have led the model to overestimating water levels.

Figure 6 shows the summary of all three verification events. Our model was able to simulate water levels within 1-13 cm for relatively large flood events. This establishes that the model is good for flood mapping purposes. It is also noted that the model has a slight degree of conservatism. This confirms that our intention of calibrating the model to match observed data as closely as possible, but with a slight degree of conservatism, has been achieved.

It has traditionally and widely been accepted that the calibration process is not meant to force the model to fit all observations, but to match the computed water surface profile to observed water levels within a certain limit. A rule of thumb used by the USACE (US Army Core of Engineers) specifies good calibration when the model predicts elevations within 30 cm of observation (Heastead Methods, 2003; Bentley Systems 2007); whereas FEMA (US Federal Emergency Management Agency) suggests a 15 cm tolerance (FEMA, 2009). Our model satisfies both criteria. Our approach of slight conservatism (a combination of hydrologic and hydraulic computations) is also congruent with the current notion of the Precautionary Principle, which applies when there exist considerable scientific uncertainties about causality, magnitude, probability, and consequences of different course of action (UNESCO, 2005). The Precautionary Principle is also a key policy of Environment Canada[6].

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[5] Email communication from Parks Canada staff dated July 17, 2015.

[6] Canada's environmental policy is also guided by the precautionary principle and is reflected in the Federal Sustainable Development Act which states that the Minister of Environment must "develop a Federal

Based on the above reasoning, the model is considered well calibrated and suitable for flood hazard mapping[7].

6.3 Computed Water Surface Profiles

Once calibrated, the model was run with the design floods. The 1:100 year computed water surface elevations and other parameters are shown in Table 10. A few typical water surface profiles and all cross-sections are included in Appendix A.

Computed water surface elevations for various flood events with return periods ranging from 2 to 500 years are presented in Tables 11 and 12. It should be pointed out that the model has been built and calibrated based on observed flood events in the 130-320 cms range (at Below Manotick gauge) occurring during spring freshet. Caution should be used when applying this model to simulate water surface profiles for flows outside this range, or for flows that occur during other seasons of the year. Such water surface profiles – simulated using the same parameters, especially the Manning's roughness coefficient – would be only approximate, and should be used with caution. This is because the river roughness can vary with flow magnitude (with higher resistance associated with lower flows) and with the time of the year (as related to the presence of instream vegetation).

It is also acknowledged that the 1:100 year flood is much larger than the flow range used for calibration. However, use of the same calibration parameter (Manning's roughness calibrated for 130-320 cms flow range) for the 1:100 year flow will result in a very slightly higher (conservative) flood level. This approach is reasonable and is widely accepted as a standard practice.

Sustainable Development Strategy based on the precautionary principle". The precautionary principle states that: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". In other words, the absence of complete scientific evidence to take precautions does not mean that precautions should not be taken – especially when there is a possibility of irreversible damage (Environment Canada, 2010).

[7] While we consider the model good enough for the purposes of floodplain mapping, we also recognize that further model adjustment/modification may be necessary for other purposes. It all depends on the purpose of the modeling and the features and phenomena a model is meant to capture. We therefore caution against using this model for other purposes without first confirming its suitability.

In cold climate areas like Ontario, floods may occur with or without ice jam. Here we have only analyzed the ice-free or open water condition. Ice-induced flooding has not been looked at because we are unaware of any ice-related flooding that caused significant concern in this area (Kars to Burritts Rapids). Downstream of Hogs Back, ice jams have historically occurred and have been managed by ice cutting/blasting for at least the last one hundred years.

6.4 Sensitivity Analysis

Flood quantiles have the highest degree of uncertainty in our computation and is most likely to affect the water surface profile. Therefore, we decided to test the sensitivity of water surface profile to flow variation.

The sensitivity analysis was conducted to determine how much the computed water surface elevations will vary with changes in the value used for the 1:100 year discharge. Six flow conditions were tested:

- 1:100 year flow increased by 5%
- 1:100 year flow increased by 10%
- 1:100 year flow increased by 20%
- 1:100 year flows decreased by 5%
- 1:100 year flow decreased by 10%
- 1:100 year flow decreased by 20%

Figures 7 and 8 show the computed water surface profiles and the differences in computed water levels for each condition. Figure 7 indicates that the computed water surface elevations are nearly horizontal and change rather uniformly over the entire length of this river reach. The sensitivity analysis indicates that the computed water level can vary by less than 0.25 m for a 10% variation in flow along most of the river reach, which is typical in the hydrologic estimation of design flow. For a 20% increase in flow, the water level can go up by 0.40 to 0.45 m.

The sensitivity analysis provides an indication of the potential effect of changes in the expected flood flows that might result from anthropologic intervention in the watershed or from natural variability such as climate change.

7. Selection of Regulatory Flood Levels

As per Section 3 of the Provincial Policy Statement under the Planning Act (MMAH, 2005, 2014), the regulatory flood in Zone 2, which includes the RVCA, is the 1:100 year flood[8]. Depending on the local hydraulic conditions, the computed water surface elevation, the energy grade or a value in between is generally taken as the Regulatory Flood Level (RFL). Engineering judgment is applied to recommend an appropriate value for the regulatory flood level at each cross-section, using the model outputs and considering hydraulic characteristics of the river reach, and the inherent limitations of numerical modeling.

When the stream velocity is relatively low and varies only gradually over relatively long river reaches, the water surface can generally be taken as the RFL.

However, near bridges, culverts and other water control structures, and on steeper reaches where streamflow velocities are higher, and may change more abruptly, the computed water surface elevation may be substantially lower than the energy grade level, with the possibility that the water level may rise to the energy grade near obstacles and irregularities in the channel profile or cross-section which may not be represented in the hydraulic model. In such cases, the regulatory flood level is generally based on the computed energy grade as a conservative approach, given that the numerical model is less likely to be a true representation of reality in such situations.

Another possible situation arises when the computed water surface profile is undulating, with downstream water levels occasionally higher than upstream levels. When this occurs, it is more often an artifact from the simplifying assumptions of the modeling scheme than a reliable prediction of the actual differences in flow velocity and depth from one cross-section to the next. Accordingly, the regulatory flood level at the upstream cross-section is taken to be equivalent to the downstream water surface elevation in these situations. Setting RFL equal to the energy grade resolves this problem.

[8] Review of historical water level indicates that it never exceeded the estimated 1:100 year flood level. In a recent study on the lower most reach from Hags Back to Rideau Falls (RVCA, 2016), it was found that the highest recorded water level at Carleton University gauge (60.35 m on 28 March 1976) was lower than the estimated 1:100 year flood level of 60.75 m. Furthermore, during subsequent studies on the upstream reaches (Hogs Back to Kars, and Kars to Burritts Rapids) (RVCA, 2017a, 2017b), the same was found at Manotick gauge (81.01 m recorded vs. 81.80 m estimated flood level) and at Becketts Landing (86.76 m recorded vs. 87.31 m estimated flood level). Therefore, the 1:100 year flood is the appropriate mapping standard for the Rideau River.

In all cases, the RFL is always between the computed water level and energy grade line. Hence, for the sake of simplicity and consistency, the energy grade elevation is often used as the RFL as a standard practice in delineating flood hazard areas.

For the present study, the regulatory flood levels were set equal to the computed energy grade and are tabulated in Table 10, along with the computed water surface elevations and energy grades at each cross-section in the model.

8. Flood Line Delineation

8.1 General

Once the RFLs are established, the plotting of 1:100 year flood lines or flood risk limits is a relatively straightforward matter. Given the topographical information in the form of LIDAR spot heights, the inundated area below the RFLs can be easily delineated manually or by using automated computer programs. In the present case, it was done manually with a focus on areas with complex topography, infrastructure, and overbank flow paths. The raw LIDAR spot heights were extensively used in the plotting the flood risk limit.

Field surveys were conducted by RVCA staff in 2015 to verify hydraulic connectivity through culvert openings and flood prone areas. This information (Table 13) was used in plotting the flood risk limit near culverts.

The record of site-specific information associated with RVCA's regulatory approval process was compiled since 2012 (Table 14). At none of the locations did the site-specific information warrant an adjustment of the flood lines. Available as-built drawings, building layer, and aerial photographs were used to determine the flood risk limit.

Special attention was paid near the outfalls of smaller tributaries to the Rideau River within the study area, since such areas are subjected to flood risk from two sources (backwater from a high Rideau River level, or an extreme flood event on the tributary). The flood plain limits on tributaries have been plotted based only on the flood elevation of the Rideau River – that is, assuming a horizontal water surface profile up along the tributary and an insignificant flow in the tributary itself. Caution needs to be applied when interpreting the flood line information produced in this study in the review of any development or watercourse alteration proposals on the downstream reaches of the tributaries – by taking into consideration the potential effect of high flows originating in the tributary watershed, possibly in combination with high water levels on the Rideau River in an appropriate manner.

8.2 Buildings in the floodplain

Presence of existing buildings within the floodplain and associated variation in the way a building could be exposed to flood risk required special attention. Recently, RVCA has consolidated a few rules for drawing flood lines in the vicinity of buildings (Appendix C), which have been followed in this study. Due to the limitations of the data and methodology used in the current mapping done at a large scale, and the small degree of (inevitable) subjectivity in drawing flood lines around buildings at a smaller scale, RVCA recommends that, should the need arise for more accurate flood line delineation near buildings, site-specific information be taken into account when dealing with flood risk at these locations. It is the practice of RVCA to refine flood lines when more accurate information becomes available.

8.3 Islands in the floodplain

Presence of small islands, especially those associated with septic beds, within the floodplain also requires special attention. Recently, RVCA has decided to show small islands with an area less than 1000 m^2 as flood risk area (Appendix C) This guidance was followed during this study.

8.4 Flood mapping data in GIS

The regulatory flood lines and cross-sections have been incorporated as separate layers in RVCA's Geographical Information System (GIS). In this system, one can view the flood lines, cross-sections, design flow, water level, energy grade, RFL, and other computed parameters. The flood lines can be overlain on the aerial photography or any other base mapping layers that are in the system and at any scale that suits the user's need.

The regulatory flood line layer is maintained, and updated as required according to the established procedures of the RVCA (RVCA 2005).

Figures 9(a-e) shows the flood risk limits as delineated in this study. At all cross-section locations, the RFL is indicated. The general surrounding and land marks are also included for easy referencing.

9. Project Deliverables

The key information or knowledge products generated from this project are:

1) The Flood Mapping Report (this Technical Memorandum) – which summarizes the analytical methods that were used and the underlying assumptions
2) The flood risk limit lines in GIS format (shape files) – identifying the extent of lands which are considered to be vulnerable to flooding during a regulatory flood event (1:100 year flood on the Rideau River)
3) The HEC-RAS model files (input and output)
4) The position and orientation of cross-sections used in the HEC-RAS model, in GIS format (shape files) – which, when used in conjunction with the HEC-RAS model output files, informs the user as to the estimated 1:100 year water surface elevation and the regulatory flood level for any location in the study area

A "documentation folder" containing working notes and relevant background information accumulated during the study process is maintained by the water resources engineering unit within RVCA's Watershed Science and Engineering Services Department.

10. Closure

The hydrotechnical and cartographic procedures used in this study generally conform to present day standards for flood hazard delineation, as set out in the MNR's Natural Hazards Technical Guide (MNR, 2002). The resulting 1:100 year flood lines are suitable for use in the RVCA's regulation limits mapping (as per Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act. The water surface profiles generated in the study will also be useful in the flood forecasting and warning services provided by the RVCA.

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Table 1 Estimated Flood Quantiles to be Used for Flood Mapping.

		Rideau River at Ottawa† (02LA004)	Rideau River Below Manotick (02LA012)	Rideau River Below Merrickville (02LA011)	Rideau River Above Smith Falls (02LA005)	Jock River Near Richmond (02LA007)	Kemptville Creek Near Kemptville (02LA006)
Return Period (year)	Annual Probability of Exceedence (%)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)
2	50	369.00	230.00	120.00	53.00	84.70	48.20
5	20	475.00	292.00	148.00	100.00	125.00	67.20
10	10	529.00	330.00	162.00	117.00	140.00	75.50
20	5	572.00	364.00	174.00	128.00	147.00	80.70
50	2	617.00	406.00	186.00	135.00	151.00	84.80
100	1	644.00	435.00	194.00	140.00	153.00	86.60
200	0.5	667.00	463.00	200.00	145.00	153.00	87.80
350††	0.3	680.00	480.00	204.00	148.00	154.00	88.00
500	0.2	691.00	497.00	207.00	150.00	154.00	88.60
Drainage Area (km^2)		3809	3138	1967	1250	526	411
Data Span		1947-2012	1981-2014	1980-2014	1970-2010	1970-2014	1970-2014
Frequency		GEV	GEV	GEV	Manual Fit	WAKEBY	WAKEBY

Note:

GEV - Generalized Extreme Value

3PLN - 3 Parameter Lognormal

LP3 - Log Pearson Type III

† Source: RVCA (2015) Rideau River Flood Risk Mapping from Hogs Back to Rideau Falls

†† 350 year flood quantile was estimated by graphical interpolation.

Table 2 Calculated "k" Exponents That Are Used In the Flow Transposition Equation in Order to Determine the Flows at Different Locations.

Return Period (Years)	Rideau River at Ottawa (02LA004) and Rideau River Below Manotick (02LA012)	Rideau River Below Manotick (02LA012) and Rideau River Below Merrickville (02LA011)	Rideau River Below Merrickville (02LA011) and Rideau River Above Smith Falls (02LA005)	Rideau River at Ottawa (02LA004) and Jock River Near Richmond (02LA007)	Rideau River at Ottawa (02LA004) and Kemptville Creek Near Kemptville (02LA006)
2	2.44	1.39	1.80	0.74	0.91
5	2.51	1.45	0.86	0.67	0.88
10	2.44	1.52	0.72	0.67	0.87
20	2.33	1.58	0.68	0.69	0.88
50	2.16	1.67	0.71	0.71	0.89
100	2.03	1.73	0.72	0.73	0.90
200	1.88	1.80	0.71	0.74	0.91
350	1.80	1.83	0.71	0.75	0.92
500	1.70	1.87	0.71	0.76	0.92

Table 3 Estimated Flood Quantile for HEC-RAS Modelling.

River	Reach	Cross-Section ID	Return Period (Year)								
			500 Yr	350 Yr	200 Yr	100 Yr	50 Yr	20 Yr	10 Yr	5 Yr	2 Yr
Rideau River	Kars to BR	29822.51	243.76	234.98	226.59	213.21	198.64	178.26	162.20	146.08	121.61
Rideau River	Kars to BR	29405	243.76	234.98	226.59	213.21	198.64	178.26	162.20	146.08	121.61
Rideau River	Kars to BR	26880	259.74	250.39	240.88	226.12	210.24	188.09	170.79	153.45	127.49
Rideau River	Kars to BR	23675	262.61	253.15	243.44	228.43	212.31	189.84	172.32	154.77	128.54
Rideau River	Kars to BR	21545	264.77	255.23	245.36	230.16	213.87	191.16	173.47	155.75	129.32
Rideau River	Kars to BR	18720	278.83	268.79	257.89	241.45	223.99	199.70	180.93	162.13	134.39
Rideau River	Kars to BR	15855	282.27	272.10	260.95	244.20	226.45	201.78	182.74	163.67	135.62
Rideau River	Kars to BR	13635	284.84	274.58	263.24	246.26	228.29	203.33	184.09	164.83	136.54
Rideau River	Kars to BR	12665	380.50	369.59	358.03	339.76	319.84	290.46	265.60	237.38	188.58
Rideau River	Kars to BR	10150	389.51	378.15	366.19	347.19	326.59	296.26	270.70	241.72	191.89
Rideau River	Kars to BR	6305	396.05	384.37	372.11	352.59	331.49	300.46	274.39	244.86	194.28
Rideau River	Kars to BR	2605	412.33	399.82	386.82	365.98	343.63	310.86	283.52	252.63	200.19
Rideau River	Kars to BR	1700	458.75	443.82	428.65	403.94	377.98	340.18	309.20	274.42	216.71
Rideau River	Kars to BR	1050	460.39	445.37	430.12	405.27	379.18	341.21	310.10	275.18	217.28
Rideau River	Kars to BR	290	460.69	445.65	430.39	405.51	379.40	341.40	310.26	275.32	217.39

Table 4 Bridge Information.

River/Reach	Bridge	Chainage (m)	Bounding Cross Sections	Top of Deck (m)	Low Chord (m)	Deck Width (m)	Coefficient of Contraction	Coefficient of Expansion	Date of Drawing	Source	Notes
Rideau River/USManotick	Roger Stevens Drive	28719	28715 & 28727	94.50	92.60	12.00	0.3	0.5	2011	City of Ottawa	
Rideau River/Kars to BR	416 Bridge										Drawings were obtained but the structure was not modelled due to it will not affect water levels because of its height.
Rideau River/Kars to BR	Merlyn Wilson Road										Drawings were obtained but the structure was not modelled due to it will not affect water levels because of its height.
Rideau River/Kars to BR	Burrits Avenue/Grenville Street										Structure was not modelled due to it will not affect water levels because of its height.

Table 5 Dam Information.

River/Reach	Bridge	Chainage (m)	Bounding Cross Sections	Top of Deck (m)	Sill (m)	Deck Width (m)	Coefficient of Contraction	Coefficient of Expansion	Date of Drawing	Source
Rideau River/Kars to BR	Burritts Rapids Dam	29452.25	29405 & 29505	90.17	88.24, 86.01, 85.89	7.50	0.3	0.5	2008	Parks Canada

Table 6 List of Modified Cross Sections.

Cross-Section	Reason for Change
-273	Added new cross sections from the 2015 Rideau River (Hogs Back to Kars) model so that the Kars to Burritts Rapids model stabilises before study area.
-285	
-565	
-755	
-925	
-1130	
-1460	
29505	New cross sections added after Burritts Rapids Dam in order to stablise the Kars to Burritts Rapids model within the study area. Bathymetry data came from the Canadian Hydrographic Service's Nautical Navigation Charts.
29605	
29822.51	

Table 7 List of Modified Bridges and Dams.

Dam or Bridge Section Number	Reason for Change
-278	Roger Stevens Dr bridge added to the model as it was a part of the cross sections that were added before the study area.
29452.25	Add Burritts Rapids Dam using drawings and information that was received from Parks Canada in the form of dam safety inspection sheets. Dam was added due to the fact that it is part of the river segment that was used to extend the model above the study area.

Table 8 Downstream Boundary Conditions (Cross Sections -1460)

Return Period (Years)	Water Level at Cross Section -1460 (m)
2	86.04
5	86.43
10	86.64
20	86.82
50	87.02
100	87.16
200	87.29
350	87.37
500	87.44

Note:

Taken from Cross Section 27540 of the RVCA (2015) Hogs Back to Kars HEC-RAS Model.

Table 9A Comparison of the Observed and Computed Water Levels on April 6, 1999.

	Nearest Cross-Section	April 6, 1999 Observed Water Level (m) Q_{Ottawa} = 397.00 m^3/s $Q_{Manotick}$ = 276.00 m^3/s $Q_{Merrickville}$ = 136.00 m^3/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Lorne Bridge	1420	86.28	86.37	9.00
WA Taylor	3525	86.30	86.39	9.00
McDermott Drain	8405	86.34	86.41	7.00
Arcand Drain	11315	86.37	86.42	5.00
Hilly Lane	12210	86.38	86.42	4.00
Becketts Stream Gauge	15855	86.41	86.43	2.00
Burritts Rapids Locks	27465	86.51	86.64	13.00
		Average Water Level Difference		7.00

Table 9B Comparison of the Observed and Computed Water Levels on April 11, 2014.

	Nearest Cross-Section	April 11, 2014 Observed Water Level (m) Q_{Ottawa} = 430.67 m³/s $Q_{Manotick}$ = 315.67 m³/s $Q_{Merrickville}$ = 140.22 m³/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Lorne Bridge	1420	86.5	86.60	10.00
McDermott Drain	8405	86.56	86.64	8.00
Hilly Lane	12210	86.57	86.65	8.00
Becketts Stream Gauge	15855	86.67	86.66	-1.00
		Average Water Level Difference		6.25

Table 9C Comparison of the Observed and Computed Water Levels on April 4, 2015.

	Nearest Cross-Section	April 4, 2015 Observed Water Level (m) Q_{Ottawa} = 171.75 m³/s $Q_{Manotick}$ = 133.61 m³/s $Q_{Merrickville}$ = 45.62 m³/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Kars Boat Launch	1700	85.37	85.53	16.00
McDermott Drain	8405	85.36	85.54	18.00
Becketts Stream Gauge	15855	85.38	85.55	17.00
Burritts Rapids Locks	27465	85.51	85.69	18.00
		Average Water Level Difference		17.25

Table 10 Regulatory Flood Levels for the 1:100 Year Flood Event.

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	Kars to BR	29822.51	213.21	88.98	88.99	-
	Kars to BR	29605	213.21	88.96	88.98	-
	Kars to BR	29505	213.21	88.96	88.98	-
	Kars to BR	29452.25	Burritts Rapids Dam			
	Kars to BR	29405	213.21	87.87	87.90	87.90
	Kars to BR	29275	213.21	87.60	87.82	87.82
	Kars to BR	28475	213.21	87.58	87.61	87.61
	Kars to BR	28450	213.21	87.56	87.60	87.60
	Kars to BR	28405	213.21	87.56	87.60	87.60
	Kars to BR	28075	213.21	87.53	87.57	87.57
	Kars to BR	27795	213.21	87.48	87.53	87.53
	Kars to BR	27465	213.21	87.48	87.50	87.50
	Kars to BR	27155	213.21	87.46	87.48	87.48
	Kars to BR	26880	226.12	87.45	87.47	87.47
	Kars to BR	26530	226.12	87.44	87.46	87.46
	Kars to BR	26285	226.12	87.42	87.44	87.44
	Kars to BR	25795	226.12	87.37	87.41	87.41
	Kars to BR	25355	226.12	87.37	87.38	87.38
	Kars to BR	25015	226.12	87.36	87.37	87.37
	Kars to BR	24565	226.12	87.36	87.37	87.37
	Kars to BR	24115	226.12	87.36	87.36	87.36
	Kars to BR	23675	228.43	87.35	87.36	87.36
	Kars to BR	23415	228.43	87.35	87.36	87.36
	Kars to BR	23195	228.43	87.35	87.36	87.36
	Kars to BR	22945	228.43	87.35	87.36	87.36
	Kars to BR	22815	228.43	87.35	87.35	87.35
	Kars to BR	22430	228.43	87.33	87.35	87.35
	Kars to BR	21945	228.43	87.33	87.34	87.34
	Kars to BR	21865	228.43	87.33	87.33	87.33
	Kars to BR	21545	230.16	87.32	87.33	87.33
	Kars to BR	21395	230.16	87.33	87.33	87.33
	Kars to BR	20195	230.16	87.32	87.33	87.33
	Kars to BR	19095	230.16	87.32	87.33	87.33
	Kars to BR	18720	241.45	87.32	87.32	87.32
	Kars to BR	18430	241.45	87.32	87.32	87.32
	Kars to BR	18145	241.45	87.32	87.32	87.32
	Kars to BR	17605	241.45	87.32	87.32	87.32
	Kars to BR	17255	241.45	87.32	87.32	87.32
	Kars to BR	16835	241.45	87.32	87.32	87.32
	Kars to BR	16475	241.45	87.31	87.32	87.32
	Kars to BR	15855	244.20	87.31	87.31	87.31
	Kars to BR	15755	244.20	87.31	87.31	87.31

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	Kars to BR	15430	244.20	87.31	87.31	87.31
	Kars to BR	15365	244.20	87.30	87.31	87.31
	Kars to BR	15300	244.20	87.30	87.31	87.31
	Kars to BR	14990	244.20	87.30	87.30	87.30
	Kars to BR	14590	244.20	87.30	87.30	87.30
	Kars to BR	14050	244.20	87.30	87.30	87.30
	Kars to BR	13635	246.26	87.30	87.30	87.30
	Kars to BR	13155	246.26	87.30	87.30	87.30
	Kars to BR	12665	339.76	87.30	87.30	87.30
	Kars to BR	12210	339.76	87.30	87.30	87.30
	Kars to BR	11895	339.76	87.30	87.30	87.30
	Kars to BR	11665	339.76	87.30	87.30	87.30
	Kars to BR	11315	339.76	87.30	87.30	87.30
	Kars to BR	11065	339.76	87.30	87.30	87.30
	Kars to BR	10885	339.76	87.30	87.30	87.30
	Kars to BR	10525	339.76	87.30	87.30	87.30
	Kars to BR	10235	339.76	87.30	87.30	87.30
	Kars to BR	10150	347.19	87.29	87.30	87.30
	Kars to BR	10060	347.19	87.29	87.29	87.29
	Kars to BR	9760	347.19	87.29	87.29	87.29
	Kars to BR	9335	347.19	87.29	87.29	87.29
	Kars to BR	9015	347.19	87.29	87.29	87.29
	Kars to BR	8635	347.19	87.29	87.29	87.29
	Kars to BR	8405	347.19	87.29	87.29	87.29
	Kars to BR	7105	347.19	87.28	87.29	87.29
	Kars to BR	6755	347.19	87.28	87.29	87.29
	Kars to BR	6305	352.59	87.28	87.28	87.28
	Kars to BR	5855	352.59	87.28	87.28	87.28
	Kars to BR	5525	352.59	87.28	87.28	87.28
	Kars to BR	5065	352.59	87.28	87.28	87.28
	Kars to BR	4665	352.59	87.27	87.28	87.28
	Kars to BR	4515	352.59	87.27	87.28	87.28
	Kars to BR	4315	352.59	87.27	87.27	87.27
	Kars to BR	4025	352.59	87.27	87.27	87.27
	Kars to BR	3775	352.59	87.27	87.27	87.27
	Kars to BR	3525	352.59	87.26	87.27	87.27
	Kars to BR	3255	352.59	87.26	87.27	87.27
	Kars to BR	2855	352.59	87.26	87.26	87.26
	Kars to BR	2605	365.98	87.26	87.26	87.26
	Kars to BR	2315	365.98	87.25	87.26	87.26
	Kars to BR	2015	365.98	87.25	87.26	87.26
	Kars to BR	1700	403.94	87.25	87.25	87.25
	Kars to BR	1420	403.94	87.22	87.25	87.25

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	Kars to BR	1050	405.27	87.23	87.24	87.24
	Kars to BR	730	405.27	87.22	87.23	87.23
	Kars to BR	290	405.51	87.22	87.23	87.23
	Kars to BR	0	405.51	87.21	87.22	87.22
	Kars to BR	-273	405.51	87.20	87.22	-
	Kars to BR	-278	Roger Stevens Drive			
	Kars to BR	-285	405.51	87.20	87.22	-
	Kars to BR	-565	405.51	87.20	87.21	-
	Kars to BR	-755	405.51	87.19	87.20	-
	Kars to BR	-925	405.51	87.19	87.20	-
	Kars to BR	-1130	405.51	87.18	87.19	-
	Kars to BR	-1460	405.51	87.16	87.18	-

Note:

RFL - Regulatory Flood Level

EGL - Energy Grade Elevation

WSEL - Computed Water Surface Elevation

Table 11 Flows and Computed Water Levels for the 100, 200, 350 and 500 Year Flood Events.

