RIDEAU VALLEY CONSERVATION AUTHORITY

Hydraulics Report – November 2004

Jock River Flood Risk Mapping (within the City of Ottawa)

Prepared for: **Rideau Valley Conservation Authority**
Prepared by: **PSR Group Ltd.** in association with **JF Sabourin and Associates Inc**

Acknowledgements

This report was prepared by staff of JF Sabourin and Associates, David McManus Engineering Ltd. and PSR Group Ltd.

In particular:

- Field survey and data collection, and hydraulic model build was completed with the assistance of Josee Forget, Philippe Perron, Antoine Vachon, P.Eng. and JF Sabourin, P.Eng. of JF Sabourin and Associates; and Paul Frigon, P.Eng., Philippa Winters, Ed Jones CET, and Colin Winters of PSR Group Ltd.

- Report preparation was undertaken by Philippe Perron of JF Sabourin and Associates, and Paul Frigon, P.Eng. and Philippa Winters of PSR Group Ltd.

- Assistance in obtaining historical water levels was provided by Rideau Valley Conservation Authority staff Patrick Larson and Bruce Reid, P.Eng.

- The development of new base mapping components was completed by Stephen Perkins with the City of Ottawa and Rideau Valley Conservation Authority staff Ewan Hardie. Flood Risk Maps were assembled by staff of David McManus Engineering under the supervision of their senior staff Sean Czaharynski, P.Eng. and John Burns, CET

- Project review and co-ordination was provided by Bruce Reid, P.Eng. and Ferdous Ahmed, P.Eng. from the Rideau Valley Conservation Authority

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1.0 Introduction

The Rideau Valley Conservation Authority (RVCA) requires new flood risk mapping for the Jock River and its major tributaries within the City of Ottawa (Monahan Drain, Smith Creek, Leamy Creek, Flowing Creek and Van Gaal Drain).

The regulatory flood level, used for flood risk mapping within the Rideau River watershed, is defined as the 100 Year flood level: the water level associated with the river discharge that has a 1% probability of being equaled or exceeded each year, or occurs, on average, once every 100 years.

The Jock River is a tributary of the Rideau River with the subwatershed having mainly rural land use; river slopes less than 0.5%; and no flow regulation. Its 556km2 drainage area is illustrated in Figure 1 and forms roughly 15% of the Rideau River watershed. The Jock River Watershed Plan – Background Report (JL Richards, 1996) delineated four distinct reaches of the watershed: in this flood risk mapping study, reaches three and four are being addressed as the lower reach, between Richmond and the Rideau River, and reach two is being addressed as the middle reach, upstream of Richmond, between the Richmond Fen and Ashton.

Flood risk mapping requires the development of hydraulic simulation models to estimate the 100 year water level based on reliable flow estimates: these flow estimates have previously been established in a technical report “Hydrology Report – July 2004 - Jock River Flood Risk Mapping (within the City of Ottawa)”. The subcatchments are illustrated in Figure 2.

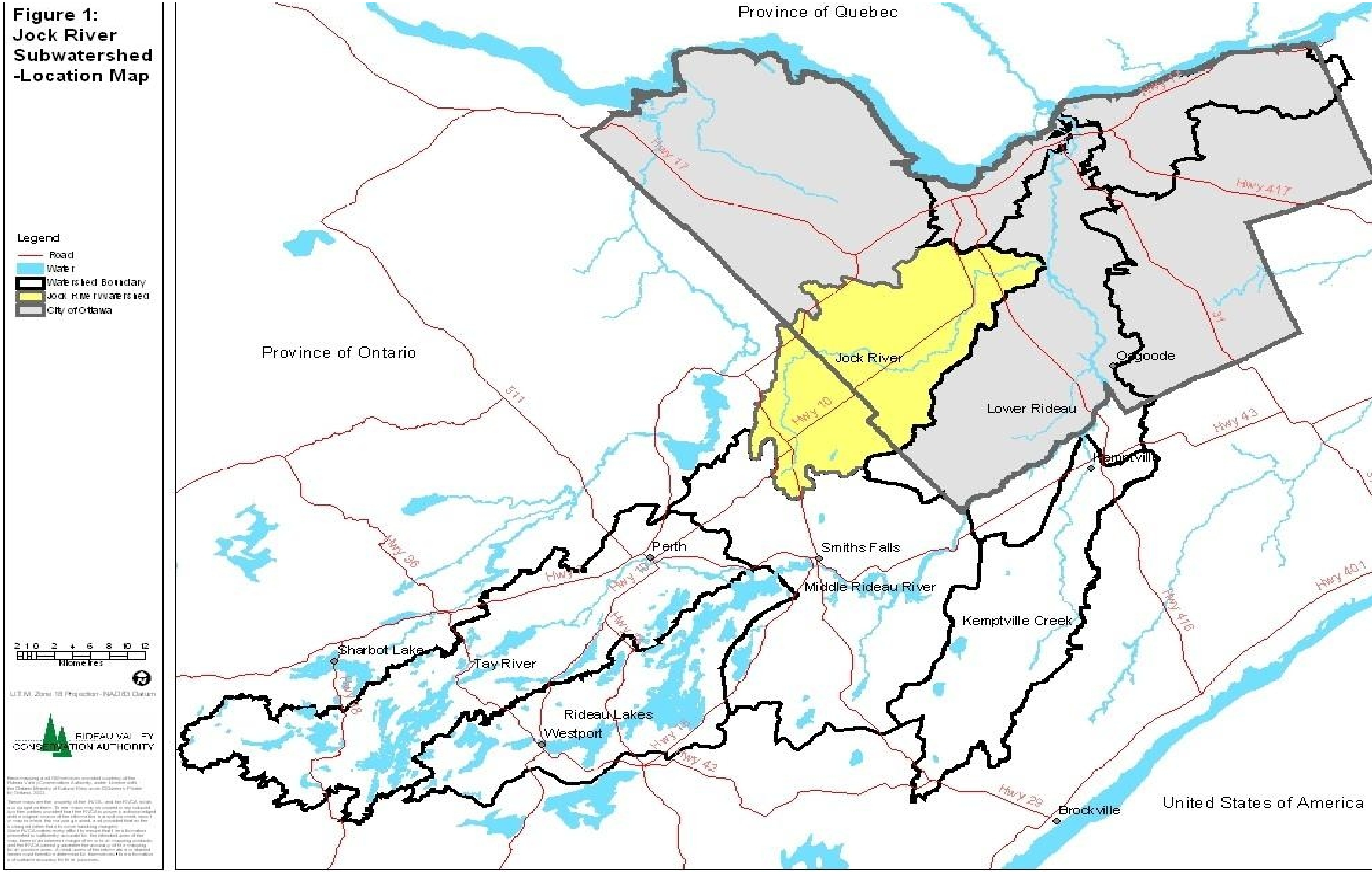
For the **lower reach**, the SSFA, derived from 34 years of record at the WSC gauge at Moodie Drive, can provide a good estimate of the 100 Year flow. All annual maximum peak flows have occurred during the Spring Runoff and proration techniques can be used to determine 100 year flow elsewhere in this reach.

