Grey Sauble Conservation Authority

Ontario Ministry of Natural Resources

BEAVER RIVER FLOODLINE MAPPING STUDY FINAL REPORT

HAMLET OF HEATHCOTE
HAMLET OF KIMBERLEY

GENERAL REPORT

December 1995

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OUR FILE NO.

95101

March 1, 1996.

Grey Sauble Conservation Authority
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Attention: Mr. Doug Hill
Director of Operations

Gentlemen:

Re: Beaver River Floodplain Mapping Project for the
Hamlets of Heathcote and Kimberley

We are pleased to submit herewith 15 copies of our final General Report and 3 copies of the Technical Report for the above noted project.

The General Report documents the tasks undertaken as part of this study. Additional supporting information is presented in the Technical version of the report.

We would like to express our sincere appreciation for the assistance provided by Authority staff and in particular, Doug Hill, who provided a great deal of insight into the floodplain problems associated with the project area during the course of this study.

All of which is respectfully submitted.

Yours very truly,

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FLOODLINE MAPPING STUDY OF THE BEAVER RIVER

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1.0 INTRODUCTION

1.1 General

In August 1995 the firm of B.M. Ross and Associates Limited was retained by the Grey Sauble Conservation Authority to undertake a floodline mapping project for the Hamlets of Kimberley and Heathcote on the Beaver River. The purpose of the study is to identify floodlines for the Regional and 100 year events within the areas of potential development in the communities.

The study areas are located in the Beaver Valley area of Grey County along a section of the watercourse that has undergone significant floodplain development over the years. Historical flooding in the study area has not resulted in high levels of flood damage. Some ice jam related flooding under lower flow conditions has also been reported in the study area.

This project was undertaken according to the requirements of the Canada-Ontario Flood Damage Reduction Program. The technical procedures followed those outlined in the Ontario Ministry of Natural Resources publication entitled "Flood Plain Management in Ontario - Technical Guidelines".

1.2 Study Objectives and Scope

The main objectives of the investigations are described in detail in the Terms of Reference and are briefly summarized as follows:

1. Conduct a background information review and documentation of available reports and maps.
2. Prepare a mapping tender for the production of topographic mapping to be used in the study.
3. Coordinate the mapping production to the Canada/Ontario Flood Reduction Program Standards.
4. Check the accuracy of the prepared maps and report, and that accuracy with respect to the specified standards.

5. Undertake a hydrologic investigation of the Beaver River Watershed above the Hamlet of Heathcote and report on the historic and various recurrence interval floods using the guidelines presented in Schedule B (Canada/Ontario Flood Damage Reduction Program) and Schedule C, in the Floodplain Management in Ontario, Technical Guidelines (January 1985).

6. Undertake a hydraulic investigation of the project areas to determine the historical and flood frequency related flood elevations through the project areas.
7. Prepare floodline maps of the project areas using the standards relating to the FDRP guidelines.
8. Prepare a General Report detailing the investigations and findings carried out under this project.
9. Present the study report to the Authority.

2.0 BACKGROUND INFORMATION

2.1 Introduction

This background information review and documentation includes a brief description of the site, an overview of the field reconnaissance study, a summary of the available mapping and a review of several reports that were utilized in subsequent analyses.

Figure No. 2.1 presents the two project areas associated with this study. They are each situated within the Beaver Valley near the lower portion of the Beaver River watershed.

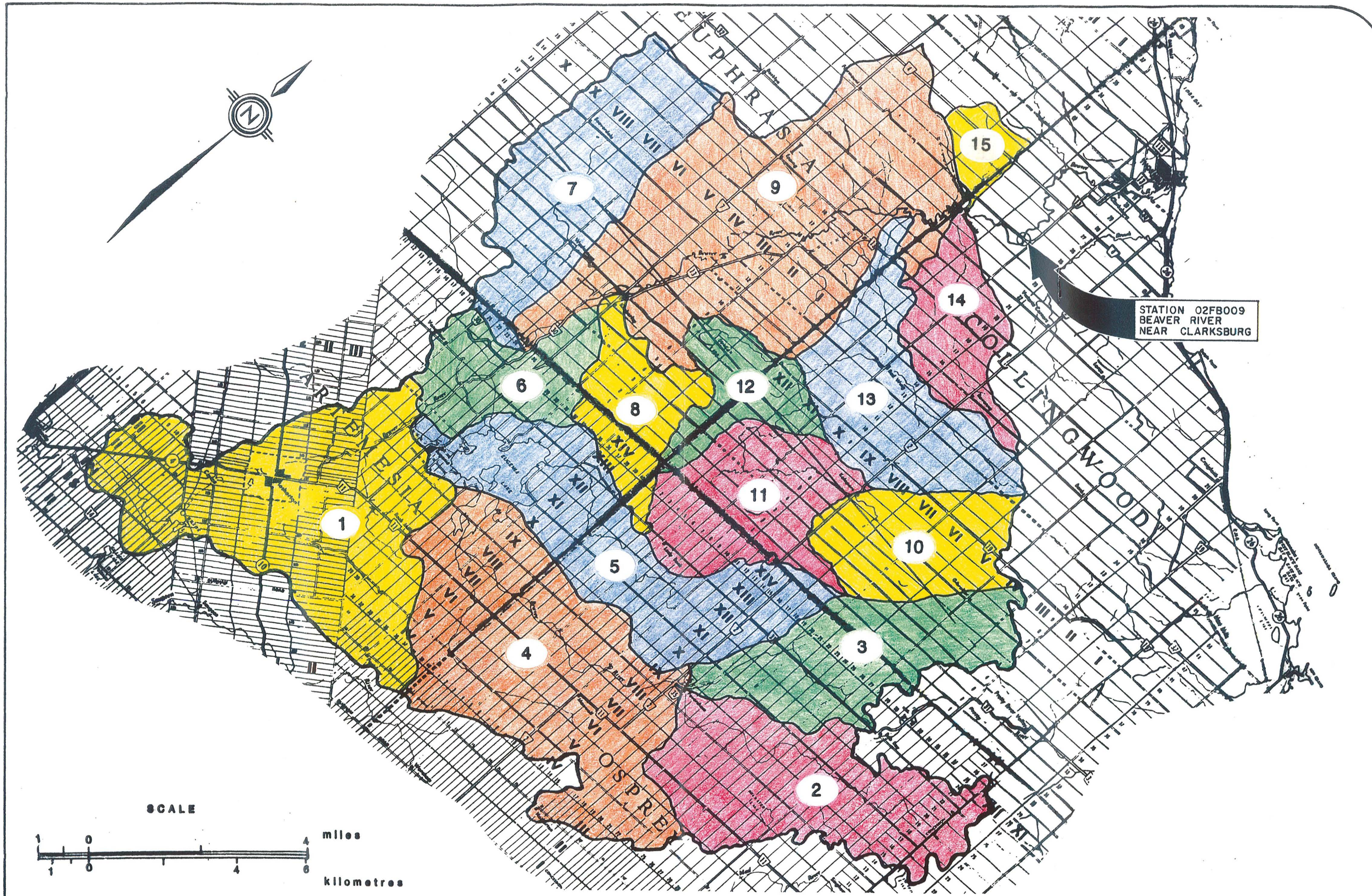
2.2 Watershed Description

The watershed area is located within Grey County and includes the following municipalities: The Town of Thornbury, the Village of Flesherton, Townships of Artemisia, Osprey, Eurphrasia, Collingwood and St. Vincent, as well as the Hamlets of Clarksburg, Heathcote and Kimberley. Many other small rural settlements are located within the watershed, many of which are located in close proximity to one of the Beaver River Tributary streams.

The river rises in the southern part of Grey County near Flesherton and at the Simcoe-Grey County boundary in the east near Singhampton. The two main tributaries, the Boyne River in the south and the Beaver River in the east, meet in the upper Beaver Valley at Eugenia, and flow northerly to Georgian Bay through the deep pre-glacial valley along the Niagara Escarpment. Mill Creek is also a significant tributary above the study area which contributes the major flow rates to the Beaver River at Heathcote. The portion of the Beaver River above Eugenia is controlled by a reservoir and hydro electric facility located at the outlet of Lake Eugenia. The flows from this area are effectively regulated for all events to the point where they have little impact on the flood hydrograph at Kimberley which is located 8 kilometres below the lake outlet.

LOCATION OF PROJECT AREAS

2.1



BEAVER RIVER WATERSHED ABOVE HEATHCOTE (SHOWING SUBWATERSHED CATCHMENT AREAS)

2.2

The watershed hydrographs are largely influenced by the nature of the convex stream profiles produced by the escarpment feature. Much of the upper watershed areas on each tributary stream are wetlands with very flat stream gradients. Historic flood hydrographs indicate very high baseflow rates which exhibit a quick response to rainfall or snowmelt events. The baseflow index for the Beaver River near Clarksburg streamgauge (WSC 02FB009) is higher than the value of the indexes for the neighbouring watershed streamflow stations. The flood hydrographs are also effected by the valley geometry which in the lower areas of the watershed between Kimberley and Heathcote, contain a great deal of flood storage due to flat channel gradients and broad wooded floodplains.

The largely rural watershed is generally under agricultural land use or a forested and wetland environment. The soils are quite permeable on the toe of the escarpment area and highly impermeable in the valley itself.

2.3 Field Work

2.3.1 General

A field reconnaissance was undertaken by B.M. Ross and Associates Limited in October and November of 1995.

The field crew collected relevant hydrologic, hydraulic and flooding information using standard surveying techniques, visual examination of channel and bank characteristics and interviews with area residents.

2.3.2 Historical Flooding

In both Heathcote and Kimberley, historical flooding has been influenced by high flows associated with ice jams. Recent flooding due to either high flows alone, or ice jam related flooding occurred in 1954, 1968, 1974, 1975, 1977, 1982, 1986, and 1990. Of these events, only the 1954 and the 1986 high water periods were rainfall produced without any ice or snowmelt induced flooding. Ice jam occurrences have produced flooding that is more extreme than free flow related occurrences of the same magnitude. While most of this flooding was not particularly severe in terms of damages, it did provide a sizeable disruption to the rural communities.

Although ice jams have been a causative factor in producing flood conditions in the past, it has not always been associated with higher flow conditions. Disruptive flooding has occurred from frazil ice occurrences. The phenomenon of frazil ice formation is rather common in this part of Ontario where atmospheric conditions can produce large quantities of ice in steeper sloped watercourses. It is generally the tributary streams in the lower reaches and the main streams in the upper watershed that produce frazil ice.

2.3.3 Stream Characteristics

During the field reconnaissance, a variety of stream characteristics were noted in the study area.

The main river channels in Kimberley are braided with multiple flow regimes throughout the study area. There are four water crossing structures on Eurphrasia Township Road 7A which crosses the Beaver Valley in Kimberley. Each of these structures carries flood flow along the river valley through this one location. The floodplain area is heavily wooded in much of this section of the study area. The river at each end of the Hamlet of Kimberley is a single channel entity. This single channel system is more typical of the reach between Kimberley and Heathcote and through Heathcote itself.The broad flat valley floor typifies the floodplain in both areas and for the most part, the floodplain area is covered with vegetation ranging from scrub brush to mature trees. There is considerable development within the floodplain area in both communities. Most of this development has existed for some time with little new areas of growth. The major impediments to flood flow would seem to be the river crossings or the roadways and the road embankments themselves.

2.3.4 Hydraulic Measurements

Channel cross-sections were obtained for use in the hydraulic analysis through standard levelling techniques and depth soundings. Fifteen sections were allocated so as to best describe hydraulic conditions. The locations of the river cross-sections are identified on Figure 2.3 and plots of the cross-sections are presented in Appendix B. The sections will subsequently be used in the HEC-2 computer program, a hydraulic model which calculates water surface profiles for steady gradually varied flow in natural or man-made channels (HEC-2 Water Surface Profiles, Users Manual, 1982). Typical roughness coefficients, expansion and contraction coefficients to be used in the hydraulic model are presented in Figures 2.3 and 2.4.

A copy of the field survey notes are available in Appendix C.

	Manning's n Range
A. Minor streams (surface width at flood stage < 30 m).	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030 - 0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035 - 0.05
c. Some weeds, light brush on banks	0.035 - 0.05
d. Some weeds, heavy brush on banks	0.05 - 0.07
e. Some weeds, dense willows on banks	0.06 - 0.08
f. For trees within channel with branches submerged at high stage, add 0.01 to 0.02 to above values	
2. Irregular section, with pools, slight channel meander; channels (a) to (e) above, add 0.01 to 0.02.	
3. Mountain stream, no vegetation in channel, banks unusually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04 - 0.05
b. Bottom of cobbles with large boulders	0.05 - 0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030 - 0.035
b. High grass	0.035 - 0.05
2. Cultivated Areas:	
a. No crop	0.03 - 0.04
b. Mature row crops	0.035 - 0.045
c. Mature field crops	0.04 - 0.05
3. Heavy weeds, scattered brush	0.05 - 0.07
4. Light brush and trees:[3]	
a. Winter	0.05 - 0.06
b. Summer	0.06 - 0.08
5. Medium to dense vegetation:[3]	
a. Winter	0.07 - 0.11
b. Summer	0.10 - 0.16
6. Dense willows, summer, not bent over by current	0.15 - 0.20
7. Cleared land with tree stumps, 250 - 370 per hectare	
a. No sprouts	0.04 - 0.05
b. With heavy growth of sprouts	0.06 - 0.08

Expansion and Contraction	Typical Values	
	Contraction	Expansion
Natural (Gradual) Transitions	0.1	0.3
Bridge Sections	0.3	0.5
Abrupt Transitions	0.6	0.8

Pier Coefficients	Typical k Values
Semicircular nose and tail	0.90
Square nose and tail	1.25

Entrance and Exit Loss Coefficients	Typical Values
Entrance	0.5
Exit	1.0

Weir Coefficients (typical road section)	Typical Value
Range 2.5 to 3.1 metric 1.4 to 1.7 imperial	3.0

Orifice Coefficient (short culverts/bridges)	Typical Value
Range 0.7 to 0.9	0.8

[1] U.S. Army Corps. of Engineers, HEC-2 Water Surface Profiles, Users Manual, September 1982.

Hydraulic Loss Coefficients[1]

2.3.5 Additional Hydrometric Data

During the period of field survey, a runoff event in the range of 37 cms was experienced. The field water level measurements taken at this time will be used to provide calibration data for the hydraulic model. Streamflow data from the downstream stream gauge was available through the Conservation Authority's flood warning network software. The location of this gauge is depicted in Figure No. 2.2. The station is identified as The Beaver River near Clarksburg (02FB009) and is Gauge Number 4 in the flood warning network.

2.4 Mapping and Hydrologic Records

2.4.1 Existing Mapping

Existing OBM 1:10000 scale topographic mapping was available (5 m contour interval) and cover all of the Beaver River watershed. Floodline elevations as determined through hydrologic and hydraulic analysis described in the following chapters were delineated on the newly prepared 1:2000 maps. Aerial photography required for the mapping was completed in 1991 and the maps were produced as part of this project.

In accordance with the Terms of Reference, a map inspection was undertaken prior to floodline delineation.

All horizontal and vertical control points for both study areas were field surveyed as part of the map accuracy check. As well, selected spot elevations and contour points were checked in each study area. The results of this map accuracy check are summarized in Appendix D.

2.4.2 Future Land Use Maps

Zoning by-laws were obtained from the Grey County Planning Department which identify proposed land use changes in the watershed municipalities. This information was used in the hydrologic computer model by modifying the runoff potential for each subwatershed affected to determine the effect on existing flood flows and, through subsequent hydraulic analysis, the effect on corresponding flood elevations.

The land use changes within the Beaver River watershed were not of a significant extent as to change overall runoff patterns or rates. The watershed does not contain any rapidly changing urban centres nor any extensively productive agricultural land use that would affect the watershed hydrologically. Reviews of past agricultural census data supports this fact.

2.4.3 Meteorologic and Discharge Records

Meteorologic records were obtained from the Atmospheric Environment Service of Canada (AES) for use in the hydrologic analysis (Appendix E).

The flood events occurring in September 1986 and November 1988 were simulated using the HYDRO-PAK and OTTHYMO-89 computer models. Precipitation data for these events from AES stations located at Walters Falls (6009274), Thornbury Slama (611HBEC), Proton Station (6116750, and Priceville (6116718), were used in preparing the model. Hourly streamflow data from the Beaver River near Clarksburg (02FB009) was used to compare model results with actual measured values. Figure No. 2.3 presents the 1986 event simulation results along with the recorded streamflow hydrograph and Figure No. 2.4 presents the 1988 event simulation results with the streamflow hydrogaph from the downstream streamgauge.

Hydrologic data since 1957 were also obtained for Water Survey of Canada gauging station 02FB009 which is located just downstream of Heathcote on County Road 13. The gauging station measures maximum daily flows and maximum instantaneous flows for a drainage area of 572 km^2 and was used to undertake statistical tests with the Consolidated Frequency Analysis 3 computer program. The hydrometric data recorded to date is summarized in Appendix F.

2.5 Literature Review

2.5.1 General

Streamflow data published and archived by Environment Canada reveal that the streamflow regime of the Beaver River is rather unique for the Region. Statistical comparisons of watersheds within this part of the Province carried out under the Canada/Ontario Flood Damage Reduction Program have provided information with which the hydrologic basis of this report have been formed.

Relevant information from the County Soils Reports (Soil Survey Report No. 17), Agricultural Statistics for Ontario 1993 and the County of Grey Official Plan, as well as other published government documents were used in preparing this report.

2.5.2 Hydrology Study of the Beaver River Basin, James F. MacLaren Ltd., April 1983 (Clarksburg Floodline Mapping)

The purpose of this study was to establish peak flows of the Beaver River. Design flow from the HYMO model for the Regional event was 179 m^3/s.