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	Kars to BR	29822.51	243.76	89.13	234.98	89.08	226.59	89.04	213.21	88.98
	Kars to BR	29605	243.76	89.11	234.98	89.05	226.59	89.01	213.21	88.96
	Kars to BR	29505	243.76	89.10	234.98	89.05	226.59	89.01	213.21	88.96
	Kars to BR	29452.25	Burritts Rapids Dam							
	Kars to BR	29405	243.76	88.13	234.98	88.06	226.59	87.99	213.21	87.87
	Kars to BR	29275	243.76	87.91	234.98	87.83	226.59	87.74	213.21	87.60
	Kars to BR	28475	243.76	87.88	234.98	87.80	226.59	87.71	213.21	87.58
	Kars to BR	28450	243.76	87.85	234.98	87.78	226.59	87.69	213.21	87.56
	Kars to BR	28405	243.76	87.85	234.98	87.78	226.59	87.69	213.21	87.56
	Kars to BR	28075	243.76	87.82	234.98	87.75	226.59	87.66	213.21	87.53
	Kars to BR	27795	243.76	87.77	234.98	87.70	226.59	87.61	213.21	87.48
	Kars to BR	27465	243.76	87.77	234.98	87.70	226.59	87.61	213.21	87.48
	Kars to BR	27155	243.76	87.76	234.98	87.68	226.59	87.60	213.21	87.46
	Kars to BR	26880	259.74	87.74	250.39	87.67	240.88	87.58	226.12	87.45
	Kars to BR	26530	259.74	87.74	250.39	87.66	240.88	87.57	226.12	87.44
	Kars to BR	26285	259.74	87.72	250.39	87.64	240.88	87.56	226.12	87.42
	Kars to BR	25795	259.74	87.67	250.39	87.59	240.88	87.51	226.12	87.37
	Kars to BR	25355	259.74	87.67	250.39	87.59	240.88	87.51	226.12	87.37
	Kars to BR	25015	259.74	87.66	250.39	87.59	240.88	87.50	226.12	87.36
	Kars to BR	24565	259.74	87.66	250.39	87.59	240.88	87.50	226.12	87.36
	Kars to BR	24115	259.74	87.66	250.39	87.59	240.88	87.50	226.12	87.36
	Kars to BR	23675	262.61	87.65	253.15	87.58	243.44	87.49	228.43	87.35
	Kars to BR	23415	262.61	87.65	253.15	87.58	243.44	87.49	228.43	87.35
	Kars to BR	23195	262.61	87.65	253.15	87.58	243.44	87.49	228.43	87.35
	Kars to BR	22945	262.61	87.65	253.15	87.57	243.44	87.49	228.43	87.35
	Kars to BR	22815	262.61	87.65	253.15	87.57	243.44	87.49	228.43	87.35
	Kars to BR	22430	262.61	87.62	253.15	87.55	243.44	87.46	228.43	87.33
	Kars to BR	21945	262.61	87.63	253.15	87.55	243.44	87.47	228.43	87.33
	Kars to BR	21865	262.61	87.63	253.15	87.56	243.44	87.47	228.43	87.33
	Kars to BR	21545	264.77	87.62	255.23	87.55	245.36	87.46	230.16	87.32
	Kars to BR	21395	264.77	87.62	255.23	87.55	245.36	87.46	230.16	87.33
	Kars to BR	20195	264.77	87.62	255.23	87.55	245.36	87.46	230.16	87.32
	Kars to BR	19095	264.77	87.62	255.23	87.54	245.36	87.46	230.16	87.32
	Kars to BR	18720	278.83	87.62	268.79	87.54	257.89	87.46	241.45	87.32
	Kars to BR	18430	278.83	87.62	268.79	87.54	257.89	87.46	241.45	87.32
	Kars to BR	18145	278.83	87.62	268.79	87.54	257.89	87.46	241.45	87.32
	Kars to BR	17605	278.83	87.62	268.79	87.54	257.89	87.46	241.45	87.32
	Kars to BR	17255	278.83	87.62	268.79	87.54	257.89	87.46	241.45	87.32
	Kars to BR	16835	278.83	87.61	268.79	87.54	257.89	87.45	241.45	87.32
	Kars to BR	16475	278.83	87.61	268.79	87.54	257.89	87.45	241.45	87.31
	Kars to BR	15855	282.27	87.60	272.10	87.53	260.95	87.45	244.20	87.31
	Kars to BR	15755	282.27	87.60	272.10	87.53	260.95	87.45	244.20	87.31

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	Kars to BR	15430	282.27	87.61	272.10	87.53	260.95	87.45	244.20	87.31
	Kars to BR	15365	282.27	87.60	272.10	87.52	260.95	87.44	244.20	87.30
	Kars to BR	15300	282.27	87.60	272.10	87.53	260.95	87.44	244.20	87.30
	Kars to BR	14990	282.27	87.60	272.10	87.52	260.95	87.44	244.20	87.30
	Kars to BR	14590	282.27	87.60	272.10	87.52	260.95	87.44	244.20	87.30
	Kars to BR	14050	282.27	87.60	272.10	87.52	260.95	87.44	244.20	87.30
	Kars to BR	13635	284.84	87.60	274.58	87.52	263.24	87.44	246.26	87.30
	Kars to BR	13155	284.84	87.60	274.58	87.52	263.24	87.44	246.26	87.30
	Kars to BR	12665	380.50	87.60	369.59	87.52	358.03	87.44	339.76	87.30
	Kars to BR	12210	380.50	87.59	369.59	87.52	358.03	87.44	339.76	87.30
	Kars to BR	11895	380.50	87.59	369.59	87.52	358.03	87.44	339.76	87.30
	Kars to BR	11665	380.50	87.59	369.59	87.52	358.03	87.44	339.76	87.30
	Kars to BR	11315	380.50	87.59	369.59	87.52	358.03	87.44	339.76	87.30
	Kars to BR	11065	380.50	87.59	369.59	87.52	358.03	87.43	339.76	87.30
	Kars to BR	10885	380.50	87.59	369.59	87.52	358.03	87.43	339.76	87.30
	Kars to BR	10525	380.50	87.59	369.59	87.52	358.03	87.43	339.76	87.30
	Kars to BR	10235	380.50	87.59	369.59	87.52	358.03	87.43	339.76	87.30
	Kars to BR	10150	389.51	87.59	378.15	87.51	366.19	87.43	347.19	87.29
	Kars to BR	10060	389.51	87.59	378.15	87.51	366.19	87.43	347.19	87.29
	Kars to BR	9760	389.51	87.59	378.15	87.51	366.19	87.43	347.19	87.29
	Kars to BR	9335	389.51	87.59	378.15	87.51	366.19	87.43	347.19	87.29
	Kars to BR	9015	389.51	87.58	378.15	87.51	366.19	87.42	347.19	87.29
	Kars to BR	8635	389.51	87.58	378.15	87.51	366.19	87.42	347.19	87.29
	Kars to BR	8405	389.51	87.58	378.15	87.51	366.19	87.42	347.19	87.29
	Kars to BR	7105	389.51	87.58	378.15	87.50	366.19	87.42	347.19	87.28
	Kars to BR	6755	389.51	87.58	378.15	87.50	366.19	87.42	347.19	87.28
	Kars to BR	6305	396.05	87.58	384.37	87.50	372.11	87.42	352.59	87.28
	Kars to BR	5855	396.05	87.58	384.37	87.50	372.11	87.42	352.59	87.28
	Kars to BR	5525	396.05	87.57	384.37	87.50	372.11	87.42	352.59	87.28
	Kars to BR	5065	396.05	87.57	384.37	87.50	372.11	87.41	352.59	87.28
	Kars to BR	4665	396.05	87.57	384.37	87.49	372.11	87.41	352.59	87.27
	Kars to BR	4515	396.05	87.56	384.37	87.49	372.11	87.40	352.59	87.27
	Kars to BR	4315	396.05	87.56	384.37	87.49	372.11	87.40	352.59	87.27
	Kars to BR	4025	396.05	87.56	384.37	87.49	372.11	87.40	352.59	87.27
	Kars to BR	3775	396.05	87.56	384.37	87.49	372.11	87.40	352.59	87.27
	Kars to BR	3525	396.05	87.55	384.37	87.48	372.11	87.40	352.59	87.26
	Kars to BR	3255	396.05	87.55	384.37	87.48	372.11	87.40	352.59	87.26
	Kars to BR	2855	396.05	87.55	384.37	87.48	372.11	87.39	352.59	87.26
	Kars to BR	2605	412.33	87.55	399.82	87.47	386.82	87.39	365.98	87.26
	Kars to BR	2315	412.33	87.55	399.82	87.47	386.82	87.39	365.98	87.25
	Kars to BR	2015	412.33	87.55	399.82	87.47	386.82	87.39	365.98	87.25
	Kars to BR	1700	458.75	87.54	443.82	87.46	428.65	87.38	403.94	87.25
	Kars to BR	1420	458.75	87.51	443.82	87.44	428.65	87.36	403.94	87.22

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	Kars to BR	1050	460.39	87.52	445.37	87.44	430.12	87.36	405.27	87.23
	Kars to BR	730	460.39	87.51	445.37	87.44	430.12	87.36	405.27	87.22
	Kars to BR	290	460.69	87.51	445.65	87.44	430.39	87.36	405.51	87.22
	Kars to BR	0	460.69	87.50	445.65	87.42	430.39	87.34	405.51	87.21
	Kars to BR	-273	460.69	87.49	445.65	87.42	430.39	87.34	405.51	87.20
	Kars to BR	-278	Roger Stevens Drive							
	Kars to BR	-285	460.69	87.49	445.65	87.42	430.39	87.34	405.51	87.20
	Kars to BR	-565	460.69	87.48	445.65	87.41	430.39	87.33	405.51	87.20
	Kars to BR	-755	460.69	87.47	445.65	87.40	430.39	87.32	405.51	87.19
	Kars to BR	-925	460.69	87.47	445.65	87.40	430.39	87.32	405.51	87.19
	Kars to BR	-1130	460.69	87.46	445.65	87.39	430.39	87.31	405.51	87.18
	Kars to BR	-1460	460.69	87.44	445.65	87.37	430.39	87.29	405.51	87.16

Note:

WSEL - Water Surface Elevation

Q500 - Flow Rate for a 500 year flood event

WL500 - Water Surface Elevation for a 500 year flood event

Q350 - Flow Rate for a 350 year flood event

WL350 - Water Surface Elevation for a 350 year flood event

Q200 - Flow Rate for a 200 year flood event

WL200 - Water Surface Elevation for a 200 year flood event

Q100 - Flow Rate for a 100 year flood event

WL100 - Water Surface Elevation for a 100 year flood event

Table 12 Flows and Computed Water Levels for the 2, 5, 10, 20 and 50 Year Flood Events.

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	Kars to BR	29822.51	198.64	88.93	178.26	88.85	162.20	88.78	146.08	88.70	121.61	88.57
	Kars to BR	29605	198.64	88.91	178.26	88.83	162.20	88.76	146.08	88.69	121.61	88.56
	Kars to BR	29505	198.64	88.91	178.26	88.83	162.20	88.76	146.08	88.69	121.61	88.56
	Kars to BR	29452.25	Burritts Rapids Dam									
	Kars to BR	29405	198.64	87.74	178.26	87.57	162.20	87.43	146.08	87.31	121.61	87.15
	Kars to BR	29275	198.64	87.45	178.26	87.23	162.20	87.03	146.08	86.79	121.61	86.57
	Kars to BR	28475	198.64	87.43	178.26	87.22	162.20	87.04	146.08	86.83	121.61	86.47
	Kars to BR	28450	198.64	87.41	178.26	87.20	162.20	87.02	146.08	86.81	121.61	86.46
	Kars to BR	28405	198.64	87.41	178.26	87.20	162.20	87.02	146.08	86.81	121.61	86.45
	Kars to BR	28075	198.64	87.38	178.26	87.16	162.20	86.98	146.08	86.77	121.61	86.40
	Kars to BR	27795	198.64	87.33	178.26	87.12	162.20	86.93	146.08	86.72	121.61	86.35
	Kars to BR	27465	198.64	87.33	178.26	87.11	162.20	86.93	146.08	86.71	121.61	86.33
	Kars to BR	27155	198.64	87.31	178.26	87.10	162.20	86.91	146.08	86.69	121.61	86.31
	Kars to BR	26880	210.24	87.30	188.09	87.08	170.79	86.90	153.45	86.68	127.49	86.29
	Kars to BR	26530	210.24	87.29	188.09	87.07	170.79	86.88	153.45	86.67	127.49	86.28
	Kars to BR	26285	210.24	87.27	188.09	87.06	170.79	86.87	153.45	86.65	127.49	86.25
	Kars to BR	25795	210.24	87.22	188.09	87.01	170.79	86.81	153.45	86.59	127.49	86.19
	Kars to BR	25355	210.24	87.22	188.09	87.00	170.79	86.81	153.45	86.59	127.49	86.18
	Kars to BR	25015	210.24	87.21	188.09	87.00	170.79	86.81	153.45	86.58	127.49	86.18
	Kars to BR	24565	210.24	87.21	188.09	87.00	170.79	86.80	153.45	86.58	127.49	86.17
	Kars to BR	24115	210.24	87.21	188.09	87.00	170.79	86.80	153.45	86.58	127.49	86.17
	Kars to BR	23675	212.31	87.20	189.84	86.99	172.32	86.80	154.77	86.57	128.54	86.16
	Kars to BR	23415	212.31	87.20	189.84	86.99	172.32	86.80	154.77	86.57	128.54	86.17
	Kars to BR	23195	212.31	87.20	189.84	86.99	172.32	86.80	154.77	86.57	128.54	86.16
	Kars to BR	22945	212.31	87.20	189.84	86.98	172.32	86.79	154.77	86.57	128.54	86.16
	Kars to BR	22815	212.31	87.20	189.84	86.98	172.32	86.79	154.77	86.57	128.54	86.16
	Kars to BR	22430	212.31	87.18	189.84	86.97	172.32	86.77	154.77	86.55	128.54	86.14
	Kars to BR	21945	212.31	87.18	189.84	86.97	172.32	86.77	154.77	86.55	128.54	86.14
	Kars to BR	21865	212.31	87.18	189.84	86.97	172.32	86.78	154.77	86.56	128.54	86.15
	Kars to BR	21545	213.87	87.18	191.16	86.96	173.47	86.77	155.75	86.55	129.32	86.14
	Kars to BR	21395	213.87	87.18	191.16	86.96	173.47	86.77	155.75	86.55	129.32	86.14
	Kars to BR	20195	213.87	87.18	191.16	86.96	173.47	86.77	155.75	86.55	129.32	86.14
	Kars to BR	19095	213.87	87.17	191.16	86.96	173.47	86.77	155.75	86.55	129.32	86.14
	Kars to BR	18720	223.99	87.17	199.70	86.96	180.93	86.77	162.13	86.55	134.39	86.14
	Kars to BR	18430	223.99	87.17	199.70	86.96	180.93	86.77	162.13	86.55	134.39	86.14
	Kars to BR	18145	223.99	87.17	199.70	86.96	180.93	86.77	162.13	86.55	134.39	86.14
	Kars to BR	17605	223.99	87.17	199.70	86.96	180.93	86.77	162.13	86.54	134.39	86.13
	Kars to BR	17255	223.99	87.17	199.70	86.96	180.93	86.77	162.13	86.54	134.39	86.13
	Kars to BR	16835	223.99	87.17	199.70	86.95	180.93	86.76	162.13	86.54	134.39	86.13
	Kars to BR	16475	223.99	87.17	199.70	86.95	180.93	86.76	162.13	86.54	134.39	86.13
	Kars to BR	15855	226.45	87.16	201.78	86.95	182.74	86.76	163.67	86.54	135.62	86.13
	Kars to BR	15755	226.45	87.16	201.78	86.95	182.74	86.76	163.67	86.54	135.62	86.13

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	Kars to BR	15430	226.45	87.16	201.78	86.95	182.74	86.76	163.67	86.54	135.62	86.13
	Kars to BR	15365	226.45	87.16	201.78	86.94	182.74	86.75	163.67	86.53	135.62	86.12
	Kars to BR	15300	226.45	87.16	201.78	86.94	182.74	86.75	163.67	86.53	135.62	86.12
	Kars to BR	14990	226.45	87.16	201.78	86.94	182.74	86.75	163.67	86.53	135.62	86.12
	Kars to BR	14590	226.45	87.16	201.78	86.94	182.74	86.75	163.67	86.53	135.62	86.12
	Kars to BR	14050	226.45	87.15	201.78	86.94	182.74	86.75	163.67	86.53	135.62	86.12
	Kars to BR	13635	228.29	87.15	203.33	86.94	184.09	86.75	164.83	86.53	136.54	86.12
	Kars to BR	13155	228.29	87.15	203.33	86.94	184.09	86.75	164.83	86.53	136.54	86.12
	Kars to BR	12665	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	12210	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	11895	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	11665	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	11315	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	11065	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	10885	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.53	188.58	86.12
	Kars to BR	10525	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.52	188.58	86.12
	Kars to BR	10235	319.84	87.15	290.46	86.94	265.60	86.75	237.38	86.52	188.58	86.12
	Kars to BR	10150	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	10060	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	9760	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	9335	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	9015	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	8635	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	8405	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	7105	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	6755	326.59	87.14	296.26	86.93	270.70	86.74	241.72	86.52	191.89	86.11
	Kars to BR	6305	331.49	87.14	300.46	86.92	274.39	86.73	244.86	86.51	194.28	86.11
	Kars to BR	5855	331.49	87.13	300.46	86.92	274.39	86.73	244.86	86.51	194.28	86.11
	Kars to BR	5525	331.49	87.13	300.46	86.92	274.39	86.73	244.86	86.51	194.28	86.10
	Kars to BR	5065	331.49	87.13	300.46	86.92	274.39	86.73	244.86	86.51	194.28	86.10
	Kars to BR	4665	331.49	87.13	300.46	86.92	274.39	86.73	244.86	86.51	194.28	86.10
	Kars to BR	4515	331.49	87.12	300.46	86.91	274.39	86.72	244.86	86.50	194.28	86.10
	Kars to BR	4315	331.49	87.12	300.46	86.91	274.39	86.72	244.86	86.50	194.28	86.10
	Kars to BR	4025	331.49	87.12	300.46	86.91	274.39	86.72	244.86	86.50	194.28	86.10
	Kars to BR	3775	331.49	87.12	300.46	86.91	274.39	86.72	244.86	86.50	194.28	86.10
	Kars to BR	3525	331.49	87.11	300.46	86.90	274.39	86.72	244.86	86.50	194.28	86.09
	Kars to BR	3255	331.49	87.11	300.46	86.90	274.39	86.72	244.86	86.50	194.28	86.09
	Kars to BR	2855	331.49	87.11	300.46	86.90	274.39	86.71	244.86	86.49	194.28	86.09
	Kars to BR	2605	343.63	87.11	310.86	86.90	283.52	86.71	252.63	86.49	200.19	86.09
	Kars to BR	2315	343.63	87.11	310.86	86.90	283.52	86.71	252.63	86.49	200.19	86.09
	Kars to BR	2015	343.63	87.11	310.86	86.90	283.52	86.71	252.63	86.49	200.19	86.09
	Kars to BR	1700	377.98	87.10	340.18	86.89	309.20	86.71	274.42	86.49	216.71	86.08
	Kars to BR	1420	377.98	87.08	340.18	86.87	309.20	86.69	274.42	86.47	216.71	86.07

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	Kars to BR	1050	379.18	87.08	341.21	86.88	310.10	86.69	275.18	86.48	217.28	86.07
	Kars to BR	730	379.18	87.08	341.21	86.87	310.10	86.69	275.18	86.47	217.28	86.07
	Kars to BR	290	379.40	87.08	341.40	86.87	310.26	86.69	275.32	86.47	217.39	86.07
	Kars to BR	0	379.40	87.07	341.40	86.86	310.26	86.68	275.32	86.46	217.39	86.07
	Kars to BR	-273	379.40	87.06	341.40	86.86	310.26	86.67	275.32	86.46	217.39	86.06
	Kars to BR	-278	Roger Stevens Drive									
	Kars to BR	-285	379.40	87.06	341.40	86.86	310.26	86.67	275.32	86.46	217.39	86.06
	Kars to BR	-565	379.40	87.05	341.40	86.85	310.26	86.67	275.32	86.45	217.39	86.06
	Kars to BR	-755	379.40	87.05	341.40	86.85	310.26	86.66	275.32	86.45	217.39	86.05
	Kars to BR	-925	379.40	87.05	341.40	86.84	310.26	86.66	275.32	86.45	217.39	86.05
	Kars to BR	-1130	379.40	87.04	341.40	86.84	310.26	86.66	275.32	86.44	217.39	86.05
	Kars to BR	-1460	379.40	87.02	341.40	86.82	310.26	86.64	275.32	86.43	217.39	86.04

Note:
WSEL - Water Surface Elevation
Q50 - Flow Rate for a 50 year flood event
WL50 - Water Surface Elevation for a 50 year flood event
Q20 - Flow Rate for a 20 year flood event
WL20 - Water Surface Elevation for a 20 year flood event
Q10 - Flow Rate for a 10 year flood event
WL10 - Water Surface Elevation for a 10 year flood event
Q5 - Flow Rate for a 5 year flood event
WL5 - Water Surface Elevation for a 5 year flood event
Q2 - Flow Rate for a 2 year flood event
WL2 - Water Surface Elevation for a 2 year flood event

Table 13 Culvert Data from Field Checks and Drawings.

Culvert	Downstream Invert (m)	Upstream Invert (m)	RFL (m)	Location	City of Ottawa Culvert ID	Source of Information	Comments
1	85.06	85.05	87.24	Roger Stevens Dr	878030	Surveyed on June 17, 2015	
2	85.53	85.45	87.24	Cobe Terr	878250	Surveyed on June 17, 2015	
3	85.21	85.26	87.29	2nd Line Rd S	878570	Surveyed on June 17, 2015	
4	86.48	86.58	87.29	2nd Line Rd S	L873050	Surveyed on June 17, 2015	
5	86.71	86.77	87.29	3rd Line Rd S	L871650	Surveyed on June 17, 2015	
6	87.05	87.14	87.26	Rideau Valley Dr S	A871330	Surveyed on June 17, 2015	
7	86.32	86.56	87.26	Rideau Valley Dr S	A871350	Surveyed on June 17, 2015	
8	86.01	86.18	87.28	Rideau Valley Dr S	A871230	Surveyed on June 17, 2015	
9	85.79	85.77	87.29	Dilworth Rd	A872110	Surveyed on June 17, 2015	
10	85.48	85.22	87.29	Dilworth Rd	878150	Surveyed on June 17, 2015	
11	85.94	85.73	87.29	Reevevraig Rd N	878530	Surveyed on June 17, 2015	
12	86.15	86.26	87.29	Reevevraig Rd N	L872050	Surveyed on June 17, 2015	
13	86.19	86.00	87.29	Dilworth Rd	A872100	Surveyed on June 17, 2015	
14	86.00	85.99	87.30	Dilworth Rd	878940	Surveyed on June 17, 2015	
15	85.98	86.64	87.30	4th Line Rd (Culvert 1 of 2)	878760	Surveyed on June 17, 2015	
16	86.22	86.41	87.30	4th Line Rd (Culvert 2 of 2)	878760	Surveyed on June 17, 2015	
17	86.51	86.57	87.30	Greenline Rd	L871130	Surveyed on June 17, 2015	
18	86.40	86.44	87.30	Reevecraig Rd S	878590	Surveyed on June 17, 2015	
19	86.48	86.71	87.30	4th Line Rd	878140	Surveyed on June 17, 2015	
20	85.84	85.87	87.30	Donnelly Dr	878120	Surveyed on June 17, 2015	
21	86.86	86.76	87.30	Fairmile Rd	L870030	Surveyed on June 17, 2015	
22	86.93	87.03	87.30	Donnelly Dr	A871030	Surveyed on June 17, 2015	
23	86.91	87.01	87.30	Donnelly Dr	A871010	Surveyed on June 17, 2015	
24	85.78	85.85	87.30	Firethorn Crt (Culvert 1 of 2)	878740	Surveyed on June 17, 2015	
25	85.82	85.89	87.30	Firethorn Crt (Culvert 2 of 2)	878740	Surveyed on June 17, 2015	
26	85.98	86.07	87.30	Fairhurst Dr (Culvert 1 of 2)	878750	Surveyed on June 17, 2015	
27	86.05	85.99	87.30	Fairhurst Dr (Culvert 2 of 2)	878750	Surveyed on June 17, 2015	
28	86.77	86.883	87.3	Fairhurst Dr at Donnelly Dr	L870015	Surveyed on June 24, 2015	
29	87.06	86.915	87.3	Fairhurst Dr	L870010	Surveyed on June 24, 2015	
30	85.53	85.428	87.3	Donnelly Dr at Fairhurst Dr	877100	Surveyed on June 24, 2015	
31		86.491	87.47	River Rd east of Burritts Rapids Rd	North Grenville Culvert	Surveyed on June 24, 2015	

32	86.57	86.882	87.44	River Rd west of Acton Corners Rd	North Grenville Culvert	Surveyed on June 24, 2015	
33	84.90	85.333	87.35	Acton Corners Rd at River Rd	North Grenville Culvert	Surveyed on June 24, 2015	
34	89.24	89.265	87.33	River Rd at Dales Creek	North Grenville Culvert	Surveyed on June 24, 2015	
35	84.98	84.891	87.33	River Rd east of Dales Creek	North Grenville Culvert	Surveyed on June 24, 2015	
36	86.38	86.354	87.33	River Rd at Muldoon Rd	North Grenville Culvert	Surveyed on June 24, 2015	
37	85.19	85.383	87.32	River Rd east of Muldoon Rd	North Grenville Culvert	Surveyed on June 24, 2015	
38	85.83	85.956	87.32	Colonel Dr at River Rd	North Grenville Culvert	Surveyed on June 24, 2015	
39	86.28	86.14	87.32	River Rd at Pioneer Dr	North Grenville Culvert	Surveyed on June 24, 2015	
40	86.97	87.413	87.32	Pioneer Dr at River Rd	North Grenville Culvert	Surveyed on June 24, 2015	
41	86.84	86.88	87.32	River Rd east of Regiment Rd	North Grenville Culvert	Surveyed on June 24, 2015	
42	86.54	87.178	87.32	River Rd west of Settlers Way	North Grenville Culvert	Surveyed on June 24, 2015	
43	86.77	86.768	87.32	Regiment Rd at Settlers Way	North Grenville Culvert	Surveyed on June 24, 2015	
44	86.41	86.53	87.32	River Rd east of Heritage Blvd	North Grenville Culvert	Surveyed on June 24, 2015	
45	85.77	86.763	87.32	River Rd east of Becketts Landing	North Grenville Culvert	Surveyed on June 24, 2015	
46	87.52	87.656	87.32	River Rd at Becketts Landing	North Grenville Culvert	Surveyed on June 24, 2015	
47	86.59	86.662	87.3	Rideau Crossing Cres	North Grenville Culvert	Surveyed on June 24, 2015	
48	86.92	86.992	87.3	River Rd north of Watermark Pl	North Grenville Culvert	Surveyed on June 24, 2015	
49	86.63	86.633	87.3	River Rd south of Earl Flynn Rd	North Grenville Culvert	Surveyed on June 24, 2015	
50	86.08	86.161	87.29	River Rd north of Sheppard Close	North Grenville Culvert	Surveyed on June 24, 2015	
51	86.68	86.59	87.29	Rideau River Rd south of Mapleshore Dr	North Grenville Culvert	Surveyed on June 25, 2015	
52	85.40	85.79	87.29	Rideau River Rd at Mapleshore Dr	North Grenville Culvert	Surveyed on June 25, 2015	
53	86.60	86.49	87.29	Boundary Rd south of River Rd	880080	Surveyed on June 25, 2015	
54	86.06	85.92	87.29	Trail across from Mapleshore Dr	North Grenville Culvert	Surveyed on June 25, 2015	

55	84.84	85.07	87.29	Trail north of Gabert Rd (Culvert 1 of 2)	North Grenville Culvert	Surveyed on June 25, 2015	
56	85.09	85.11	87.29	Trail north of Gabert Rd (Culvert 2 of 2)	North Grenville Culvert	Surveyed on June 25, 2015	
57	84.42	85.80	87.29	Trail at Gabert Rd (Culvert 1 of 2)	North Grenville Culvert	Surveyed on June 25, 2015	
58	84.74	85.98	87.29	Trail at Gabert Rd (Culvert 2 of 2)	North Grenville Culvert	Surveyed on June 25, 2015	
59	84.66	84.76	87.29	Gabert Rd east of Trail	North Grenville Culvert	Surveyed on June 25, 2015	
60	85.05	85.41	87.29	River Rd south of Dalmeny Rd	888490	Surveyed on June 25, 2015	
61		86.95	87.28	River Rd north of Dalmeny Rd	888090	Surveyed on June 25, 2015	Downstream end could not be surveyed due to the culvert being collapsed. Water was seen flowing through culvert though.
62	85.61	85.62	87.27	River Rd south of Osgoode Main St	888080	Surveyed on June 25, 2015	
63	85.42	85.41	87.27	River Rd north of Osgoode Main St	888070	Surveyed on June 25, 2015	
64	86.15	86.10	87.26	River Rd south of Cabin Rd	A881090	Surveyed on June 25, 2015	
65	86.65	86.76	87.26	River Rd at Cabin Rd	A881110	Surveyed on June 25, 2015	
66	86.87	87.03	87.26	Cabin Rd at River Rd	L884010	Surveyed on June 25, 2015	
67	86.21	86.15	87.27	Cabin Rd east of River Rd	L884030	Surveyed on June 25, 2015	
68			87.27	River Rd north of Dalmeny Rd	A882560	Surveyed on June 25, 2015	Culvert could not be found at site.
69			87.28	Osgoode Main St east of River Rd	A881010	Surveyed on June 25, 2015	Culvert could not be found at site.
70	85.34		87.28	River Rd north of Dalmeny Rd	888280	Surveyed on June 26, 2015	Could not survey upstream end due to high vegetation.
71	86.22	86.32	87.30	Donnelly Dr east of Becketts Landing	868100	Drawings	
72	86.8	86.80	87.82	River Rd west of Dywer Hill Rd	867710	Drawings	

Note:

Culverts that are highlighted in orange had poor site access and/or poor measuring conditions; therefore the invert values are only approximations.

Culverts that are highlighted blue mean that the dimensions of the culvert could not be measured due to the culvert being submerged. Therefore the invert values are approximations.

Table 14 List of RVCA Regulation Permit Files

RVCA File #	Location	Year	Flood Line Change Required?	Brief Description	Closest HEC-RAS cross-section	Drawing Number
RV6-0113	2382 DONNELLY DR	2013	No	RAISE DRIVEWAY AS PART OF SEVERANCE CONDITION		
RV6-1510	2649 RIVER RD	2010	No	CONSTRUCT CRAWLSPACE FOUNDATION UNDER COTTAGE		
RV6-3610	4404 RIDEAU RIVER	2010	No	CONSTRUCT NEW DWELLING		
RV6-3910	3332 N RIVER RD	2010	No	TEAR DOWN EXISTING BUILDING AND REBUILD		
RV6-5810	7479 CARTER RD	2010	No	TEAR DOWN AND REBUILD DWELLING		
RV6-1412	2296 REEVE CRAIG R	2012	No	REPLACE SEPTIC SYSTEM WITH WATERLOO BIOFILTER		
RV6-2712	RIDEAU CROSSI	2012	No	CONSTRUCT NEW DWELLING IN SUBDIVISION		
RV6-0414	2 LOCKMASTERS LANE	2014	No	CONSTRUCTION/RECONSTRUCTION		
RV6-2313	RIVER RD	2013	No	CONSTRUCTION/RECONSTRUCTION		

Note: No files were used in the adjustment of floodlines.