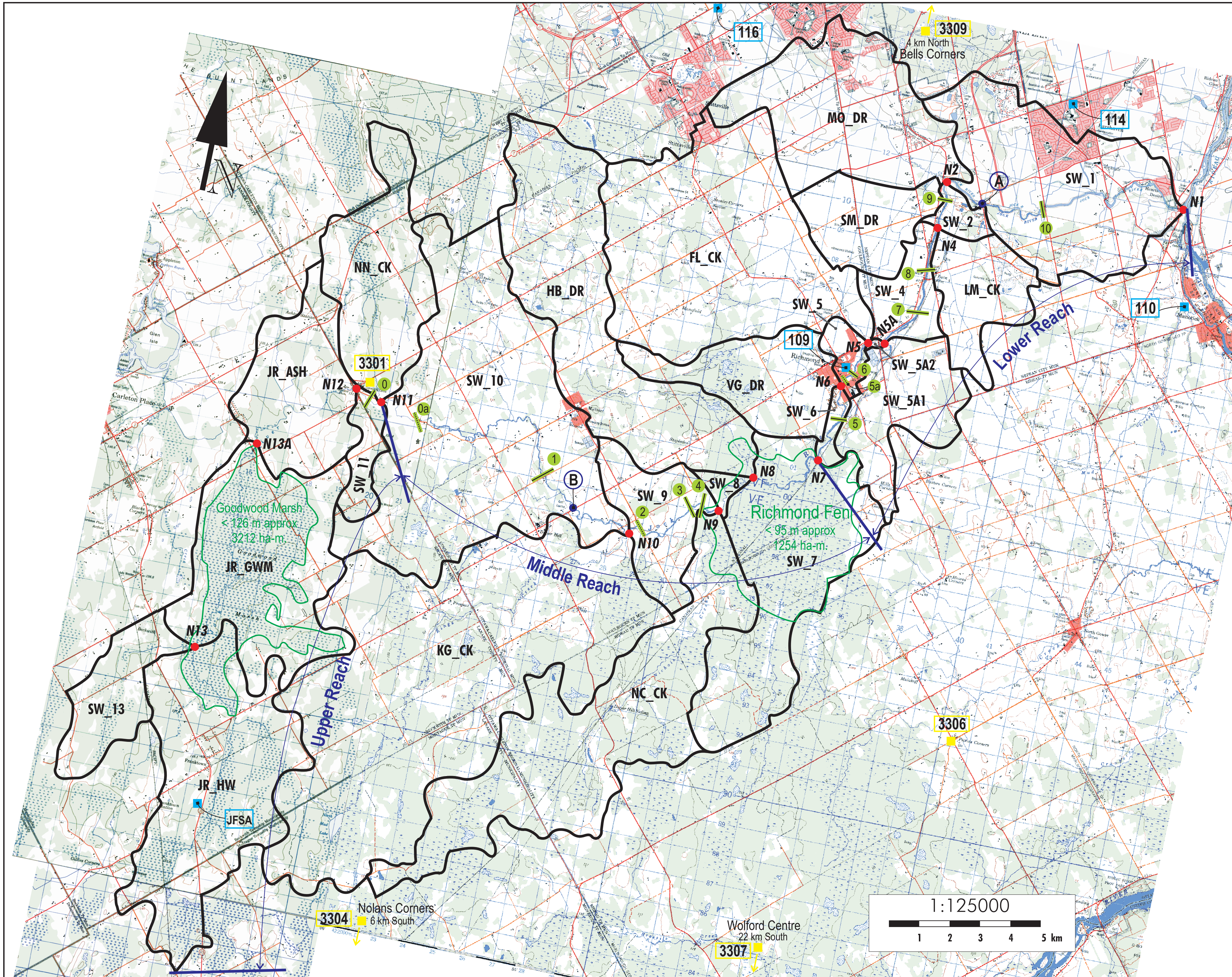
For the **middle reach**, a calibrated and validated hydrologic model, with spring snowmelt+rainfall events as an input, should provide the best estimate of the 100 Year flow.