The study concluded that the Timmins storm flood flow at the Clarksburg outlet on the Beaver River, based upon the calibrated desegregated basin model is 179 m^3/s and the 100 year flood flow at the outlet based upon flood frequency analysis is 99 m^3/s.

2.5.3 North Grey Region Conservation Report, Department of Planning and Development of Ontario 1959

This study was carried out as part of the agreement with the Province when the North Grey Region Authority was formed in 1957. The report consists of six distinct areas of coverage dealing with land, forest, water and wildlife, history and recreation. The report produced provided the basic resource base for the Authority until specific project issues could be separately studied.

3.0 HYDROLOGIC ANALYSIS

3.1 General

The basic objective of the hydrologic analyses was to provide estimates of the 2, 5, 10, 20, 50, 100 year and Regional (Timmins) design flood hydrographs for the study area as outlined in Figure 2.1. The design flows are to be used for input to the hydraulic analysis for determination of water surface profiles within the study limits.

Two methods were considered for estimating peak flows:

1) statistical
2) modelling

The statistical analyses included both single analyses and application of Regional flood frequency techniques as discussed in Section 3.2. The deterministic peak flow estimates were undertaken using the HYDRO-PAK and OTTHYMO models as summarized in Section 3.3. Application of the HYDRO-PAK and OTTHYMO models were also required in order to determine peak flows associated with the Regional (Timmins) Storm rainfall event.

3.2 Statistical Peak Flow Estimates

3.2.1 Introduction

A variety of statistical data analysis techniques are available to provide estimates of peak flows. The procedures for undertaking single station analyses are outlined in Section 3.3.2. Secondary estimates obtained by applying the Regional prediction methods are outlined in Section 3.3.3 and 3.3.4. The statistical peak flow estimates were then compared to the deterministic estimates (see Section 3.3).

3.2.2 Single Station Analysis

Streamflow data with a record length of 20 years or more is considered to be most appropriate for use in predicting peak flows associated with rainfall conditions (Ontario Ministry of Natural Resources, 1984). The available period of record at Station No. 02FB009 located near the downstream boundary of the study area is 33 years of instantaneous peak flows (see Figure 2.2 for station location).

The gauge is a mechanical device that is float-activated. The water levels are measured by a Stevens Analog Recorder (Model #A71) which is clock-driven. The gauge is rarely influenced by downstream water levels due to the hydraulics of the channel downstream. Ice jams do affect the water levels at the gauge during some spring runoff events.

The rating curve has been relatively stable for the past 33 years. Several changes have been made to the curve to maintain a good relationship between physical flow measurements and those developed using the curve. The rating curve used at present was developed in April 1985.

The statistical analyses of available peak flow were undertaken using the CFA program (Pilon, et al, 1993). This program fits the following frequency distributions to the available peak data series:

* Gumbel I (Generalized Extreme Value)
* Log Normal
* Three Parameter Log Normal (3 PLN)
* Log Pearson Type III (LP3)
* Wakeby

The 3PLN and LP3 distributions have generally been found to be the most suitable for practical applications in Ontario.

Prior to undertaking peak flow analyses, statistical tests were undertaken to confirm that the available sample is a reliable data set of trend-free measurements of independent random events from a homogeneous population. The CFA program was also used for undertaking suitable tests.

The following tests were undertaken using the CFA-3 program:

i) Spearman Test for Independence
ii) Spearman Test of Trend
iii) Run Test for General Randomness, and
iv) Mann-Whitney Split Sample Test for Homogeneity

The results of the tests (see Appendix G) indicate that the data sample is a reliable set of measurements of independent random events from a homogeneous population.

The frequency distributions previously identified were fit to the available hydrometric data. The resulting curves and tables of peak flow estimates for the instantaneous daily peak flow series are summarized in Appendix G.

Previous investigations have shown that streamflow data for ungauged watersheds in Southern Ontario typically agree closely with the 3-Parameter Log Normal Distribution as is the case here. Therefore, the primary peak flow estimates having a 3-Parameter Log Normal distribution (3PLN) are the most realistic flow developed via the Single Station Analysis. Table 3.1 summarizes the results of the instantaneous flow series frequency analysis for the 3-Parameter Log Normal distribution.

3.2.3 Regional Frequency Analysis

The following regional techniques were used to provide secondary peak flow estimates for comparison purposes:

a) the index method (Ontario Ministry of Natural Resources, 1984)
b) the regression method (Moin and Shaw, 1986)

The index method consists of calculating an index flood which is then combined with a regional dimensionless frequency curve.

The Index Flood Method is outlined in detail in the Technical Guidelines (Ontario Ministry of Natural Resources, 1984). The Beaver River watershed lies in Region 3 according to the Flood Frequency Regions map in the Guidelines. The following relationship applies for estimating the Index Flood:

$Q2 = CA^n$

where Q2 = 2 year return period (3PLN) flood, m^3/s

A = drainage area, km^2

C = constant

n = exponent

The necessary parameters for the Beaver River watershed (Region 3) are summarized in Table H.1.

TABLE 3.1

SINGLE STATION ANALYSIS - PEAK FLOW ESTIMATES

THREE - PARAMETER LOG NORMAL DISTRIBUTION

Return Period (years)	02FB009 Instantaneous Peak Flow Series	Beaver River below Kimberley Peak Flow Series	Beaver River below Heathcote Peak Flow Series
2	57.4	47.0	56.8
5	71.1	58.3	70.4
10	78.8	64.6	78.0
20	85.4	70.0	84.5
50	93.2	76.4	92.3
100	98.6	80.8	97.6
Drainage Area	572 sk	441 sk	563 sk
Adjustment Factor		.82	.99

* all flow in m^3/s

Guidelines indicate that for Region 3, the range of drainage areas for which the Index Flood Method is applicable is 86.0 - 3960 km^2. Within this range there are 15 stations with over 9 years of continuous flow data from which the regional relationships were developed. There are, in addition, 3 stations in Region 3 with between 5 and 9 years of continuous flow data that range in drainage area from 329.0 to 381 km^2 also used to develop the regional relationships. The Beaver River watershed drains a total of 608 km^2 of land and has maintained a continuous recording of streamflow data since 1958 at WSC gauging station 02FB009.

The top part of Figure H.1 shows the general relationship between drainage area and index floods for Region 3. The frequency curve on the lower half of the same figure, developed from instantaneous peak flow series, describes the Ratio to Index Flood for a particular return period and Q2 (Index Flood) defines the peak flow for the return period. (Substitution of the appropriate parameters from Table H.1 resulted in an Index Flood flow of 138 m^3/s). A similar procedure is followed using the dimensionless frequency curve with an expected probability adjustment to estimate flows that include the adjustment. Table 3.2 summarizes the results of the Regional Frequency Analysis using the Index Flood Method.

b) <u>Regression Method</u>

Regression equations (Moin and Shaw, 1986) were used to produce secondary peak flow estimates for the Beaver River watershed. The watershed falls within Flood Frequency Region C and the corresponding regression equation has the form:

$$\text{Log}(Q_T) = a_0 + a_1 \log(\text{AREA}) + a_2 (\text{BFI})^{1/2} + a_3 (\text{SLP})^{1/3}$$
$$+ a_4 (\text{ACLS})^{1/2} + a_5 \text{SLP} + a_6 \log(\text{MAR}) + a_7 \text{MAP}$$
$$+ a_{10} \text{SHP}$$

where AREA = drainage area, km^2

BFI = base flow index

TABLE 3.2

REGIONAL FREQUENCY ANALYSIS

INDEX FLOOD METHOD

Recurrence Interval (years)	Ratio to Index Flood	Peak Flow (m^3/s)	
		below Kimberley	below Heathcote
2	1.00	47.0	56.8
5	1.23	57.8	69.8
10	1.50	70.5	85.2
20	1.70	79.9	96.6
50	2.06	96.8	117.0
100	2.30	108.6	130.6

SLP = slope of main channel, m/km
ACLS = area controlled by lakes and swamps, %
MAR = mean annual runoff, mm
MAP = mean annual precipitation, mm
and SHP = shape factor ($length^2/area$)

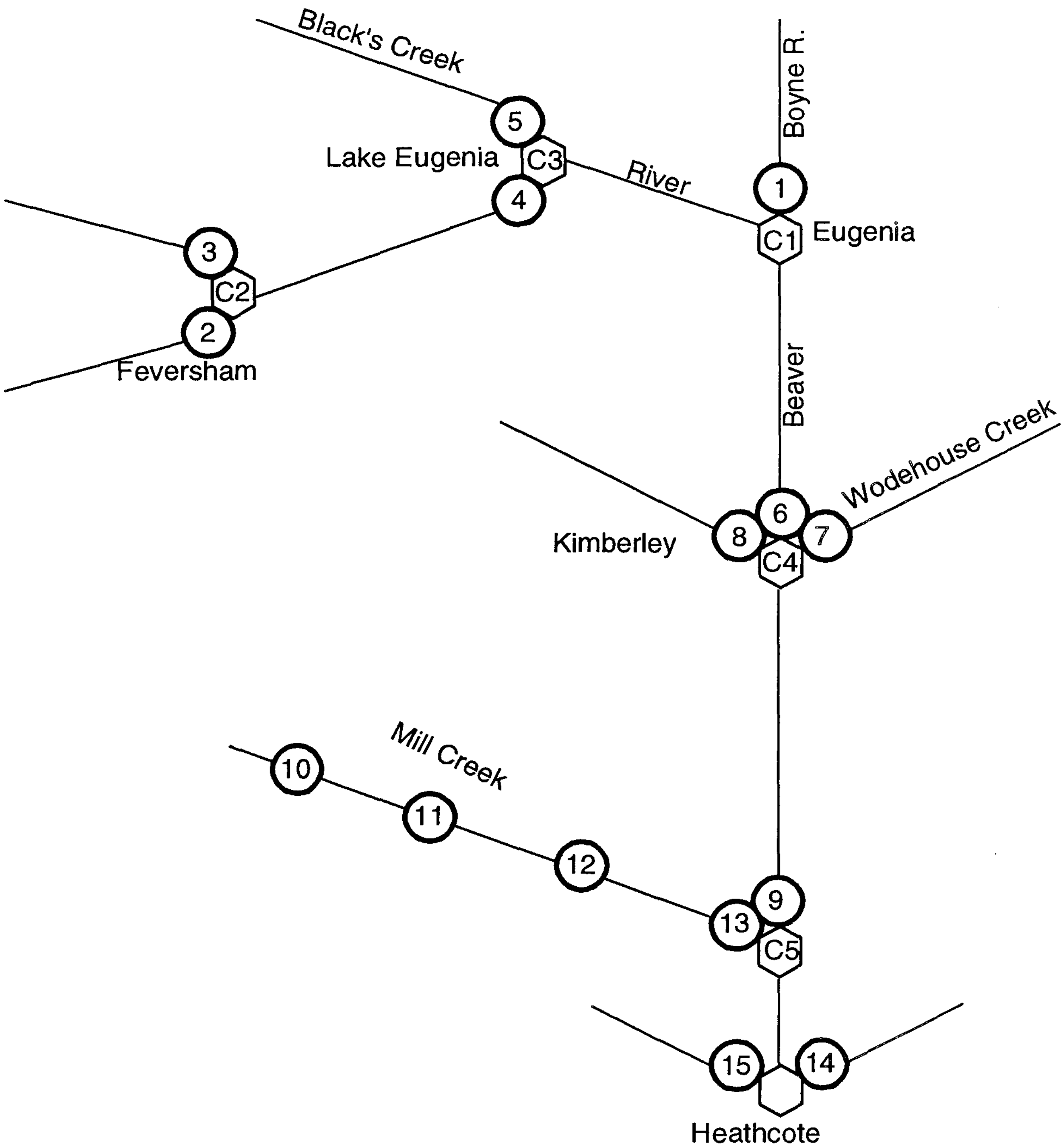
This regression equation produces instantaneous peak flows for various recurrence intervals for watersheds within Region C. The watershed parameters (station 02FB009 in Table I.1) were found to fall within the range of applicability of the regional prediction equation (Tables I.2 and I.3). The regression coefficients for Region C are summarized in Table I.4.

3.3 Deterministic Peak Flow Estimates

3.3.1 Description of the Deterministic Model

OTTHYMO was selected for this application due to its adaptability to model a variety of different watersheds and the requirement to estimate peak flows associated with the Regional Storm. The OTTHYMO model, a modified version of HYMO, is a single event watershed simulation model which was developed to determine the volume and peak flow of surface runoff.

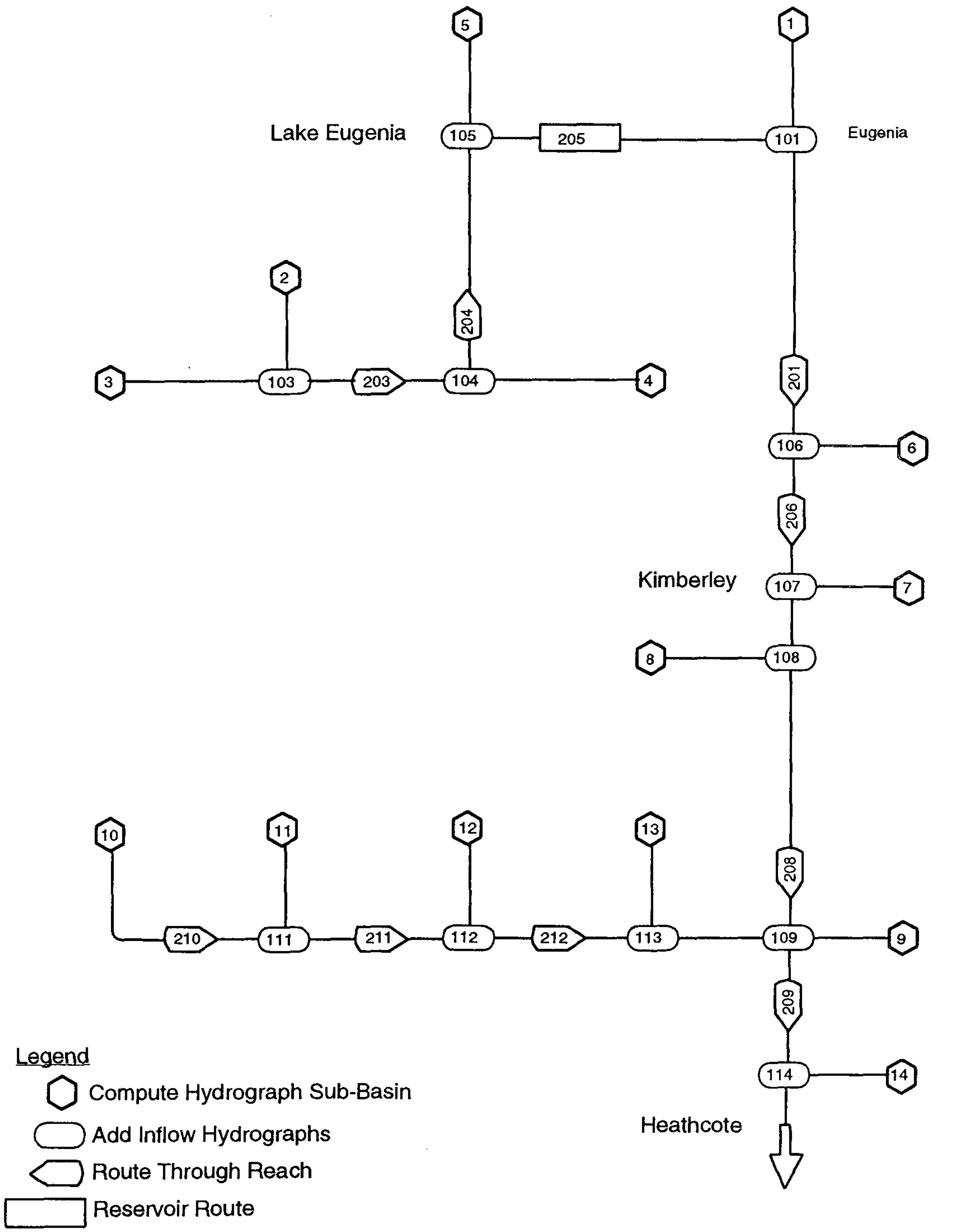
The HYDRO-PAK model was produced as a computer tool to be used for checking hydrology study results. Its routines include most of the exceptable methods of hydrograph simulation currently in use by hydrologists. It is capable of reproducing results of HYMO and HYMO Variant programs when given the same input values. The program has several features which make it more usable for this study. It contains a minimum infiltration option and a baseflow recovery option which enhance the models capability with regards to modelling watersheds such as the Beaver River.



HYDRO-PAK Model Logic

Beaver River Watershed above Heathcote

3.1



OTTHYMO Model Logic

Beaver River Watershed above Heathcote

3.2

TABLE 3.3

REGIONAL FREQUENCY ANALYSIS -

MOIN AND SHAW REGRESSION METHOD

BEAVER RIVER ABOVE KIMBERLEY

Return Period (years)	Primary Equation Instantaneous Peak Flows (m^3/s)	Secondary Equation Instantaneous Peak Flows (m^3/s)
2	94.4	89.9
5	143.3	157.4
10	177.0	191.9
20	210.3	225.9
50	243.0	489.4
100	277.2	556.6

BEAVER RIVER ABOVE HEATHCOTE

Return Period (years)	Primary Equation Instantaneous Peak Flows (m^3/s)	Secondary Equation Instantaneous Peak Flows (m^3/s)
2	112.1	112.9
5	168.1	191.0
10	206.5	231.4
20	244.3	270.9
50	271.7	556.0
100	308.8	629.3

HYDRO-PAK is also a variant of the HYMO model developed by Williams and Hahn. The modelling setup is very similar to OTTHYMO with a few additional requirements which allow the modelling of watersheds that exhibit significantly different hydrograph shapes such as the Beaver River.