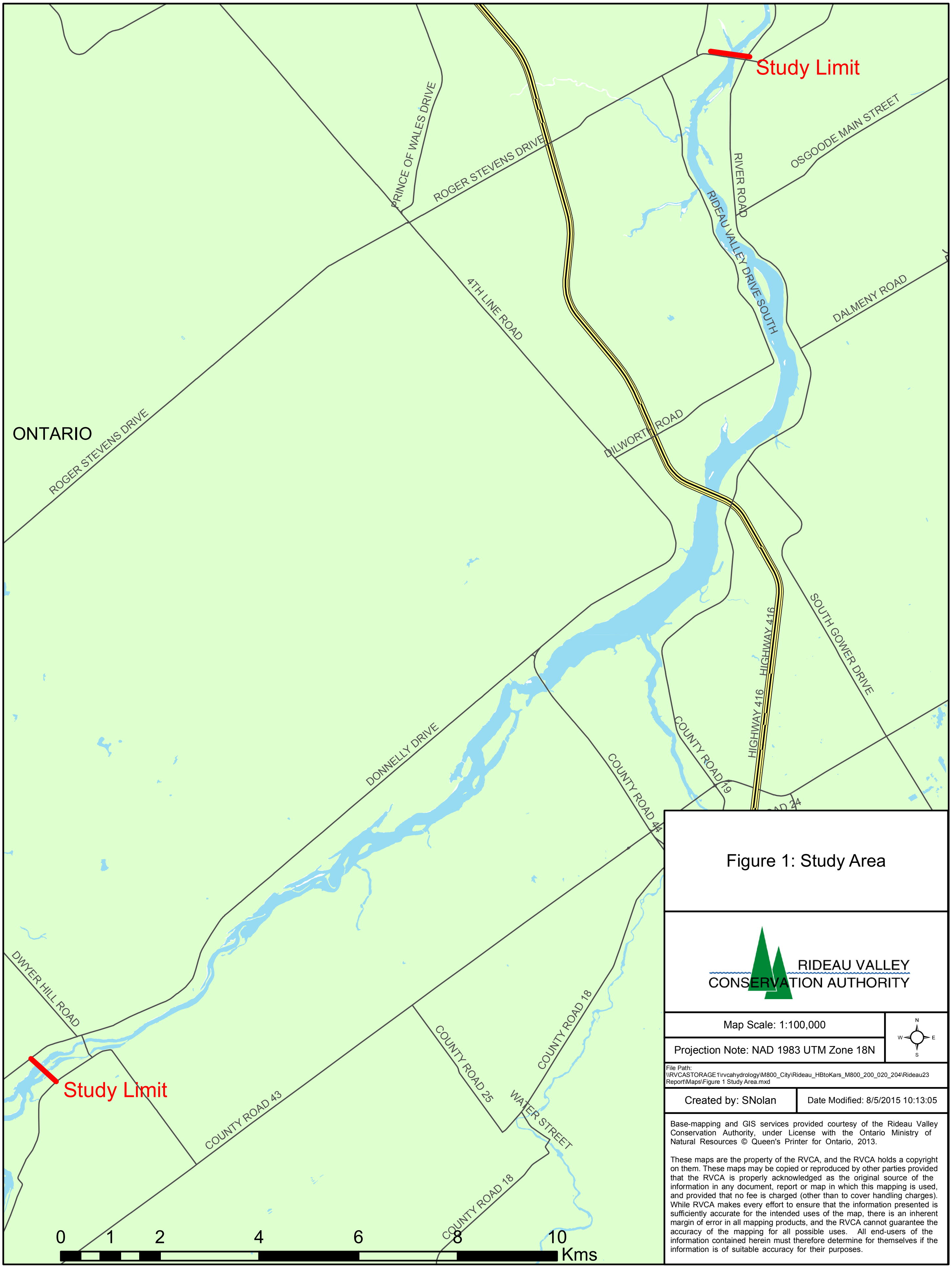


Figure 1: Study Area

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:100,000

Projection Note: NAD 1983 UTM Zone 18N

File Path: \\RVCASTORAGE1\rvcahydrology\M800_City\Rideau_HBtoKars_M800_200_020_204\Rideau23 Report\Maps\Figure 1 Study Area.mxd

Created by: SNolan

Date Modified: 8/5/2015 10:13:05

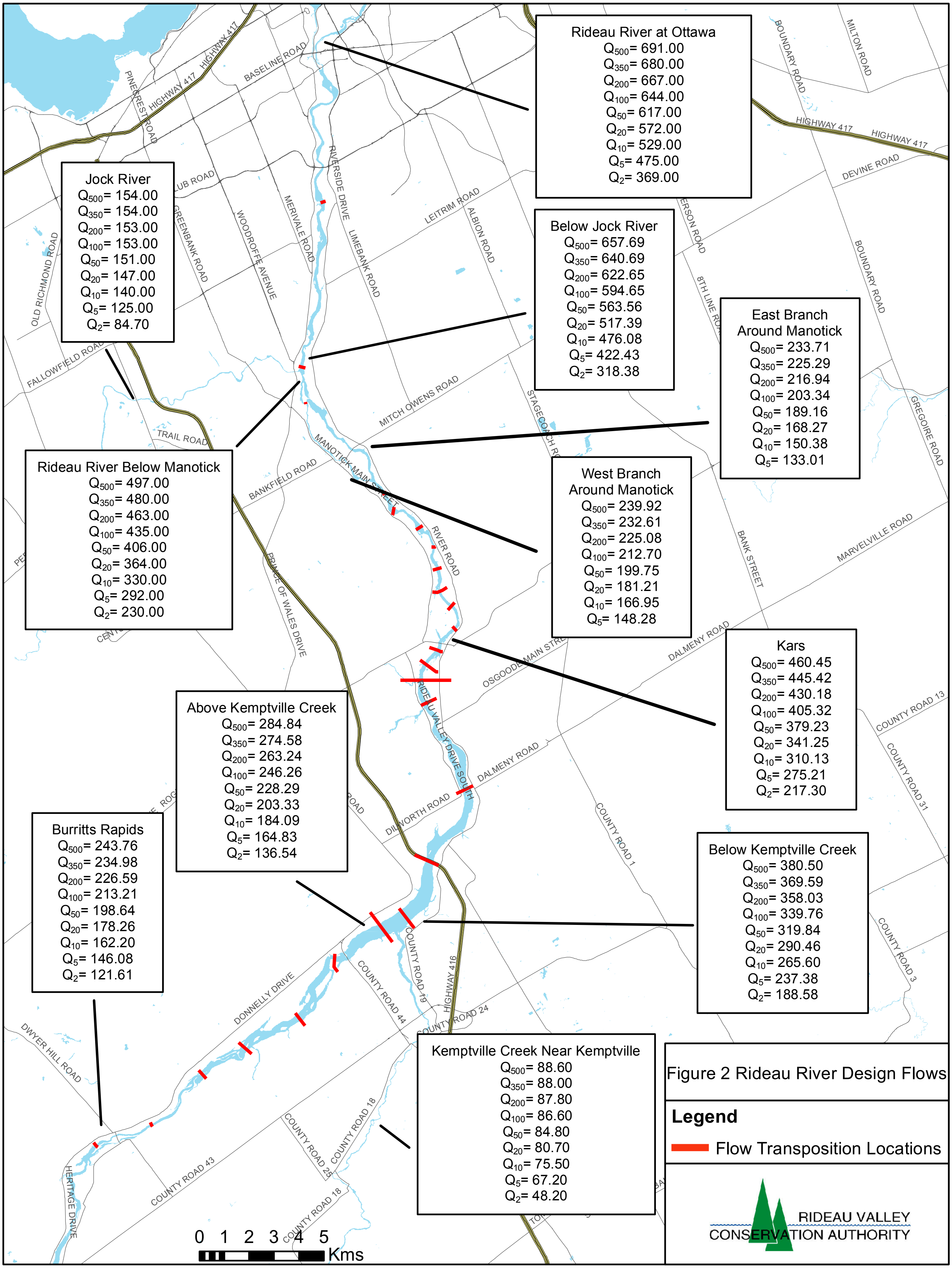
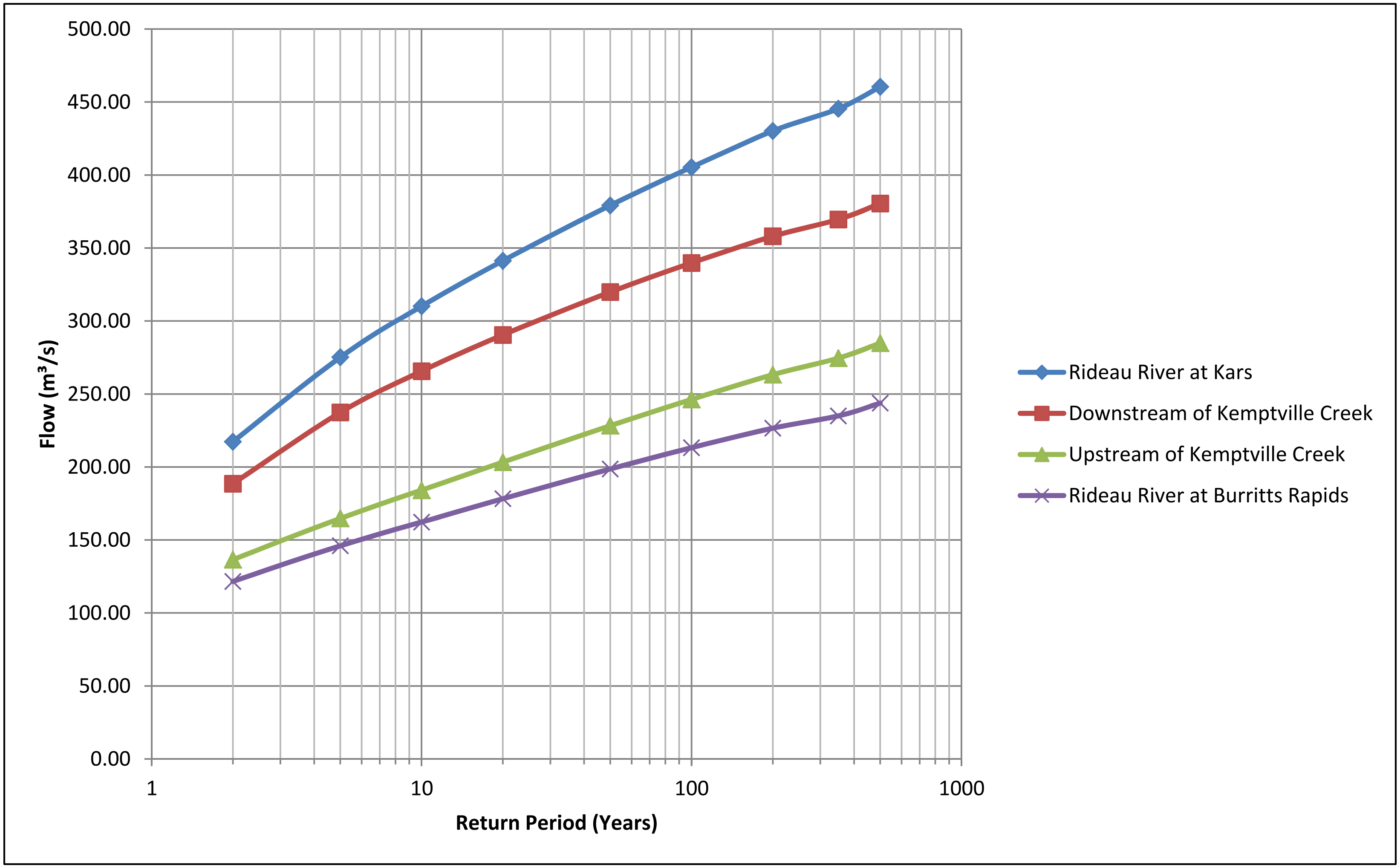


Figure 2 Rideau River Design Flows

Figure 3 Estimated Rideau River Design Flows



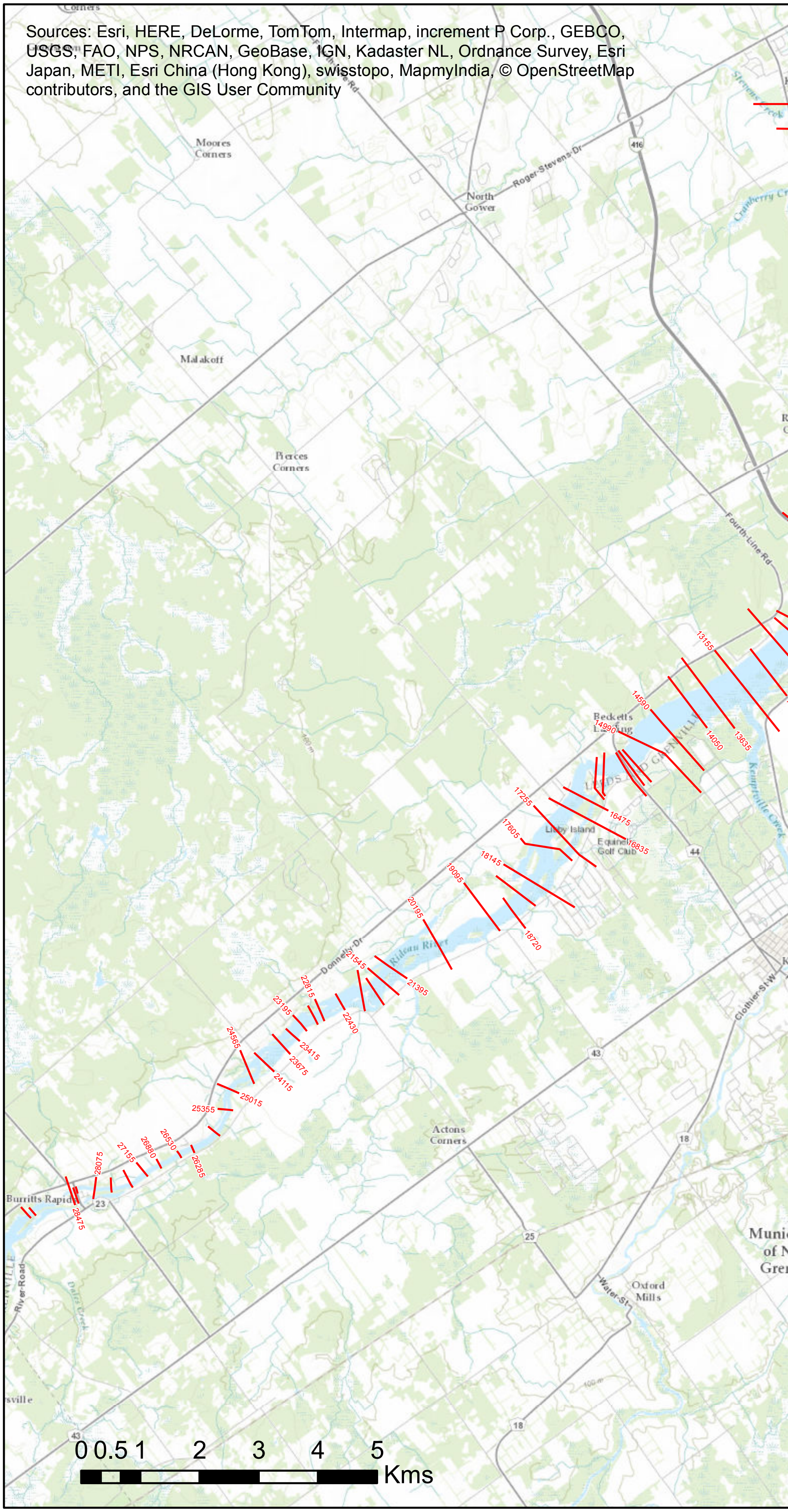


Figure 4 HEC-RAS Schematic

Legend

HEC-RAS Cross-Section

RIDEAU VALLEY CONSERVATION AUTHORITY

1:100,000

Projection Note: NAD 1983 UTM Zone 18N

File Path: \\RVCASTORAGE1\rvcahydrology\M800_City\Rideau_KarstoBR_M800_200_020_210\KarsToBR Report\Maps_V3\Figure 8 HEC-RAS XS.mxd

Created by: SNolan

Date Modified: 10/30/2015 3:39:34

Figure 5 Calibration of the HEC-RAS Model to the Rideau River Below Merrickville (02LA011) Stream Gauge Rating Curve.

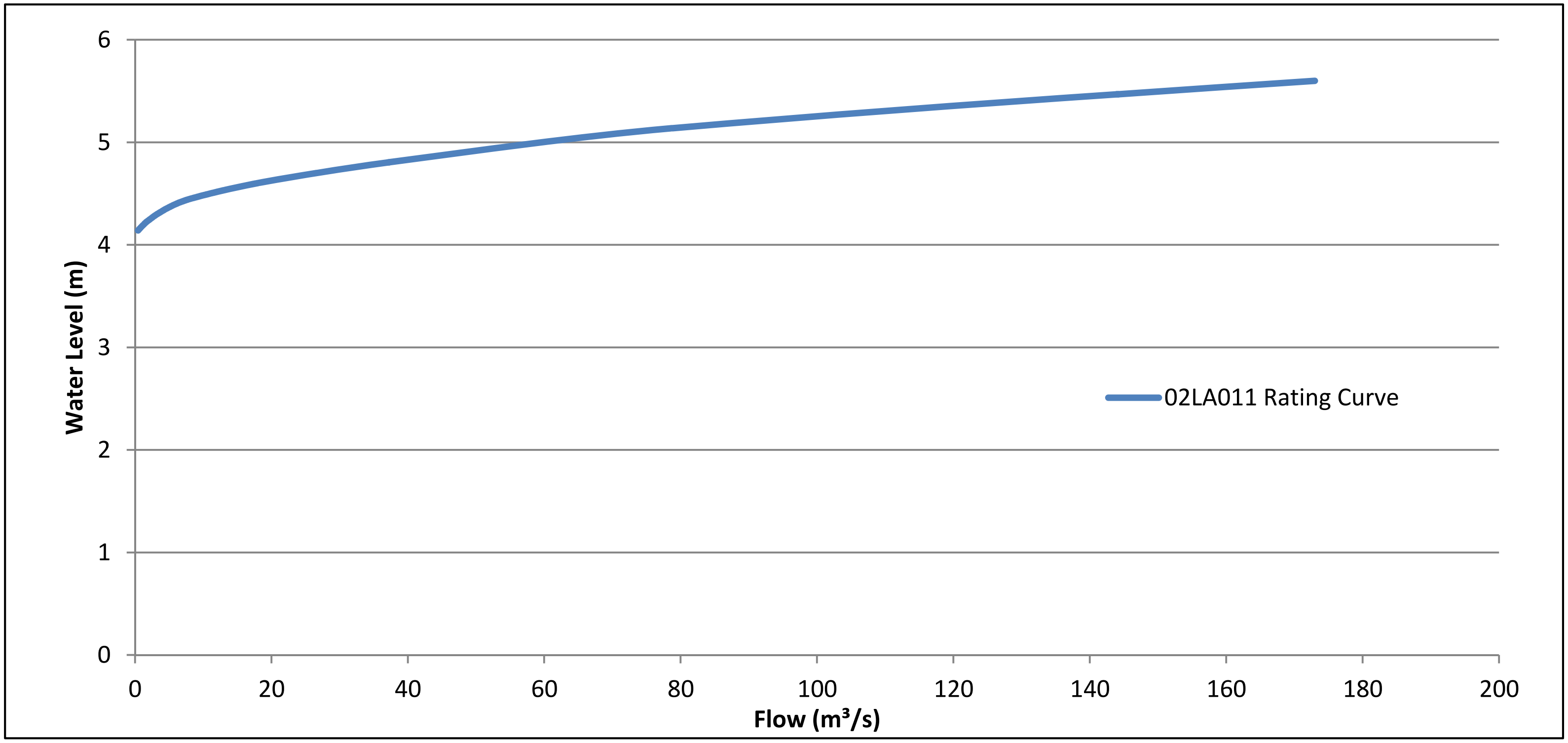


Figure 6 Difference Between Observed and Computed Water Levels for the Kars to Burritts Rapids Reach.

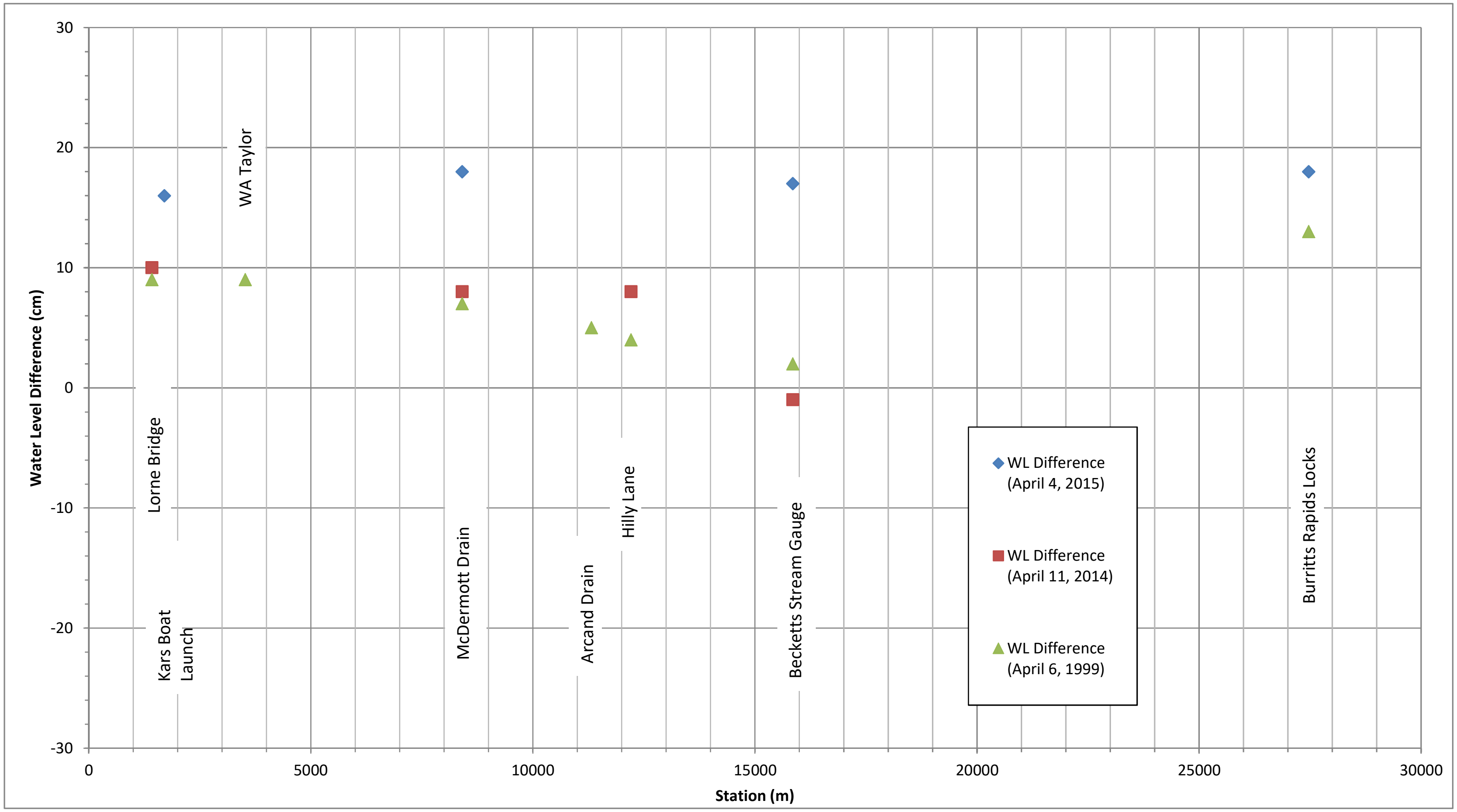


Figure 7 Sensitivity Analysis of Computed Water Level to Design Flow for the Kars to Burritts Rapids Reach.

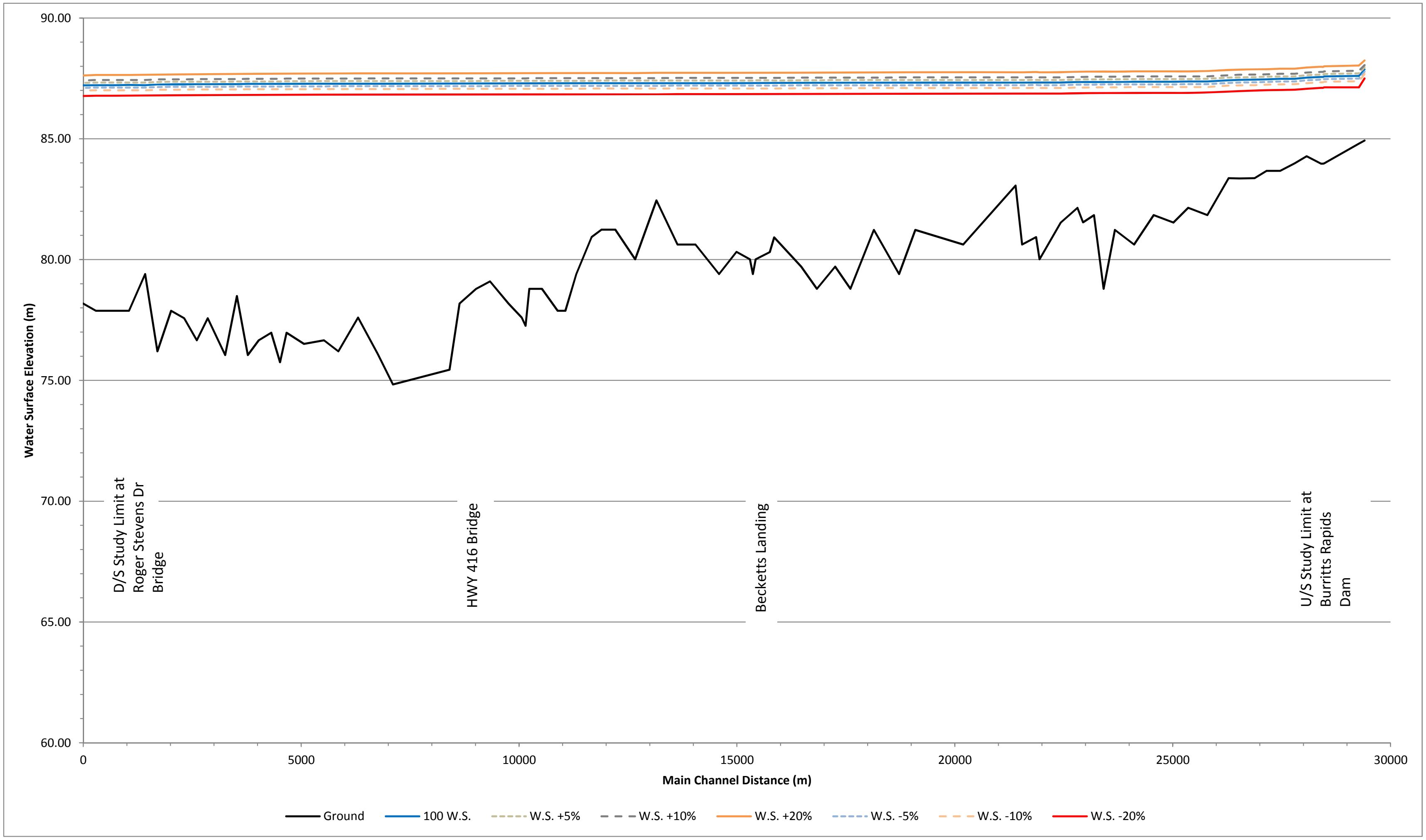
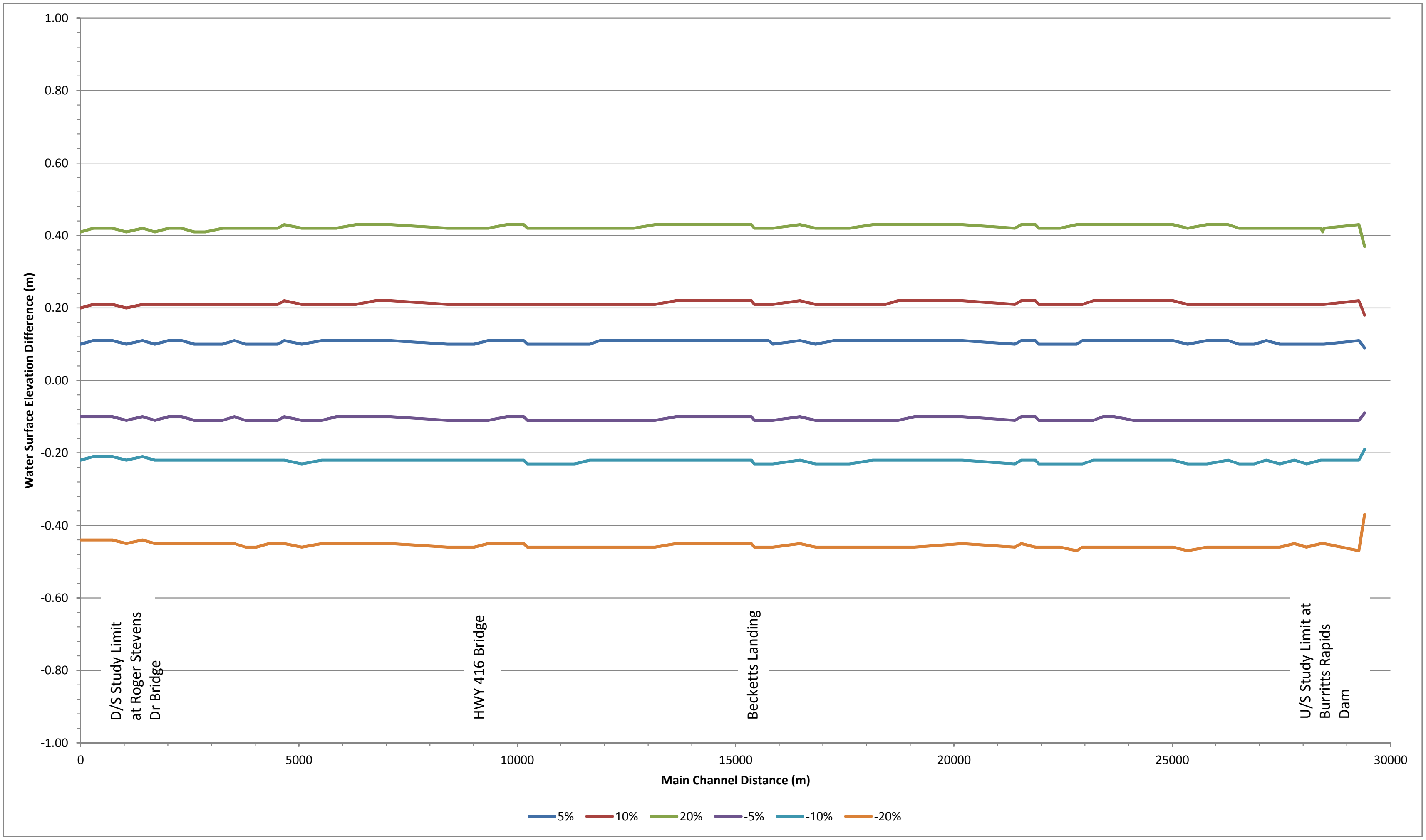
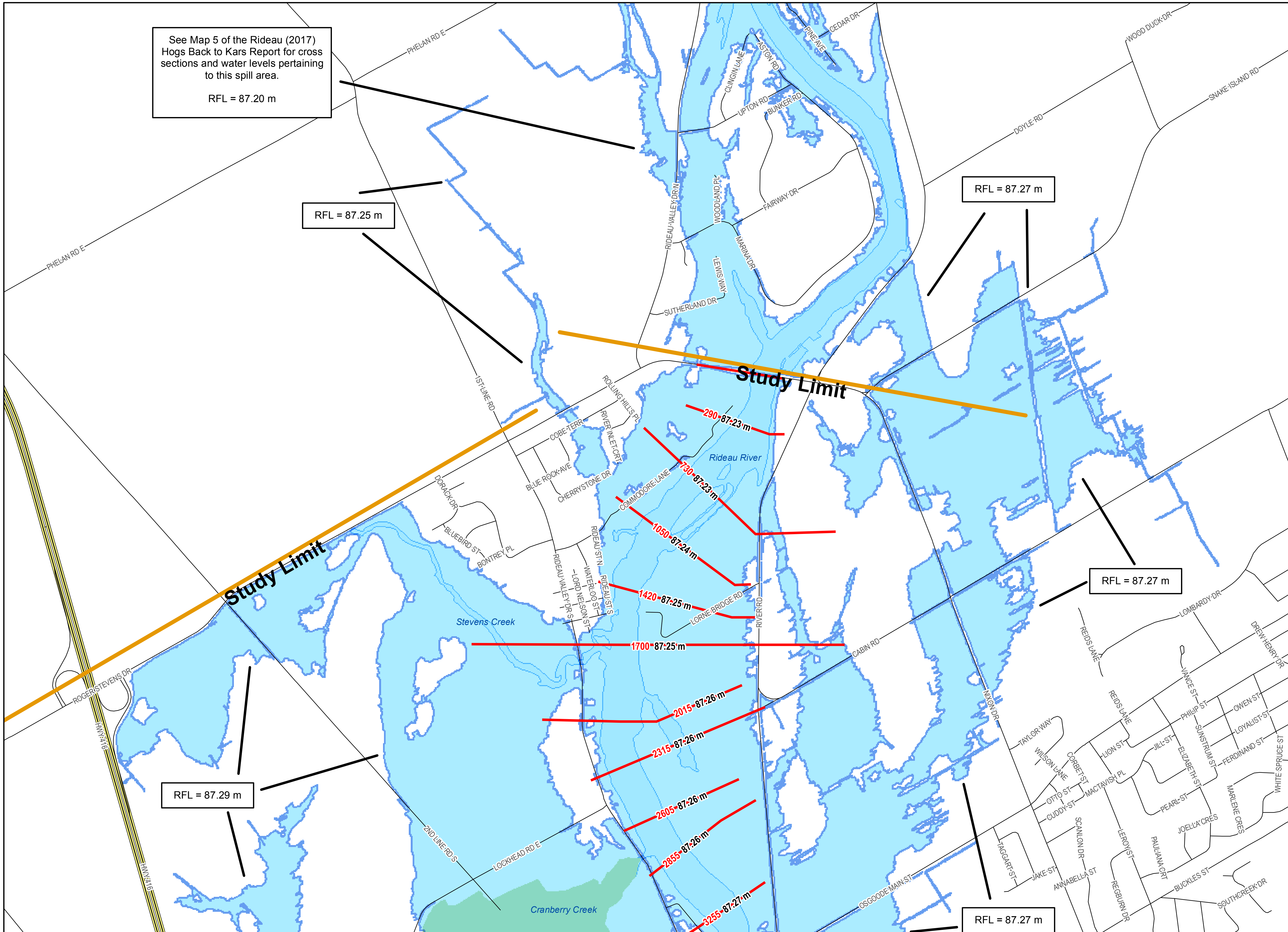
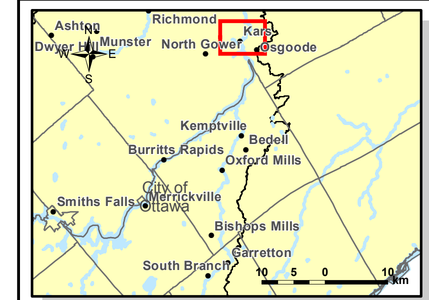


Figure 8 Sensitivity Analysis of Computed Water Level to Design Flow (Water Level Difference) for the Kars to Burritts Rapids Reach.