It is anticipated that maximum flood levels on **a tributary** will be influenced by flood levels on the Jock River: whether this occurs during a Spring or Summer event is not known. The maximum 100 Year flood level for a tributary would be based on hydraulic analysis that would consider flows on the Jock River and the tributary that, together, have a combined probability of once in 100 years.

The report, in hand, provides the necessary hydraulic simulation, using HEC-RAS software (version 3.1.1 – May 2003), to estimate the required water levels so they may be plotted on appropriate maps. This has been completed in conformance with the HEC-RAS manual and MNR approved technical guidelines for floodplain mapping. Cross sections for the hydraulic model have been developed based two components: a channel cross section and related overbank (floodplain) sections. Channel sections were field surveyed while overbanks

Figure 1: Jock River Subwatershed -Location Map





Legend:

- Watershed
- Bogs (Reservoir)
- Nodes
- Flow gauges
- Rain gauges
- Snow course stations
- River Cross-Sections (based on topo. maps)
- River Cross-Sections adjusted with field data
- Reaches limits

Flow gauges ID

- A 02LA007- Jock River near Richmond
- B Jock River at Franktown Rd

Rain gauges ID

- 109 Richmond
- 110 Manotick
- 114 Barrhaven
- 116 Maple Grove
- JFSA JFSA Inc, Temporary Rain Gauge 2003

Snow course stations ID

- 3301 Ashton
- 3304 Nolans Corners
- 3306 Pierces Corners
- 3307 Bells Corners
- 3309 Wolford Centre

Client:

RIDEAU VALLEY CONSERVATION AUTHORITY

Project:

Jock River Flood Plain Mapping Study

Title:

Watershed Delineation

J.F. Sabourin & Associates Inc.
WATER RESOURCES AND ENVIRONMENTAL CONSULTANTS
OTTAWA (613) 727-5199
GATINEAU (819) 243-6858

Figure 2

Ref. File: Base Map Jock River B.cdr

sections were derived from digital base mapping. Appropriate digital base maps have been developed and provided by the City of Ottawa.

It is important to note that the calibration/validation effort, in both hydrology and hydraulics, concentrated on the simulation of high flows for the purpose of flood risk mapping: the estimates of more frequent Return Period flows and flood levels, such as the 2 year and 5 year, should be used with caution.

2.0 Base Mapping

The City of Ottawa has provided 1:2000 mapping, with 0.5m contours, for the Lower and Middle reaches of the Jock River. The digital maps have been photogrammetrically derived from air photography acquired by the RVCA in the Fall of 2001.

Two different scales of air photo were acquired, covering different areas, to ensure accuracy in areas where the topography was relatively flat and in the largely urban area of Richmond. This provides a level of confidence in the accuracy of the contours. The Lower Reach, that included Richmond, was photographed at 1:3600 while the Middel Reach was photographed at 1:6000.

Vertical and Horizontal Control was provided so that the 1:3600 photos were triangulated with an accuracy of and .025m and .045m, respectively and the 1:6000 photos had a triangialtion accuracy of .037 and .059 rexpectively.

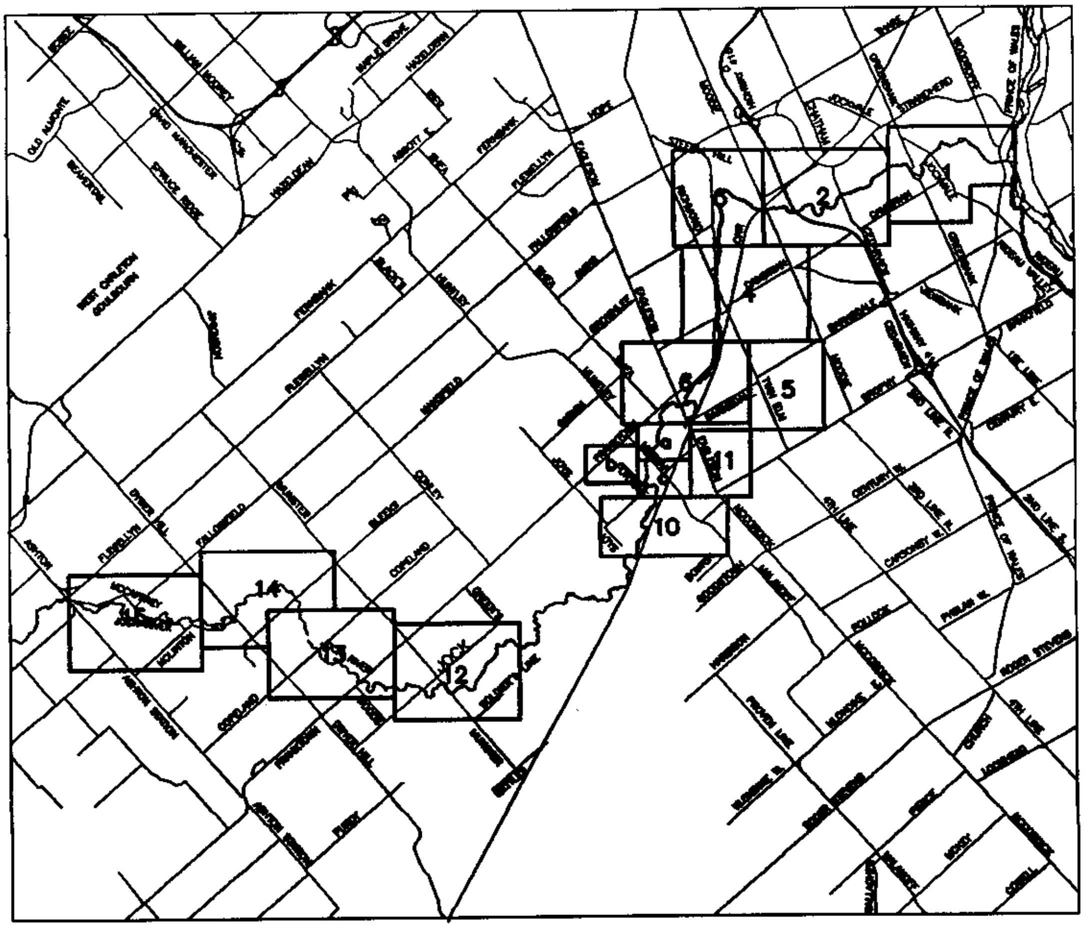
Field checks for completeness and accuracy were completed by the City of Ottawa and confirm that the digital mapping has 0.3m horizontal accuracy and 0.25m vertical accuracy for the Middle Reach and 0.12m horizontal accuracy and 0.08m vertical accuracy for the Lower Reach. These are within aceptable limits as defined in floodplain mapping regulations where 0.33m vertical accuracy and and 1.0m horizontal accuracy are prescribed.