The baseflow recovery routines in HYDRO-PAK allow the hydrograph shape typical of the Beaver River watershed to be modelled. OTTHYMO will not produce the same recession limb on the simulated hydrograph. With the exception of the baseflow data and channel routing functions, the input data variables used by the two programs were basically equivilent.

The peak flows from each model were also similar being within 15 percent of each other. The higher peak flows produced by HYDRO-PAK were attributed to baseflow recovery component inclusion in the model.

Generally speaking, a watershed is broken down into sub-areas corresponding to the number of points at which flow estimates are required. The runoff volume for each sub-area is computed by the U.S. Soil Conservation Service (SCS) Curve Number (CN) method which accounts for soil characteristics and antecedent moisture conditions. This volume is distributed in time using a unit hydrograph to obtain a hydrograph from each subwatershed. The unit hydrograph is described by complex gamma and exponential decay functions of two parameters; namely the time to peak (tp) and recession constant (k).

Channel routing of flow hydrographs OTTHYMO is accomplished using the Variable Storage Coefficient method. This is a non-linear procedure which adjusts travel time through a reach to account for the variation in water surface slope (University of Ottawa, 1982). In order to utilize this method the slope and length of the reach must be specified with a 'typical' valley channel cross-section; the only parameters which must be estimated are values of Manning's 'n' for the floodplain and for the channel.

In HYDRO-PAK, the channel routing is accomplished by the Muskingum method in channels where the flow is not subjected to major backwater conditions, and by the lag and route (storage indication routing) method where significant backwater is experienced. The routing data is developed from the HEC2 model data for the lag and route method of routing.

In summary, the two models produce similar results, but the HYDRO-PAK model allows a better calibration of the entire natural hydrograph and was chosen as the final model since there was greater reliance in the flood peaks produced for upstream areas.

3.3.2 Model Input

i) 100 Year Design Rainfall

Total rainfall amounts for the 100 year duration return period event were derived from Intensity-Duration-Frequency curves for the Mount Forest AES and the Owen Sound MOE Stations (Appendix E).

The maximum depth of 88 millimetres of rainfall was used for this analysis since the major portion of the Beaver Watershed falls under the rainfall patterns more typical of the Mount Forest location. The rainfall distribution used was the 12 hour SCS distribution (Ontario Ministry of Natural Resources 1984 - see Figure J.4 and J.5).

ii) Design Rainfall for Regional Event

For the Regional flow simulation, the Timmins storm was used. The Timmins event is a well-documented storm with a known duration and temporal distribution. Again, the Equivalent Circular Area Method was used for calculating the drainage area of the Beaver River (850 km^2) and the corresponding reduction factor for the point rainfall is 70% (see Table J.8). The rainfall hyetograph for the Timmins event is described in Table 3.4 and Figures J.6 and J.7.

iii) Physical Parameters

The Beaver River watershed is outlined on Figure 3.2. The sub-basins shown were delineated on the basis of drainage patterns, type of cover and land use (i.e. urban, rural and forest cover, etc.).

The watershed boundaries and physical characteristics were derived from field surveys, available mapping and, where necessary, from hydrologic reports of the Beaver River watershed completed earlier. Topographic mapping with five metre contour intervals was available for most downstream sub-basins which empty into Lake Huron. 1:10,000 Ontario Basic Mapping Series were used for upper drainage basin areas. The physical parameters such as length of stream, basin elevation difference and drainage area were used to develop unit hydrograph parameters such as time to peak (tp), and recession constant (K). (B is a function of K and tp). The HYDRO-PAK and OTTHYMO models then make use of the unit hydrograph parameters to simulate the rainfall-runoff process for the watershed. The physical parameters are listed in Table J.3.

It should be noted that if future applications of the model require refined flow estimates from subwatershed areas, some additional field work may be required in order to achieve appropriate model refinements.

TABLE 3.4

TIMMINS STORM POINT RAINFALL

WITH AREAL REDUCTION OF 70%

Hour	Depth (mm)
1	10.8
2	13.5
3	8.1
4	1.3
5	4.1
6	13.5
7	31.1
8	13.5
9	16.2
10	8.1
11	9.5
12	5.4
	135.1

Flow hydrographs from the upper sub-area are routed through the lower sub-areas based on the input data. The hydrograph computed as inflow from the lower sub-area is then added onto the routed hydrograph to obtain the design flow at the outlet of the lower sub-area and this process was continued to the outlet. Figure 3.1 describes this logic in a flow chart format for the HYDRO-PAK model and Figure No. 3.2 describes the logic for the OTTHYMO model.

iv) Soil Cover Complex Number

The OTTHYMO model uses a runoff index factor which combines the soil group and land use characteristics and is referred to as a hydrologic soil cover complex number (CN). The soils for each sub-basin were classified by hydrologic soil group using the soil characteristics and MTO soils tables (Ontario Ministry of Transportation and Communications, 1982). Information on soil characteristics such as slope, stoniness, drainage, rockiness, soil profile and soil association name was obtained from surficial soil maps of the Beaver River watershed. The soil classification and land use characteristics for each sub-area were used to assign complex numbers according to procedure described in the U.S. Soil Conservation Service Handbook (SCS, 1972) (also see Figures J.1 and J.2). The weighted complex numbers for Antecedent Moisture Condition I, II and III (AMC I, AMC II and AMC III) are summarized in Table J.3). Antecedent moisture condition II represents the case where soil saturation conditions are average prior to the design flood event and condition III represents the situation where significant rainfall occurring prior to the event has saturated the soil and/or the ground may be frozen or partially frozen. Figure J.3 describes the translation between AMC II and AMC III.

3.3.3 Model Calibration

Daily precipitation for the study area was available from Priceville, Proton Station, Walers Falls, Singhampton and Thornbury. Rainfall hourly distribution for chosen events was examined at various hourly recording tipping bucket rain gauges. The 12 hour event total distributions were fairly closely matching the 12 hour SCS Type II distribuion and this distribituion was utilized in the event modelling.

Hourly discharge records are available for the period of 1982 to the present from WSC Station 02FB009, just downstream of Heathcote (Figure 3.2). For the concurrent period of hourly discharge records, two significant flow events were identified. (For many events where significant discharge was recorded, the event was not necessarily rainfall produced). Table 3.5 summarizes the characteristics of the two events.

The HYDRO-PAK and OTTHYMO models were calibrated by adjusting the calculated watershed parameters until a reasonable agreement in measured and simulated peak flows was obtained. The results can be seen in Figure 3.3 and 3.4. The physical model input parameters are summarized in Table J.3.

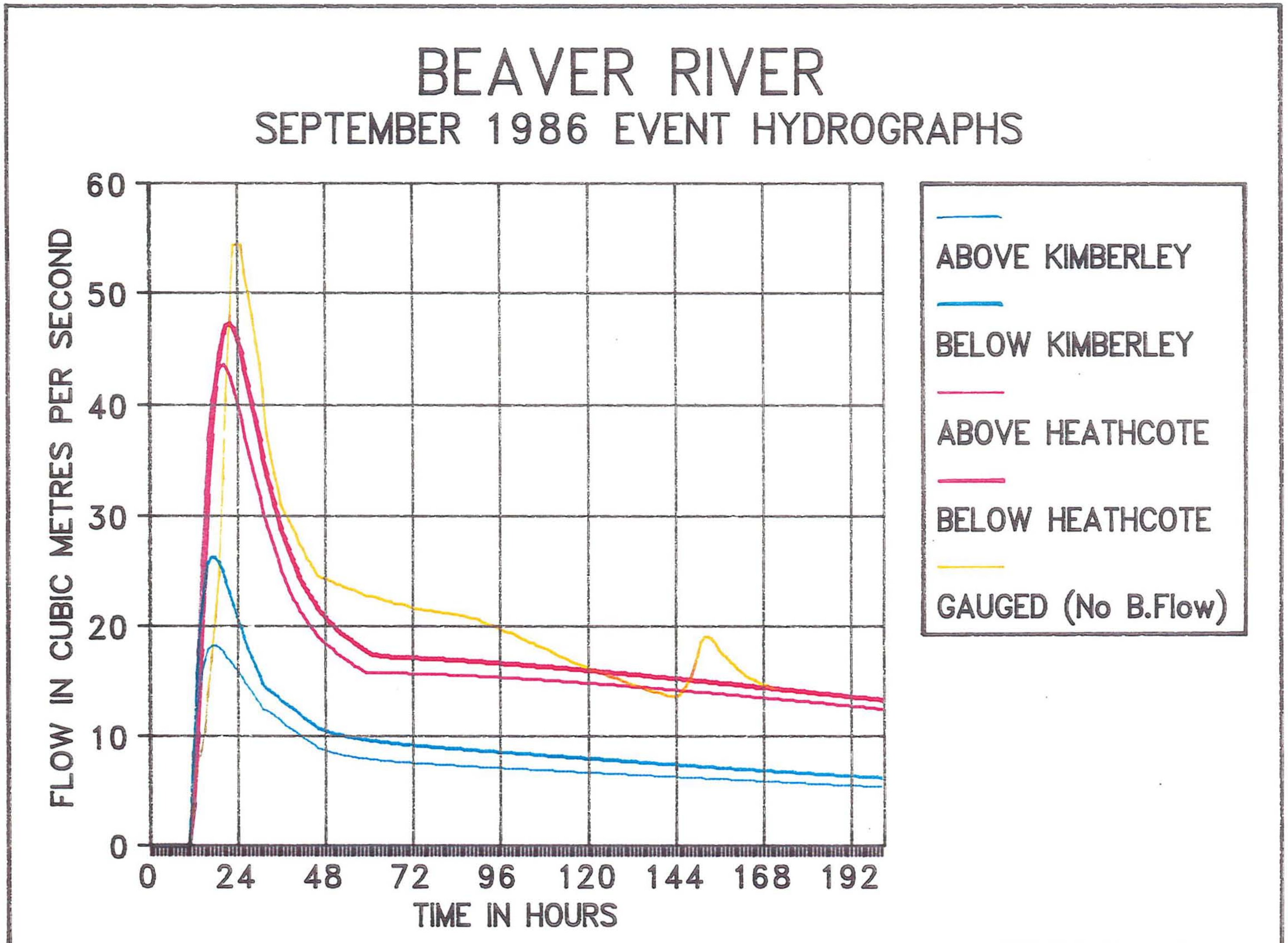
The calibrated models concentrated initially on obtaining an acceptable agreement between observed and predicted peak flows through the study reach. The total hydrographs were then calibrated by including baseflow recovery variables so that the total event hydrographs was simulated. At the present time, it is our opinion that additional measurements would only refine the simulated hydrograph shape and not have a significant improvement on the accuracy of peak flow simulations in the study area. However, use of the present model for providing refined flow estimates for upstream subwatershed areas may require additional field work for refinement of model parameters and calibration, etc.

TABLE 3.5

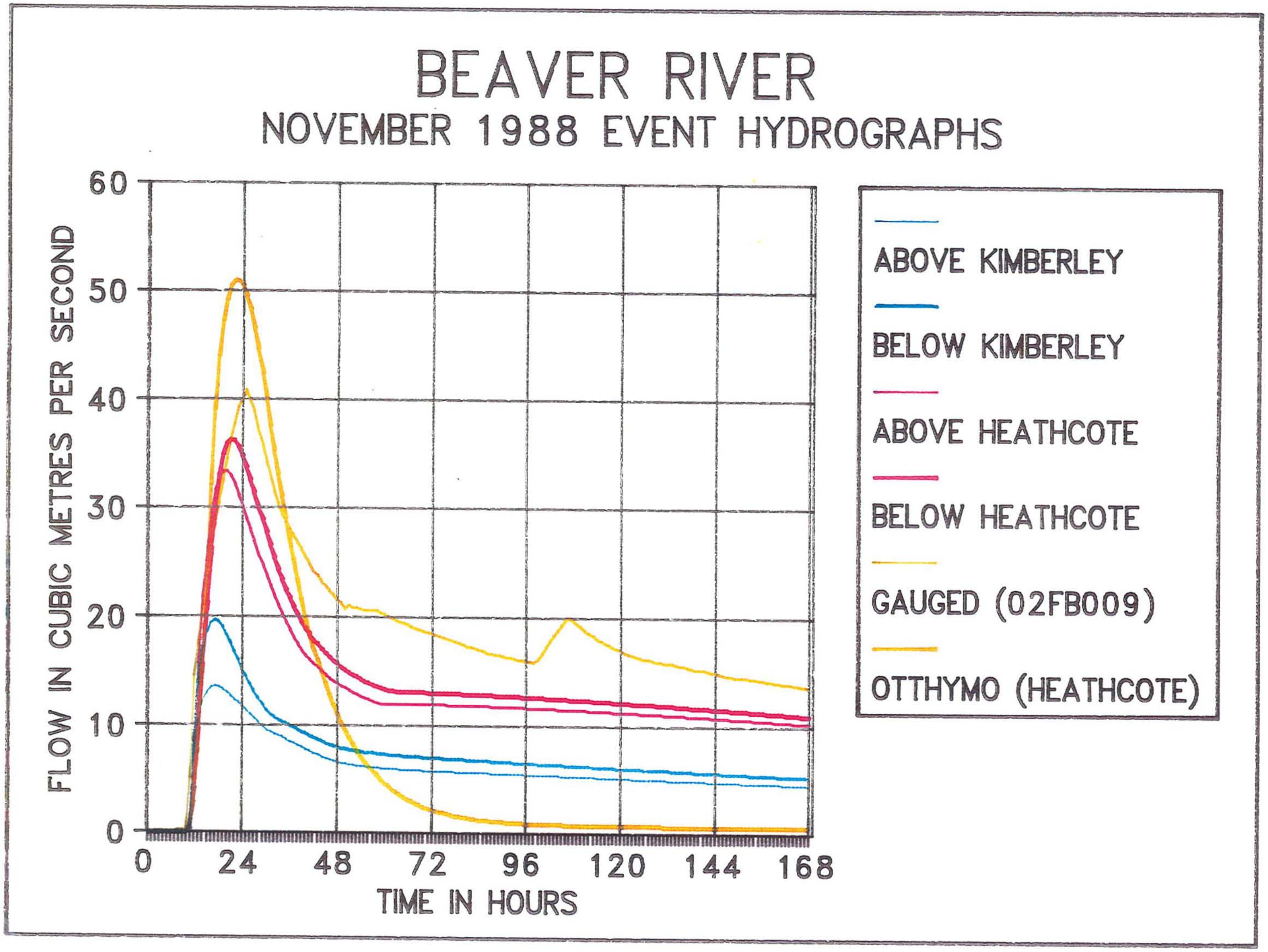
RAINFALL EVENTS FOR MODEL CALIBRATION

AND VERIFICATION

Event	Date	Depth of Rainfall (mm) 12 hr	Measured Peak Flows At Sta 02FB009 (m^3/s)
1	Sept. 10, 1986	70.	70.7
2	Nov. 9, 1988	35.0	40.9



September 1986 Event Simulation



November 1988 Event Simulation

3.4

3.3.4 Computed Design Flood Hydrographs: Deterministic Model

Calibration of the model to measured rainfall/runoff events allowed for the prediction of realistic peak flows for the Timmins and 1:100 year storm events through deterministic analysis. Results of the simulation for the Timmins event are given in the detailed output in Appendix J. Figure 3.6 describes the 1:100 year, 12 hour duration hydrograph from the model. Rainfall depth of the 1:100 year event (88 mm) was developed from Intensity-Duration-Frequency curves associated with the Mount Forest AES and Owen Sound M.O.E. climatological stations. The total rainfall was distributed over a 12-hour period using the SCS II distribution (Section 3.3.2). The peak flows generated by the model for the 1:100 year event and Timmins storm are presented in Table No. 3.6.

3.4 <u>Summary and Conclusions of Hydrologic Analysis</u>

Primary estimates of peak flow were determined from a Single Station Analysis using the Consolidated Frequency Analysis computer program (Section 3.2.2). The flows are summarized in Table 3.6. It was concluded that peak flows estimated by the Three Parameter Log Normal Frequency Analysis including and Expected Probability Adjustment were the most realistic for the study area.

Secondary estimates were undertaken using two Regional frequency techniques, namely, the Index Method and the Regression Method. The Index Method consists of calculating an index flood (2 year return period) which is then combined with a regional dimensionless frequency curve (Section 3.2.3a). The results of the Index Flood Method are summarized in Table 3.6.