Rideau River
Flood Plain Mapping
Kars to Burritts Rapids
Index:1



- Rideau River Floodplain
- Waterbody

Roads

- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9a

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000

Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017

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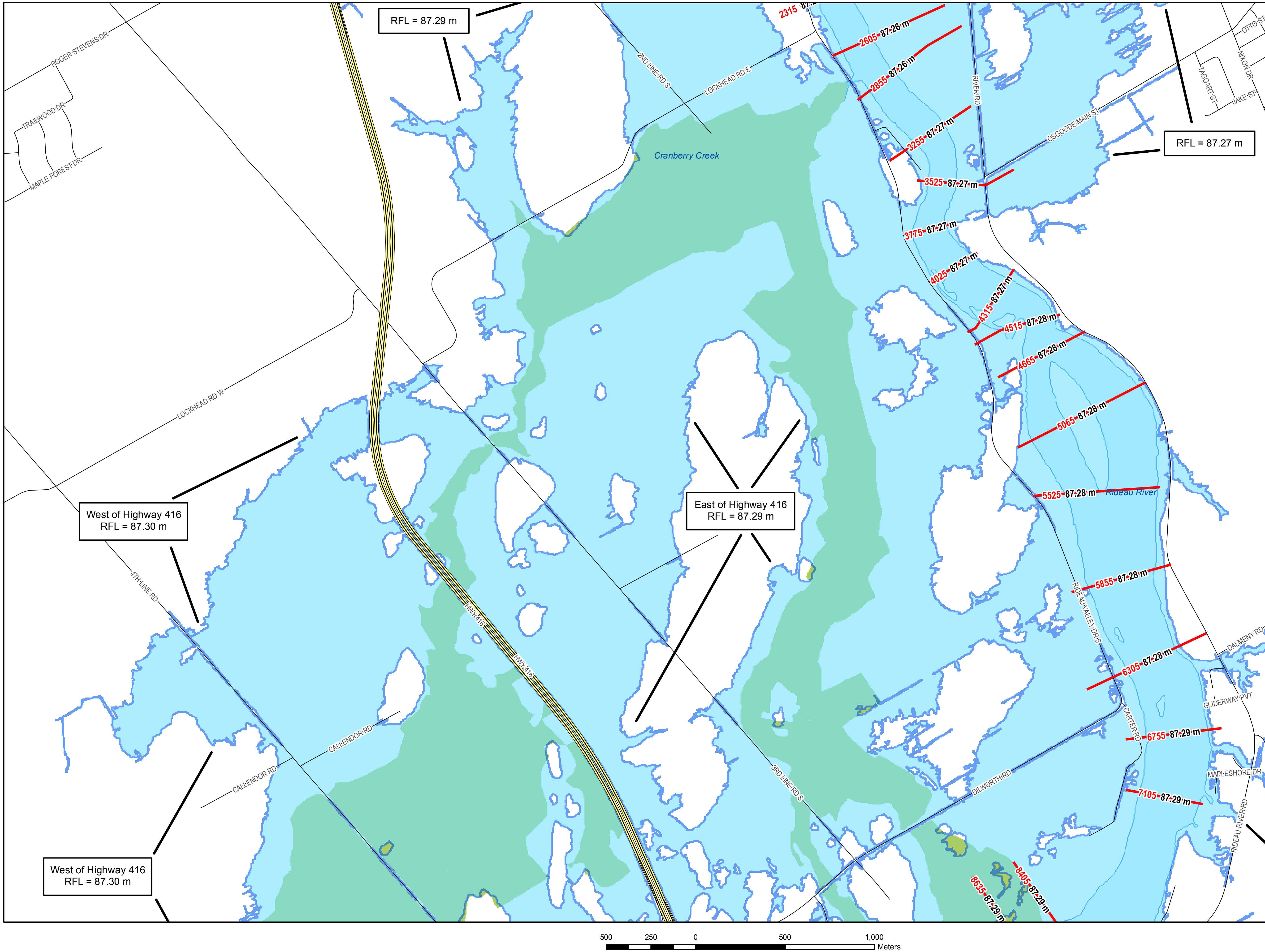
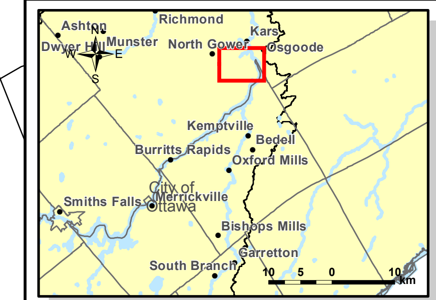


Rideau River Flood Plain Mapping

Kars to Burritts Rapids

Index:2



- Rideau River Floodplain
- Waterbody

Roads

- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9b

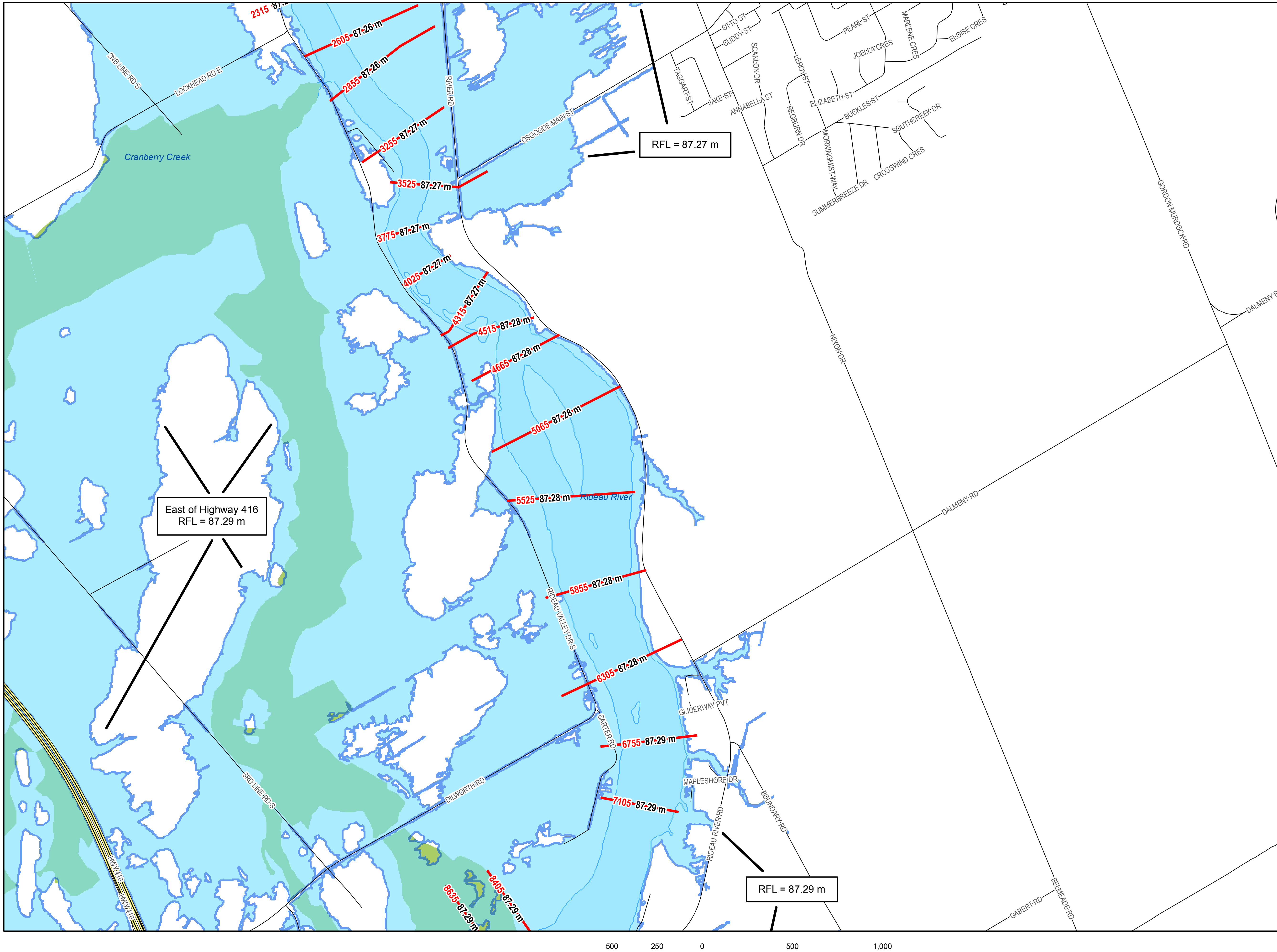
RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000

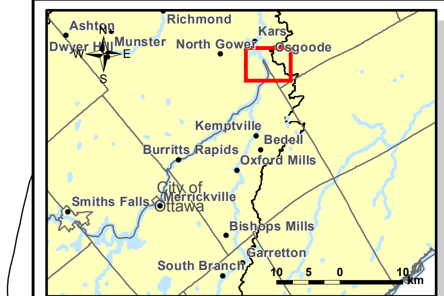
Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017



Rideau River Flood Plain Mapping

Kars to Burritts Rapids

Index:3



Rideau River Floodplain

Waterbody

Roads

Freeway

Road

Rapid Transit

RVCA Boundary

Evaluated Wetlands

Provincially Significant

Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9c

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

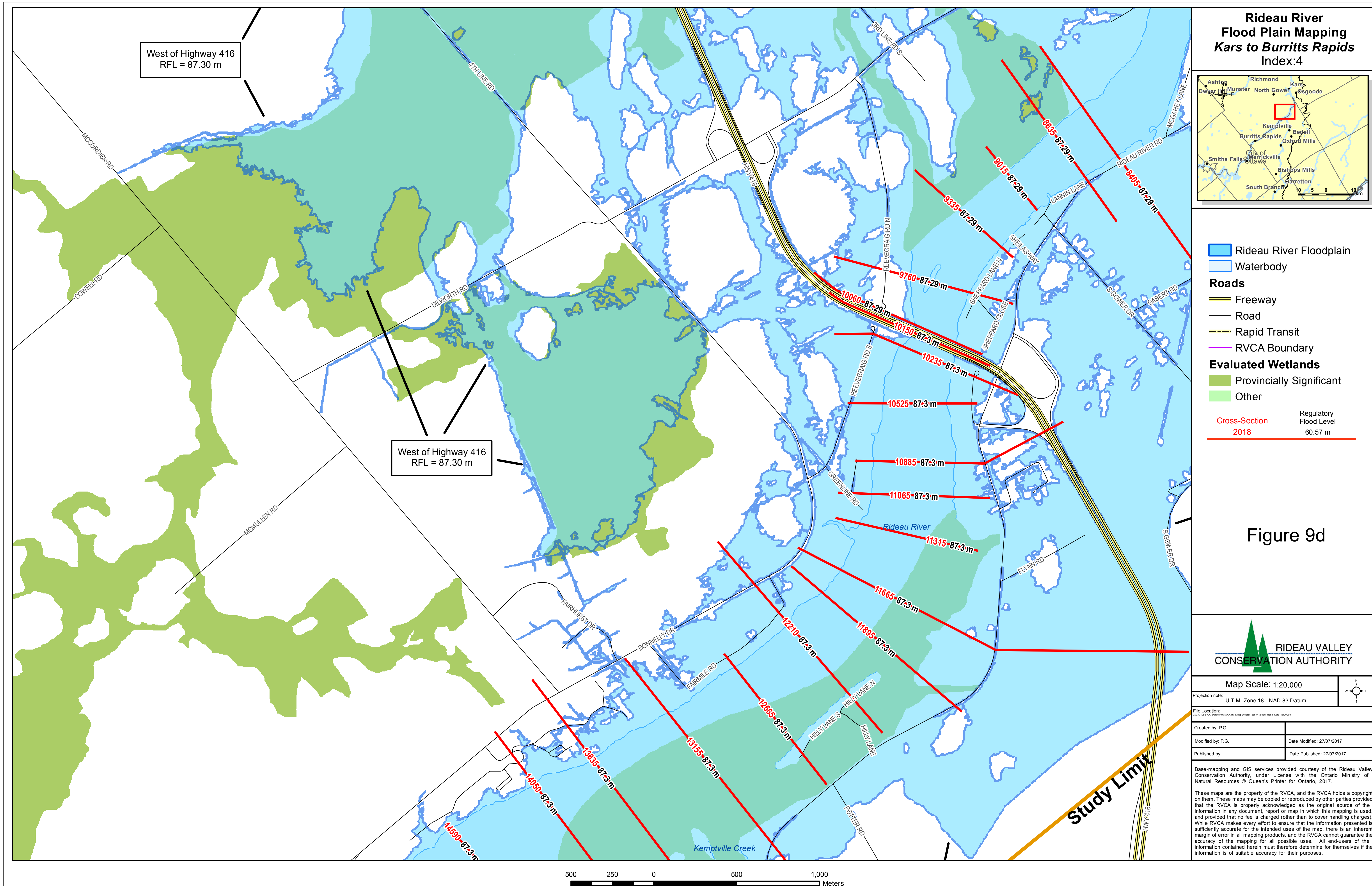
Projection note: U.T.M. Zone 18 - NAD 83 Datum

File Location:

Created by: P.G.

Modified by: P.G. | Date Modified: 27/07/2017

Published by: | Date Published: 27/07/2017


Rideau River
Flood Plain Mapping
Kars to Burritts Rapids
Index:4
Ashton
Richmond
Munster
North Gower
Kars
Osgoode
Dwyer Hill
Kemptville
Bedell
Burritts Rapids
Oxford Mills
Smiths Falls
City of Ottawa
Merrickville
Bishops Mills
South Branch
Garretton
Rideau River Floodplain
Waterbody
Roads
Freeway
Road
Rapid Transit
RVCA Boundary
Evaluated Wetlands
Provincially Significant
Other
Cross-Section
2018
Regulatory
Flood Level
60.57 m
Figure 9d
RIDEAU VALLEY
CONSERVATION AUTHORITY
Map Scale: 1:20,000
Projection note:
U.T.M. Zone 18 - NAD 83 Datum
File Location:
Created by: P.G.
Modified by: P.G.
Date Modified: 27/07/2017
Published by:
Date Published: 27/07/2017
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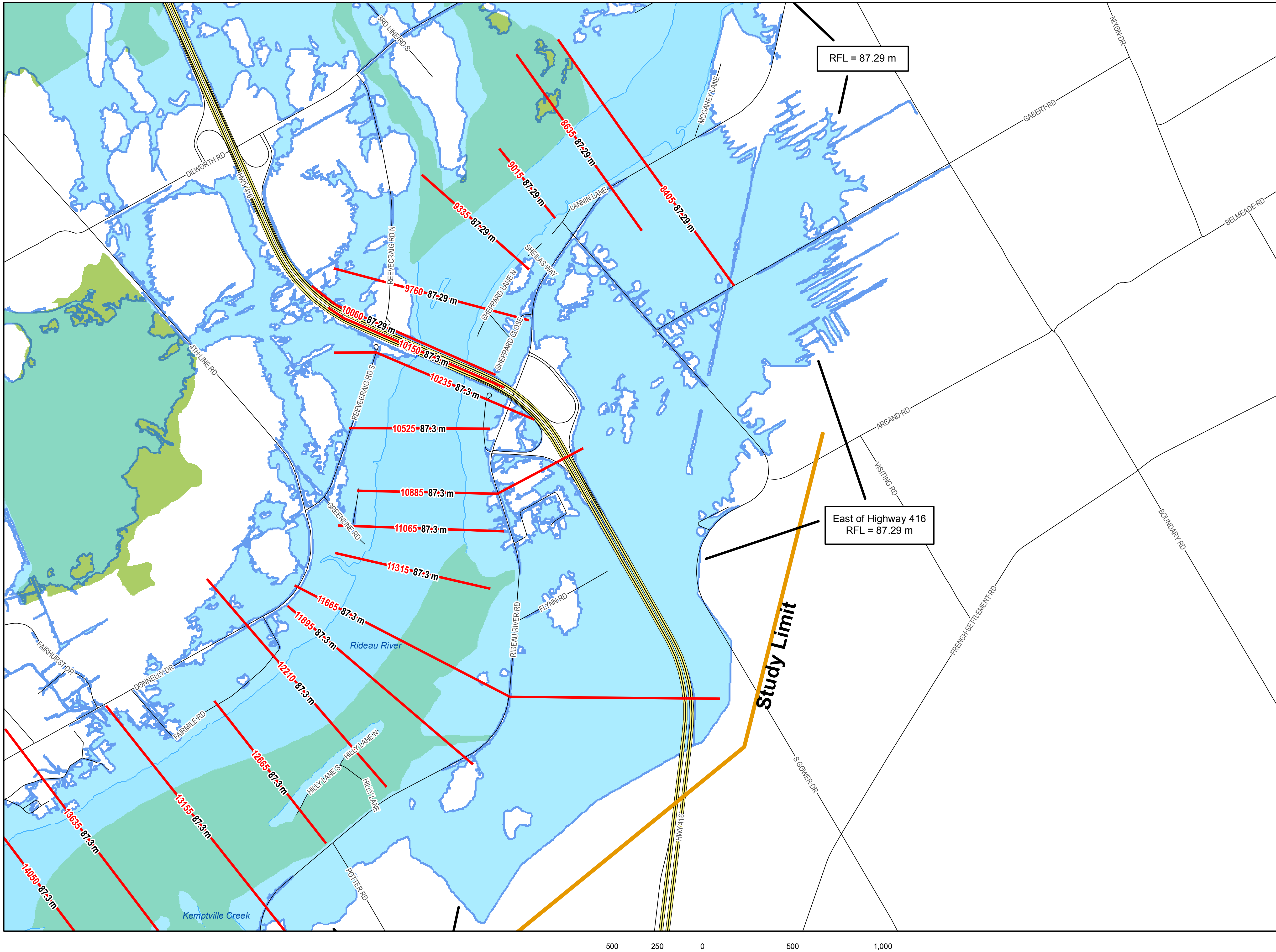
West of Highway 416
RFL = 87.30 m
West of Highway 416
RFL = 87.30 m
Study Limit
Rideau River
Kemptville Creek
8635 87.29 m
8405 87.29 m
9015 87.29 m
9335 87.29 m
9760 87.29 m
10060 87.29 m
10150 87.3 m
10235 87.3 m
10525 87.3 m
10885 87.3 m
11065 87.3 m
11315 87.3 m
11665 87.3 m
11895 87.3 m
12210 87.3 m
12665 87.3 m
13155 87.3 m
13635 87.3 m
14050 87.3 m
14590 87.3 m
MCCORDICK RD
COWELL RD
4TH LINE RD
3RD LINE RD S
DILWORTH RD
MCMULLEN RD
FAIRHURST DR
DONNELLY DR
FAIRMILE RD
HWY 416
REEVECRAIG RD N
REEVECRAIG RD S
GREENLINE RD
SHEPPARD LANE N
SHEPPARD CLOSE
SHEILAS WAY
LANNIN LANE
RIDEAU RIVER RD
MCGAHEY LANE
S GOWER DR
GABERT RD
FLYNN RD
HILLY LANE N
HILLY LANE S
HILLY LANE
POTTER RD
500 250 0 500 1,000
Meters



Rideau River Flood Plain Mapping
Kars to Burritts Rapids
Index:5

Ashton, Richmond, Kars, Dwyer Hill, Munster, North Gower, Osgoode, Kemptville, Bedell, Burritts Rapids, Oxford Mills, City of Ottawa, Merrickville, Smiths Falls, Bishops Mills, Garretton, South Branch, 10 5 0 10 km

Rideau River Floodplain
Waterbody

Roads

Freeway
Road
Rapid Transit
RVCA Boundary

Evaluated Wetlands

Provincially Significant
Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9e

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

File Location:

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Modified by: P.G. — Date Modified: 27/07/2017

Published by: — Date Published: 27/07/2017

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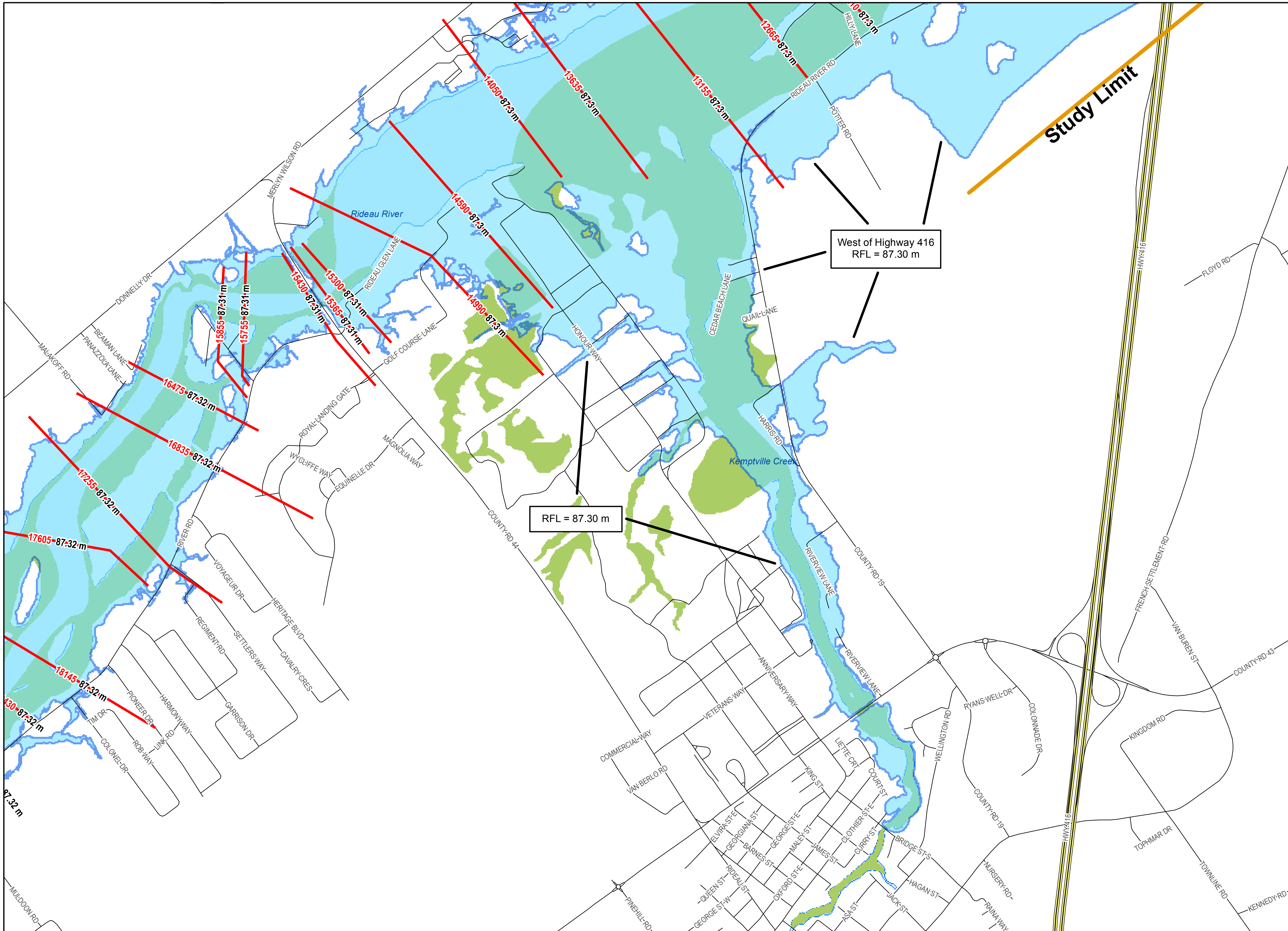
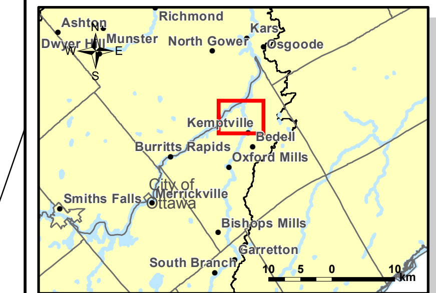
Rideau River Flood Plain Mapping
Kars to Burritts Rapids
Index:6





- Rideau River Floodplain
- Waterbody

Roads
- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands
- Provincially Significant
- Other

Cross-Section 2018	Regulatory Flood Level 60.57 m

Figure 9f

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000

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Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017

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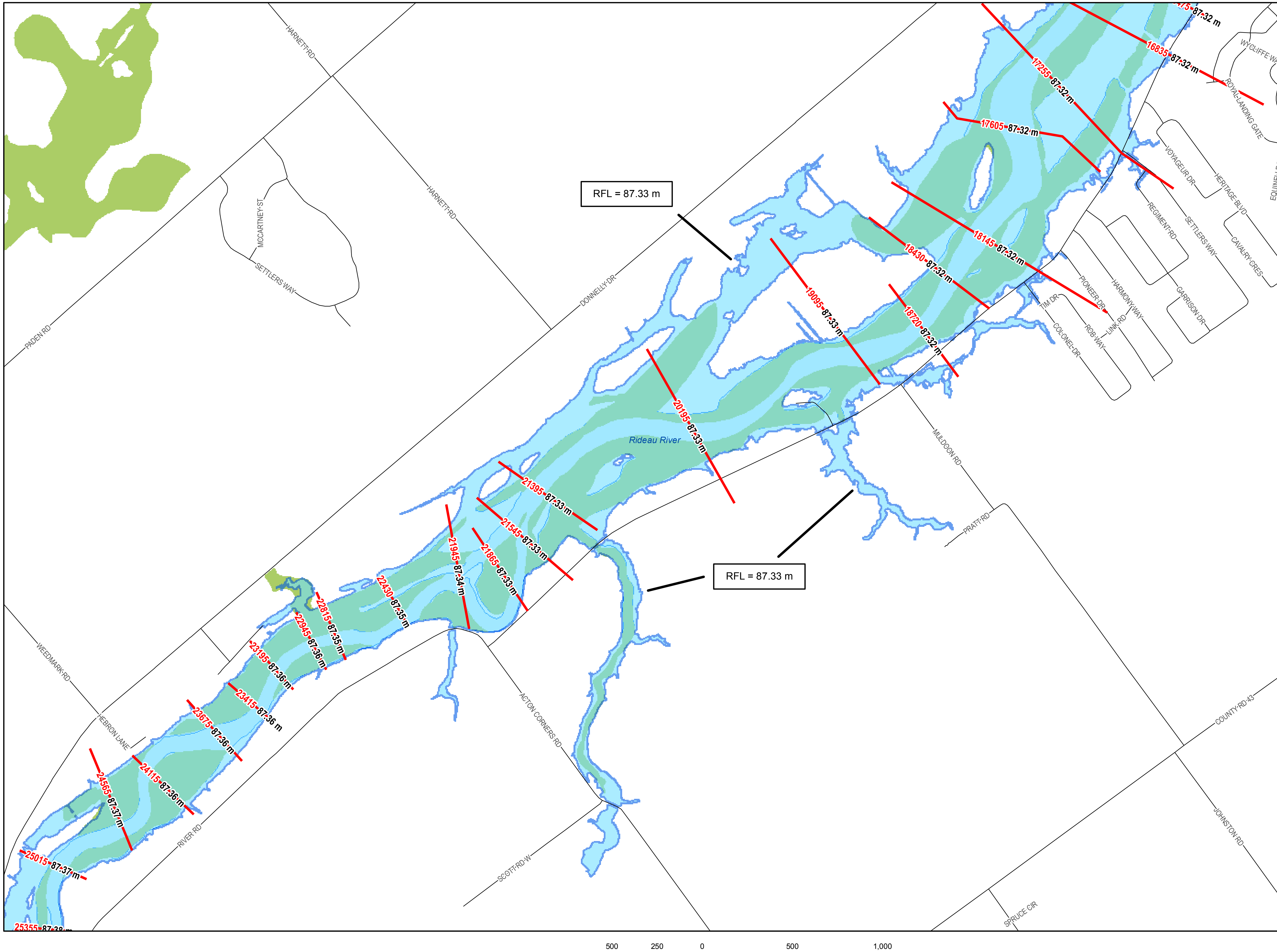


Rideau River Flood Plain Mapping
Kars to Burritts Rapids
Index:7

Ashton, Richmond, Kars, Dwyer Hill, Munster, North Gower, Osgoode, Kemptville, Bedell, Burritts Rapids, Oxford Mills, City of Ottawa, Merrickville, Smiths Falls, Bishops Mills, Garretton, South Branch

Rideau River Floodplain
Waterbody

Roads
Freeway
Road
Rapid Transit
RVCA Boundary

Evaluated Wetlands
Provincially Significant
Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9g

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

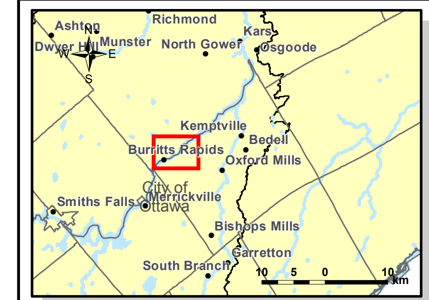
File Location:

Created by: P.G.