Flood Risk Maps were developed at a scale of 1:5000 for rural areas and 1:2000 for the urban area of Richmond: both with 0.5 m contouring. The layout is illustrated in Figure 3.

3.0 Cross Sections

Cross sections were developed using a combination of field survey, interpolation and the 0.5m contour digital base mapping to develop the necessary channel and overbank components. All channel sections relating to bridges and culverts were field surveyed while overbanks were derived from digital mapping. Other sections were developed, at minimum intervals of 500m., by interpolating the channel section and deriving the relevant overbank elements from the digital base mapping. Cross sections were also defined at locations where significant changes in stream alignment and slope occurred as well as at locations where the stream width/floodplain

SHEET INDEX TABLEAU D'ASSEMBLAGE



15 1:5000 Map Sheet

e 1:2000 Map Sheet

Figure 3 – Mapsheet Layout

significantly increased or decreased. The general layout of the river centreline and related cross sections and tributaries is provided in Figure 3a.

Field survey relied heavily on the use of GPS equipment, not only to establish a series of accurate temporary bench marks on each bridge and culvert but also, where topography and bridge layout permitted, to survey channel sections, both upstream and downstream of these bridge locations, from bank to bank. All overbanks were based on data from the 0.5m contour mapping and were extracted from the digital maps using EAGLE III software. The cross sections are illustrated in Appendix A and their locations may be determined from the "reduced scale" flood risk maps supplied in Appendix F. The elevations and co-ordinates obtained from GPS were found to be within 0.01m. – 0.03m., both vertically and horizontally, when compared to geodetic bench marks.

Manning's 'n' values, which are used to characterise the friction effect of the channel and overbank material on flow, were derived from field and air photo investigation. Both Chow (1959) and the USGS (2001) were used in estimating the appropriate values through comparison with observations.

Expansion and contraction coefficients of 0.1 and 0.3 respectively, were used for all cross sections except those upstream and downstream of bridges and culverts where 0.3 and 0.5 were used: these larger coefficients reflect the more rapid change in velocity due to flow contraction through the bridge or culvert opening.

Starting water surface levels, or boundary conditions, for the Lower Reach, were based on maximum water levels for the Rideau River for the relevant 2 through 100 year event: this implies an assumption of concurrent peaks. For the Middle Reach, it was assumed that the corresponding Return Period water levels for the Lower Reach would form the starting water surface level: this implies that the water level through the wetland separating the two reaches is constant.

4.0 Structures

All bridges and culverts were surveyed in the field – standard methods, rather than GPS, were used in some cases due to bridge configuration and a resulting poor satellite reception. The information collected for all bridges and culverts is provided in Appendix B. Typically, the channel under the bridge and the roadway was surveyed; the abutment width and soffit elevation were also determined.

5.0 Calibration

The hydraulic model was calibrated, as effectively as possible (given data limitations both in the number of events and the locations monitored), using the following observed water levels:

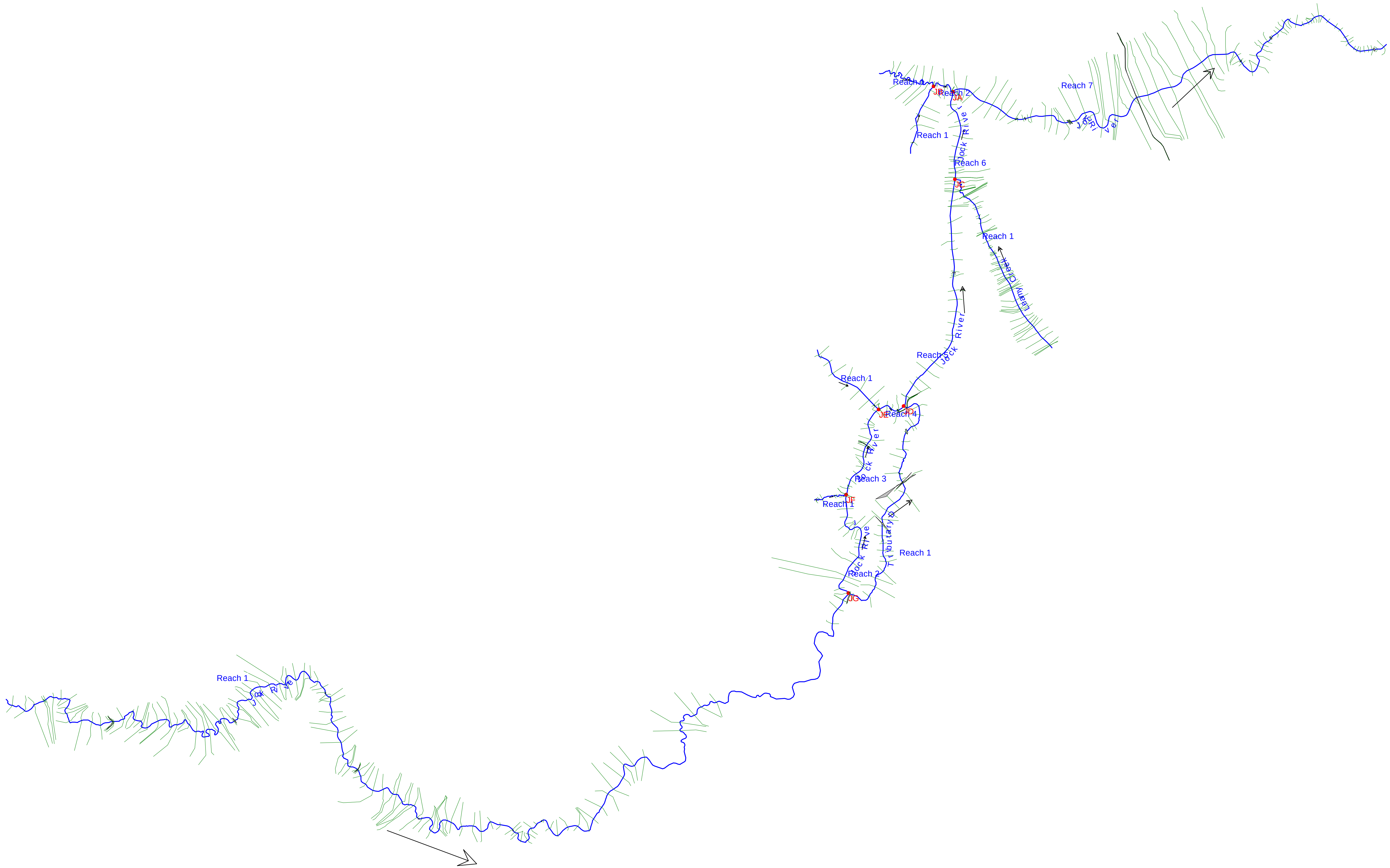


Figure 3a - River Centreline and Cross-section Layout

- Jock River at Moodie Drive – WSC Rating Curve
- observed water levels in Richmond in 1999 (136m3/s at Moodie) at
    - Flowing Creek at Perth Street
    - Jock River at McBean Street Bridge
    - Van Gaal Drain at Fowler Street
- Jock River at Greenbank Road in 1998 (126 m3/s at Moodie).

Starting from field observations and standard values described in the HEC-RAS Users Manual , Chow and USGS manual, both Manning's 'n' and expansion/contraction coefficients were assigned to each cross section; these were subsequently modified, during calibration runs, until the estimated values approximated observed values.

A summary output of the calibration modeling results is provided in Appendix C. A comparison of observed and estimated values for water levels at Moodie Drive is provided in Figure 4 and shows good correlation between observed and simulated water levels. For the remaining locations, a summary is provided in Table 1 and, again, good agreement is observed.

The sensitivity of changes in water level to changes in Manning's" n" is illustrated in Figures A1 and A2, in Appendix A, where a 25% change in both channel and overbank "n" values was introduced.

6.0 Water Surface Profiles

The recommended flows for generating 100 year water levels are summarised in Table 2. The application of theses flows to the hydraulic model is described below.

6.1 Lower Reach

Flows for the 2 through 100 year Spring events were identified for various locations in the Lower Reach: they were estimated using areal proration techniques as applied to the results of Single Station Frequency Analysis of maximum instantaneous peak flows at Moodie Drive. The flows were then used as inputs to the hydraulic model which resulted in estimates of water levels for every cross section. Water surface profiles for the 5 year and 100 year Spring events are provided in Figure 5. Summary tables are provided in Appendix D

6.2 Middle Reach

Flows for the 2 through 100 year Spring events were identified for various locations in the Middle Reach: they were estimated using a hydrologic model of maximum instantaneous peak flows for the Spring event; areal proration techniques were used to supplement the data. The flows were then used as inputs to the hydraulic model which resulted in estimates of water levels for every cross section. Water surface profiles for the 5 year and 100 year Spring events are provided in Figure 6. Summary tables are provided in Appendix D