The regression equation for the study area (Region C) is described in Section 3.2.3.b. All of the watershed parameters which are

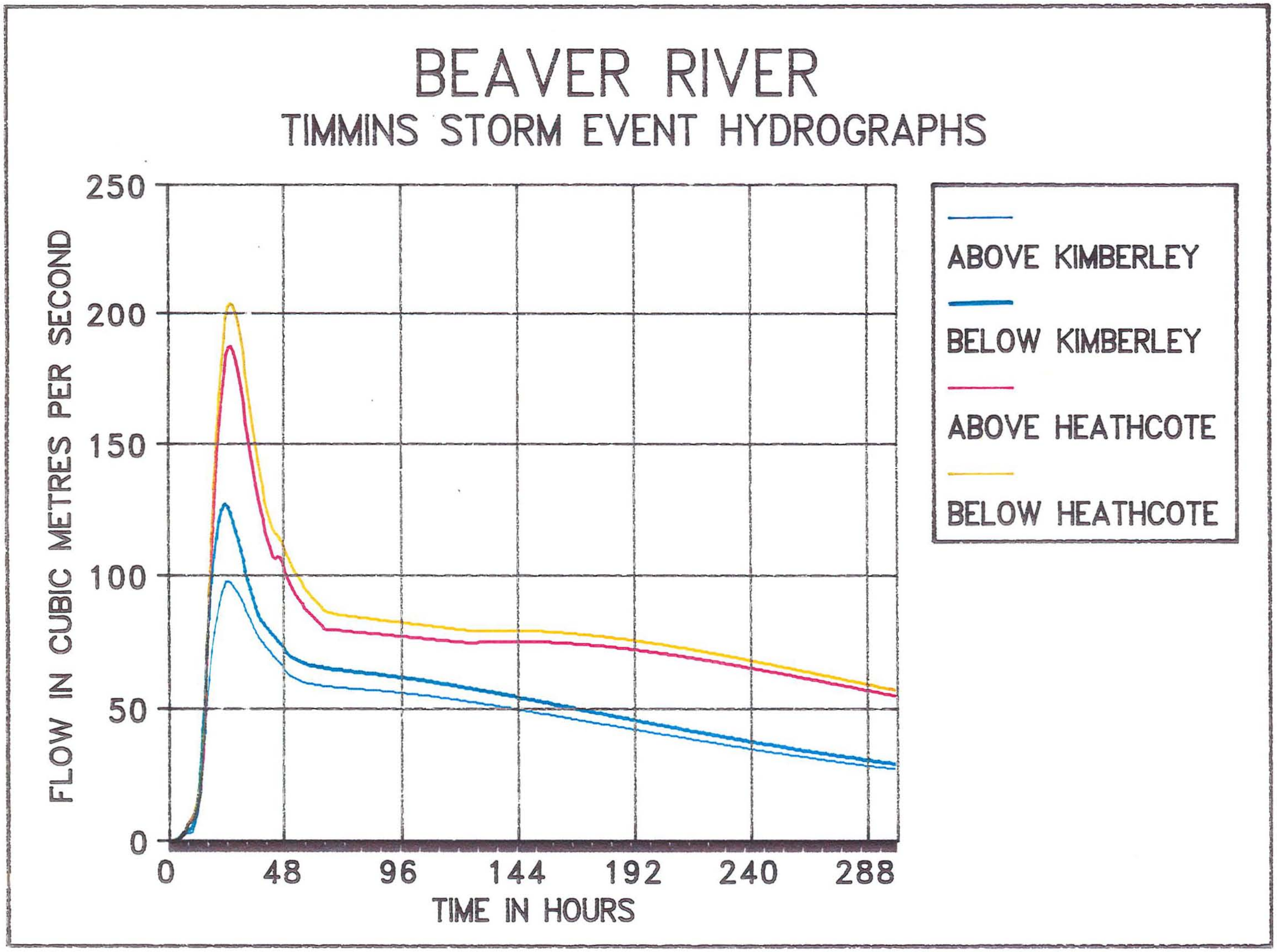
TABLE 3.6

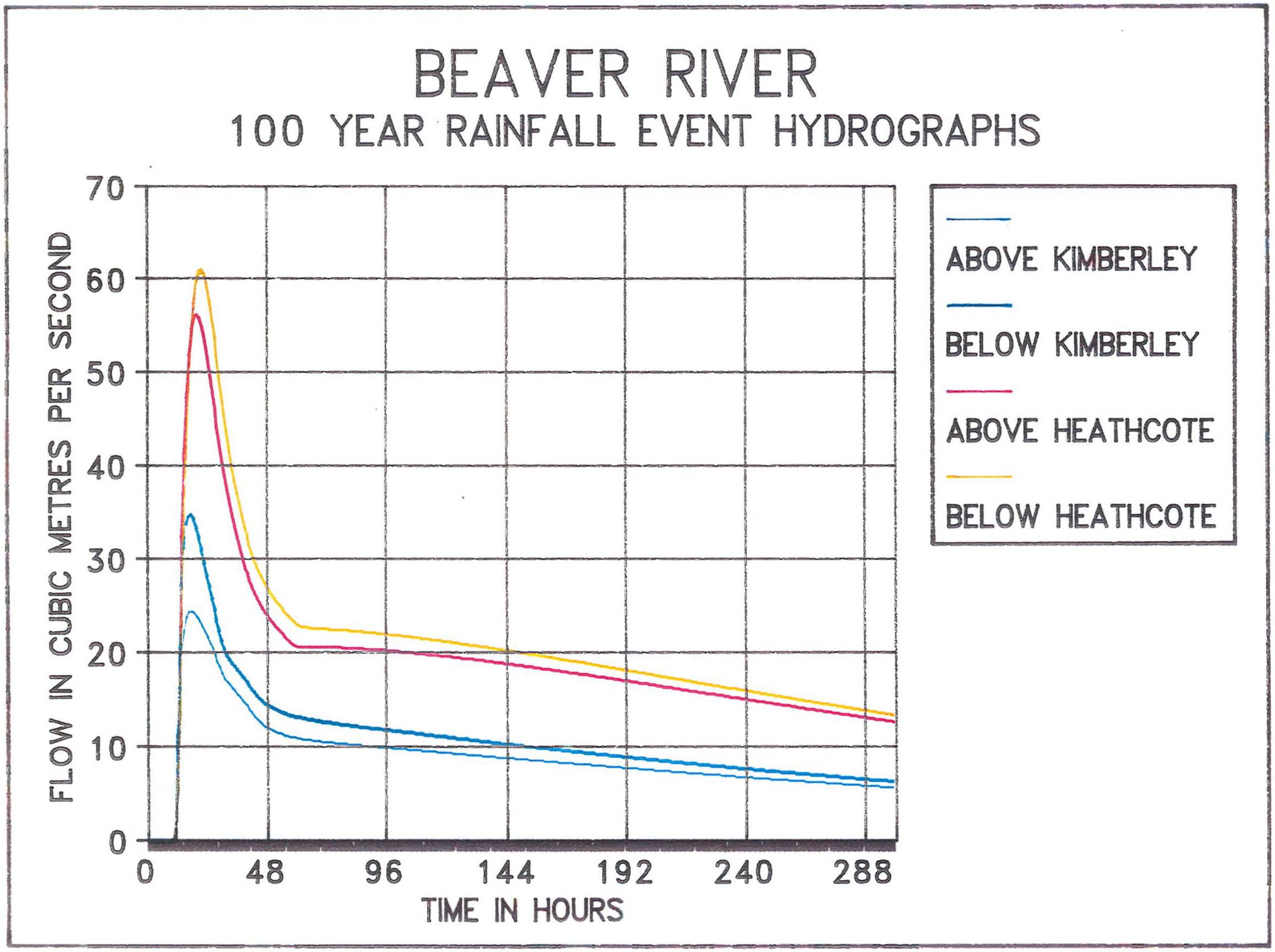
SUMMARY OF INSTANTANEOUS PEAK FLOWS (m^3/s)

Return Period (years)	Single Station Analysis 3PLN*		Regional Frequency Analysis Index Flood Method/Regression Equation				Deter-ministic Model above Kimberley	Deter - ministic Model above Heathcote
	Above Kimberley	above Heathcote	above Kimberley	above Heathcote	above Kimberley	above Heathcote		
2	(21.8) 40.2	47.0	47.2	56.7	94.4	112.1	N/A	N/A
5	(28.3) 49.8	58.3	58.0	69.7	143.3	168.1	N/A	N/A
10	(32.2) 55.2	64.6	70.3	85.1	177.0	206.5	N/A	N/A
20	(35.7) 59.8	70.0	80.2	96.4	210.3	244.3	N/A	N/A
50	(40.0) 65.2	76.4	97.2	116.8	243.0	271.7	N/A	N/A
100	(43.1) 69.0	80.8	108.6	130.4	277.2	308.8	24.3	56.3
Timmins	(N/A) 97.3	N/A	N/A	N/A	N/A	N/A	97.3	192.6

* Three-parameter Log-normal Distribution

Note: Kimberley data based upon 02FB003 (16 years of record) is presented in (brackets).


BEAVER RIVER
TIMMINS STORM EVENT HYDROGRAPHS
250
200
150
100
50
0
FLOW IN CUBIC METRES PER SECOND
0
48
96
144
192
240
288
TIME IN HOURS
ABOVE KIMBERLEY
BELOW KIMBERLEY
ABOVE HEATHCOTE
BELOW HEATHCOTE



One Hundred Year Event Simulation | 3.6

summarized in Table I.1 for Station 02FB009 were found to fall within the range of applicability of the regional equation. Results of the frequency analysis using the regression equation are summarized in Table 3.6.

The rainfall/runoff process for the Timmins and 100 year storms was simulated using HYDRO-PAK which is a deterministic single-event model used to determine the volume and peak flow of surface runoff (Section 3.3.1). Rainfall depths for the 100 year storm were obtained from Intensity-Duration-Frequency curves produced for the Mount Forest AES and Owen Sound M.O.E. The Timmins storm is well documented in the Floodplain Management in Ontario Technical Guidelines (Ontario Ministry of Natural Resources, 1984) (Section 3.3.2). Watershed parameters for each sub-basin were derived from field surveys, available mapping and previous reports on the Beaver River watershed. ARS 3-Parameter equations were used to develop values for K and tp.

Having derived all the necessary watershed parameters, the HYDRO-PAK moodel was then calibrated to two significant flow events recorded at Station 02FB009. The selection of the ARS 3-Parameter equations for tp, K and B values was based on modelling experience on regional watersheds of the model and the similarity between the uncalibrated hydrographs and the measured hydrographs for the two equations. Calibration of the unit hydrograph parameters led to better agreement between the simulated and measured hydrographs. However, maintaining B values above .10, which is the recommended average for the study area, presented some limitations as to how much the parameters could be adjusted. The calibrated values are summarized in Table J.3.

The peak flows for the 100 Year, 12 hour duration and Timmins events above Kimberley generated by the calibrated models are 24.3 and 72.5 m^3/s respectively. The peak flows for the 100 Year, 12 hour duration and Timmins events above Heathcote are 98 and 255 m^3/s respectively. The 100 year 12 hour duration event simulation produced a lower peak flow for Kimberley than the frequency.

It is apparent from Table 3.6 that the 100 year simulated flood flow above Heathcote is not comparable with the 100 year flood flow predicted by statistical methods. It is not reasonable to use the simulated values for the 100 year 12 hour duration flows on the Beaver River. The Beaver River watershed is not a natural runoff watershed. The Lake Eugenia control structure regulates flows from a 193 square kilometre portion of the watershed. This is to say that 65 percent of the watershed above Kimberley is regulated by a structure that can reduce the regional design flow above the control structure to 20% of the natural runoff peak flow. Watersheds with such large portions of controlled runoff do not produce reliable frequency analyses. Only 35 percent of the area above Heathcote is regulated by the Eugenia Lake structure and as a result, the frequency analyses are more reliable and produce a better fit for the larger watershed area.

Table 3.7 presents the recommended Project Area design flows to be used in the development of the floodplain mapping for the two project areas. The design flows used for Kimberley reflect the substitution of an unregulated watershed for the currently regulated runoff pattern associated with the drainage basin above Kimberley.

The values in this table reflect the use of the statistical values generated by the records from station 02FB009 prorated to the drainage area above the point of interest by using the equation.

$Q_1/Q_2 = (A^1/A^2)^{.75}$.

The values produced by this method give close agreement with the flood index method in the lower frequency ranges only, and the values associated with the Regional Frequency Regression equations do not exhibit any close relationship to other developed methods. This is largely due to the significant difference between the Beaver River Watershed and other drainage basins in Region C of Ontario.

TABLE 3.7

PROJECT AREA DESIGN FLOWS

EVENT	ABOVE KIMBERLEY	BELOW KIMBERLEY	ABOVE HEATHCOTE	BELOW HEATHCOTE	GAUGE 02FB009
2 Year	40.2	47.0	55.1	56.8	57.4
5 year	49.8	58.3	68.2	70.4	71.1
10 Year	55.2	64.6	75.6	78.0	78.8
20 Year	59.8	70.0	82.0	84.5	85.4
50 Year	65.2	76.4	89.5	92.3	93.2
100 Year	69.0	80.8	94.6	97.6	98.6
Timmins Storm	97.3	127.3	187	204	N/A
Drainage Area	352.9	441.9	545	563	572
Adjustment Factor	.70	.82	.96	.99	N/A

4.0 HYDRAULIC ANALYSES

4.1 Methodology

4.1.1 General Overview

The main purpose of the hydraulic analysis was to transform peak discharge estimates into flood profiles along the study reaches. This was undertaken by utilizing a mathematical model to simulate water surface profiles corresponding to the 2, 5, 10, 20, 50, 100 year and Regional (Timmins) flood events.

A backwater model was developed to simulate the existing hydraulic characteristics of the channel and floodplain as interpreted from 1:2000 scale mapping and from the results of field topographic and reconnaissance surveys. These surveys are discussed in Section 4.2. The backwater model was calibrated using measured water levels and peak discharge collected as part of these investigations. The model calibration is discussed in Section 4.3.

The flood profiles associated with the 2, 5, 10, 20, 50, 100 year and Regional peak discharge rates were then established based on the calibrated model, and the higher of the 100 year and Regional floodlines plotted on the 1:2000 scale mapping. The flood profiles are discussed in Section 4.4.

In order to define the degree of sensitivity of simulated flood profiles to variations in the hydraulic model input parameters, sensitivity testing was undertaken. This aspect is discussed in Section 4.5.

4.1.2 Model Description

In order to estimate the flood levels associated with each of the required flood peaks, a mathematical backwater model was applied to simulate the hydraulic characteristics along the Beaver River.

The effects of channel and floodplain storage on flood profiles along the study reach were generally not considered to be significant due to the comparatively large volume of the flood hydrograph. In cases where the effects of storage are not significant, it is a standard practice to assume steady state flow conditions in the computation of the backwater profiles.

Where a steady state backwater computation is employed, the appropriate peak discharge input to the model is the instantaneous peak of the flood hydrograph.

In the case of gradually varied steady flow, the equations of continuity and momentum describing the one-dimensional flow can be simplified to the form of the well-known Bernoulli equation:

$$\frac{\partial h}{\partial x} = (S_o - S_f) \quad / \quad (1 - v^2/gh) \qquad (4.1)$$

where h = depth of flow (m)
x = distance in direction of flow (m)
S_o = bottom slope (m/m)
S_f = boundary frictional effect (m/m)
v = velocity in direction of flow (m/s)
g = acceleration due to gravity (m/s^2)

For natural channels, energy losses occur due to flow resistance. The resulting friction slope can be determined from the Manning's equation:

$$S_f = \quad (nv/R^{2/3})^2 \qquad (4.2)$$

where n = Manning's roughness coefficient
R = hydraulic radius

The HEC-2 model (USCE, May 1991) has been successfully used in many similar practical applications. Therefore, this model was selected since it is a well proven and well documented nonproprietary technique which is flexible to use. The model can be applied in the future to evaluate the effects of recommended hydraulic improvements and any proposed channelization or filling along the study reach.

The program calculates water surface profiles for flow in natural or manmade channels, assuming that such flow is steady and gradually varied. The simplified one-dimensional equations of continuity and motion are solved using the standard step method with energy losses due to friction evaluated by the Manning's equation.

In addition, the model can calculate critical depth at each cross-section and can compute profiles for supercritical flow, where required. Backwater profiles can be run for subcritical flow conditions by specifying a starting water level at the downstream end of a stream reach being simulated. For supercritical flow conditions flood profiles can be computed by starting the computation at a known water level at the upstream end of a given study reach.

The model can take into account the following factors:

1) Channel roughness
2) Floodplain roughness
3) Islands or flow divisions
4) Bends in the stream or floodplain
5) Cross-sectional area of the stream channel and floodplain
6) Slope of the channel and floodplain
7) Energy losses at hydraulic structures, including bridges, culverts, weirs, dams, etc.
8) Channel and floodplain expansion and contraction losses
9) Variation in discharge along the study reach (i.e. due to tributary inflows.)

The model requires input of channel and floodplain cross-sections and associated hydraulic parameters at frequent locations along the study reach. The cross-sections are normally located where changes occur in slope, cross-sectional area or channel roughness, and at bridges or other hydraulic impediments to the flow.

A major advantage of the HEC-2 model is that the channel and flood-plain roughness (Manning's 'n') can be varied for each cross-section in the program. This provides a means of describing the various local factors on which the roughness coefficient depends such as channel composition, type and extent of vegetation, etc.

Energy losses created at hydraulic structures, such as bridges and culverts, are computed in the program in two parts. First the energy losses due to expansion and contraction of the flow at the cross-section on the upstream and downstream sides of the structure are calculated, and second, the energy loss through the structure itself is computed by either using the special bridge or the normal bridge sub-routine in the HEC-2 model. Energy losses due to expansion and contraction of flow are calculated by employing expansion and contraction coefficients which are multiplied by the absolute difference in velocity heads between cross-sections to estimate the energy loss caused by the transition.

When the normal bridge subroutine is used the water level is computed at the bridge or culvert section in the same manner as normal river cross-sections, but excluding the cross-sectional area of any existing piers, deck or wingwalls below the water surface. When the water surface elevation exceeds the bottom chord, the wetted perimeter of the section is also adjusted. The special bridge routine computes losses through the structure for low flow or for any combination of weir flow and pressure flow.

The Beaver River was modelled in two reaches. The Heathcote project area was modelled from a point 1320 metres downstream of the Grey County Road No. 13 to a point 3900 metres upstream of this starting location.

The Kimberley project area was modelled from a point 1720 metres downstream of the Grey County Road No. 13 to a point 3200 metres upstream of this starting location.

The specific characteristics of the channel and floodplain modelled are discussed in detail later in this report.

4.2 Hydraulic Model and Input Data

4.2.1 Field Survey

Cross-section data was by and large supplied by the mapping contractor as part of the photogrametic plan preparation. The river channel portions of the prepared cross-sections were provided by field survey information. Specific additional information relating to bridge structures and their associated cross sections were provided by field survey information.

All topographic information collected during the field surveys was related to geodetic elevation and where possible, all sections were located by means of reference to recognizable land marks located near the floodplain.