Modified by: P.G. — Date Modified: 27/07/2017

Published by: — Date Published: 27/07/2017

Rideau River
Flood Plain Mapping
Kars to Burritts Rapids
Index:8



Rideau River Floodplain
Waterbody

Roads

Freeway
Road
Rapid Transit
RVCA Boundary

Evaluated Wetlands

Provincially Significant
Other

Cross-Section	Regulatory Flood Level
2018	60.57 m

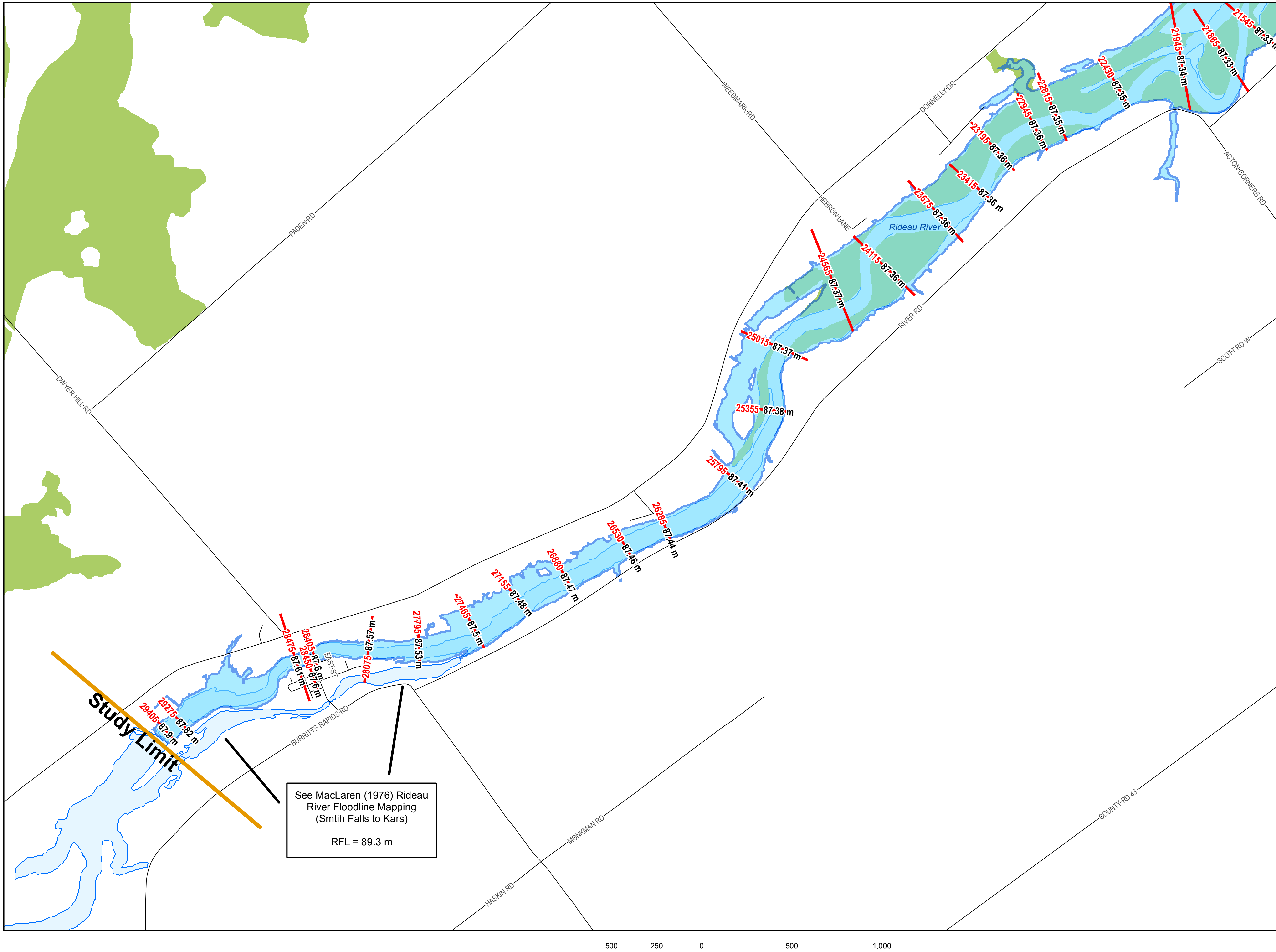


Figure 9h

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

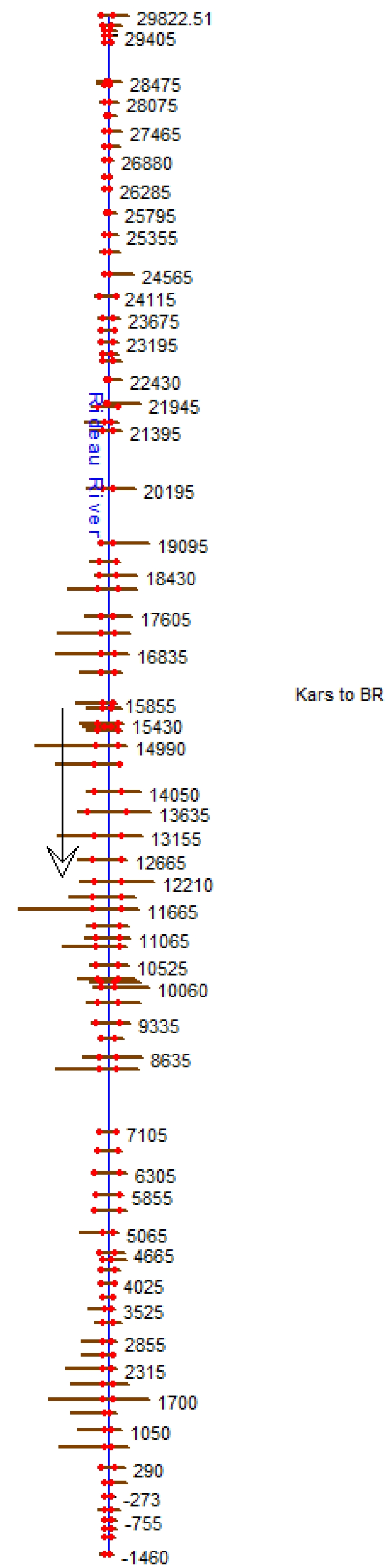
Projection note: U.T.M. Zone 18 - NAD 83 Datum

File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000

Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017

Appendix A

HEC-RAS Profiles and Cross-Sections


29822.51
29405
28475
28075
27465
26880
26285
25795
25355
24565
24115
23675
23195
22430
21945
21395
Rideau River
20195
19095
18430
17605
16835
Kars to BR
15855
15430
14990
14050
13635
13155
12665
12210
11665
11065
10525
10060
9335
8635
7105
6305
5855
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4665
4025
3525
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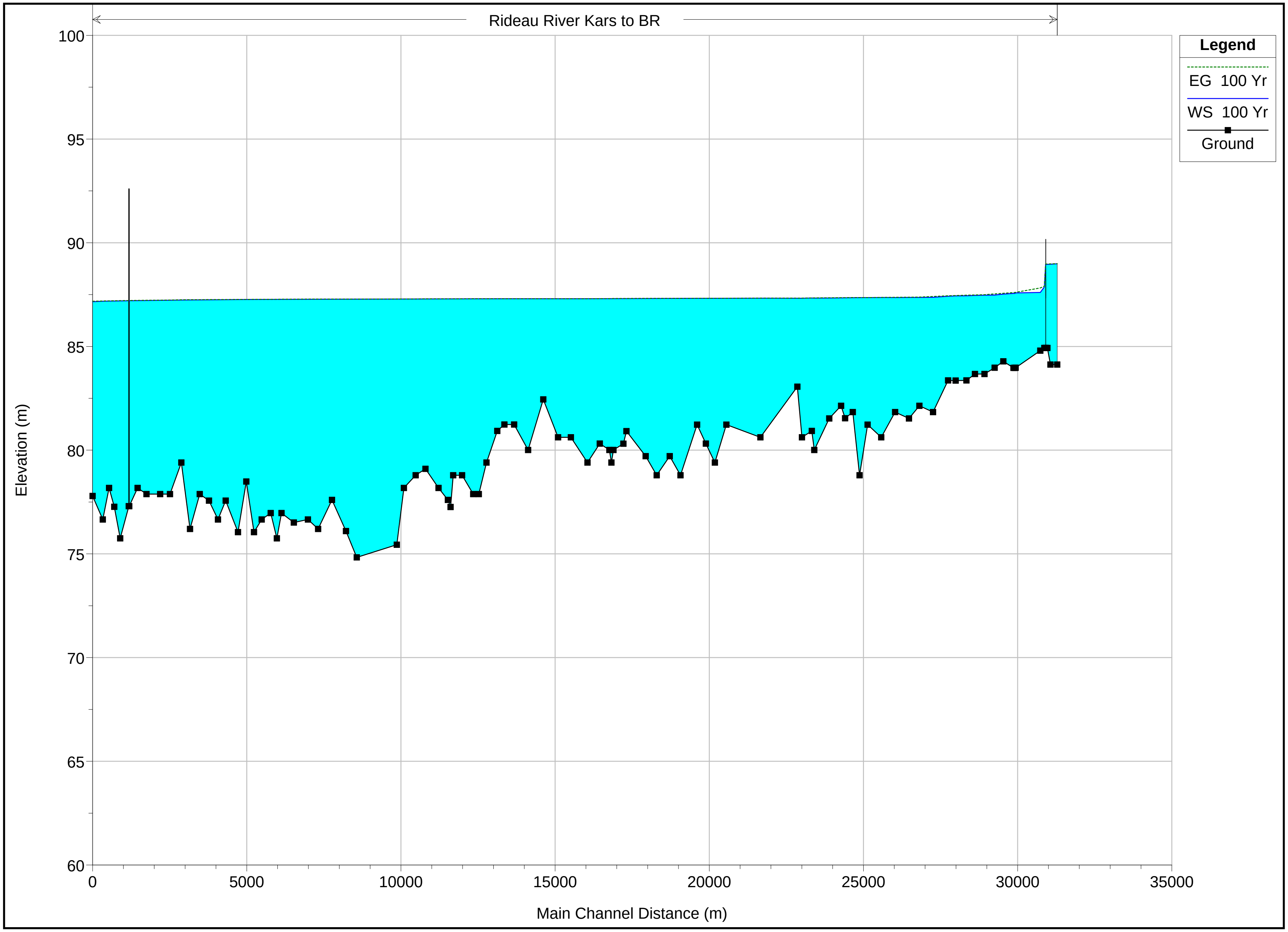
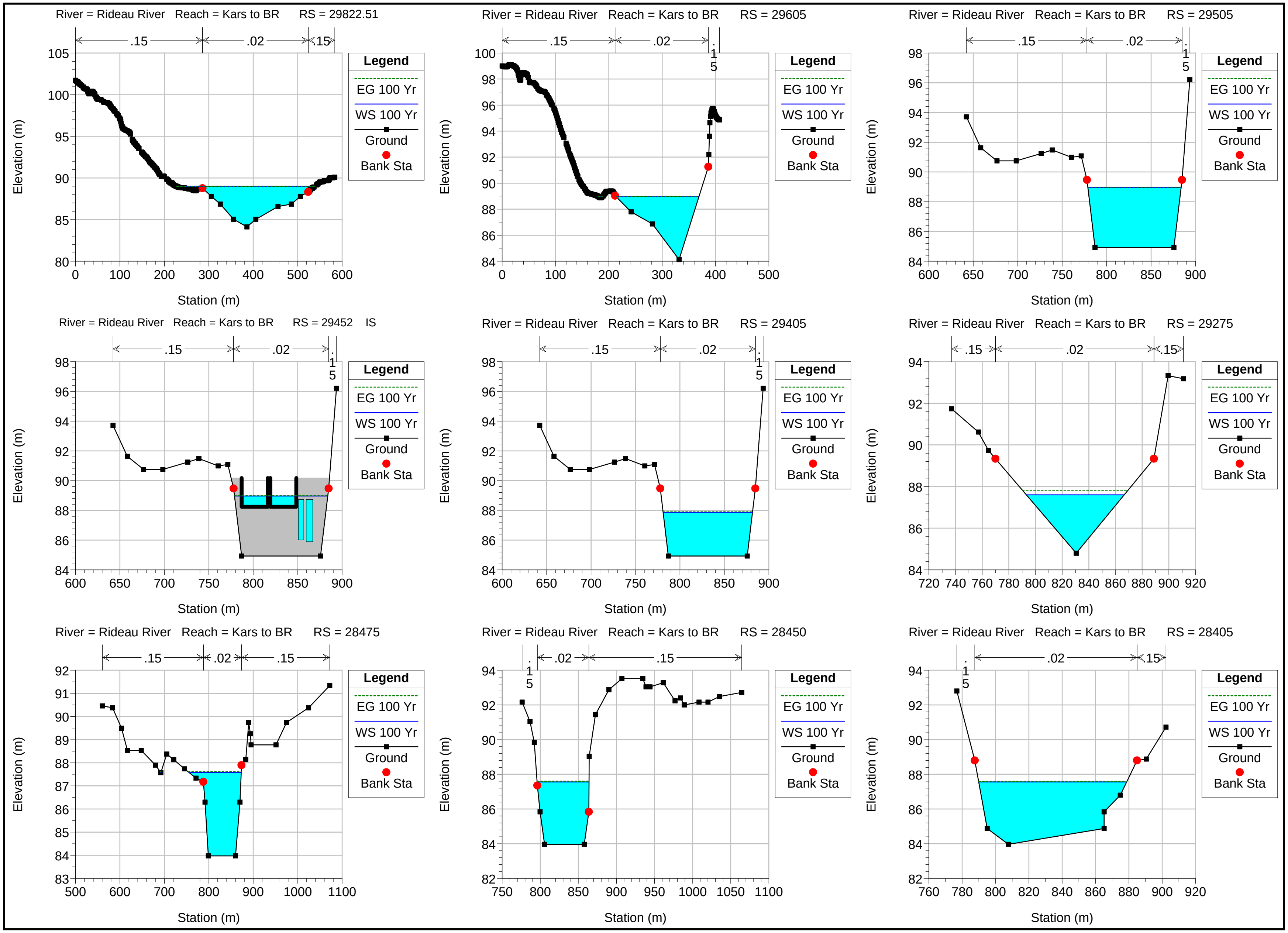
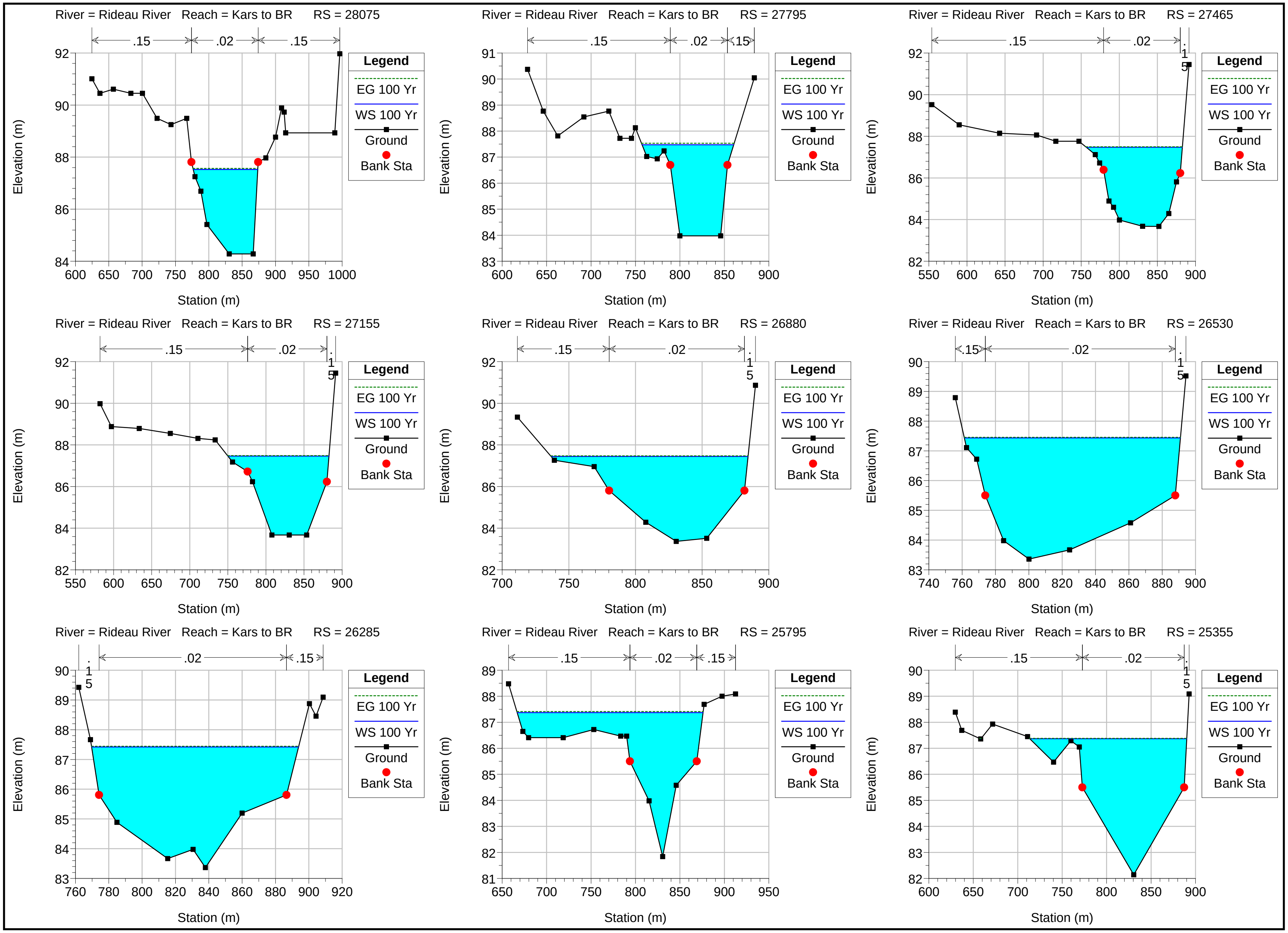
2315
1700
1050
290
-273
-755
-1460

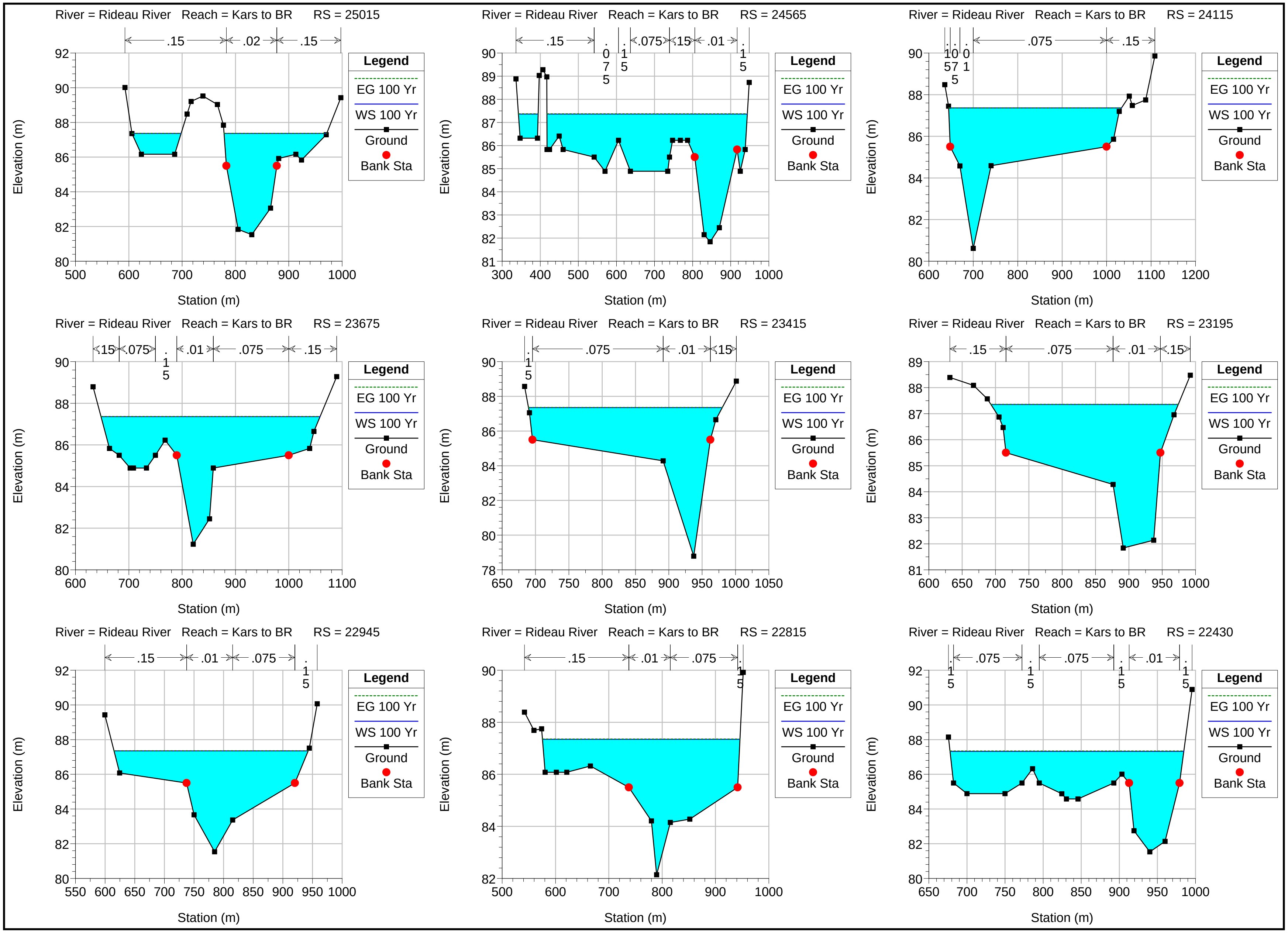


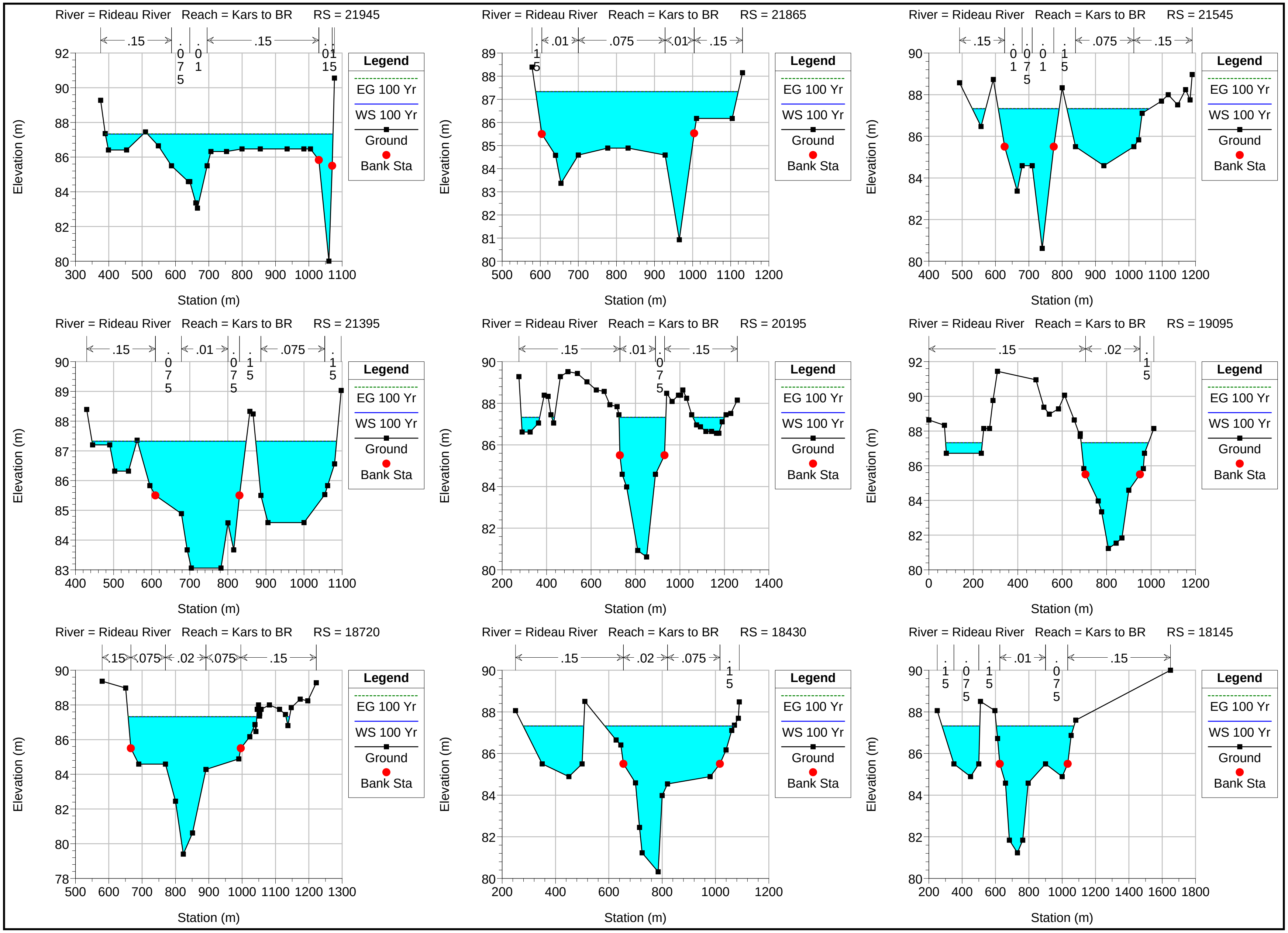
Rideau River Kars to BR
Legend
EG 100 Yr
WS 100 Yr
Ground
Elevation (m)
100
95
90
85
80
75
70
65
60
0
5000
10000
15000
20000
25000
30000
35000
Main Channel Distance (m)


River = Rideau River Reach = Kars to BR RS = 29822.51
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 29605
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 29505
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 29452 IS
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 29405
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 29275
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 28475
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 28450
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 28405
.15
.02
.15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta

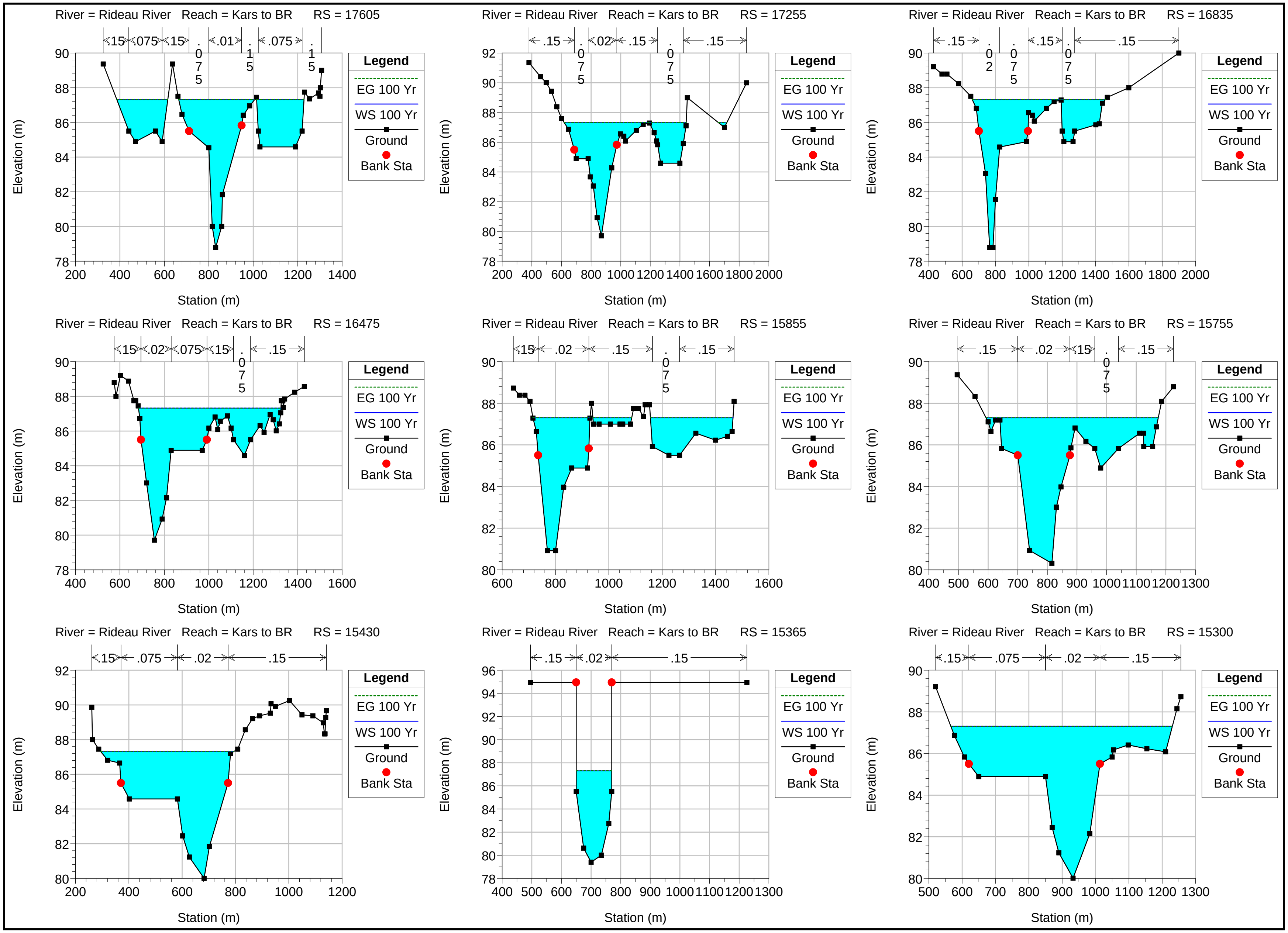


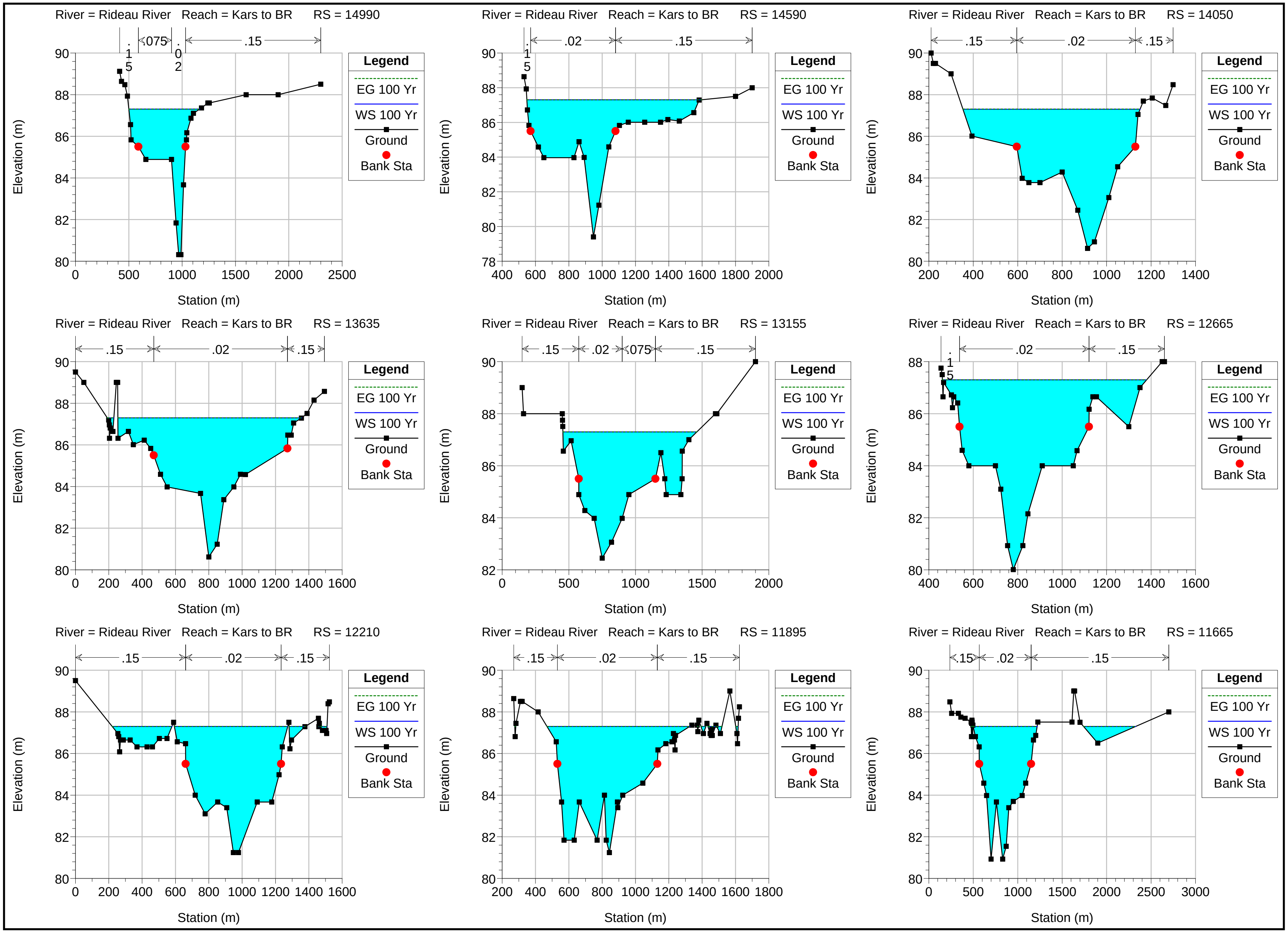
River = Rideau River Reach = Kars to BR RS = 28075
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 27795
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 27465
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 27155
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 26880
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 26530
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 26285
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 25795
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 25355
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)


River = Rideau River Reach = Kars to BR RS = 25015
River = Rideau River Reach = Kars to BR RS = 24565
River = Rideau River Reach = Kars to BR RS = 24115
River = Rideau River Reach = Kars to BR RS = 23675
River = Rideau River Reach = Kars to BR RS = 23415
River = Rideau River Reach = Kars to BR RS = 23195
River = Rideau River Reach = Kars to BR RS = 22945
River = Rideau River Reach = Kars to BR RS = 22815
River = Rideau River Reach = Kars to BR RS = 22430
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
.15
.02
.075
.01

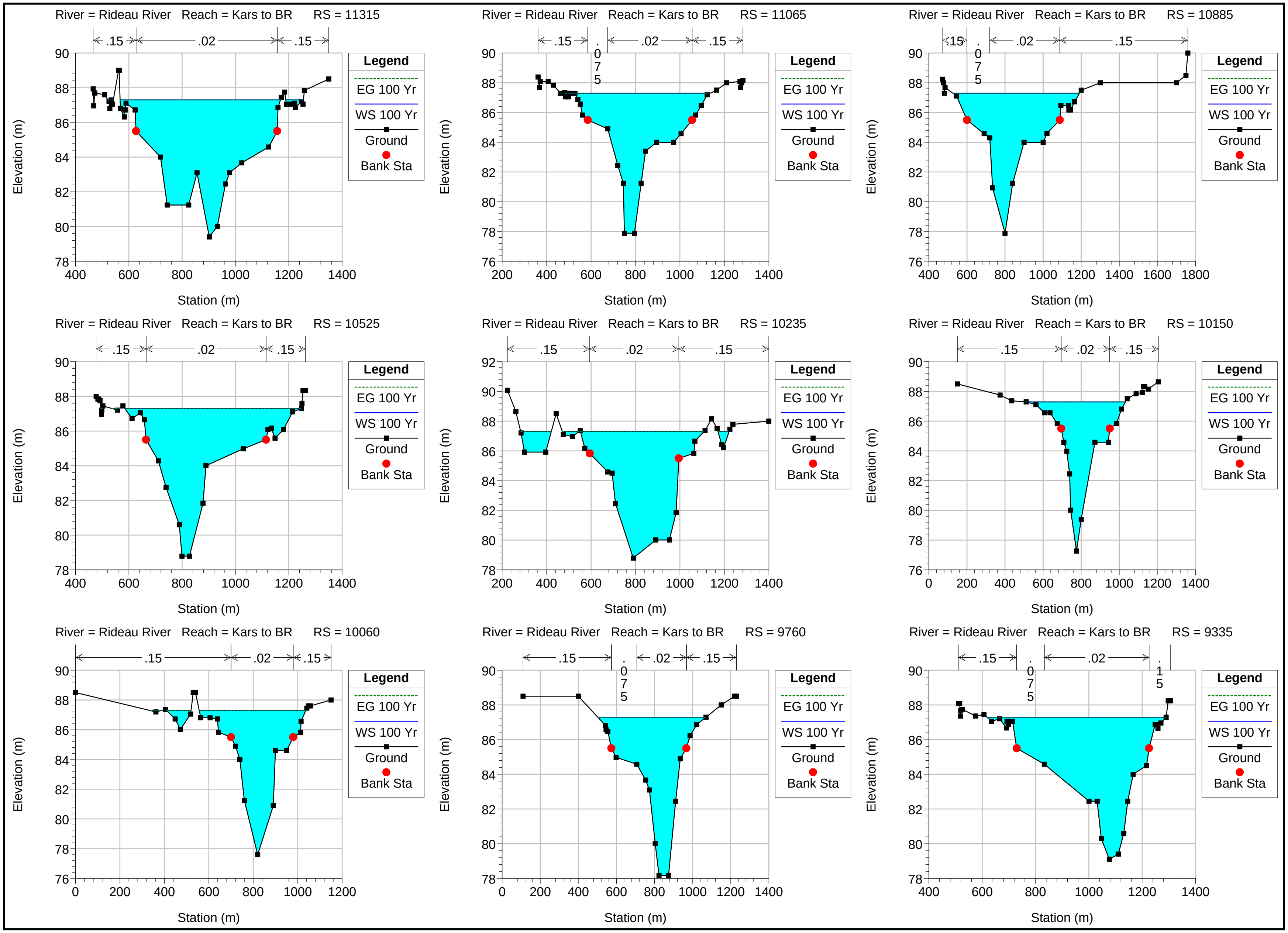


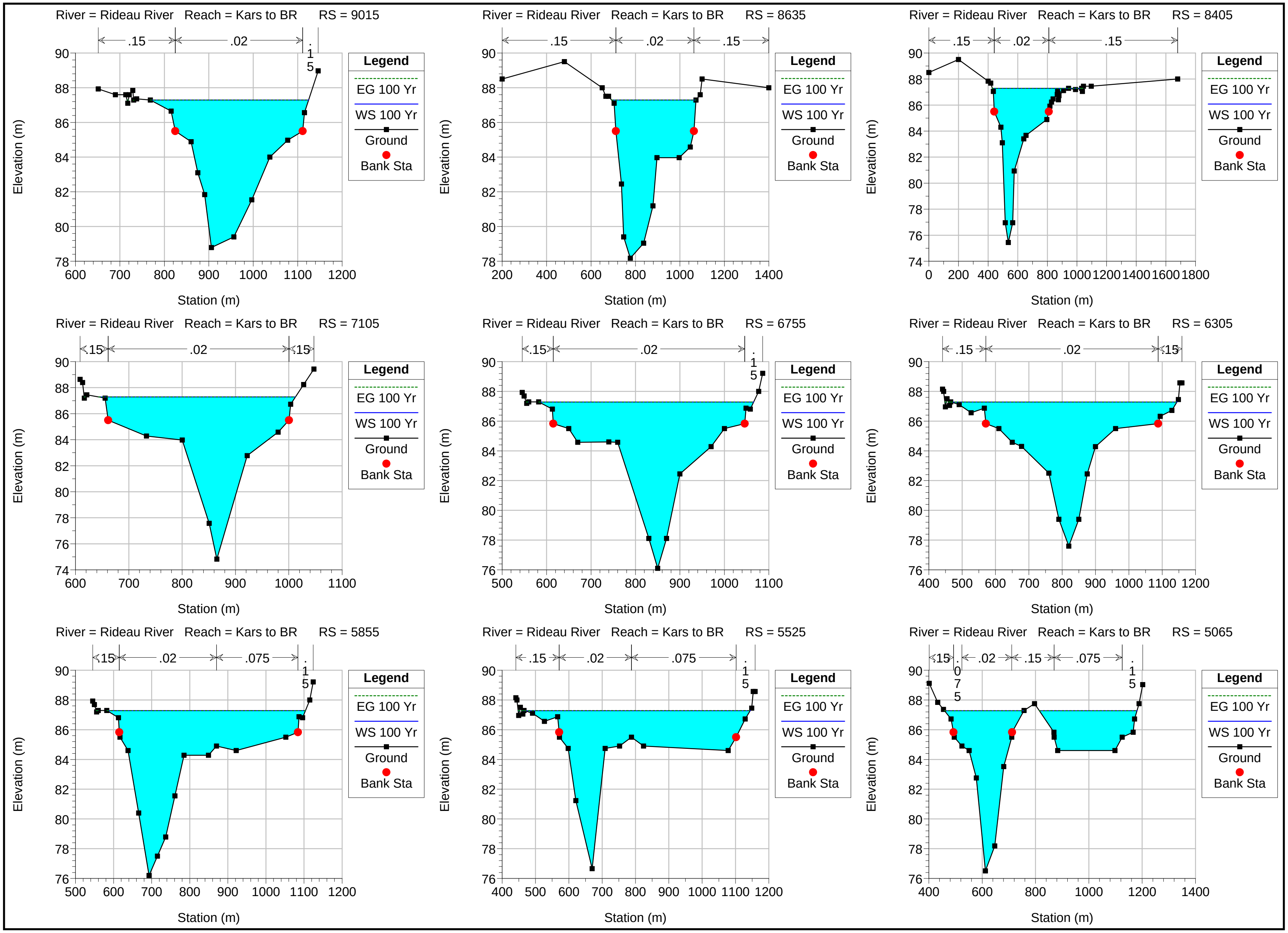
River = Rideau River Reach = Kars to BR RS = 21945
River = Rideau River Reach = Kars to BR RS = 21865
River = Rideau River Reach = Kars to BR RS = 21545
River = Rideau River Reach = Kars to BR RS = 21395
River = Rideau River Reach = Kars to BR RS = 20195
River = Rideau River Reach = Kars to BR RS = 19095
River = Rideau River Reach = Kars to BR RS = 18720
River = Rideau River Reach = Kars to BR RS = 18430
River = Rideau River Reach = Kars to BR RS = 18145
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)


River = Rideau River Reach = Kars to BR RS = 17605
River = Rideau River Reach = Kars to BR RS = 17255
River = Rideau River Reach = Kars to BR RS = 16835
River = Rideau River Reach = Kars to BR RS = 16475
River = Rideau River Reach = Kars to BR RS = 15855
River = Rideau River Reach = Kars to BR RS = 15755
River = Rideau River Reach = Kars to BR RS = 15430
River = Rideau River Reach = Kars to BR RS = 15365
River = Rideau River Reach = Kars to BR RS = 15300
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

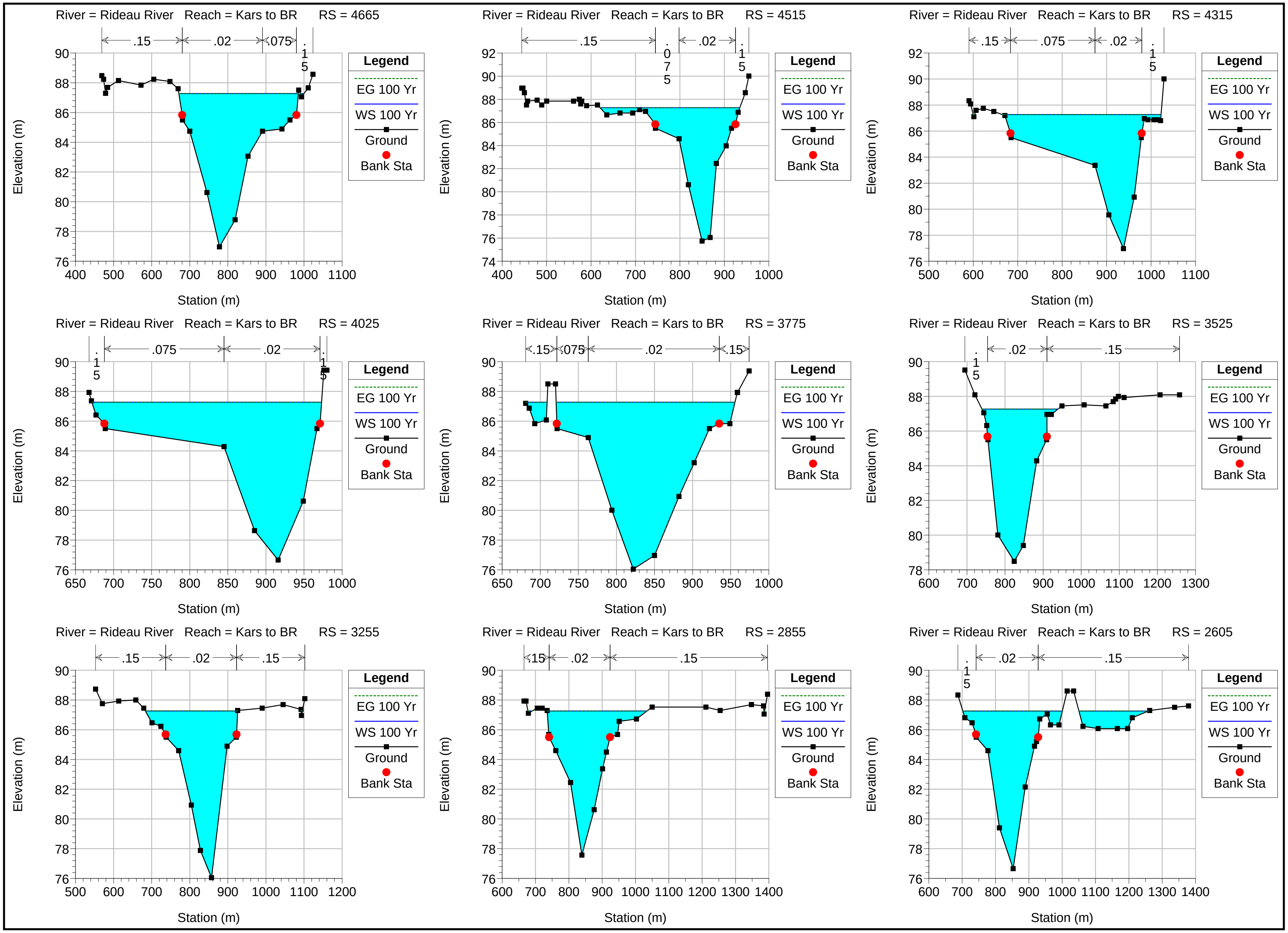


River = Rideau River Reach = Kars to BR RS = 14990
.15 .075 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 14590
.15 .02 .15
River = Rideau River Reach = Kars to BR RS = 14050
.15 .02 .15
River = Rideau River Reach = Kars to BR RS = 13635
.15 .02 .15
River = Rideau River Reach = Kars to BR RS = 13155
.15 .02 .075 .15
River = Rideau River Reach = Kars to BR RS = 12665
.15 .02 .15
River = Rideau River Reach = Kars to BR RS = 12210
.15 .02 .15
River = Rideau River Reach = Kars to BR RS = 11895
.15 .02 .15
River = Rideau River Reach = Kars to BR RS = 11665
.15 .02 .15

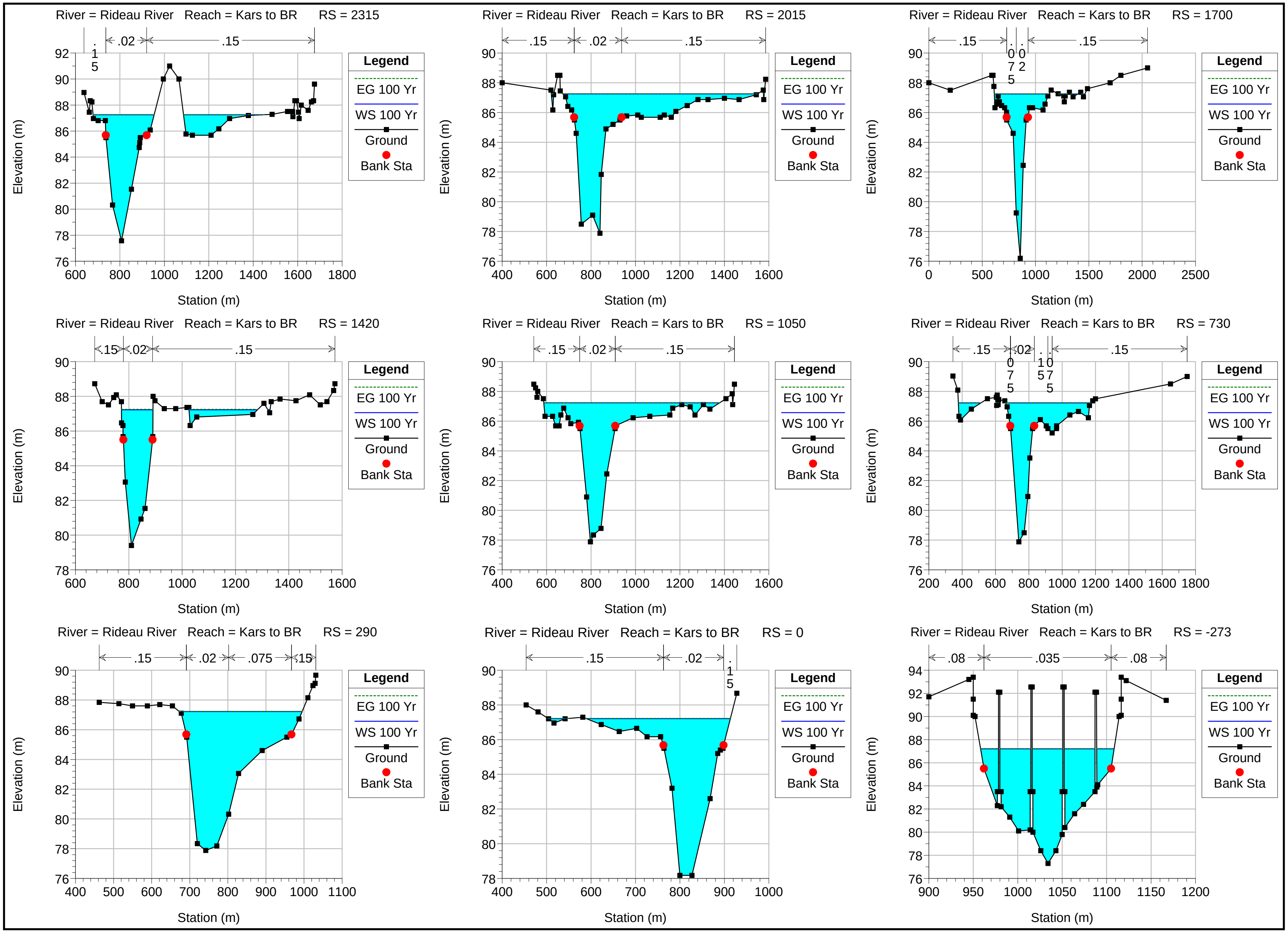

River = Rideau River Reach = Kars to BR RS = 11315
.15
.02
.15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = Kars to BR RS = 11065
.15
.075
.02
.15
River = Rideau River Reach = Kars to BR RS = 10885
.15
.075
.02
.15
River = Rideau River Reach = Kars to BR RS = 10525
.15
.02
.15
River = Rideau River Reach = Kars to BR RS = 10235
.15
.02
.15
River = Rideau River Reach = Kars to BR RS = 10150
.15
.02
.15
River = Rideau River Reach = Kars to BR RS = 10060
.15
.02
.15
River = Rideau River Reach = Kars to BR RS = 9760
.15
.075
.02
.15
River = Rideau River Reach = Kars to BR RS = 9335
.15
.075
.02
.15

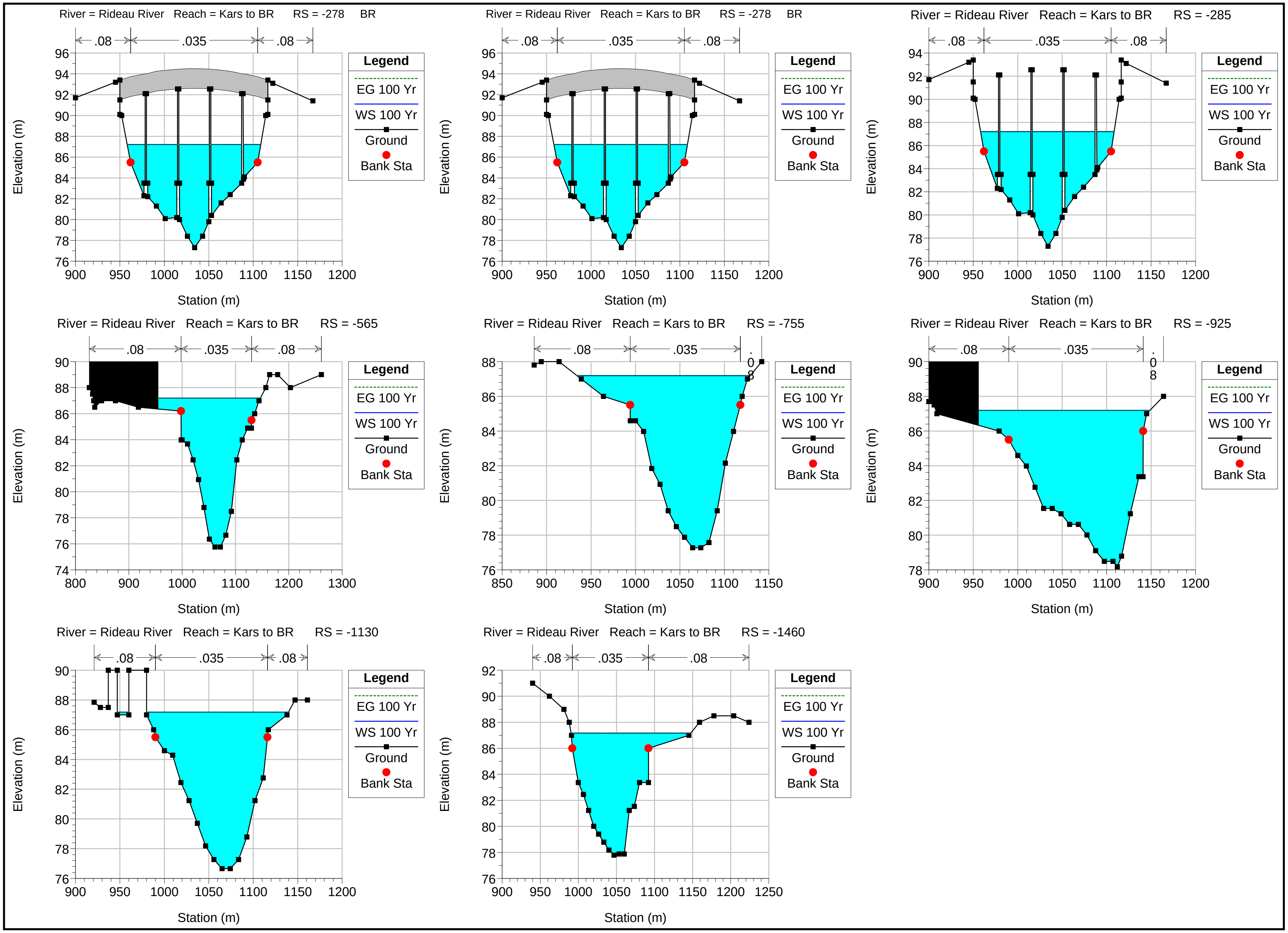


River = Rideau River Reach = Kars to BR RS = 9015
River = Rideau River Reach = Kars to BR RS = 8635
River = Rideau River Reach = Kars to BR RS = 8405
River = Rideau River Reach = Kars to BR RS = 7105
River = Rideau River Reach = Kars to BR RS = 6755
River = Rideau River Reach = Kars to BR RS = 6305
River = Rideau River Reach = Kars to BR RS = 5855
River = Rideau River Reach = Kars to BR RS = 5525
River = Rideau River Reach = Kars to BR RS = 5065
.15
.02
.075
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)



River = Rideau River Reach = Kars to BR RS = 4665
.15 .02 .075 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 4515
.15 .075 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 4315
.15 .075 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 4025
.15 .075 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 3775
.15 .075 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 3525
.15 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 3255
.15 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 2855
.15 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = 2605
.15 .02 .15
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta


River = Rideau River Reach = Kars to BR RS = 2315
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
92 90 88 86 84 82 80 78 76
600 800 1000 1200 1400 1600 1800
River = Rideau River Reach = Kars to BR RS = 2015
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78 76
400 600 800 1000 1200 1400 1600
River = Rideau River Reach = Kars to BR RS = 1700
.15 .075 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78 76
0 500 1000 1500 2000 2500
River = Rideau River Reach = Kars to BR RS = 1420
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78
600 800 1000 1200 1400 1600
River = Rideau River Reach = Kars to BR RS = 1050
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78 76
400 600 800 1000 1200 1400 1600
River = Rideau River Reach = Kars to BR RS = 730
.15 .075 .02 .15 .075 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78 76
200 400 600 800 1000 1200 1400 1600 1800
River = Rideau River Reach = Kars to BR RS = 290
.15 .02 .075 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78 76
400 500 600 700 800 900 1000 1100
River = Rideau River Reach = Kars to BR RS = 0
.15 .02 .15
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
90 88 86 84 82 80 78
400 500 600 700 800 900 1000
River = Rideau River Reach = Kars to BR RS = -273
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
94 92 90 88 86 84 82 80 78 76
900 950 1000 1050 1100 1150 1200



River = Rideau River Reach = Kars to BR RS = -278 BR
.08
.035
.08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = Kars to BR RS = -278 BR
River = Rideau River Reach = Kars to BR RS = -285
River = Rideau River Reach = Kars to BR RS = -565
River = Rideau River Reach = Kars to BR RS = -755
River = Rideau River Reach = Kars to BR RS = -925
River = Rideau River Reach = Kars to BR RS = -1130
River = Rideau River Reach = Kars to BR RS = -1460

Table A.1 Manning's n per Cross Section.