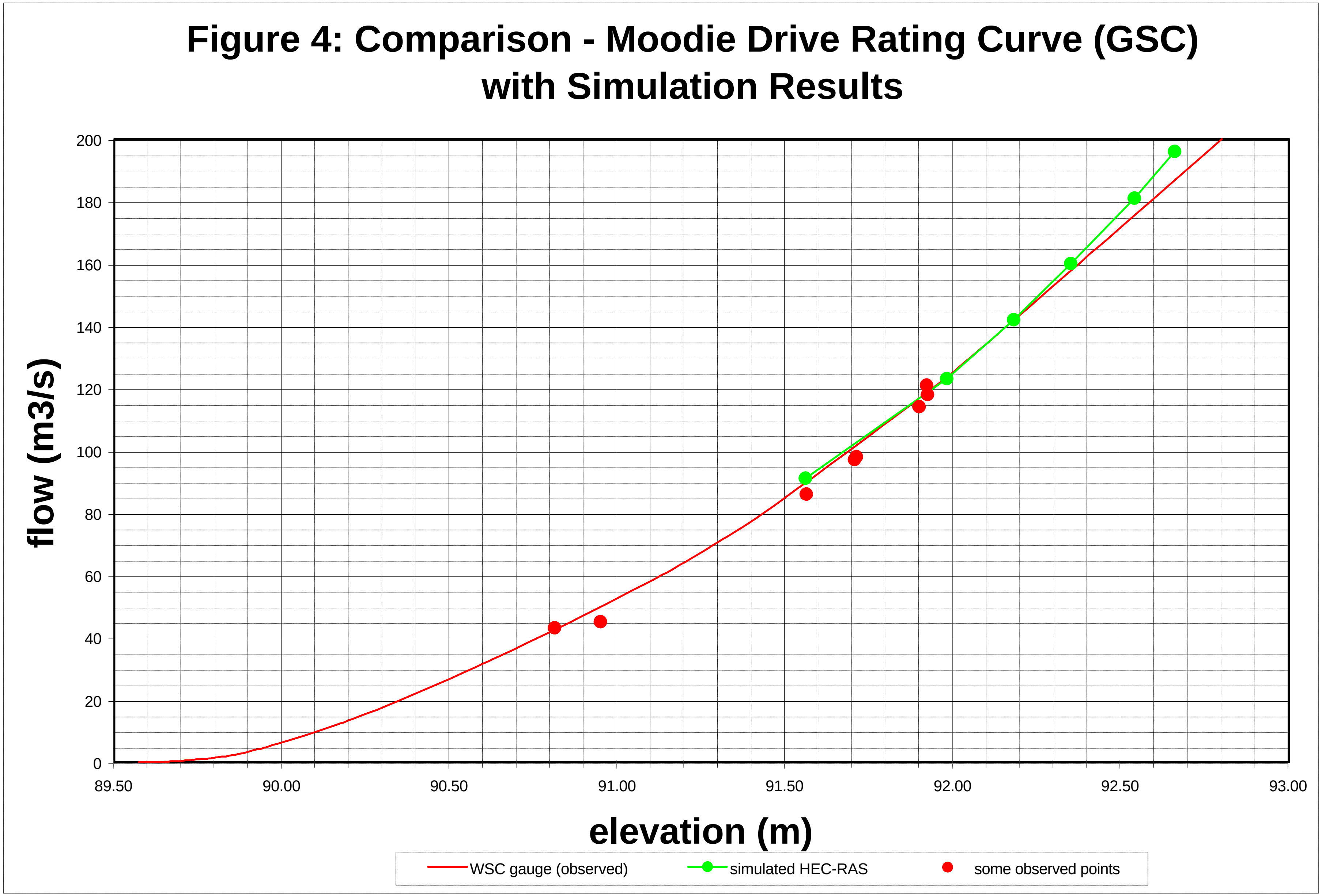


Figure 4: Comparison - Moodie Drive Rating Curve (GSC)
with Simulation Results
flow (m3/s)
200
180
160
140
120
100
80
60
40
20
0
89.50
90.00
90.50
91.00
91.50
92.00
92.50
93.00
elevation (m)
WSC gauge (observed)
simulated HEC-RAS
some observed points

Table 1 – Calibration Results

	Water Level (metres)			
Location	April 1999		March 1998	
	Observed	Estimated	Observed	Estimated
Jock River – East of Greenbank	n/a	n/a	90.4	90.3
Jock River at Moodie Drive	92.1	92.1	92.0	92.0
Flowing Creek at Perth Street	93.0	93.0	n/a	n/a
Jock River at McBean Street	93.2	93.3	n/a	n/a
Van Gaal Drain at Fowler Street	93.2	93.4	n/a	n/a

Table 2: Recommended Spring and Summer Flows – Jock River and Tributaries

Flows (m3/s)

Location and Hydrologic Model Reference #

(Spring – SSFA – observed/prorated)*

*(Spring event – 10 day volume - modeled)**

*(Summer event – SCS 24 hour - modeled)**

Return Period=> (years)	**2**	**5**	**10**	**20**	**50**	**100**
Rideau River (N1)	95	129	148	167	189	205
Moodie Drive and d/s Monoghan Drain(N2)	91	123	142	160	181	196
d/s Flowing Creek (N5)	82	110	127	144	162	176
d/s Richmond Fen (N7)	72	98	113	127	144	156
d/s King Creek (N10) (u/s Richmond Fen)	*46*	*70*	*86*	*107*	*125*	*141*
Franktown Road (N10-KC)	*27*	*42*	*51*	*64*	*74*	*83*
Ashton (N12)	*8*	*11*	*13*	*16*	*18*	*20*
Monaghan Drain	*11*	*18*	*22*	*29*	*34*	*40*
Flowing Creek	*15*	*22*	*28*	*37*	*44*	*51*
King Creek	*11*	*16*	*20*	*25*	*30*	*34*