Floodplain and channel roughness coefficients were also assessed utilizing standard procedures developed by Chow (see Section 2.0) and by the U.S. Dept. of Transportation (U.S. Dept. Transportation, 1984) for confirmation of the original estimates.

i) Cross-sections

There were a total of 36 cross-sections in the Heathcote model including 13 tributary cross-sections. The mapping contractor provided 21 cross sections and the remaining cross sections were developed from the 1:2000 scale base mapping and field surveys. The locations of all cross-sections are indicated on the flood risk maps.

There were a total of 36 cross-section in the Kimberley model including 8 tributary cross sections. The mapping contractor provided 27 cross sections and the remaining cross sections were developed from the 1:2000 scale base mapping and field surveys. The location of all of the Kimberley project area cross sections are depicted on the Kimberley area flood risk maps.

By means of a comparison of field surveys to the 1:2000 scale topographic mapping, it was evident that the elevations denoted on the mapping and determined from the surveys were, similar along the study reach. Therefore, it was decided that the mapping could be used to supplement the field surveys where necessary.

A more detailed discussion of the physical characteristics of the stream channels and floodplain can be found in Section 4.2.2 of this report.

4.2.2 Channel and Floodplain Characteristics

The channel and floodplain characteristics of the study reach were identified by means of field reconnaissance surveys, and interpretation of the available mapping and background information. Much of the entire study area has homes or cottages along the banks of the river.

Manning's roughness coefficients were determined based on relative cover, type and amount of vegetation, channel configuration and natural physical constraints relative to the channel and overbank reaches along the watercourse. Typical roughness coefficients were then determined based on field observations of channel and overbank characteristics, experience in conducting similar investigations, and with reference to the classification techniques developed by Chow (Chow, 1959) and the U.S, Department of Transportation (U.S. Dept. Transportation, 1984). Table 2.1 summarizes the typical values. However, previous investigations have shown that significant differences between simulated and observed water levels may result from using published 'n' values. Therefore, it is not unusual to find calibrated values falling outside the typical range. A summary of calibrated Manning's roughness coefficients determined for the various reaches within the study area is given in Table 4.1-a and 4.1-b.

TABLE 4.1-a

SUMMARY OF CALIBRATED ROUGHNESS COEFFICIENTS FOR HEATHCOTE

Cross-Section	Left Overbank	Right Overbank	Channel
1	.075 DB	.075 DB	.045 Sc
2	.065 HB	.075 DB	.045 Sc
3	.065 HB	.075 DB	.045 Sc
4	.065 HB	.075 DB	.045 Sc
5	.065 HB	.060 B	.045 Sc
5.5	.060 B	.065 HB	.045 Sc
6	.060 B	.065 HB	.045 Sc
7	.060 B	.065 HB	.045 Sc
8	.060 B	.065 HB	.045 Sc
9	.060 B	.065 HB	.035 CC
9.1	.060 B	.065 HB	.035 CC
10	.055 LG	.055 LG	.035 CC
10.1	.060 B	.065 HB	.045 Sc
10.2	.060 B	.065 HB	.045 Sc
11	.060 B	.065 HB	.045 Sc
12	.060 B	.065 HB	.045 Sc
13	.065 HB	.065 HB	.045 Sc
14	.065 HB	.070 DB	.045 Sc
15	.075 DB	.070 DB	.045 Sc
16	.065 HB	.070 DB	.045 Sc
17	.070 DB	.070 DB	.045 Sc
18	.075 DB	.065 HB	.045 Sc

LEGEND: Left-Right Overbank Channel

Left-Right Overbank	Channel
HDB - Heavy dense bush	CC - Clean channel
DB - Dense wooded area	Sc - Stony channel
B - Brush	Bc - Braided channel
LG - Long grass and weeds	SSC - Smaller stones

TABLE 4.1-b

SUMMARY OF CALIBRATED ROUGHNESS COEFFICIENTS FOR KIMBERLEY

Cross-Section	Left Overbank	Right Overbank	Channel
1	.080 HDB	.075 DB	.040 SSC
2	.080 HDB	.080	.040 SSC
3	.080 HDB	.075 DB	.040 SSC
4	.080 HDB	.075 DB	.040 SSC
5	.075 DB	.070 DB	.040 SSC
6	.075 DB	.065 HB	.040 SSC
7	.075 DB	.075 DB	.065 BC
8	.070 DB	.070 DB	.045 Sc
9	.075 DB	.080	.045 Sc
10	.075 DB	.080	.045 Sc
11	.070 DB	.065 HB	.045 Sc
12.1	.070 DB	.065 HB	.035 CC
12.2	.060 B	.065 HB	.035 CC
12.3	.065 HB	.065 HB	.045 Sc
13	.075 DB	.075 DB	.045 Sc
14	.065 HB	.070 DB	.045 Sc
15	.060 B	.065 HB	.045 Sc
16	.060 B	.060 B	.040 SSC
16.1	.060 B	.060 B	.040 SSC
17	.060 B	.075 DB	.040 SSC
18	.065 HB	.075 DB	.040 SSC
19	.065 HB	.070 DB	.040 SSC
20	.065 HB	.070 DB	.040 SSC
21	.075 DB	.075 DB	.040 SSC
22	.065 HB	.080	.040 SSC
23	.060 B	.075 DB	.040 SSC
24	.060 B	.070 DB	.040 SSC
25	.060 B	.075 DB	.040 SSC
26	.060 B	.070 DB	.040 SSC

LEGEND: Left-Right Overbank Channel

HDB - Heavy dense bush
DB - Dense wooded area
B - Brush
LG - Long grass and weeds

CC - Clean channel
Sc - Stony channel
Bc - Braided channel
SSC - Smaller stones

4.2.3 Hydraulic Model Application

In order to simulate the flood levels associated with the 2, 5, 10, 20, 50, 100 year and Regional peak flows, the available background and field data were input to the HEC-2 program.

With respect to input of available data, the following criteria are generally established in order to define cross-section locations and characteristics.

i) All sections are coded as if looking downstream along the watercourse.

ii) Field measured cross-sections used in the hydraulic model are referenced to the supplementary field report according to the sequential numbering system developed during the field surveys.

iii) In some cases, the field measured cross-sections were used more than once as typical cross-sections along particular reaches. This is to facilitate the accurate coding of bridges as described in the HEC2 program documentation (USCE, May 1991).

Head losses through the hydraulic structures are simulated using the special bridge method, as described in the HEC-2 Users Manual (USCE, May 1991). This option allows a combination of pressure and weir flow to be modelled.

Boundary conditions and other model input parameters were determined as follows:

i) All computations are initially undertaken assuming a condition of free flow. That is, the hydraulic structures are considered to be free from any temporary obstructions which would reduce their effective discharge capacity during the passing of peak storm flows.

ii) The hydraulic coefficients are derived as previously outlined in Section 4.2.2 and subsequently applied in the sensitivity analysis as discussed in Section 4.5.

Rapidly varying consecutive sections, bridge entrances and outlets, floodplain structures, etc. were accounted in the choice of expansion and contraction coefficients, following recommended values found in the HEC-2 manual (USCE, May 1991). The general criteria for determining these coefficients are summarized in Table 4.2, together with typical values.

4.3 Model Calibration

4.3.1 General

In order to accurately reflect the potential flood conditions along the Beaver River, the HEC-2 model was calibrated and verified using field measured high water levels collected as part of the field survey program conducted in 1995. The observed water levels were utilized in conjunction with corresponding discharges in order to refine the backwater model parameters determined during the field reconnaissance phase of the study.

The general procedures for calibration of the HEC-2 model are summarized in the following section.

4.3.2 Methodology

The HEC-2 model calibration was undertaken by modifying the channel and floodplain roughness coefficients (Manning's "n") and other hydraulic parameters (e.g. expansion and contraction coefficients, see table 4.2) until acceptable simulation accuracy was achieved. The Manning's roughness coefficient is the most sensitive parameter with respect to calibration of water levels on the Beaver River.

TABLE 4.2

Summary of Expansion

and Contraction Coefficients *

Parameter	Range of Typical Values
Expansion Coefficient:	
i) Gradually varying sections	0.3
ii) Rapidly varying sections and hydraulic constraints	0.5
iii) Abrupt variations between sections and severe hydraulic constraints	0.6 - 1.0
Contraction Coefficients:	
i) Gradually varying sections	0.1
ii) Rapidly varying sections and hydraulic constraints	0.3
iii) Abrupt variations between sections and severe hydraulic constraints	0.5 - 0.8

NOTE: Source (USCE, May 1991)

Water level measurements collected by field personnel during the study period at predetermined locations along the river were used to calibrate the HEC2 model.

Discharge data corresponding to the water level measurements was obtained from Water Survey of Canada gauging station 02FB009.

The sensitive hydraulic model parameters were identified and adjusted, as required, until a suitable comparison between measured and computed water levels at the gauge locations was achieved.

4.3.3 Model Calibration Summary

The following summarized the calibration results:

1) The initial uncalibrated backwater model utilized the hydraulic parameters as determined from the field reconnaissance surveys of the study area. Starting water surface elevations were taken by preparing a model run which used a critical depth start option and contained additional starting cross-sections developed from cross-section number 1.0. The developed water surface elevations for cross-section number 2.0 were input to the final model as starting water surface elevations for each applied flow value.

2) It was found that use of Manning's roughness coefficients, as determined initially during the field reconnaissance survey, resulted in water levels slightly lower on average than those recorded during the field survey. To calibrate the model an increase in roughness values was required. Table 4.1-a and 4.1-b summarizes the calibrated n values for each project area.

TABLE 4.3-a
SUMMARY OF BACKWATER MODEL CALIBRATION
HEATHCOTE PROJECT AREA

Section No.	Flow cms	Water Level	Energy Level	Observed Water Level and Location of OBs.
2.00	11.00 12.00	225.61 225.65	225.64 225.68	225.51 @ 100 metres downstream of 2.00
3.00	11.00 12.00	225.93 225.97	225.96 226.00	
5.00	11.00 12.00	226.68 226.72	226.74 226.77	226.63 @ 30 metres downstream of 5.00
6.00	11.00 12.00	227.32 227.36	227.34 227.39	227.42 @ 70 metres upstream of 6.00
7.00	11.00 12.00	227.50 227.56	227.50 227.56	
8.00	11.00 12.00	227.53 227.59	227.53 227.59	
9.00	11.00 12.00	227.53 227.59	227.53 227.59	
10.20	11.00 12.00	227.55 227.61	227.56 227.62	227.56 @ 100 metres downstream of 11.00
11.00	11.00 12.00	227.60 227.66	227.61 227.67	
13.00	11.00 12.00	227.82 227.89	227.83 227.90	227.82 @ sec. 13.00
18.00	11.00 12.00	228.08 228.16	228.09 228.17	228.25 @ 160 metres upstream of 18.00

Note: Observed flow at 02FB009 was 11.9 cms Nov. 26 1995 at time of survey.

TABLE 4.3-b

SUMMARY OF BACKWATER MODEL CALIBRATION

KIMBERLEY PROJECT AREA

Section No.	Flow cms	Water Level	Energy Level	Observed Water Level and Location of OBs.
2.00	5.00 6.00 11.00	231.14 231.14 231.15	231.14 231.14 231.16	231.16 @ sec. 2.00
3.00	5.00 6.00 11.00	231.14 231.14 231.17	231.14 231.14 231.17	231.18 @ 25 metres upstream of 3.00
5.00	5.00 6.00 11.00	231.15 231.15 231.20	231.15 231.15 231.20	231.23 @ 60 metres upstream of 5.0
6.00	5.00 6.00 11.00	231.16 231.18 231.26	231.17 231.18 231.27	
7.00	5.00 6.00 11.00	231.45 231.48 231.59	231.52 231.54 231.62	231.96 @35 metres upstream of 7.00
10.00	5.00 6.00 11.00	233.21 233.23 233.27	233.25 233.28 233.41	233.24 @ sec. 10.00 (west channel)
12.30	5.00 6.00 11.00	234.28 234.31 234.43	234.28 234.31 234.43	234.28 @ sec. 12.30 (south channel)
17.00	5.00 6.00 11.00	235.06 235.11 235.27	235.08 235.12 235.28	235.61 upstream of sec.17.00 (west channel)
18.00	5.00 6.00 11.00	235.64 235.64 235.69	235.68 235.70 235.82	
21.00	5.00 6.00 11.00	237.40 237.57 237.89	237.48 237.65 237.91	237.58 @ sec. 21.00 (west channel)

Note: Observed flow at 02FB009 was 11.9 cms Nov. 26 1995 at time of survey.

3) The calibrated model yielded water levels averaging within ±0.02 m of the recorded water levels.

Table 4.3-a and 4.3-b summarizes the results of the backwater model calibration on the Beaver River for the Heathcote and Kimberley project areas, respectively.

4.4 Design Flood Profiles

The main objective of this investigation was to determine flood profiles along the study reaches for floods with a recurrence interval of 2, 5, 10, 20, 50, 100 years and the Regional event. The Regulatory flood elevation at any location is the higher of the two simulations.

The following briefly outlines the main assumptions in the application of the calibrated model for the simulation of the flood profiles on the Beaver River:

1) The hydraulic coefficients used in the development of the 2, 5, 10, 20, 50, 100 year and Regional event flood profiles were those as calibrated.

2) All bridges and hydraulic constraints were assumed free of any temporary obstruction which may reduce the hydraulic discharge capacity.

3) Peak flows summarized in Table 3.6 were used in determining the 2, 5, 10, 20, 50, 100 year and Regional event flood profiles.

Water elevations corresponding to the Timmins and 100 year discharges are summarized in Tables 4.4-a and 4.4-b of this report. (Tables 4.4-a and 4.4-b is derived from the summary tables at the end of Attachment L.1.)

The extent of the flooded areas associated with the Regulatory flood profile was determined by plotting the floodline on topographic maps at a scale of 1:2000. Interpretation of the backwater profiles and associated computer output, together with an assessment of the extent of flooded areas was undertaken in order to identify flood hazard locations and dead water areas.

4.5 Sensitivity Testing on Design Flood Profiles

4.5.1 Methodology

In order to assess variations in the magnitude of various input parameters on flood profiles along the study reaches, various sensitivity simulations were undertaken.

Based on a review of the initial model simulation, the field reconnaissance survey, and on previous results of backwater modelling on similar watercourses in Ontario the following parameters were determined to be of most importance with respect to definition of flood levels in the study area:

- peak discharge rates along the watercourse
- definition of channel and floodplain roughness coefficients (Manning's 'n')
- the influence of initial water level variations

During the sensitivity testing, the relative importance of model variables was determined by changing one variable within prescribed limits while holding the remaining variables and input parameters constant during a simulation. By noting the change in magnitude of computed water levels, the relative importance and sensitivity of each parameter was established. All sensitivity analyses were undertaken utilizing the calibrated model and the existing condition mean annual, 100 year and Regional flows developed as part of these investigations.

4.5.2 Sensitivity to Peak Discharge

Sensitivity simulations to peak discharge were conducted utilizing variations in the computed Regional, 100 year and mean annual peak discharges.

As expected, the peak discharge had some effect on variation of water levels. The impact of increased flows on the water levels is more prominent where channel sections are relatively narrow. Tables 4.5-a and 4.5-b summarize the results of the sensitivity tests for variations in flows. The 4.5-a series tables refer to the Heathcote project area while the 4.5-b series tables refer to the Kimberley project area.

TABLE 4.4-a
HEATHCOTE PROJECT AREA
SUMMARY OF HYDRAULIC CALCULATIONS

Section Number	Q* m^3/s	Depth m	Water Elevation	Velocity m/s
2	56.8 97.6 203.6	2.18 2.57 3.32	226.84 227.23 227.98	0.98 1.18 1.50
3	56.8 97.6 203.6	1.99 2.39 3.15	227.00 227.40 228.16	0.82 0.89 1.04
4	56.8 97.6 203.6	1.77 2.14 2.89	227.15 227.52 228.27	1.15 1.42 1.46
4.5	56.8 97.6 203.6	1.48 1.87 2.56	227.33 227.72 228.41	1.11 1.10 1.18
5	56.8 97.6 203.6	1.49 1.83 2.43	227.43 227.77 228.37	2.23 2.50 2.55
5.5	56.8 97.6 203.6	1.96 2.39 2.95	227.91 228.34 228.90	1.00 1.08 1.37
6	56.8 97.6 203.6	1.75 2.13 2.72	228.26 228.64 229.23	1.19 1.50 2.04
7	55.1 94.6 186.8	1.97 2.39 3.04	228.40 228.82 229.47	0.31 0.35 0.44
8	55.1 94.6 186.8	2.56 2.97 3.62	228.45 228.86 229.51	0.67 0.93 1.29
9	55.1 94.6 186.8	2.67 3.09 3.76	228.46 228.88 229.55	0.66 0.97 1.74
9.1	55.1 94.6 186.8	2.66 3.08 3.78	228.46 228.88 229.58	0.66 0.97 1.74
10	55.1 94.6 186.8	2.66 3.10 3.91	228.46 228.90 229.71	0.65 0.91 1.20
10.1	55.1 94.6 186.8	2.67 3.13 3.97	228.48 228.94 229.78	0.88 1.04 1.13
10.2	55.1 94.6 186.8	2.71 3.17 4.01	228.53 228.99 229.83	0.68 0.83 0.92

TABLE 4.4-a
HEATHCOTE PROJECT AREA
SUMMARY OF HYDRAULIC CALCULATIONS

Section Number	Q* m^3/s	Depth m	Water Elevation	Velocity m/s
11	55.1	2.77	228.67	0.79
	94.6	3.23	229.13	0.73
	186.8	4.04	229.94	0.67
12	55.1	2.88	228.90	0.80
	94.6	3.27	229.29	0.75
	186.8	4.02	230.04	0.67
13	55.1	3.08	229.05	0.64
	94.6	3.44	229.41	0.66
	186.8	4.14	230.11	0.65
14	55.1	3.02	229.10	0.45
	94.6	3.38	229.46	0.54
	186.8	4.07	230.15	0.60
15	55.1	3.11	229.15	0.38
	94.6	3.48	229.52	0.43
	186.8	4.16	230.20	0.49
16	55.1	3.06	229.18	0.37
	94.6	3.42	229.54	0.45
	186.8	4.10	230.22	0.52
17	55.1	2.86	229.22	0.49
	94.6	3.22	229.58	0.51
	186.8	3.90	230.26	0.54
18	55.1	2.77	229.28	0.38
	94.6	3.13	229.64	0.40
	186.8	3.79	230.30	0.43

* Note: Flows presented in this table represent the 2 year, 100 year, and Timmins event peak flow rates respectively.