Cross Section (m)	Reach	Left Overbank	Channel	Right Overbank
29822.51	Kars to BR	0.15	0.02	0.15
29605	Kars to BR	0.15	0.02	0.15
29505	Kars to BR	0.15	0.02	0.15
29405	Kars to BR	0.15	0.02	0.15
29275	Kars to BR	0.15	0.02	0.15
28475	Kars to BR	0.15	0.02	0.15
28450	Kars to BR	0.15	0.02	0.15
28405	Kars to BR	0.15	0.02	0.15
28075	Kars to BR	0.15	0.02	0.15
27795	Kars to BR	0.15	0.02	0.15
27465	Kars to BR	0.15	0.02	0.15
27155	Kars to BR	0.15	0.02	0.15
26880	Kars to BR	0.15	0.02	0.15
26530	Kars to BR	0.15	0.02	0.15
26285	Kars to BR	0.15	0.02	0.15
25795	Kars to BR	0.15	0.02	0.15
25355	Kars to BR	0.15	0.02	0.15
25015	Kars to BR	0.15	0.02	0.15
24565	Kars to BR	0.15,0.075,0.15,0.075,0.15	0.01	0.15
24115	Kars to BR	0.15	0.075,0.01,0.075	0.15
23675	Kars to BR	0.15,0.075,0.15	0.01,0.075	0.15
23415	Kars to BR	0.15	0.075,0.01	0.15
23195	Kars to BR	0.15	0.075,0.01	0.15
22945	Kars to BR	0.15	0.01,0.075	0.15
22815	Kars to BR	0.15	0.01,0.075	0.15
22430	Kars to BR	0.15,0.075,0.15,0.075,0.15	0.01	0.15
21945	Kars to BR	0.15,0.075,0.01,0.15	0.01	0.15
21865	Kars to BR	0.15	0.01,0.075,0.01	0.15
21545	Kars to BR	0.15	0.01,0.075,0.01	0.15,0.075,0.15
21395	Kars to BR	0.15	0.075,0.01,0.075	0.15,0.075,0.15
20195	Kars to BR	0.15	0.01,0.075	0.15
19095	Kars to BR	0.15	0.02	0.15
18720	Kars to BR	0.15	0.075,0.02,0.075	0.15
18430	Kars to BR	0.15	0.02,0.075	0.15
18145	Kars to BR	0.15,0.075,0.15	0.01,0.075	0.15
17605	Kars to BR	0.15,0.075,0.15	0.075,0.01	0.15,0.075,0.15
17255	Kars to BR	0.15	0.075,0.02	0.15,0.075,0.15
16835	Kars to BR	0.15	0.02,0.075	0.15,0.075,0.15
16475	Kars to BR	0.15	0.02,0.075	0.15,0.075,0.15
15855	Kars to BR	0.15	0.02	0.15,0.075,0.15
15755	Kars to BR	0.15	0.02	0.15,0.075,0.15
15430	Kars to BR	0.15	0.075,0.02	0.15

15365	Kars to BR	0.15	0.02	0.15
15300	Kars to BR	0.15	0.075,0.02	0.15
14990	Kars to BR	0.15	0.075,0.02	0.15
14590	Kars to BR	0.15	0.02	0.15
14050	Kars to BR	0.15	0.02	0.15
13635	Kars to BR	0.15	0.02	0.15
13155	Kars to BR	0.15	0.02,0.075	0.15
12665	Kars to BR	0.15	0.02	0.15
12210	Kars to BR	0.15	0.02	0.15
11895	Kars to BR	0.15	0.02	0.15
11665	Kars to BR	0.15	0.02	0.15
11315	Kars to BR	0.15	0.02	0.15
11065	Kars to BR	0.15	0.075,0.02	0.15
10885	Kars to BR	0.15	0.075,0.02	0.15
10525	Kars to BR	0.15	0.02	0.15
10235	Kars to BR	0.15	0.02	0.15
10150	Kars to BR	0.15	0.02	0.15
10060	Kars to BR	0.15	0.02	0.15
9760	Kars to BR	0.15	0.075,0.02	0.15
9335	Kars to BR	0.15	0.075,0.02	0.15
9015	Kars to BR	0.15	0.02	0.15
8635	Kars to BR	0.15	0.02	0.15
8405	Kars to BR	0.15	0.02	0.15
7105	Kars to BR	0.15	0.02	0.15
6755	Kars to BR	0.15	0.02	0.15
6305	Kars to BR	0.15	0.02	0.15
5855	Kars to BR	0.15	0.02,0.075	0.15
5525	Kars to BR	0.15	0.02,0.075	0.15
5065	Kars to BR	0.15	0.075,0.02,0.15	0.15,0.075,0.15
4665	Kars to BR	0.15	0.02,0.075	0.15
4515	Kars to BR	0.15	0.075,0.02	0.15
4315	Kars to BR	0.15	0.075,0.02	0.15
4025	Kars to BR	0.15	0.075,0.02	0.15
3775	Kars to BR	0.15	0.075,0.02	0.15
3525	Kars to BR	0.15	0.02	0.15
3255	Kars to BR	0.15	0.02	0.15
2855	Kars to BR	0.15	0.02	0.15
2605	Kars to BR	0.15	0.02	0.15
2315	Kars to BR	0.15	0.02	0.15
2015	Kars to BR	0.15	0.02	0.15
1700	Kars to BR	0.15	0.075,0.02	0.15
1420	Kars to BR	0.15	0.02	0.15
1050	Kars to BR	0.15	0.02	0.15
730	Kars to BR	0.15	0.075,0.02	0.15,0.075,0.15
290	Kars to BR	0.15	0.02,0.075	0.15

0	Kars to BR	0.15	0.02	0.15
-273	Kars to BR	0.08	0.035	0.08
-285	Kars to BR	0.08	0.035	0.08
-565	Kars to BR	0.08	0.035	0.08
-755	Kars to BR	0.08	0.035	0.08
-925	Kars to BR	0.08	0.035	0.08
-1130	Kars to BR	0.08	0.035	0.08
-1460	Kars to BR	0.08	0.035	0.08

Appendix B

Field Verification of LIDAR Data

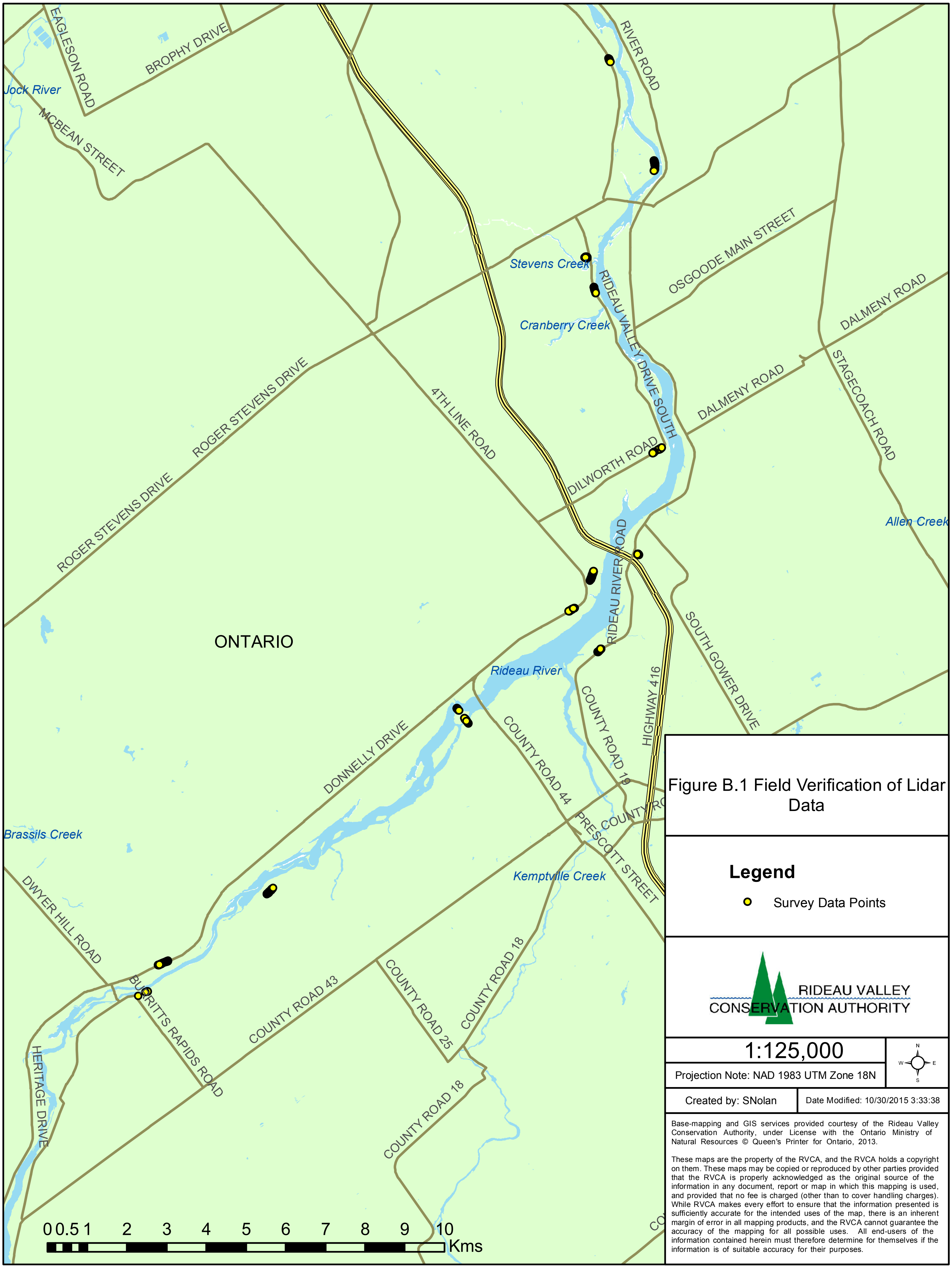


Figure B.1 Field Verification of Lidar Data

Legend

Survey Data Points

RIDEAU VALLEY CONSERVATION AUTHORITY

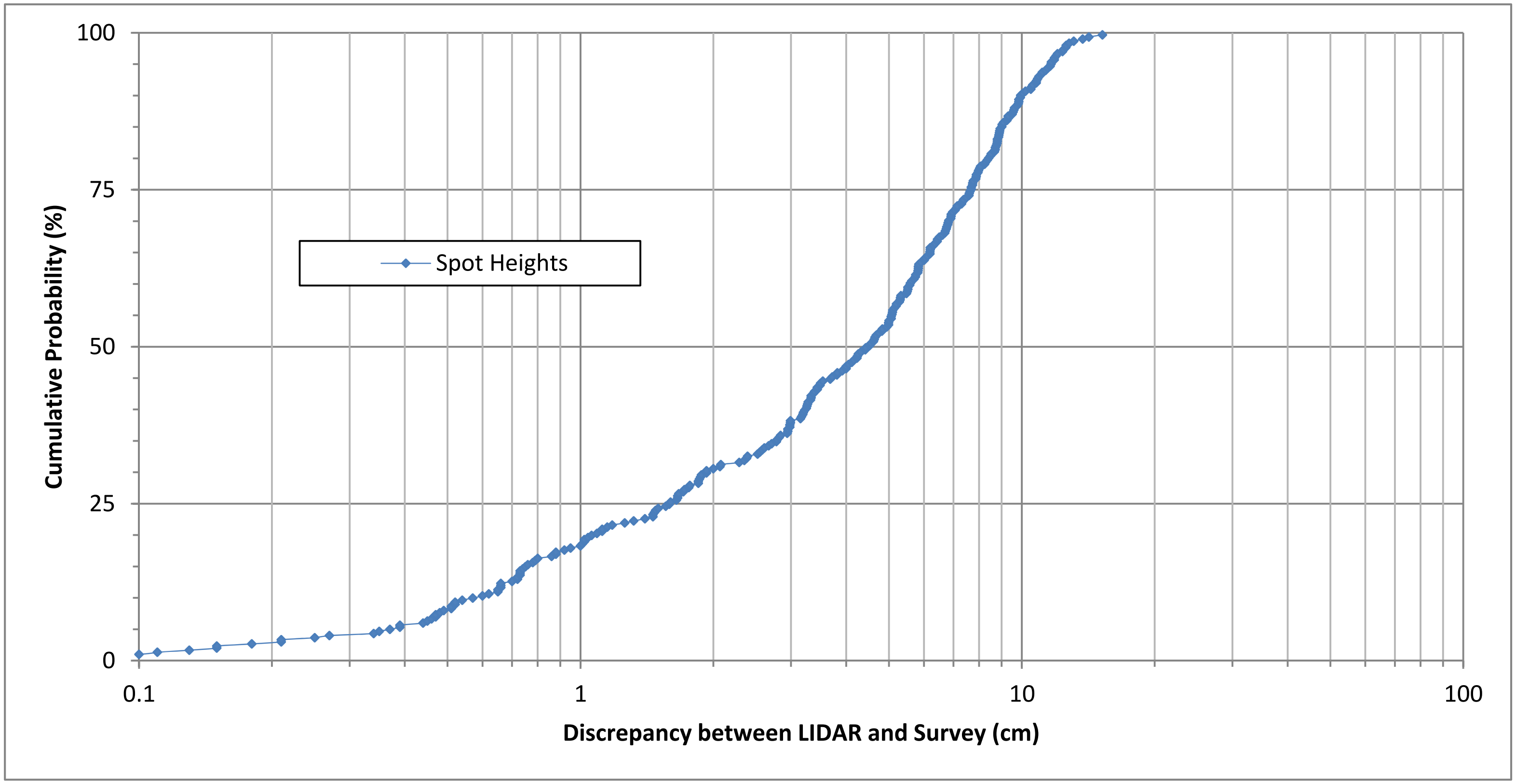
1:125,000

Projection Note: NAD 1983 UTM Zone 18N

Created by: SNolan

Date Modified: 10/30/2015 3:33:38

Figure B.2 Field Verification of LIDAR Data for the Rideau River from Kars to Burritts Rapids.



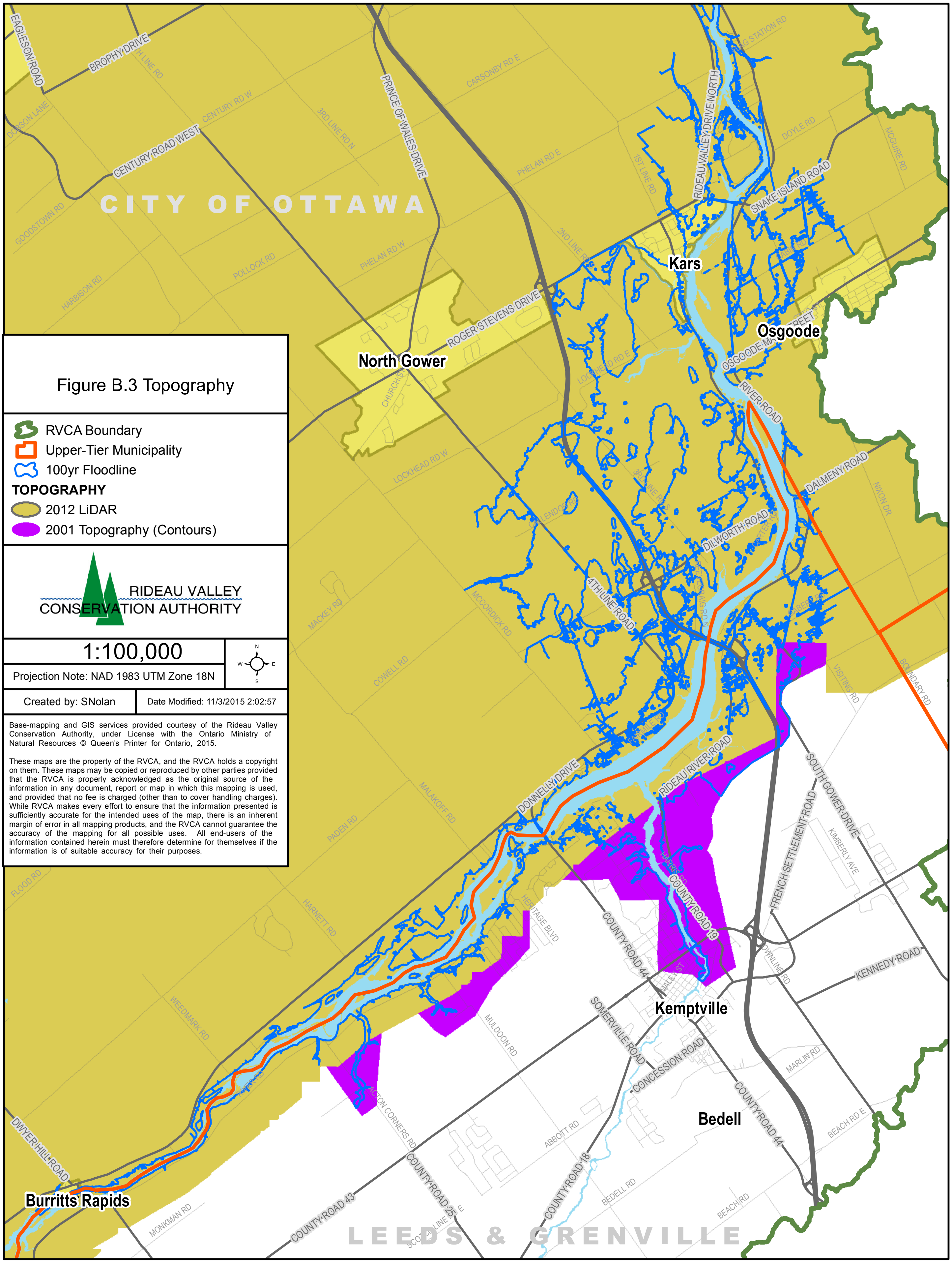


Figure B.3 Topography
RVCA Boundary
Upper-Tier Municipality
100yr Floodline
TOPOGRAPHY
2012 LiDAR
2001 Topography (Contours)
RIDEAU VALLEY
CONSERVATION AUTHORITY
1:100,000
Projection Note: NAD 1983 UTM Zone 18N
Created by: SNolan
Date Modified: 11/3/2015 2:02:57
N
W
E
S
CITY OF OTTAWA
LEEDS & GRENVILLE
North Gower
Kars
Osgoode
Kemptville
Bedell
Burritts Rapids
EAGLESON ROAD
BROPHY DRIVE
CENTURY ROAD WEST
CENTURY RD W
PRINCE OF WALES DRIVE
CARSONBY RD E
RIDEAU VALLEY DRIVE NORTH
SNAKE ISLAND ROAD
DOYLE RD
MCGUIRE RD
GOODSTOWN RD
POLLOCK RD
PHELAN RD W
PHELAN RD E
HARBISON RD
ROGER STEVENS DRIVE
3RD LINE RD N
1ST LINE RD
2ND LINE RD S
RIVER ROAD
DALMENY ROAD
NIXON DR
LOCKHEAD RD W
DILWORTH ROAD
4TH LINE ROAD
MCCORDICK RD
MACKEY RD
COWELL RD
MALAKOFF RD
PADEN RD
DONNELLY DRIVE
RIDEAU RIVER ROAD
FLOOD RD
HARNETT RD
WEEDMARK RD
HERITAGE BLVD
COUNTY ROAD 44
COUNTY ROAD 19
SOUTH GOWER DRIVE
FRENCH SETTLEMENT ROAD
KIMBERLY AVE
KENNEDY ROAD
VISITING RD
BOUNDARY RD
SOMERVILLE ROAD
CONCESSION ROAD
MULDOON RD
MARLIN RD
BEACH RD E
ABBOTT RD
ACTON CORNERS RD
COUNTY ROAD 25
COUNTY ROAD 18
COUNTY ROAD 43
BEDELL RD
BEACH RD
MONKMAN RD
DWYER HILL ROAD

Table B.1 Field Verification of LIDAR Data (Spot Heights)

	Lidar Points	2015 RVCA Field Survey - Rideau River from Kars to Burritts Rapids									
Location ID	Z (m)	X (m)	Y (m)	Z (m)	Horizontal Accuracy (m)	Veritcal Accuracy (m)	Date/Time	Field Observations	△Z (m)	|△Z| (cm)	|△Z|>0.33m
spot241	88.996	449543.05	5004889.55	89.07	0.01	0.017	5/26/2015 10:18		-0.076	7.6	
spot242	88.9299	449547.78	5004880.91	89.02	0.012	0.019	5/26/2015 10:19		-0.093	9.3	
spot243	88.8908	449552.34	5004872.52	88.94	0.011	0.018	5/26/2015 10:19		-0.053	5.3	
spot244	88.8072	449557.18	5004863.36	88.89	0.012	0.019	5/26/2015 10:20		-0.079	7.9	
spot245	88.7789	449562.01	5004854.38	88.85	0.012	0.019	5/26/2015 10:21		-0.068	6.8	
spot246	88.7521	449566.63	5004845.60	88.80	0.011	0.017	5/26/2015 10:22		-0.051	5.1	
spot247	88.7501	449570.21	5004838.96	88.78	0.011	0.018	5/26/2015 10:22		-0.030	3.0	
spot248	88.6449	449574.05	5004831.45	88.74	0.011	0.018	5/26/2015 10:23		-0.093	9.3	
spot249	88.642	449577.91	5004824.04	88.70	0.012	0.02	5/26/2015 10:23		-0.062	6.2	
spot250	88.5964	449581.87	5004816.16	88.69	0.012	0.019	5/26/2015 10:24		-0.089	8.9	
spot251	88.5625	449586.02	5004807.78	88.66	0.011	0.019	5/26/2015 10:24		-0.093	9.3	
spot252	88.5253	449589.88	5004799.65	88.61	0.011	0.018	5/26/2015 10:25		-0.089	8.9	
spot253	88.5012	449593.79	5004791.52	88.58	0.012	0.019	5/26/2015 10:25		-0.080	8.0	
spot254	88.503	449597.95	5004782.74	88.57	0.011	0.019	5/26/2015 10:25		-0.063	6.3	
spot255	88.4499	449602.01	5004773.96	88.51	0.011	0.018	5/26/2015 10:26		-0.061	6.1	
spot256	88.3641	449605.95	5004765.37	88.48	0.012	0.019	5/26/2015 10:26		-0.116	11.6	
spot257	88.3152	449609.81	5004756.94	88.44	0.012	0.02	5/26/2015 10:27		-0.126	12.6	
spot258	88.2907	449613.83	5004748.25	88.37	0.012	0.019	5/26/2015 10:27		-0.082	8.2	
spot259	88.2385	449617.75	5004739.28	88.33	0.012	0.02	5/26/2015 10:27		-0.087	8.7	
spot260	88.1664	449621.57	5004730.62	88.28	0.012	0.02	5/26/2015 10:28		-0.109	10.9	
spot261	88.1089	449625.50	5004721.77	88.24	0.012	0.019	5/26/2015 10:28		-0.131	13.1	
spot262	88.1072	449629.05	5004713.30	88.22	0.011	0.018	5/26/2015 10:29		-0.108	10.8	
spot263	88.0856	449632.47	5004704.66	88.20	0.01	0.017	5/26/2015 10:30		-0.114	11.4	
spot264	88.1523	449636.10	5004696.30	88.21	0.011	0.018	5/26/2015 10:31		-0.056	5.6	
spot265	88.1687	449639.56	5004687.58	88.22	0.011	0.018	5/26/2015 10:31		-0.046	4.6	
spot266	88.1276	449643.07	5004678.86	88.25	0.012	0.02	5/26/2015 10:31		-0.118	11.8	
spot267	88.1195	449646.43	5004670.34	88.24	0.011	0.019	5/26/2015 10:32		-0.117	11.7	
spot268	88.104	449649.80	5004661.86	88.23	0.011	0.018	5/26/2015 10:32		-0.128	12.8	
spot269	88.1371	449653.12	5004653.12	88.24	0.011	0.018	5/26/2015 10:32		-0.102	10.2	
spot270	88.1405	449656.46	5004644.60	88.26	0.01	0.017	5/26/2015 10:32		-0.118	11.8	
spot271	88.1192	450759.61	5002171.68	88.15	0.008	0.013	5/26/2015 10:38		-0.030	3.0	
spot272	88.086	450762.23	5002162.34	88.12	0.011	0.017	5/26/2015 10:39		-0.035	3.5	
spot273	88.026	450764.79	5002152.03	88.06	0.011	0.018	5/26/2015 10:39		-0.032	3.2	
spot274	87.9951	450767.01	5002142.84	88.05	0.012	0.019	5/26/2015 10:39		-0.056	5.6	
spot275	87.9734	450769.30	5002133.86	88.05	0.012	0.02	5/26/2015 10:40		-0.081	8.1	
spot276	87.9809	450770.78	5002126.22	88.02	0.012	0.02	5/26/2015 10:40		-0.038	3.8	
spot277	88.0255	450772.26	5002117.91	88.06	0.012	0.02	5/26/2015 10:40		-0.033	3.3	
spot278	88.0313	450773.96	5002109.34	88.06	0.011	0.018	5/26/2015 10:41		-0.033	3.3	

spot279	88.0287	450775.70	5002102.31	88.09	0.011	0.018	5/26/2015 10:41		-0.058	5.8	
spot280	88.0903	450777.30	5002094.90	88.11	0.011	0.018	5/26/2015 10:41		-0.015	1.5	
spot281	88.0562	450778.86	5002087.19	88.13	0.011	0.018	5/26/2015 10:42		-0.077	7.7	
spot282	88.1226	450780.63	5002080.01	88.17	0.012	0.019	5/26/2015 10:42		-0.042	4.2	
spot283	88.1526	450782.21	5002071.48	88.16	0.011	0.018	5/26/2015 10:42		-0.003	0.3	
spot284	88.1367	450783.16	5002065.05	88.17	0.011	0.018	5/26/2015 10:43		-0.033	3.3	
spot285	88.1439	450784.18	5002056.24	88.17	0.011	0.019	5/26/2015 10:43		-0.027	2.7	
spot286	88.1545	450785.43	5002049.51	88.20	0.011	0.019	5/26/2015 10:44		-0.040	4.0	
spot287	88.1566	450786.47	5002041.40	88.21	0.011	0.019	5/26/2015 10:44		-0.051	5.1	
spot288	88.2492	450787.91	5002034.06	88.24	0.011	0.019	5/26/2015 10:44		0.005	0.5	
spot289	88.2432	450787.89	5002027.29	88.24	0.011	0.018	5/26/2015 10:45		0.007	0.7	
spot290	88.2482	450787.62	5002018.66	88.21	0.011	0.018	5/26/2015 10:45		0.039	3.9	
spot291	88.2096	450787.34	5002011.58	88.19	0.01	0.019	5/26/2015 10:45		0.019	1.9	
spot292	88.1871	450786.83	5002003.17	88.19	0.012	0.019	5/26/2015 10:45		-0.004	0.4	
spot293	88.2115	450785.20	5001979.88	88.24	0.011	0.02	5/26/2015 10:48		-0.025	2.5	
spot294	88.2489	450779.92	5001952.86	88.24	0.011	0.02	5/26/2015 10:50		0.011	1.1	
spot295	88.3548	450775.33	5001945.21	88.32	0.011	0.019	5/26/2015 10:51		0.033	3.3	
spot296	88.3328	450771.90	5001935.93	88.35	0.011	0.019	5/26/2015 10:51		-0.013	1.3	
spot297	88.3677	450768.99	5001928.46	88.36	0.011	0.02	5/26/2015 10:51		0.005	0.5	
spot298	88.3796	450765.44	5001921.23	88.34	0.011	0.02	5/26/2015 10:52		0.042	4.2	
spot299	88.3191	450762.00	5001914.87	88.32	0.011	0.019	5/26/2015 10:52		-0.005	0.5	
spot300	88.3286	450757.12	5001906.34	88.31	0.011	0.019	5/26/2015 10:52		0.015	1.5	
spot301	86.8825	449042.39	4999745.59	86.87	0.009	0.017	5/26/2015 11:03		0.009	0.9	
spot302	86.8648	449037.03	4999741.27	86.86	0.012	0.02	5/26/2015 11:04		0.009	0.9	
spot303	86.8107	449032.00	4999739.21	86.84	0.012	0.02	5/26/2015 11:04		-0.033	3.3	
spot304	86.8008	449025.93	4999735.37	86.81	0.01	0.018	5/26/2015 11:04		-0.007	0.7	
spot305	86.8319	449020.95	4999730.25	86.84	0.011	0.019	5/26/2015 11:05		-0.005	0.5	
spot306	86.9126	449016.14	4999724.22	86.90	0.011	0.019	5/26/2015 11:05		0.013	1.3	
spot307	86.9643	449018.13	4999717.80	86.97	0.011	0.019	5/26/2015 11:05		-0.006	0.6	
spot308	86.9898	449021.36	4999711.88	86.98	0.011	0.018	5/26/2015 11:06		0.015	1.5	
spot309	86.9358	449028.77	4999714.68	86.95	0.011	0.019	5/26/2015 11:06		-0.010	1.0	
spot310	86.9364	449036.65	4999716.94	86.94	0.011	0.018	5/26/2015 11:06		-0.008	0.8	
spot311	86.9632	449042.81	4999721.79	86.94	0.012	0.018	5/26/2015 11:07		0.025	2.5	
spot312	86.8525	449048.96	4999725.95	86.88	0.011	0.019	5/26/2015 11:07		-0.029	2.9	
spot313	86.8592	449056.83	4999724.83	86.85	0.011	0.018	5/26/2015 11:08		0.009	0.9	
spot314	86.8378	449062.12	4999719.69	86.84	0.011	0.019	5/26/2015 11:08		0.002	0.2	
spot315	86.8635	449063.64	4999712.59	86.86	0.011	0.019	5/26/2015 11:08		0.008	0.8	
spot316	86.9004	449065.28	4999705.99	86.89	0.011	0.019	5/26/2015 11:08		0.007	0.7	
spot317	86.8185	449071.11	4999705.88	86.81	0.011	0.019	5/26/2015 11:09		0.007	0.7	
spot318	86.7579	449075.80	4999710.79	86.72	0.011	0.019	5/26/2015 11:09		0.035	3.5	
spot319	86.7629	449074.40	4999717.34	86.74	0.011	0.02	5/26/2015 11:09		0.023	2.3	
spot320	86.7178	449073.26	4999724.05	86.76	0.011	0.02	5/26/2015 11:10		-0.041	4.1	
spot321	86.7424	449070.85	4999731.65	86.75	0.012	0.019	5/26/2015 11:10		-0.005	0.5	