* **font type and underlining indicate technique used in deriving flow**

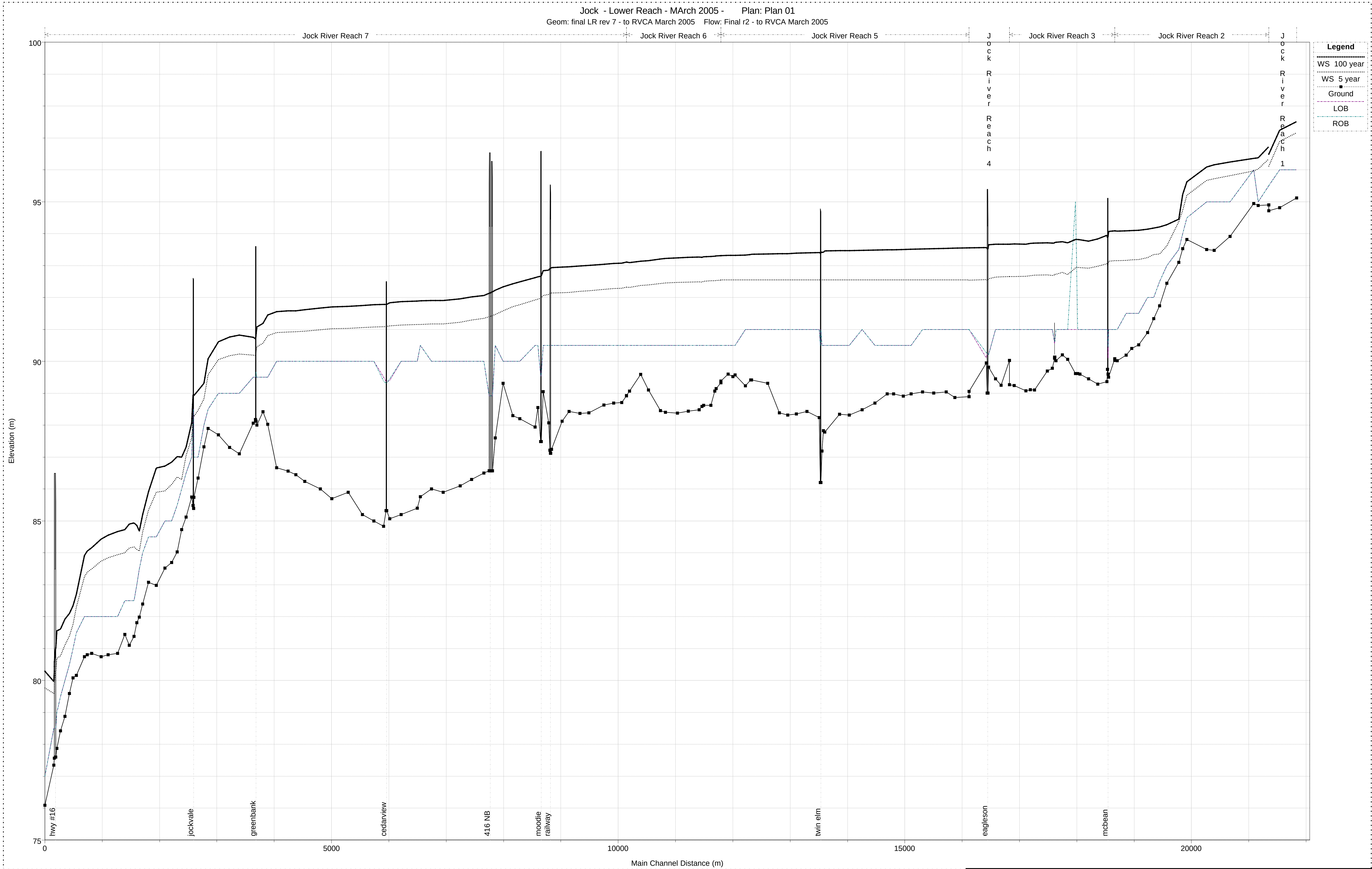


Figure 5- Water Surface Profile - Lower Reach

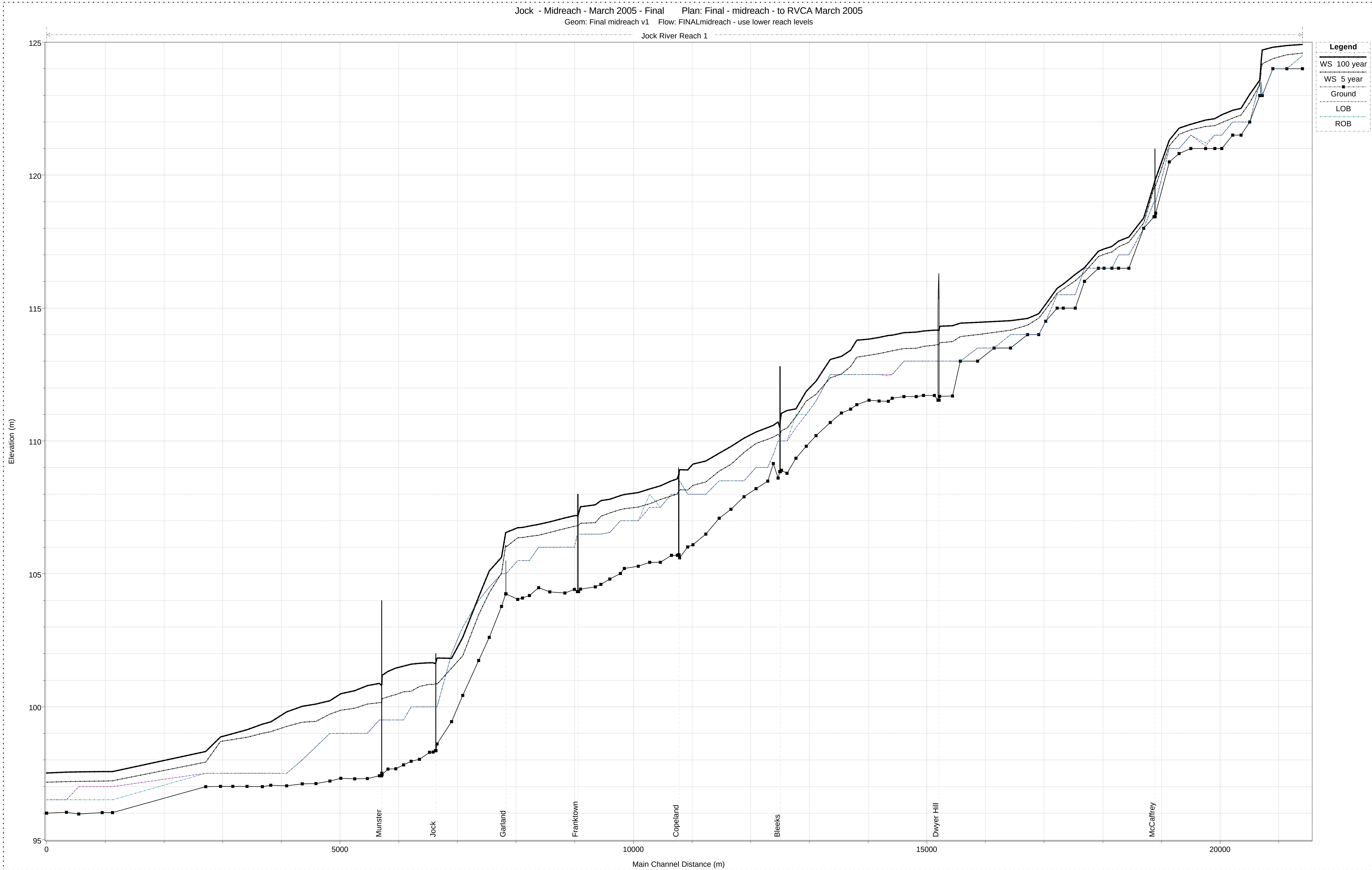


Figure 6 - Water Surface Profile - Middle Reach

6.3 Tributaries

The 100 Year flood level for a tributary will be influenced by water levels in the Jock River. The maximum 100 Year flood level for a tributary is based on hydraulic analysis that considers flows on the Jock River, and the tributary, that have a combined probability of once in 100 years.

For Summer events, the 2, 5 , 10, 20, 50 and 100 year flows on the tributaries were modeled with corresponding 100, 50, 20, 10, 5 and 2 year flows on the tributary; each combination having a combined probability of a 100 year water level on the tributary.

For the Spring event, it was assumed that, as a result of the timing of tributary peaks determined in the hydrologic modelling and with confirmation by RVCA staff observations, the main peak on the Jock was observed to occur at least 12 hours after the tributary peak.

A review of the results of combined probability modelling, compared with those of the Spring modelling, suggest that the Spring flows and water level on the Jock River produce the maximum 100 year water levels on the tributaries. The profiles are provided in Appendix E and results summarised in Table 3.

6.4 Flood Risks

Water Crossings

- based on a review of the 100 Year Jock River water surface profile in the Lower Reach, all structures appear to be adequately sized to convey the 100 Year event without increasing upstream water levels.
- based on a review of the 100 Year Jock River water surface profile in the Middle Reach, structures at Munster Road, Jock Trail, Franktown Road, Copeland Road and Bleeks Road all appear slightly undersized for the 100 Year event and have a minor impact on upstream water levels.