TABLE 4.4-b
KIMBERLEY PROJECT AREA
SUMMARY OF HYDRAULIC CALCULATIONS

Section Number	Q* m^3/s	Depth m	Water Elevation	Velocity m/s
2	47.0 80.8 127.3	1.87 2.10 2.31	231.37 231.60 231.81	0.95 1.12 1.25
3	47.0 80.8 127.3	2.18 2.41 2.63	231.47 231.70 231.92	0.64 0.77 0.90
4	47.0 80.8 127.3	2.08 2.33 2.56	231.52 231.77 232.00	0.80 0.98 1.12
5	47.0 80.8 127.3	1.90 2.16 2.40	231.60 231.86 232.10	0.64 0.71 0.80
6	47.0 80.8 127.3	1.25 1.50 1.75	231.68 231.93 232.18	0.61 0.62 0.69
7	47.0 80.8 127.3	0.84 1.06 1.29	231.89 232.11 232.34	0.98 0.94 0.88
8	47.0 80.8 127.3	1.08 1.28 1.47	232.28 232.48 232.67	0.64 0.79 0.91
9	47.0 80.8 127.3	1.14 1.35 1.54	232.54 232.75 232.94	0.57 0.62 0.71
10	47.0 80.8 127.3	1.29 1.33 1.30	233.88 233.92 233.89	0.27 0.45 0.73
11	47.0 80.8 127.3	0.94 1.03 1.15	233.93 234.02 234.14	0.84 1.20 1.56
12.1	47.0 80.8 127.3	1.07 1.22 1.38	234.00 234.15 234.31	1.70 2.43 3.20
12.2	47.0 80.8 127.3	1.17 1.44 1.95	234.10 234.37 234.88	1.48 1.92 1.76
12.3	47.0 80.8 127.3	1.31 1.67 2.10	234.29 234.65 235.08	0.91 0.77 0.61
13	47.0 80.8 127.3	1.11 1.23 1.42	234.97 235.09 235.28	1.46 1.86 1.78

TABLE 4.4-b
KIMBERLEY PROJECT AREA
SUMMARY OF HYDRAULIC CALCULATIONS

Section Number	Q* m^3/s	Depth m	Water Elevation	Velocity m/s
14	47.0 80.8 127.3	1.05 1.25 1.41	235.35 235.55 235.71	0.71 0.83 1.01
15	47.0 80.8 127.3	1.04 1.25 1.44	235.59 235.80 235.99	0.75 0.83 0.95
16	47.0 80.8 127.3	1.38 1.61 1.82	235.69 235.92 236.13	1.60 2.41 2.20
16.1	47.0 80.8 127.3	1.42 1.73 2.15	235.73 236.04 236.46	2.74 3.87 1.20
17	47.0 80.8 127.3	1.70 2.27 2.18	236.01 236.58 236.49	0.42 0.30 0.53
18	47.0 80.8 127.3	1.15 1.68 1.64	236.07 236.60 236.56	1.61 0.68 1.15
19	47.0 80.8 127.3	1.00 1.09 1.23	236.69 236.78 236.92	0.55 0.70 0.77
20	47.0 80.8 127.3	1.23 1.46 1.58	237.22 237.45 237.57	1.97 1.76 1.89
21	47.0 80.8 127.3	1.88 2.05 2.19	238.27 238.44 238.58	0.68 0.69 0.82
22	40.2 69.0 97.3	1.37 1.54 1.67	238.80 238.97 239.10	1.65 1.83 1.89
23	40.2 69.0 97.3	1.43 1.62 1.74	239.38 239.57 239.69	1.43 1.62 1.74
24	40.2 69.0 97.3	1.37 1.55 1.67	239.99 240.17 240.29	1.37 1.53 1.64
25	40.2 69.0 97.3	1.32 1.52 1.64	240.52 240.72 240.84	1.37 1.62 1.73
26	40.2 69.0 97.3	1.29 1.52 1.63	240.84 241.07 241.18	1.26 1.35 1.46

* Note: Flow presented in this table represent the 2 year, 100 year, and Timmins event peak flow rates respectively.

4.5.3 Summary of Results and Conclusions of Sensitivity Analysis

The results of the sensitivity testing are summarized in Tables 4.5-a and 4.5-b. The following points summarize the main findings and conclusions of the sensitivity analyses on computed flood profiles along the study watercourse.

1) The sensitivity of the flood profile along the watercourse to variation in peak discharge can be summarized by the following:
   - variation in peak flow is the most sensitive parameter with respect to flood levels
   - the impact of increased flows on the water levels is more noticeable where channel constrictions occur
   - results of the sensitivity tests for variation in peak discharge are summarized in Tables 4.5-a and 4.5-b.

4.6 Conclusions of Hydraulic Analysis

The HEC-2 backwater model was successfully utilized to determine flood profiles along the Beaver River using channel and floodplain characteristics determined from the field surveys.

The following conclusions were derived from the hydraulic analysis:

1) The flood profiles were more sensitive to variation in discharge and channel and floodplain roughness coefficients and less sensitive to starting water surface elevation.
2) Testing of the backwater model by comparison to observed flood levels has confirmed the accuracy of the flood level simulations for bank full capacity flows.
3) The results of the calibrated model agree well with the observed elevations and, for the purposes of this investigation, it is our opinion that the hydraulic model produces realistic water surface elevations through the study reach for the range of flows used.

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
2.00	87.84	2.26	226.92	227.00	0.52	1.40	0.01	17.31	70.53	0.00	0.04	13.19
2.00	92.72	2.30	226.96	227.04	0.54	1.42	0.01	19.27	73.45	0.00	0.04	13.88
2.00	97.60	2.34	227.00	227.08	0.56	1.44	0.01	21.36	76.24	0.00	0.04	14.57
2.00	102.48	2.38	227.04	227.12	0.58	1.46	0.13	23.33	79.13	0.02	0.04	15.18
2.00	107.36	2.41	227.07	227.16	0.60	1.48	0.14	25.33	82.00	0.03	0.04	15.79
3.00	87.84	2.18	227.19	227.22	0.41	1.01	0.32	29.39	51.87	6.58	0.09	29.43
3.00	92.72	2.22	227.23	227.26	0.42	1.02	0.33	31.90	53.59	7.23	0.09	30.87
3.00	97.60	2.26	227.27	227.30	0.43	1.03	0.34	34.38	55.35	7.87	0.09	32.30
3.00	102.48	2.29	227.30	227.34	0.44	1.04	0.35	36.91	57.01	8.56	0.09	33.63
3.00	107.36	2.33	227.34	227.38	0.45	1.05	0.36	39.46	58.65	9.25	0.09	34.95
4.00	87.84	1.99	227.37	227.46	0.59	1.45	0.00	16.89	70.95	0.00	0.12	45.73
4.00	92.72	2.03	227.41	227.50	0.61	1.48	0.00	18.55	74.17	0.00	0.12	47.88
4.00	97.60	2.07	227.45	227.54	0.63	1.52	0.00	20.23	77.37	0.00	0.12	49.97
4.00	102.48	2.10	227.48	227.58	0.65	1.54	0.00	21.97	80.51	0.00	0.12	52.01
4.00	107.36	2.14	227.52	227.62	0.66	1.57	0.00	23.77	83.59	0.00	0.12	54.04
4.50	87.84	1.75	227.60	227.64	0.40	1.15	0.49	35.33	50.75	1.76	0.16	56.16
4.50	92.72	1.79	227.64	227.68	0.41	1.15	0.49	38.75	52.07	1.90	0.16	58.81
4.50	97.60	1.83	227.68	227.72	0.42	1.16	0.50	42.17	53.40	2.03	0.16	61.39
4.50	102.48	1.86	227.71	227.76	0.43	1.16	0.51	45.63	54.68	2.17	0.16	63.92
4.50	107.36	1.90	227.75	227.79	0.44	1.16	0.51	49.10	55.95	2.31	0.15	66.45
5.00	87.84	1.75	227.69	228.02	0.77	2.54	0.00	0.76	87.08	0.00	0.17	62.59
5.00	92.72	1.77	227.71	228.05	0.83	2.61	0.00	0.89	91.83	0.00	0.17	65.56
5.00	97.60	1.78	227.72	228.09	0.87	2.68	0.00	1.01	96.59	0.00	0.16	68.44
5.00	102.48	1.84	227.78	228.12	0.92	2.58	0.00	1.36	101.12	0.00	0.16	71.37
5.00	107.36	1.87	227.81	228.15	0.96	2.60	0.00	1.56	105.80	0.00	0.16	74.23

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
5.50	87.84	2.32	228.27	228.30	0.42	1.04	0.41	40.37	46.49	0.98	0.21	72.13
5.50	92.72	2.36	228.31	228.34	0.43	1.06	0.42	43.76	47.92	1.04	0.21	75.48
5.50	97.60	2.39	228.34	228.38	0.44	1.07	0.42	47.18	49.32	1.10	0.21	78.73
5.50	102.48	2.42	228.37	228.41	0.45	1.10	0.43	50.28	51.03	1.16	0.20	82.09
5.50	107.36	2.45	228.40	228.44	0.46	1.11	0.44	53.67	52.47	1.22	0.20	85.31
6.00	87.84	2.05	228.56	228.66	1.04	1.43	0.32	14.96	70.00	2.88	0.26	100.63
6.00	92.72	2.09	228.60	228.70	1.06	1.46	0.34	15.72	73.54	3.46	0.26	105.20
6.00	97.60	2.13	228.64	228.74	1.08	1.50	0.36	16.48	77.04	4.08	0.26	109.63
6.00	102.48	2.16	228.67	228.78	1.11	1.53	0.37	17.24	80.54	4.71	0.26	113.84
6.00	107.36	2.20	228.71	228.82	1.13	1.57	0.39	17.98	83.97	5.40	0.26	118.12
7.00	85.14	2.30	228.73	228.74	0.05	0.34	0.00	0.06	85.08	0.00	0.39	124.89
7.00	89.87	2.35	228.78	228.78	0.06	0.35	0.04	0.11	89.75	0.00	0.38	130.44
7.00	94.60	2.39	228.82	228.82	0.06	0.35	0.04	0.17	94.42	0.01	0.38	135.84
7.00	99.33	2.43	228.86	228.86	0.07	0.36	0.05	0.25	99.06	0.02	0.37	140.96
7.00	104.06	2.46	228.89	228.90	0.08	0.36	0.06	0.34	103.70	0.02	0.37	146.17
8.00	85.14	2.89	228.78	228.82	0.00	0.87	0.00	0.00	85.14	0.00	0.44	156.59
8.00	89.87	2.93	228.82	228.86	0.00	0.90	0.00	0.00	89.87	0.00	0.44	163.26
8.00	94.60	2.97	228.86	228.90	0.00	0.93	0.00	0.00	94.60	0.00	0.43	169.76
8.00	99.33	3.01	228.90	228.95	0.00	0.95	0.00	0.00	99.33	0.00	0.43	175.96
8.00	104.06	3.05	228.94	228.99	0.00	0.98	0.00	0.00	104.06	0.00	0.42	182.23
9.00	85.14	3.00	228.79	228.83	0.00	0.90	0.00	0.00	85.14	0.00	0.45	159.48
9.00	89.87	3.05	228.84	228.88	0.00	0.93	0.00	0.00	89.87	0.00	0.45	166.21
9.00	94.60	3.09	228.88	228.92	0.00	0.97	0.00	0.00	94.60	0.00	0.44	172.76
9.00	99.33	3.13	228.92	228.97	0.00	1.00	0.00	0.00	99.33	0.00	0.44	179.01
9.00	104.06	3.17	228.96	229.01	0.00	1.04	0.00	0.00	104.06	0.00	0.43	185.32

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
9.10	85.14	3.00	228.80	228.84	0.00	0.90	0.00	0.00	85.14	0.00	0.46	160.62
9.10	89.87	3.04	228.84	228.88	0.00	0.93	0.00	0.00	89.87	0.00	0.45	167.36
9.10	94.60	3.08	228.88	228.93	0.00	0.97	0.00	0.00	94.60	0.00	0.44	173.93
9.10	99.33	3.12	228.92	228.97	0.00	1.00	0.00	0.00	99.33	0.00	0.44	180.19
9.10	104.06	3.16	228.96	229.02	0.00	1.04	0.00	0.00	104.06	0.00	0.43	186.52
10.00	85.14	3.01	228.81	228.85	0.00	0.85	0.00	0.00	85.14	0.00	0.46	162.57
10.00	89.87	3.05	228.85	228.89	0.00	0.88	0.00	0.00	89.87	0.00	0.46	169.35
10.00	94.60	3.10	228.90	228.94	0.00	0.91	0.00	0.00	94.60	0.00	0.45	175.95
10.00	99.33	3.14	228.94	228.98	0.00	0.94	0.00	0.00	99.33	0.00	0.44	182.24
10.00	104.06	3.18	228.98	229.03	0.00	0.97	0.00	0.00	104.06	0.00	0.44	188.60
10.10	85.14	3.04	228.85	228.88	0.25	1.00	0.35	2.98	57.17	24.99	0.50	173.06
10.10	89.87	3.08	228.89	228.93	0.26	1.02	0.36	3.40	59.20	27.27	0.49	180.19
10.10	94.60	3.13	228.94	228.98	0.27	1.04	0.37	3.85	61.16	29.59	0.48	187.14
10.10	99.33	3.18	228.99	229.02	0.28	1.05	0.38	4.33	63.07	31.93	0.47	193.78
10.10	104.06	3.22	229.03	229.07	0.29	1.07	0.40	4.88	64.87	34.31	0.47	200.49
10.20	85.14	3.08	228.90	228.92	0.35	0.80	0.22	4.34	63.21	17.58	0.53	187.06
10.20	89.87	3.13	228.95	228.97	0.36	0.82	0.23	4.67	65.54	19.66	0.53	194.87
10.20	94.60	3.17	228.99	229.02	0.37	0.83	0.24	5.00	67.77	21.82	0.52	202.52
10.20	99.33	3.22	229.04	229.07	0.37	0.84	0.24	5.33	69.74	24.26	0.51	209.86
10.20	104.06	3.27	229.09	229.11	0.38	0.85	0.25	5.65	71.57	26.83	0.51	217.26
11.00	85.14	3.14	229.04	229.06	0.25	0.74	0.00	38.63	46.51	0.00	0.72	256.04
11.00	89.87	3.19	229.09	229.10	0.26	0.73	0.00	42.66	47.21	0.00	0.72	267.82
11.00	94.60	3.24	229.14	229.15	0.26	0.73	0.00	46.70	47.90	0.00	0.72	279.43
11.00	99.33	3.28	229.18	229.20	0.27	0.72	0.00	50.72	48.61	0.00	0.71	290.63
11.00	104.06	3.33	229.23	229.24	0.28	0.72	0.00	54.74	49.32	0.00	0.71	301.85

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
12.00	85.14	3.19	229.21	229.23	0.00	0.76	0.23	0.00	41.85	43.29	0.96	351.95
12.00	89.87	3.23	229.25	229.27	0.00	0.75	0.24	0.00	42.26	47.61	0.96	369.68
12.00	94.60	3.28	229.30	229.31	0.00	0.75	0.24	0.00	42.81	51.79	0.96	386.87
12.00	99.33	3.32	229.34	229.35	0.00	0.74	0.25	0.00	43.19	56.14	0.96	403.82
12.00	104.06	3.36	229.38	229.39	0.00	0.74	0.25	0.00	43.57	60.49	0.96	420.68
13.00	85.14	3.36	229.33	229.34	0.09	0.65	0.22	0.58	35.91	48.65	1.19	441.16
13.00	89.87	3.40	229.37	229.38	0.10	0.66	0.22	0.72	36.64	52.51	1.20	463.80
13.00	94.60	3.44	229.41	229.42	0.10	0.66	0.23	0.89	37.29	56.42	1.20	485.73
13.00	99.33	3.48	229.45	229.46	0.11	0.66	0.23	1.08	37.84	60.41	1.20	507.80
13.00	104.06	3.51	229.48	229.49	0.11	0.66	0.23	1.27	38.52	64.28	1.20	529.40
14.00	85.14	3.30	229.38	229.39	0.21	0.52	0.12	37.65	39.87	7.62	1.38	511.76
14.00	89.87	3.34	229.42	229.43	0.22	0.53	0.12	40.17	41.20	8.49	1.38	537.62
14.00	94.60	3.38	229.46	229.47	0.22	0.54	0.12	42.71	42.46	9.43	1.38	562.91
14.00	99.33	3.42	229.50	229.51	0.23	0.55	0.13	45.22	43.75	10.36	1.38	588.32
14.00	104.06	3.45	229.53	229.54	0.23	0.56	0.13	47.75	44.96	11.35	1.38	613.11
15.00	85.14	3.40	229.44	229.44	0.06	0.42	0.18	0.50	32.95	51.70	1.69	616.66
15.00	89.87	3.44	229.48	229.48	0.07	0.43	0.18	0.62	34.09	55.16	1.68	646.91
15.00	94.60	3.48	229.52	229.52	0.07	0.43	0.19	0.76	35.19	58.65	1.68	676.68
15.00	99.33	3.51	229.55	229.56	0.07	0.44	0.19	0.90	36.32	62.11	1.68	706.26
15.00	104.06	3.55	229.59	229.60	0.08	0.45	0.20	1.06	37.41	65.59	1.68	735.37
16.00	85.14	3.34	229.46	229.47	0.12	0.43	0.12	7.78	63.05	14.31	1.82	675.50
16.00	89.87	3.38	229.50	229.51	0.12	0.44	0.13	8.64	65.32	15.92	1.81	708.32
16.00	94.60	3.42	229.54	229.55	0.12	0.45	0.13	9.53	67.49	17.58	1.81	740.70
16.00	99.33	3.46	229.58	229.58	0.13	0.46	0.14	10.43	69.68	19.22	1.81	772.72
16.00	104.06	3.49	229.61	229.62	0.13	0.46	0.14	11.38	71.78	20.91	1.81	804.33