spot322	86.7572	449068.47	4999739.05	86.75	0.011	0.018	5/26/2015 11:10		0.006	0.6	
spot323	86.7811	449067.43	4999746.51	86.81	0.01	0.019	5/26/2015 11:11		-0.030	3.0	
spot324	86.8419	449056.88	4999745.42	86.83	0.011	0.019	5/26/2015 11:11		0.008	0.8	
spot325	86.9047	449051.06	4999744.53	86.89	0.011	0.019	5/26/2015 11:11		0.018	1.8	
spot326	86.9	449049.48	4999736.41	86.91	0.011	0.019	5/26/2015 11:12		-0.010	1.0	
spot327	86.8813	449041.55	4999733.99	86.90	0.011	0.019	5/26/2015 11:12		-0.017	1.7	
spot328	86.8527	449034.90	4999731.75	86.87	0.011	0.019	5/26/2015 11:12		-0.019	1.9	
spot329	86.932	449028.45	4999726.77	86.88	0.01	0.018	5/26/2015 11:12		0.051	5.1	
spot330	86.922	449038.28	4999725.31	86.91	0.011	0.019	5/26/2015 11:13		0.008	0.8	
spot331	88.34	449242.25	4998985.14	88.36	0.011	0.018	5/26/2015 11:26		-0.020	2.0	
spot332	88.3414	449245.20	4998976.45	88.36	0.013	0.02	5/26/2015 11:27		-0.017	1.7	
spot333	88.3615	449248.17	4998967.78	88.37	0.011	0.019	5/26/2015 11:27		-0.004	0.4	
spot334	88.2988	449250.97	4998959.33	88.33	0.012	0.019	5/26/2015 11:27		-0.028	2.8	
spot335	88.2349	449253.71	4998950.78	88.28	0.01	0.017	5/26/2015 11:28		-0.046	4.6	
spot336	88.2127	449256.75	4998942.25	88.22	0.011	0.018	5/26/2015 11:28		-0.007	0.7	
spot337	88.1518	449259.75	4998932.85	88.15	0.011	0.018	5/26/2015 11:28		0.005	0.5	
spot338	88.128	449262.28	4998924.99	88.12	0.011	0.018	5/26/2015 11:28		0.007	0.7	
spot339	88.047	449264.97	4998916.74	88.10	0.011	0.018	5/26/2015 11:29		-0.057	5.7	
spot340	88.0492	449267.39	4998909.42	88.09	0.01	0.017	5/26/2015 11:29		-0.037	3.7	
spot341	88.062	449270.18	4998900.99	88.05	0.01	0.017	5/26/2015 11:29		0.014	1.4	
spot342	88.0456	449272.90	4998892.47	88.04	0.011	0.017	5/26/2015 11:30		0.009	0.9	
spot343	88.0596	449275.48	4998884.65	88.05	0.01	0.017	5/26/2015 11:30		0.015	1.5	
spot344	88.0422	449278.21	4998876.58	88.07	0.01	0.016	5/26/2015 11:30		-0.024	2.4	
spot345	88.0666	449280.60	4998869.01	88.10	0.01	0.017	5/26/2015 11:31		-0.029	2.9	
spot346	88.0995	449282.92	4998861.51	88.10	0.01	0.016	5/26/2015 11:31		0.002	0.2	
spot347	88.1742	449285.42	4998854.11	88.18	0.012	0.019	5/26/2015 11:31		-0.009	0.9	
spot348	88.1595	449287.82	4998846.55	88.21	0.011	0.018	5/26/2015 11:31		-0.046	4.6	
spot349	88.1926	449290.32	4998838.85	88.23	0.012	0.019	5/26/2015 11:32		-0.034	3.4	
spot350	88.2106	449293.06	4998830.79	88.28	0.01	0.016	5/26/2015 11:32		-0.067	6.7	
spot351	87.7812	450964.02	4994940.29	87.75	0.009	0.014	5/26/2015 11:40		0.032	3.2	
spot352	87.7506	450956.05	4994935.74	87.74	0.01	0.016	5/26/2015 11:40		0.007	0.7	
spot353	87.7888	450947.59	4994930.78	87.76	0.012	0.02	5/26/2015 11:41		0.028	2.8	
spot354	87.8028	450938.95	4994925.84	87.78	0.012	0.02	5/26/2015 11:41		0.026	2.6	
spot355	87.7608	450929.88	4994920.83	87.77	0.011	0.019	5/26/2015 11:42		-0.011	1.1	
spot356	87.7865	450921.58	4994916.08	87.77	0.014	0.019	5/26/2015 11:42		0.017	1.7	
spot357	87.7289	450913.15	4994911.38	87.73	0.012	0.019	5/26/2015 11:42		-0.002	0.2	
spot358	87.7902	450903.77	4994905.90	87.74	0.01	0.018	5/26/2015 11:43		0.048	4.8	
spot359	87.774	450896.46	4994901.92	87.73	0.011	0.018	5/26/2015 11:43		0.040	4.0	
spot360	87.7724	450889.35	4994897.63	87.74	0.014	0.019	5/26/2015 11:44		0.028	2.8	
spot361	87.7673	450881.63	4994893.44	87.77	0.012	0.02	5/26/2015 11:44		0.001	0.1	
spot362	87.7906	450872.51	4994888.24	87.80	0.012	0.02	5/26/2015 11:45		-0.010	1.0	
spot363	87.783	450865.09	4994883.82	87.79	0.013	0.02	5/26/2015 11:47		-0.006	0.6	
spot364	87.768	450856.96	4994879.42	87.78	0.012	0.02	5/26/2015 11:49		-0.016	1.6	

spot365	87.6116	450769.78	4994829.60	87.61	0.012	0.02	5/26/2015 11:55		0.007	0.7	
spot366	87.5792	450756.53	4994822.09	87.57	0.012	0.02	5/26/2015 11:55		0.010	1.0	
spot367	87.5135	450749.86	4994818.41	87.55	0.012	0.02	5/26/2015 11:56		-0.032	3.2	
spot368	87.571	450742.97	4994814.48	87.52	0.012	0.02	5/26/2015 11:56		0.050	5.0	
spot369	87.5689	450735.41	4994809.85	87.54	0.012	0.02	5/26/2015 11:57		0.032	3.2	
spot370	87.5371	450725.78	4994804.61	87.54	0.012	0.02	5/26/2015 11:58		0.002	0.2	
spot371	87.9	449144.58	4991591.63	87.92	0.006	0.011	5/26/2015 12:06		-0.015	1.5	
spot372	87.8635	449149.83	4991599.50	87.88	0.007	0.011	5/26/2015 12:06		-0.019	1.9	
spot373	87.8522	449154.85	4991607.36	87.86	0.007	0.011	5/26/2015 12:06		-0.008	0.8	
spot374	87.8436	449159.79	4991615.56	87.84	0.007	0.012	5/26/2015 12:06		0.007	0.7	
spot375	87.7824	449164.18	4991623.78	87.80	0.007	0.012	5/26/2015 12:07		-0.016	1.6	
spot376	87.8092	449168.13	4991632.07	87.79	0.008	0.013	5/26/2015 12:07		0.017	1.7	
spot377	87.7891	449171.76	4991639.76	87.82	0.008	0.014	5/26/2015 12:07		-0.034	3.4	
spot378	87.8129	449175.10	4991648.28	87.82	0.009	0.015	5/26/2015 12:07		-0.005	0.5	
spot379	87.7625	449178.30	4991657.15	87.77	0.009	0.015	5/26/2015 12:08		-0.011	1.1	
spot380	87.7592	449181.67	4991665.99	87.75	0.009	0.015	5/26/2015 12:08		0.005	0.5	
spot381	87.6943	449184.61	4991674.62	87.70	0.009	0.015	5/26/2015 12:08		-0.005	0.5	
spot382	87.6795	449187.67	4991682.23	87.68	0.009	0.016	5/26/2015 12:08		0.002	0.2	
spot383	87.6339	449188.80	4991691.60	87.70	0.009	0.016	5/26/2015 12:09		-0.069	6.9	
spot384	87.6547	449192.28	4991701.52	87.66	0.01	0.016	5/26/2015 12:09		-0.007	0.7	
spot385	87.4917	449196.86	4991711.62	87.57	0.01	0.017	5/26/2015 12:09		-0.076	7.6	
spot386	87.5382	449198.90	4991719.02	87.59	0.01	0.017	5/26/2015 12:10		-0.047	4.7	
spot387	87.522	449201.64	4991727.62	87.56	0.01	0.017	5/26/2015 12:10		-0.040	4.0	
spot388	87.5365	449204.89	4991735.93	87.56	0.011	0.018	5/26/2015 12:10		-0.023	2.3	
spot389	87.4791	449207.63	4991744.07	87.56	0.011	0.019	5/26/2015 12:11		-0.085	8.5	
spot390	87.5523	449210.36	4991751.71	87.58	0.012	0.018	5/26/2015 12:11		-0.027	2.7	
spot391	87.5382	449213.49	4991759.75	87.56	0.011	0.018	5/26/2015 12:12		-0.021	2.1	
spot392	87.5179	449216.14	4991768.61	87.53	0.011	0.019	5/26/2015 12:13		-0.010	1.0	
spot393	87.4604	449219.34	4991775.97	87.49	0.011	0.018	5/26/2015 12:13		-0.033	3.3	
spot394	87.4264	449222.35	4991783.58	87.44	0.011	0.018	5/26/2015 12:13		-0.017	1.7	
spot395	87.4007	449224.49	4991791.75	87.45	0.01	0.018	5/26/2015 12:14		-0.044	4.4	
spot396	87.4315	449226.74	4991797.51	87.43	0.013	0.019	5/26/2015 12:14		-0.002	0.2	
spot397	87.4856	449229.80	4991805.77	87.44	0.011	0.019	5/26/2015 12:14		0.043	4.3	
spot398	87.4556	449232.56	4991813.06	87.46	0.011	0.019	5/26/2015 12:14		0.001	0.1	
spot399	87.4087	449235.25	4991820.71	87.41	0.011	0.02	5/26/2015 12:15		0.003	0.3	
spot400	87.3852	449238.18	4991829.57	87.44	0.011	0.019	5/26/2015 12:15		-0.051	5.1	
spot401	87.9909	448759.17	4990900.44	87.94	0.009	0.014	5/26/2015 12:45		0.052	5.2	
spot402	87.9876	448750.91	4990896.06	87.91	0.012	0.019	5/26/2015 12:45		0.078	7.8	
spot403	87.8529	448743.19	4990891.90	87.85	0.009	0.018	5/26/2015 12:45		-0.001	0.1	
spot404	87.8833	448735.23	4990887.15	87.83	0.012	0.02	5/26/2015 12:46		0.056	5.6	
spot405	87.8648	448727.09	4990882.80	87.78	0.012	0.019	5/26/2015 12:46		0.083	8.3	
spot406	87.7928	448719.06	4990878.18	87.74	0.012	0.02	5/26/2015 12:46		0.053	5.3	
spot407	87.7403	448709.41	4990872.90	87.69	0.012	0.02	5/26/2015 12:47		0.048	4.8	

spot408	87.7229	448701.51	4990868.59	87.66	0.011	0.018	5/26/2015 12:47		0.062	6.2	
spot409	87.7209	448694.73	4990864.81	87.65	0.012	0.019	5/26/2015 12:48		0.076	7.6	
spot410	87.6894	448688.09	4990861.22	87.63	0.012	0.018	5/26/2015 12:48		0.058	5.8	
spot411	87.7173	448681.26	4990857.44	87.65	0.01	0.018	5/26/2015 12:49		0.068	6.8	
spot412	87.7362	448674.10	4990853.57	87.64	0.01	0.018	5/26/2015 12:49		0.096	9.6	
spot413	87.6904	448666.66	4990849.27	87.64	0.01	0.018	5/26/2015 12:49		0.047	4.7	
spot414	87.7289	448659.06	4990844.95	87.65	0.011	0.019	5/26/2015 12:49		0.079	7.9	
spot415	87.7476	448651.14	4990840.67	87.68	0.01	0.019	5/26/2015 12:50		0.068	6.8	
spot416	87.7063	448643.07	4990836.19	87.66	0.011	0.019	5/26/2015 12:50		0.042	4.2	
spot417	87.7616	448635.03	4990831.68	87.69	0.011	0.019	5/26/2015 12:51		0.071	7.1	
spot418	87.7425	448627.95	4990827.74	87.71	0.01	0.019	5/26/2015 12:51		0.030	3.0	
spot419	87.7591	448620.70	4990823.78	87.71	0.01	0.019	5/26/2015 12:51		0.053	5.3	
spot420	87.7489	448613.70	4990819.94	87.70	0.01	0.018	5/26/2015 12:52		0.050	5.0	
spot421	92.585	438519.40	4982014.24	92.53	0.012	0.02	5/26/2015 13:14		0.052	5.2	
spot422	92.5562	438509.11	4982010.12	92.50	0.012	0.02	5/26/2015 13:17		0.058	5.8	
spot423	92.5389	438500.73	4982006.50	92.45	0.013	0.02	5/26/2015 13:18		0.089	8.9	
spot424	92.5332	438493.26	4982003.25	92.46	0.013	0.019	5/26/2015 13:18		0.069	6.9	
spot425	92.5906	438484.91	4981999.72	92.47	0.012	0.018	5/26/2015 13:19		0.124	12.4	
spot426	92.5709	438476.98	4981996.23	92.50	0.012	0.019	5/26/2015 13:19		0.075	7.5	
spot427	92.5871	438468.50	4981992.21	92.53	0.013	0.02	5/26/2015 13:23		0.059	5.9	
spot428	92.5751	438459.58	4981988.44	92.49	0.013	0.02	5/26/2015 13:24		0.090	9.0	
spot429	92.5622	438449.58	4981984.00	92.47	0.012	0.02	5/26/2015 13:26		0.090	9.0	
spot430	92.6033	438440.50	4981980.10	92.49	0.012	0.02	5/26/2015 13:26		0.109	10.9	
spot431	92.6199	438432.21	4981976.54	92.53	0.012	0.02	5/26/2015 13:27		0.088	8.8	
spot432	92.6485	438423.77	4981972.91	92.57	0.012	0.02	5/26/2015 13:28		0.079	7.9	
spot433	92.6648	438414.19	4981968.82	92.59	0.012	0.02	5/26/2015 13:28		0.074	7.4	
spot434	92.6885	438405.87	4981965.21	92.59	0.012	0.019	5/26/2015 13:29		0.096	9.6	
spot435	92.647	438398.09	4981961.76	92.58	0.012	0.02	5/26/2015 13:29		0.065	6.5	
spot436	92.6121	438389.51	4981958.18	92.55	0.012	0.019	5/26/2015 13:30		0.058	5.8	
spot437	92.5803	438380.57	4981953.97	92.52	0.012	0.02	5/26/2015 13:30		0.058	5.8	
spot438	92.5965	438372.21	4981950.39	92.50	0.012	0.02	5/26/2015 13:30		0.101	10.1	
spot439	92.5382	438363.81	4981946.89	92.43	0.012	0.02	5/26/2015 13:31		0.111	11.1	
spot440	92.3878	438355.72	4981943.56	92.31	0.012	0.02	5/26/2015 13:31		0.077	7.7	
spot441	92.2377	438346.10	4981939.49	92.15	0.013	0.02	5/26/2015 13:32		0.087	8.7	
spot442	92.0895	438337.02	4981935.48	91.98	0.013	0.02	5/26/2015 13:32		0.111	11.1	
spot443	91.9763	438329.24	4981932.10	91.85	0.013	0.02	5/26/2015 13:32		0.124	12.4	
spot444	91.858	438321.45	4981928.78	91.77	0.013	0.02	5/26/2015 13:33		0.088	8.8	
spot445	91.8034	438313.33	4981925.12	91.71	0.013	0.02	5/26/2015 13:33		0.098	9.8	
spot446	91.7514	438304.51	4981921.40	91.69	0.013	0.02	5/26/2015 13:34		0.060	6.0	
spot447	91.8226	438296.27	4981917.95	91.70	0.01	0.02	5/26/2015 13:35		0.120	12.0	
spot448	91.8458	438287.28	4981913.92	91.70	0.01	0.02	5/26/2015 13:36		0.142	14.2	
spot449	91.8524	438278.63	4981910.31	91.72	0.01	0.02	5/26/2015 13:37		0.137	13.7	
spot450	91.8263	438269.88	4981906.73	91.75	0.012	0.02	5/26/2015 13:37		0.073	7.3	

spot451	91.6722	437773.64	4981131.92	91.66	0.012	0.02	5/26/2015 13:56		0.011	1.1	
spot452	91.6073	437956.66	4981220.44	91.68	0.006	0.013	5/26/2015 14:03		-0.070	7.0	
spot453	91.8651	437996.54	4981240.40	91.89	0.01	0.019	5/26/2015 14:07		-0.024	2.4	
spot454	91.9142	438003.33	4981243.71	91.93	0.01	0.018	5/26/2015 14:08		-0.019	1.9	
spot455	92.1144	441010.37	4983695.65	92.08	0.011	0.018	5/26/2015 14:20		0.034	3.4	
spot456	92.1222	441016.09	4983701.51	92.09	0.011	0.019	5/26/2015 14:20		0.033	3.3	
spot457	92.1673	441021.92	4983706.84	92.09	0.011	0.019	5/26/2015 14:20		0.077	7.7	
spot458	92.1879	441028.42	4983712.87	92.09	0.01	0.018	5/26/2015 14:21		0.096	9.6	
spot459	92.1814	441034.34	4983718.86	92.12	0.01	0.017	5/26/2015 14:21		0.064	6.4	
spot460	92.1925	441042.35	4983726.59	92.07	0.01	0.018	5/26/2015 14:22		0.120	12.0	
spot461	92.1852	441048.88	4983732.93	92.07	0.011	0.019	5/26/2015 14:22		0.113	11.3	
spot462	92.148	441054.87	4983738.76	92.08	0.011	0.019	5/26/2015 14:22		0.073	7.3	
spot463	92.1159	441060.80	4983744.40	92.07	0.011	0.019	5/26/2015 14:23		0.050	5.0	
spot464	92.1247	441066.22	4983749.61	92.09	0.011	0.019	5/26/2015 14:23		0.034	3.4	
spot465	92.208	441072.18	4983755.64	92.10	0.011	0.019	5/26/2015 14:23		0.108	10.8	
spot466	92.1562	441078.85	4983761.93	92.12	0.011	0.019	5/26/2015 14:24		0.038	3.8	
spot467	92.1955	441085.11	4983768.13	92.14	0.011	0.018	5/26/2015 14:24		0.057	5.7	
spot468	92.1349	441090.95	4983773.50	92.13	0.011	0.018	5/26/2015 14:24		0.004	0.4	
spot469	92.1792	441097.15	4983779.46	92.10	0.011	0.018	5/26/2015 14:25		0.080	8.0	
spot470	92.1059	441104.31	4983786.46	92.09	0.011	0.018	5/26/2015 14:25		0.016	1.6	
spot471	92.1013	441111.14	4983793.22	92.09	0.011	0.018	5/26/2015 14:25		0.007	0.7	
spot472	92.1482	441117.39	4983799.20	92.10	0.011	0.018	5/26/2015 14:26		0.045	4.5	
spot473	92.1605	441124.75	4983806.29	92.11	0.011	0.018	5/26/2015 14:27		0.046	4.6	
spot474	92.1918	441130.53	4983811.87	92.14	0.011	0.018	5/26/2015 14:27		0.055	5.5	
spot475	92.2516	441136.49	4983817.57	92.14	0.011	0.018	5/26/2015 14:27		0.117	11.7	
spot476	92.2383	441142.57	4983823.53	92.15	0.011	0.018	5/26/2015 14:27		0.089	8.9	
spot477	92.243	441148.85	4983829.58	92.18	0.011	0.018	5/26/2015 14:28		0.062	6.2	
spot478	92.1934	441154.61	4983835.12	92.20	0.011	0.019	5/26/2015 14:28		-0.011	1.1	
spot479	92.2529	441160.76	4983841.05	92.23	0.011	0.019	5/26/2015 14:29		0.028	2.8	
spot480	92.2845	441166.71	4983846.65	92.27	0.012	0.02	5/26/2015 14:31		0.018	1.8	
spot481	88.2031	446086.01	4987999.99	88.14	0.011	0.016	5/26/2015 14:41		0.067	6.7	
spot482	88.0878	446078.97	4988007.54	87.98	0.013	0.019	5/26/2015 14:42		0.105	10.5	
spot483	87.9136	446074.39	4988014.10	87.84	0.013	0.019	5/26/2015 14:42		0.079	7.9	
spot484	87.8753	446069.02	4988021.06	87.72	0.012	0.018	5/26/2015 14:43		0.152	15.2	
spot485	87.7664	446063.53	4988028.47	87.67	0.012	0.018	5/26/2015 14:43		0.098	9.8	
spot486	87.7425	446058.10	4988035.69	87.66	0.011	0.017	5/26/2015 14:43		0.084	8.4	
spot487	87.6359	446052.36	4988042.15	87.57	0.014	0.02	5/26/2015 14:44		0.068	6.8	
spot488	87.5151	446045.95	4988048.44	87.45	0.013	0.02	5/26/2015 14:44		0.066	6.6	
spot489	87.4801	446040.54	4988054.43	87.39	0.012	0.019	5/26/2015 14:44		0.087	8.7	
spot490	87.4761	446035.19	4988060.70	87.37	0.013	0.02	5/26/2015 14:45		0.105	10.5	
spot491	87.4609	446029.62	4988067.69	87.37	0.013	0.019	5/26/2015 14:45		0.091	9.1	
spot492	87.4705	446024.10	4988074.63	87.37	0.014	0.019	5/26/2015 14:45		0.097	9.7	
spot493	87.5362	446019.09	4988081.29	87.44	0.013	0.019	5/26/2015 14:46		0.099	9.9	

spot494	87.5631	446013.73	4988088.29	87.47	0.013	0.018	5/26/2015 14:46		0.095	9.5	
spot495	87.6198	446008.52	4988095.09	87.51	0.011	0.017	5/26/2015 14:46		0.106	10.6	
spot496	87.6414	446003.75	4988101.40	87.54	0.011	0.016	5/26/2015 14:46		0.099	9.9	
spot497	87.675	445998.90	4988107.64	87.55	0.011	0.015	5/26/2015 14:46		0.126	12.6	
spot498	87.6391	445994.11	4988114.00	87.55	0.012	0.016	5/26/2015 14:47		0.089	8.9	
spot499	87.5919	445989.17	4988120.55	87.59	0.013	0.017	5/26/2015 14:47		0.000	0.0	
spot500	87.5205	445984.26	4988126.85	87.53	0.011	0.018	5/26/2015 14:47		-0.007	0.7	
spot501	88.511	445790.90	4988381.82	88.51	0.01	0.016	5/26/2015 14:53		-0.001	0.1	
spot502	88.4672	445790.50	4988373.98	88.42	0.012	0.018	5/26/2015 14:53		0.044	4.4	
spot503	88.6402	445797.19	4988368.31	88.59	0.01	0.016	5/26/2015 14:54		0.055	5.5	
spot504	88.9026	445803.95	4988366.34	88.85	0.011	0.017	5/26/2015 14:54		0.051	5.1	
spot505	89.1093	445808.45	4988359.66	89.05	0.012	0.018	5/26/2015 14:54		0.064	6.4	
spot506	89.3421	445813.72	4988352.67	89.27	0.012	0.018	5/26/2015 14:55		0.071	7.1	
spot507	89.5764	445818.37	4988345.61	89.50	0.012	0.02	5/26/2015 14:55		0.077	7.7	
spot508	89.7432	445823.29	4988338.86	89.70	0.012	0.02	5/26/2015 14:57		0.043	4.3	
spot509	89.7481	445838.94	4988318.02	89.66	0.012	0.02	5/26/2015 14:58		0.084	8.4	
spot510	89.5801	445844.13	4988311.10	89.55	0.012	0.019	5/26/2015 14:59		0.026	2.6	
spot511	86.8322	449344.66	4989795.40	86.75	0.008	0.015	5/26/2015 15:16		0.085	8.5	
spot512	86.7861	449352.39	4989801.81	86.73	0.013	0.02	5/26/2015 15:18		0.060	6.0	
spot513	86.753	449357.33	4989805.89	86.70	0.01	0.02	5/26/2015 15:19		0.053	5.3	
spot514	86.6994	449364.57	4989812.27	86.65	0.009	0.017	5/26/2015 15:20		0.049	4.9	
spot515	86.6487	449370.24	4989816.88	86.63	0.011	0.019	5/26/2015 15:20		0.019	1.9	
spot516	86.692	449376.51	4989822.17	86.62	0.009	0.016	5/26/2015 15:20		0.069	6.9	
spot517	86.6852	449382.50	4989827.28	86.63	0.009	0.018	5/26/2015 15:21		0.055	5.5	
spot518	86.6474	449389.12	4989832.62	86.59	0.01	0.015	5/26/2015 15:21		0.057	5.7	
spot519	86.63	449395.32	4989837.84	86.54	0.009	0.017	5/26/2015 15:22		0.087	8.7	
spot520	86.5656	449401.83	4989843.20	86.50	0.009	0.017	5/26/2015 15:22		0.064	6.4	
spot521	86.5804	449408.23	4989848.17	86.51	0.009	0.018	5/26/2015 15:22		0.071	7.1	
spot522	86.5839	449414.14	4989853.22	86.52	0.009	0.017	5/26/2015 15:24		0.067	6.7	
spot523	86.601	449420.47	4989858.35	86.51	0.008	0.016	5/26/2015 15:27		0.088	8.8	
spot524	86.5659	449427.43	4989863.61	86.50	0.009	0.018	5/26/2015 15:27		0.062	6.2	
spot525	86.5263	449433.91	4989868.28	86.53	0.011	0.016	5/26/2015 15:28		-0.004	0.4	
spot526	86.6832	449409.10	4989866.16	86.59	0.013	0.019	5/26/2015 15:29		0.098	9.8	
spot527	89.8716	450353.51	4992245.96	89.82	0.007	0.01	5/26/2015 15:36		0.051	5.1	
spot528	89.7696	450358.79	4992241.17	89.77	0.012	0.017	5/26/2015 15:36		-0.004	0.4	
spot529	89.811	450362.51	4992236.54	89.76	0.012	0.017	5/26/2015 15:36		0.055	5.5	
spot530	89.7634	450368.48	4992231.91	89.78	0.011	0.016	5/26/2015 15:37		-0.018	1.8	
spot531	89.8342	450375.00	4992232.94	89.80	0.012	0.018	5/26/2015 15:37		0.037	3.7	
spot532	89.8102	450380.45	4992238.16	89.84	0.012	0.019	5/26/2015 15:37		-0.030	3.0	
spot533	89.9448	450383.09	4992244.06	89.93	0.013	0.019	5/26/2015 15:38		0.012	1.2	
spot534	89.9315	450378.48	4992249.64	89.93	0.012	0.018	5/26/2015 15:38		0.004	0.4	
spot535	89.9093	450373.54	4992254.65	89.94	0.012	0.018	5/26/2015 15:38		-0.032	3.2	
spot536	89.9779	450368.57	4992259.41	90.00	0.012	0.019	5/26/2015 15:39		-0.017	1.7	

spot537	90.0733	450362.85	4992264.79	90.05	0.012	0.019	5/26/2015 15:39		0.019	1.9	
spot538	90.1164	450354.99	4992266.79	90.08	0.01	0.017	5/26/2015 15:39		0.035	3.5	
spot539	89.9413	450350.64	4992260.09	89.96	0.013	0.018	5/26/2015 15:39		-0.021	2.1	
spot540	89.8796	450350.11	4992251.61	89.89	0.013	0.018	5/26/2015 15:40		-0.005	0.5	
									Mean △Z :	4.9	
									Median △Z :	4.5	0 yes out of 300 spot elevations
									Max △Z :	15.2	
									Min △Z :	0.0	

Appendix C

Buildings and Islands in Floodplain – RVCA Policy

Ferdous Ahmed

From: Ewan Hardie
Sent: Wednesday, June 29, 2016 10:35 AM
To: Ferdous Ahmed
Subject: Buildings in the Floodplain Guidelines

Hi Ferdous,
As discussed at recent meetings please consider the following guidelines when undertaking floodplain mapping projects

Effective June 13th 2016, when plotting floodlines RVCA staff will use the following guidelines in order to apply a conservative approach to the delineation of the regulatory floodplain, specifically in areas that have buildings that are in the floodplain or affected by the floodplain:

1. Include any buildings in the floodplain that have any part of the footprint touching the floodplain. This is done to be conservative based on the lack of knowledge on the conditions around the buildings: soil conditions, window wells, walk out doors, building egress are all not known at the time of a floodplain mapping study so it is wise to adopt a conservative approach and include building footprints in the floodplain.
2. With regards to dry islands in and around buildings, islands will be removed if they did not meet the minimum mapping unit acceptable for the data. An envelope of 2 metres around building footprints is to be considered. If the floodplain comes close to or is in this 2m building envelope the entire envelope should be included in the floodplain. This approach is also consistent with the above approach (building footprints) in that the lack of knowledge of the conditions around the building forces the uses of a conservative approach, which is to remove the islands
3. In cases where a building has been included in the floodplain (because of the above criteria), the adjacent building will need to be included in the floodplain as well because of a lack of data in between the buildings and/or the 2m building envelope rule.
4. In the case of townhome or connected type buildings and the floodplain touching the foundations, the building footprint should be included up to the next visible unit partition where the elevation changes

Thanks

Ewan Hardie

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From: Ewan Hardie
Sent: Thursday, July 6, 2017 5:12 PM
To: Ferdous Ahmed
Cc: Brian Stratton
Subject: Floodplain delineation guidance

Good Afternoon Ferdous,

As discussed here is the documentation of the guidance that was given to RVCA staff when it comes to plotting floodlines using LiDAR data for this most recent project.

Guidance:

When delineating the regulatory flood water levels, RVCA staff will follow a precautionary principle to include island areas in the floodplain that are up to 1000 square metres.

Ewan Hardie

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