Roadways

- based on a review of the 100 Year Jock River water surface profile in the Lower Reach, the major roadways affected by the 100 Year event are: Richmond Road between Steeple Hill and Richmond - portions of the roadway are estimated to experience minor flooding (up to 0.1m in depth); Eagleson Road .
- based on a review of the 100 Year Jock River water surface profile in the Middle Reach, no major roadways appear to be affected by the 100 Year event.

Structures

- based on a review of the 100 Year Jock River water surface profile in the Lower Reach, there are 25+/- buildings in the floodplain

Table 3: Tributary 100 Year flood Levels

Tributary	Event		
	100 Year Spring Jock River	100 Yr Summer (Jock River) 2 Year (Trib)	2 Year Summer (Jock River) 100 Yr (Trib)
Monaghan Drain	93.1	92.3	93.0
Smith Drain	93.1	92.6	92.9
Leamy Creek	93.3	92.7	93.0
Flowing Creek	93.7	n/a	93.2
Van Gaal Drain	94.1	93.0	93.1

- based on a review of the 100 Year Jock River water surface profile in the Middle Reach, there are no buildings in the floodplain

7.0 Flood Risk Maps

The 100 Year water levels identified in the hydraulic analyses were plotted on the 1:2000 and 1:5000 scale base maps for both urban and rural areas, respectively. Reduced scale versions of these maps are provided in Appendix F.

In our opinion, the delineation of these flood susceptible areas are suitable for use in the RVCA's flood plain management program and the municipalities' land use planning and approvals programs.

References

1. Open-Channel Hydraulics – Ven Te Chow - 1959
2. Verified Roughness Characteristics of Natural Channels – USGS - 2001
3. HEC-RAS River Analysis System – Users Manual v3.1 – USACE - November 2002