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
17.00	85.14	3.15	229.51	229.51	0.18	0.51	0.07	56.69	28.12	0.33	2.07	769.22
17.00	89.87	3.18	229.54	229.55	0.19	0.51	0.08	60.64	28.82	0.40	2.07	806.31
17.00	94.60	3.22	229.58	229.59	0.19	0.51	0.08	64.61	29.49	0.49	2.07	843.03
17.00	99.33	3.26	229.62	229.63	0.19	0.52	0.09	68.55	30.19	0.59	2.06	879.12
17.00	104.06	3.30	229.66	229.66	0.20	0.52	0.09	72.51	30.86	0.69	2.06	914.90
18.00	85.14	3.05	229.56	229.56	0.13	0.40	0.16	18.45	31.60	35.09	2.48	914.17
18.00	89.87	3.09	229.60	229.60	0.13	0.40	0.16	19.80	32.44	37.62	2.48	957.86
18.00	94.60	3.13	229.64	229.64	0.14	0.40	0.16	21.16	33.25	40.18	2.48	1001.24
18.00	99.33	3.17	229.68	229.68	0.14	0.40	0.16	22.52	34.08	42.73	2.47	1043.60
18.00	104.06	3.20	229.71	229.72	0.14	0.41	0.17	23.88	34.88	45.30	2.47	1085.76

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
-6.00	85.14	2.05	228.56	228.66	0.84	1.44	0.32	12.01	70.27	2.86	2.53	970.05
-6.00	89.87	2.09	228.60	228.70	0.85	1.47	0.34	12.62	73.82	3.43	2.53	1016.12
-6.00	94.60	2.13	228.64	228.74	0.87	1.50	0.36	13.23	77.32	4.05	2.52	1061.88
-6.00	99.33	2.16	228.67	228.78	0.89	1.54	0.37	13.83	80.79	4.70	2.52	1106.50
-6.00	104.06	2.20	228.71	228.82	0.91	1.57	0.39	14.43	84.22	5.41	2.51	1150.93
601.00	10.71	1.65	228.81	228.81	0.09	0.23	0.08	1.79	6.59	2.33	2.74	979.80
601.00	11.30	1.69	228.85	228.85	0.09	0.23	0.08	1.98	6.75	2.58	2.74	1026.45
601.00	11.90	1.73	228.89	228.89	0.09	0.23	0.08	2.16	6.91	2.82	2.74	1072.80
601.00	12.49	1.77	228.93	228.93	0.09	0.23	0.08	2.35	7.07	3.07	2.74	1117.99
601.00	13.09	1.80	228.96	228.96	0.09	0.23	0.08	2.55	7.22	3.32	2.74	1163.01
602.00	10.71	1.41	228.82	228.82	0.13	0.31	0.12	3.58	7.01	0.12	2.82	984.62
602.00	11.30	1.45	228.86	228.86	0.13	0.31	0.11	3.93	7.25	0.13	2.82	1031.63
602.00	11.90	1.49	228.90	228.90	0.13	0.31	0.10	4.28	7.47	0.15	2.83	1078.36
602.00	12.49	1.52	228.93	228.94	0.13	0.31	0.09	4.63	7.69	0.17	2.83	1123.93
602.00	13.09	1.56	228.97	228.97	0.13	0.30	0.09	4.99	7.90	0.20	2.83	1169.34
603.00	10.71	1.13	228.86	228.89	0.00	0.76	0.00	0.00	10.71	0.00	2.86	987.85
603.00	11.30	1.16	228.89	228.92	0.00	0.71	0.00	0.00	11.30	0.00	2.86	1035.14
603.00	11.90	1.20	228.93	228.95	0.00	0.68	0.00	0.00	11.90	0.00	2.87	1082.16
603.00	12.49	1.24	228.97	228.99	0.00	0.64	0.00	0.00	12.49	0.00	2.87	1128.01
603.00	13.09	1.27	229.00	229.02	0.00	0.63	0.00	0.00	13.09	0.00	2.87	1173.69
604.00	10.71	1.19	229.12	229.18	0.01	1.09	0.15	0.00	10.67	0.03	2.87	988.58
604.00	11.30	1.20	229.13	229.19	0.01	1.13	0.16	0.00	11.26	0.05	2.88	1035.93
604.00	11.90	1.21	229.14	229.21	0.01	1.17	0.18	0.00	11.84	0.06	2.88	1083.00
604.00	12.49	1.23	229.16	229.23	0.01	1.20	0.19	0.00	12.41	0.08	2.88	1128.92
604.00	13.09	1.25	229.18	229.25	0.01	1.22	0.21	0.00	12.97	0.12	2.88	1174.65

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
605.00	10.71	1.17	229.15	229.21	0.00	1.14	0.00	0.00	10.71	0.00	2.88	988.67
605.00	11.30	1.18	229.16	229.23	0.00	1.19	0.00	0.00	11.30	0.00	2.88	1036.03
605.00	11.90	1.20	229.18	229.25	0.00	1.24	0.00	0.00	11.90	0.00	2.88	1083.10
605.00	12.49	1.21	229.19	229.28	0.00	1.28	0.00	0.00	12.49	0.00	2.88	1129.02
605.00	13.09	1.23	229.21	229.30	0.00	1.32	0.00	0.00	13.09	0.00	2.89	1174.76
605.10	10.71	1.18	229.16	229.23	0.00	1.13	0.00	0.00	10.71	0.00	2.88	988.72
605.10	11.30	1.20	229.18	229.25	0.00	1.18	0.00	0.00	11.30	0.00	2.88	1036.07
605.10	11.90	1.22	229.20	229.27	0.00	1.22	0.00	0.00	11.90	0.00	2.88	1083.15
605.10	12.49	1.23	229.21	229.29	0.00	1.27	0.00	0.00	12.49	0.00	2.89	1129.07
605.10	13.09	1.26	229.24	229.32	0.00	1.30	0.00	0.00	13.09	0.00	2.89	1174.81
606.00	10.71	1.20	229.20	229.24	0.16	0.86	0.01	0.03	10.68	0.00	2.88	988.78
606.00	11.30	1.23	229.23	229.27	0.17	0.89	0.01	0.03	11.27	0.00	2.88	1036.13
606.00	11.90	1.25	229.25	229.29	0.18	0.92	0.01	0.04	11.86	0.00	2.89	1083.21
606.00	12.49	1.27	229.27	229.31	0.19	0.94	0.01	0.05	12.44	0.00	2.89	1129.13
606.00	13.09	1.29	229.29	229.34	0.21	0.96	0.01	0.07	13.02	0.00	2.89	1174.87
607.00	10.71	1.18	229.57	229.69	0.00	1.52	0.00	0.00	10.71	0.00	2.90	989.95
607.00	11.30	1.21	229.60	229.72	0.00	1.53	0.00	0.00	11.30	0.00	2.90	1037.35
607.00	11.90	1.24	229.63	229.75	0.00	1.55	0.00	0.00	11.90	0.00	2.91	1084.46
607.00	12.49	1.26	229.65	229.78	0.00	1.56	0.00	0.00	12.49	0.00	2.91	1130.43
607.00	13.09	1.29	229.68	229.81	0.00	1.57	0.00	0.00	13.09	0.00	2.91	1176.21
608.00	10.71	1.55	230.33	230.44	0.33	1.51	0.30	0.05	10.62	0.04	2.92	990.82
608.00	11.30	1.58	230.36	230.48	0.35	1.55	0.32	0.07	11.19	0.05	2.93	1038.24
608.00	11.90	1.61	230.39	230.52	0.37	1.59	0.34	0.09	11.75	0.06	2.93	1085.40
608.00	12.49	1.64	230.42	230.55	0.39	1.62	0.36	0.10	12.31	0.08	2.93	1131.39
608.00	13.09	1.67	230.45	230.59	0.41	1.66	0.38	0.13	12.87	0.09	2.93	1177.21

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
-6.00	10.71	2.05	228.56	228.57	0.13	0.17	0.04	1.82	8.54	0.35	3.38	1001.01
-6.00	11.30	2.09	228.60	228.60	0.13	0.18	0.04	1.92	8.97	0.42	3.38	1048.78
-6.00	11.90	2.13	228.64	228.64	0.13	0.18	0.04	2.01	9.40	0.49	3.37	1096.28
-6.00	12.49	2.16	228.67	228.68	0.14	0.19	0.05	2.10	9.82	0.57	3.36	1142.59
-6.00	13.09	2.20	228.71	228.71	0.14	0.19	0.05	2.19	10.24	0.66	3.35	1188.74
620.00	17.91	1.51	228.57	228.61	0.46	1.40	0.42	1.05	6.15	10.71	3.45	1009.86
620.00	18.90	1.55	228.61	228.65	0.44	1.33	0.41	1.15	6.01	11.75	3.44	1058.21
620.00	19.90	1.59	228.65	228.68	0.43	1.26	0.39	1.25	5.88	12.77	3.44	1106.29
620.00	20.89	1.63	228.69	228.71	0.41	1.20	0.38	1.34	5.79	13.76	3.44	1153.18
620.00	21.89	1.66	228.72	228.75	0.40	1.15	0.37	1.44	5.70	14.75	3.43	1199.92
621.00	17.91	1.01	229.43	229.63	0.74	2.22	0.69	0.81	14.29	2.81	3.46	1012.03
621.00	18.90	1.02	229.44	229.65	0.76	2.25	0.71	0.90	14.86	3.14	3.46	1060.61
621.00	19.90	1.04	229.46	229.67	0.78	2.27	0.72	1.01	15.40	3.49	3.46	1108.93
621.00	20.89	1.06	229.48	229.69	0.80	2.30	0.74	1.11	15.95	3.84	3.45	1156.06
621.00	21.89	1.08	229.50	229.71	0.81	2.33	0.75	1.21	16.49	4.19	3.45	1203.04
622.00	17.91	1.15	230.73	230.85	0.76	1.92	0.71	1.02	10.82	6.07	3.48	1013.52
622.00	18.90	1.17	230.75	230.88	0.78	1.95	0.73	1.10	11.25	6.56	3.48	1062.17
622.00	19.90	1.19	230.77	230.90	0.80	1.99	0.74	1.18	11.69	7.03	3.48	1110.57
622.00	20.89	1.21	230.79	230.92	0.81	2.02	0.76	1.26	12.11	7.53	3.47	1157.77
622.00	21.89	1.23	230.81	230.94	0.83	2.05	0.77	1.34	12.52	8.03	3.47	1204.81
623.00	17.91	1.13	231.62	231.78	0.78	2.06	0.70	4.84	12.66	0.40	3.50	1014.95
623.00	18.90	1.15	231.64	231.81	0.80	2.09	0.71	5.30	13.16	0.44	3.49	1063.66
623.00	19.90	1.18	231.67	231.83	0.81	2.11	0.72	5.77	13.65	0.48	3.49	1112.12
623.00	20.89	1.20	231.69	231.86	0.83	2.14	0.74	6.24	14.13	0.52	3.49	1159.38
623.00	21.89	1.22	231.71	231.88	0.84	2.17	0.75	6.72	14.60	0.56	3.49	1206.49

TABLE 4.5a-1
HEATHCOTE PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
624.00	17.91	1.01	232.56	232.77	0.79	2.10	0.68	1.13	16.56	0.22	3.51	1015.92
624.00	18.90	1.03	232.58	232.80	0.82	2.15	0.70	1.26	17.41	0.24	3.51	1064.68
624.00	19.90	1.05	232.60	232.83	0.84	2.20	0.72	1.38	18.26	0.26	3.50	1113.18
624.00	20.89	1.07	232.62	232.86	0.87	2.25	0.74	1.51	19.09	0.29	3.50	1160.48
624.00	21.89	1.09	232.64	232.89	0.89	2.30	0.76	1.64	19.93	0.31	3.50	1207.63
625.00	17.91	1.15	233.65	233.95	0.86	2.54	0.89	0.28	16.10	1.53	3.52	1016.68
625.00	18.90	1.18	233.68	233.99	0.88	2.59	0.92	0.31	16.88	1.71	3.52	1065.47
625.00	19.90	1.21	233.71	234.03	0.90	2.63	0.94	0.34	17.66	1.90	3.51	1114.00
625.00	20.89	1.24	233.74	234.06	0.92	2.67	0.96	0.38	18.43	2.08	3.51	1161.33
625.00	21.89	1.26	233.76	234.10	0.94	2.71	0.98	0.41	19.20	2.28	3.51	1208.51

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
2.00	183.24	2.90	227.56	227.68	0.82	1.74	0.31	58.20	124.39	0.64	0.04	23.98
2.00	193.42	2.96	227.62	227.74	0.85	1.77	0.33	62.77	129.85	0.79	0.03	24.92
2.00	203.60	3.02	227.68	227.80	0.87	1.80	0.34	67.37	135.28	0.95	0.03	25.84
2.00	213.78	3.07	227.73	227.86	0.89	1.83	0.36	72.09	140.55	1.14	0.03	26.72
2.00	223.96	3.13	227.79	227.91	0.91	1.84	0.37	76.93	145.68	1.35	0.03	27.64
3.00	183.24	2.83	227.84	227.88	0.57	1.16	0.46	79.38	83.24	20.62	0.08	52.69
3.00	193.42	2.89	227.90	227.94	0.58	1.17	0.47	84.78	86.44	22.21	0.08	54.77
3.00	203.60	2.95	227.96	228.00	0.59	1.19	0.48	90.18	89.61	23.80	0.08	56.80
3.00	213.78	3.01	228.02	228.06	0.61	1.20	0.49	95.66	92.69	25.44	0.08	58.84
3.00	223.96	3.06	228.07	228.11	0.62	1.22	0.50	101.02	95.92	27.02	0.08	60.85
4.00	183.24	2.62	228.00	228.10	0.62	1.71	0.00	66.33	116.91	0.00	0.11	84.52
4.00	193.42	2.67	228.05	228.15	0.62	1.71	0.00	73.82	119.59	0.00	0.11	88.31
4.00	203.60	2.73	228.11	228.20	0.63	1.70	0.00	81.45	122.15	0.00	0.11	92.02
4.00	213.78	2.79	228.17	228.26	0.63	1.69	0.00	89.36	124.42	0.00	0.11	95.80
4.00	223.96	2.84	228.22	228.31	0.64	1.69	0.00	96.98	126.98	0.00	0.11	99.34
4.50	183.24	2.36	228.21	228.25	0.54	1.25	0.60	103.83	74.93	4.48	0.15	105.65
4.50	193.42	2.41	228.26	228.30	0.56	1.26	0.61	111.28	77.37	4.78	0.15	110.59
4.50	203.60	2.46	228.31	228.35	0.57	1.28	0.62	118.75	79.77	5.07	0.15	115.41
4.50	213.78	2.51	228.36	228.40	0.58	1.29	0.62	126.31	82.09	5.37	0.15	120.36
4.50	223.96	2.55	228.40	228.45	0.59	1.30	0.63	133.79	84.49	5.67	0.14	124.93
5.00	183.24	2.23	228.17	228.58	1.02	2.90	0.44	7.06	175.05	1.13	0.15	117.95
5.00	193.42	2.27	228.21	228.62	1.05	2.91	0.49	8.42	183.08	1.91	0.15	123.47
5.00	203.60	2.31	228.25	228.67	1.09	2.94	0.54	9.69	191.08	2.83	0.15	128.85
5.00	213.78	2.36	228.30	228.70	1.10	2.90	0.62	11.40	197.80	4.58	0.15	134.45
5.00	223.96	2.42	228.36	228.73	1.11	2.83	0.68	13.40	203.50	7.06	0.15	139.71

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
5.50	183.24	2.88	228.83	228.88	0.59	1.29	0.52	108.80	72.27	2.17	0.19	134.45
5.50	193.42	2.93	228.88	228.92	0.61	1.32	0.53	116.19	74.93	2.30	0.19	140.63
5.50	203.60	2.97	228.92	228.97	0.63	1.35	0.54	123.64	77.53	2.43	0.19	146.65
5.50	213.78	3.01	228.96	229.01	0.65	1.38	0.56	130.69	80.54	2.56	0.19	152.89
5.50	223.96	3.04	228.99	229.04	0.67	1.42	0.58	137.86	83.41	2.68	0.18	158.93
6.00	183.24	2.63	229.14	229.30	1.35	1.97	0.60	28.78	132.46	22.00	0.23	181.89
6.00	193.42	2.68	229.19	229.35	1.33	2.00	0.62	30.26	138.02	25.14	0.23	189.80
6.00	203.60	2.73	229.24	229.40	1.31	2.03	0.64	31.80	143.39	28.41	0.23	197.55
6.00	213.78	2.77	229.28	229.45	1.29	2.06	0.66	33.40	148.45	31.94	0.23	205.24
6.00	223.96	2.81	229.32	229.49	1.28	2.10	0.68	35.04	153.75	35.17	0.23	212.64
7.00	168.12	2.94	229.37	229.38	0.13	0.42	0.10	2.86	164.91	0.34	0.33	222.75
7.00	177.46	3.00	229.43	229.44	0.14	0.43	0.11	3.35	173.70	0.41	0.33	232.30
7.00	186.80	3.05	229.48	229.49	0.14	0.44	0.11	3.86	182.45	0.49	0.33	241.66
7.00	196.14	3.10	229.53	229.54	0.15	0.45	0.12	4.41	191.16	0.57	0.32	251.02
7.00	205.48	3.14	229.57	229.58	0.15	0.46	0.12	4.95	199.88	0.65	0.32	259.83
8.00	168.12	3.52	229.41	229.48	0.00	1.23	0.00	0.00	168.12	0.00	0.38	273.21
8.00	177.46	3.57	229.46	229.54	0.00	1.26	0.00	0.00	177.46	0.00	0.37	284.46
8.00	186.80	3.62	229.51	229.59	0.00	1.29	0.00	0.00	186.80	0.00	0.37	295.51
8.00	196.14	3.67	229.56	229.65	0.00	1.32	0.00	0.00	196.14	0.00	0.36	306.52
8.00	205.48	3.71	229.60	229.69	0.45	1.29	0.00	8.41	197.07	0.00	0.36	318.47
9.00	168.12	3.66	229.45	229.57	0.00	1.56	0.00	0.00	168.12	0.00	0.38	276.88
9.00	177.46	3.71	229.50	229.64	0.00	1.65	0.00	0.00	177.46	0.00	0.38	288.19
9.00	186.80	3.76	229.55	229.70	0.00	1.74	0.00	0.00	186.80	0.00	0.37	299.30
9.00	196.14	3.81	229.60	229.77	0.00	1.82	0.00	0.00	196.14	0.00	0.37	310.37
9.00	205.48	3.85	229.64	229.83	0.00	1.91	0.00	0.00	205.48	0.00	0.36	322.65

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
9.10	168.12	3.67	229.47	229.59	0.00	1.57	0.00	0.00	168.12	0.00	0.38	278.17
9.10	177.46	3.73	229.53	229.66	0.00	1.65	0.00	0.00	177.46	0.00	0.38	289.48
9.10	186.80	3.78	229.58	229.73	0.00	1.74	0.00	0.00	186.80	0.00	0.37	300.59
9.10	196.14	3.83	229.63	229.80	0.00	1.83	0.00	0.00	196.14	0.00	0.37	311.66
9.10	205.48	3.88	229.68	229.86	0.00	1.91	0.00	0.00	205.48	0.00	0.37	323.94
10.00	168.12	3.76	229.56	229.63	0.19	1.17	0.22	4.38	157.77	5.97	0.39	281.09
10.00	177.46	3.84	229.64	229.70	0.21	1.18	0.24	5.74	164.13	7.59	0.38	292.52
10.00	186.80	3.91	229.71	229.78	0.22	1.20	0.26	7.24	170.22	9.34	0.38	303.77
10.00	196.14	3.98	229.78	229.85	0.24	1.21	0.27	8.93	175.95	11.26	0.37	314.98
10.00	205.48	4.05	229.85	229.92	0.25	1.22	0.29	10.64	181.68	13.16	0.37	327.39
10.10	168.12	3.82	229.63	229.67	0.39	1.12	0.46	15.56	82.52	70.05	0.42	300.81
10.10	177.46	3.90	229.71	229.75	0.40	1.13	0.47	17.28	84.85	75.33	0.41	313.45
10.10	186.80	3.97	229.78	229.82	0.41	1.13	0.48	19.03	87.13	80.64	0.41	325.91
10.10	196.14	4.05	229.86	229.89	0.42	1.14	0.48	20.85	89.28	86.01	0.40	338.39
10.10	205.48	4.11	229.92	229.96	0.43	1.15	0.49	22.63	91.55	91.30	0.40	351.98
10.20	168.12	3.86	229.68	229.71	0.42	0.90	0.33	10.28	91.60	66.24	0.46	327.67
10.20	177.46	3.94	229.76	229.78	0.43	0.91	0.34	10.98	94.29	72.19	0.45	341.67
10.20	186.80	4.01	229.83	229.85	0.43	0.91	0.35	11.69	96.94	78.17	0.45	355.49
10.20	196.14	4.08	229.90	229.93	0.43	0.92	0.36	12.41	99.47	84.26	0.44	369.37
10.20	205.48	4.15	229.97	229.99	0.44	0.93	0.36	13.14	102.12	90.23	0.44	384.25
11.00	168.12	3.90	229.80	229.81	0.32	0.68	0.00	110.42	57.70	0.00	0.68	463.04
11.00	177.46	3.97	229.87	229.88	0.33	0.67	0.00	118.53	58.93	0.00	0.68	483.86
11.00	186.80	4.04	229.94	229.95	0.33	0.67	0.00	126.64	60.16	0.00	0.67	504.43
11.00	196.14	4.11	230.01	230.02	0.33	0.67	0.00	134.79	61.35	0.00	0.67	525.23
11.00	205.48	4.18	230.08	230.09	0.34	0.67	0.00	142.84	62.64	0.00	0.67	546.54

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
12.00	168.12	3.88	229.90	229.91	0.00	0.67	0.29	0.00	48.85	119.27	0.97	655.20
12.00	177.46	3.95	229.97	229.98	0.00	0.67	0.29	0.00	49.73	127.73	0.97	685.80
12.00	186.80	4.02	230.04	230.05	0.00	0.67	0.30	0.00	50.63	136.17	0.97	716.06
12.00	196.14	4.09	230.11	230.12	0.00	0.66	0.30	0.00	51.50	144.64	0.96	746.69
12.00	205.48	4.15	230.17	230.18	0.00	0.66	0.30	0.00	52.46	153.02	0.96	777.18
13.00	168.12	4.01	229.98	229.99	0.15	0.65	0.27	5.57	45.15	117.39	1.23	828.89
13.00	177.46	4.07	230.04	230.05	0.15	0.65	0.27	6.42	45.96	125.08	1.23	868.63
13.00	186.80	4.14	230.11	230.12	0.15	0.65	0.27	7.31	46.74	132.75	1.22	908.00
13.00	196.14	4.21	230.18	230.18	0.15	0.64	0.28	8.26	47.48	140.40	1.22	947.89
13.00	205.48	4.27	230.24	230.24	0.16	0.64	0.28	9.23	48.27	147.99	1.22	987.09
14.00	168.12	3.94	230.02	230.03	0.26	0.59	0.17	81.03	56.98	30.11	1.41	960.04
14.00	177.46	4.01	230.09	230.09	0.27	0.60	0.18	85.68	58.43	33.36	1.41	1006.58
14.00	186.80	4.07	230.15	230.16	0.27	0.60	0.19	90.32	59.84	36.64	1.41	1052.76
14.00	196.14	4.13	230.21	230.22	0.27	0.60	0.19	94.98	61.19	39.97	1.41	1099.60
14.00	205.48	4.19	230.27	230.28	0.27	0.60	0.20	99.63	62.59	43.27	1.40	1145.37
15.00	168.12	4.03	230.07	230.08	0.13	0.48	0.23	5.07	50.23	112.83	1.69	1144.50
15.00	177.46	4.09	230.13	230.14	0.14	0.49	0.23	5.78	51.97	119.71	1.68	1199.72
15.00	186.80	4.16	230.20	230.20	0.14	0.49	0.23	6.54	53.68	126.58	1.68	1254.59
15.00	196.14	4.22	230.26	230.27	0.14	0.49	0.24	7.35	55.35	133.44	1.68	1310.27
15.00	205.48	4.28	230.32	230.33	0.14	0.50	0.24	8.20	57.02	140.26	1.68	1364.48
16.00	168.12	3.97	230.09	230.10	0.16	0.51	0.19	27.05	95.33	45.74	1.81	1248.38
16.00	177.46	4.04	230.16	230.16	0.16	0.52	0.19	29.69	98.29	49.48	1.81	1308.61
16.00	186.80	4.10	230.22	230.23	0.16	0.52	0.19	32.40	101.17	53.23	1.81	1368.51
16.00	196.14	4.16	230.28	230.29	0.17	0.52	0.20	35.21	103.92	57.01	1.81	1429.34
16.00	205.48	4.22	230.34	230.35	0.17	0.53	0.20	38.04	106.69	60.75	1.80	1488.48

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
17.00	168.12	3.77	230.13	230.14	0.22	0.54	0.12	126.63	38.58	2.91	2.06	1416.90
17.00	177.46	3.84	230.20	230.20	0.23	0.54	0.12	134.51	39.60	3.35	2.06	1485.53
17.00	186.80	3.90	230.26	230.26	0.23	0.54	0.13	142.39	40.60	3.81	2.06	1553.85
17.00	196.14	3.96	230.32	230.33	0.23	0.55	0.13	150.27	41.57	4.30	2.06	1623.24
17.00	205.48	4.02	230.38	230.38	0.24	0.55	0.13	158.12	42.55	4.81	2.05	1690.60
18.00	168.12	3.67	230.18	230.18	0.16	0.42	0.19	42.72	44.13	81.27	2.46	1674.04
18.00	177.46	3.73	230.24	230.24	0.16	0.43	0.20	45.52	45.38	86.56	2.46	1754.80
18.00	186.80	3.79	230.30	230.31	0.17	0.43	0.20	48.40	46.58	91.81	2.46	1835.17
18.00	196.14	3.85	230.36	230.37	0.17	0.43	0.20	51.39	47.73	97.02	2.45	1916.76
18.00	205.48	3.91	230.42	230.42	0.17	0.43	0.20	54.37	48.90	102.21	2.45	1995.80

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
-6.00	168.12	2.63	229.14	229.28	1.02	1.86	0.57	21.80	125.42	20.89	2.50	1770.14
-6.00	177.46	2.68	229.19	229.33	1.01	1.89	0.59	22.93	130.67	23.86	2.50	1855.28
-6.00	186.80	2.73	229.24	229.38	0.99	1.93	0.61	24.09	135.75	26.96	2.49	1940.03
-6.00	196.14	2.77	229.28	229.43	0.97	1.95	0.62	25.30	140.55	30.28	2.49	2026.08
-6.00	205.48	2.81	229.32	229.47	0.97	1.99	0.64	26.55	145.60	33.33	2.49	2109.30
601.00	40.77	2.25	229.41	229.42	0.18	0.38	0.16	10.49	16.00	14.28	2.65	1790.83
601.00	43.03	2.30	229.46	229.47	0.18	0.37	0.16	11.22	16.38	15.43	2.65	1877.17
601.00	45.30	2.35	229.51	229.51	0.18	0.37	0.16	11.95	16.77	16.59	2.64	1963.12
601.00	47.56	2.40	229.56	229.56	0.19	0.37	0.16	12.66	17.14	17.77	2.64	2050.44
601.00	49.83	2.44	229.60	229.60	0.19	0.37	0.16	13.36	17.55	18.92	2.64	2134.74
602.00	40.77	2.01	229.42	229.43	0.26	0.50	0.14	19.85	18.20	2.72	2.71	1802.99
602.00	43.03	2.06	229.47	229.48	0.26	0.50	0.14	21.16	18.69	3.19	2.71	1890.09
602.00	45.30	2.11	229.52	229.53	0.27	0.50	0.15	22.44	19.18	3.68	2.70	1976.79
602.00	47.56	2.16	229.57	229.57	0.27	0.50	0.15	23.70	19.66	4.20	2.70	2064.86
602.00	49.83	2.20	229.61	229.62	0.27	0.50	0.15	24.94	20.18	4.71	2.70	2149.84
603.00	40.77	1.73	229.46	229.50	0.26	0.82	0.24	1.78	37.69	1.30	2.74	1812.49
603.00	43.03	1.78	229.51	229.54	0.26	0.80	0.24	2.20	39.22	1.61	2.74	1900.28
603.00	45.30	1.83	229.56	229.58	0.26	0.79	0.24	2.66	40.71	1.94	2.74	1987.66
603.00	47.56	1.87	229.60	229.63	0.27	0.78	0.25	3.14	42.13	2.29	2.74	2076.43
603.00	49.83	1.91	229.64	229.67	0.27	0.78	0.25	3.62	43.57	2.64	2.73	2162.04
604.00	40.77	1.57	229.50	229.79	0.70	2.47	0.66	0.35	37.46	2.96	2.75	1814.86
604.00	43.03	1.59	229.52	229.82	0.73	2.54	0.68	0.40	39.27	3.37	2.75	1902.82
604.00	45.30	1.62	229.55	229.86	0.75	2.59	0.71	0.45	41.01	3.83	2.75	1990.39
604.00	47.56	1.64	229.57	229.89	0.78	2.63	0.73	0.52	42.68	4.37	2.75	2079.36
604.00	49.83	1.67	229.60	229.92	0.80	2.68	0.76	0.58	44.33	4.92	2.74	2165.15

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
605.00	40.77	1.53	229.51	230.07	0.00	3.33	0.00	0.00	40.77	0.00	2.75	1815.02
605.00	43.03	1.54	229.52	230.14	0.00	3.50	0.00	0.00	43.03	0.00	2.75	1902.99
605.00	45.30	1.54	229.52	230.21	0.00	3.66	0.00	0.00	45.30	0.00	2.75	1990.56
605.00	47.56	1.55	229.53	230.28	0.00	3.84	0.00	0.00	47.56	0.00	2.75	2079.54
605.00	49.83	1.57	229.55	230.35	0.00	3.96	0.00	0.00	49.83	0.00	2.74	2165.34
605.10	40.77	1.81	229.79	230.20	0.00	2.82	0.00	0.00	40.77	0.00	2.75	1815.08
605.10	43.03	1.88	229.86	230.28	0.00	2.86	0.00	0.00	43.03	0.00	2.75	1903.06
605.10	45.30	1.96	229.94	230.37	0.00	2.90	0.00	0.00	45.30	0.00	2.75	1990.63
605.10	47.56	2.05	230.03	230.45	0.00	2.90	0.00	0.00	47.56	0.00	2.75	2079.61
605.10	49.83	2.13	230.11	230.54	0.00	2.92	0.00	0.00	49.83	0.00	2.74	2165.41
606.00	40.77	2.15	230.15	230.25	0.52	1.44	0.33	2.94	37.09	0.74	2.75	1815.20
606.00	43.03	2.24	230.24	230.33	0.52	1.43	0.29	3.57	38.37	1.10	2.75	1903.19
606.00	45.30	2.33	230.33	230.42	0.51	1.40	0.28	4.29	39.35	1.66	2.75	1990.78
606.00	47.56	2.43	230.43	230.51	0.49	1.35	0.27	5.10	40.00	2.47	2.75	2079.77
606.00	49.83	2.52	230.52	230.59	0.47	1.31	0.27	5.97	40.38	3.48	2.74	2165.59
607.00	40.77	2.08	230.47	230.63	0.46	1.83	0.43	2.26	37.17	1.34	2.77	1818.92
607.00	43.03	2.14	230.53	230.68	0.48	1.80	0.44	2.99	38.26	1.78	2.77	1907.34
607.00	45.30	2.20	230.59	230.73	0.49	1.76	0.45	3.83	39.19	2.28	2.77	1995.45
607.00	47.56	2.27	230.66	230.78	0.49	1.71	0.46	4.79	39.92	2.85	2.77	2085.08
607.00	49.83	2.33	230.72	230.84	0.50	1.66	0.46	5.84	40.51	3.47	2.77	2171.62
608.00	40.77	2.34	231.12	231.50	1.08	2.95	0.54	2.06	34.82	3.89	2.79	1821.88
608.00	43.03	2.46	231.24	231.53	1.04	2.67	0.56	2.42	33.44	7.18	2.79	1910.89
608.00	45.30	2.51	231.29	231.56	1.04	2.63	0.59	2.63	33.63	9.04	2.79	1999.41
608.00	47.56	2.54	231.32	231.58	1.05	2.65	0.61	2.80	34.36	10.40	2.79	2089.39
608.00	49.83	2.53	231.31	231.61	1.12	2.83	0.64	2.91	36.45	10.46	2.78	2176.15

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
-6.00	40.77	2.63	229.14	229.15	0.30	0.44	0.13	6.40	29.46	4.91	2.97	1839.00
-6.00	43.03	2.68	229.19	229.20	0.30	0.44	0.14	6.73	30.70	5.61	2.97	1929.28
-6.00	45.30	2.73	229.24	229.24	0.29	0.45	0.14	7.07	31.89	6.33	2.97	2018.76
-6.00	47.56	2.77	229.28	229.29	0.29	0.46	0.15	7.43	33.02	7.11	2.97	2109.66
-6.00	49.83	2.81	229.32	229.33	0.28	0.47	0.15	7.80	34.20	7.83	2.96	2196.96
620.00	36.00	2.12	229.18	229.19	0.28	0.68	0.26	2.81	4.59	28.60	3.12	1860.30
620.00	38.00	2.17	229.23	229.24	0.27	0.65	0.26	3.02	4.53	30.45	3.12	1952.00
620.00	40.00	2.22	229.28	229.28	0.26	0.63	0.26	3.24	4.50	32.26	3.12	2042.92
620.00	42.00	2.26	229.32	229.33	0.25	0.61	0.25	3.47	4.47	34.07	3.13	2135.33
620.00	44.00	2.30	229.36	229.37	0.25	0.60	0.25	3.69	4.49	35.82	3.12	2223.87
621.00	36.00	1.27	229.69	229.94	1.00	2.67	0.92	2.82	23.41	9.77	3.14	1867.66
621.00	38.00	1.29	229.71	229.96	1.02	2.71	0.94	3.07	24.30	10.64	3.14	1959.93
621.00	40.00	1.31	229.73	229.99	1.04	2.74	0.96	3.32	25.17	11.51	3.14	2051.39
621.00	42.00	1.33	229.75	230.01	1.06	2.78	0.98	3.58	26.02	12.40	3.14	2144.37
621.00	44.00	1.35	229.77	230.04	1.08	2.82	1.00	3.83	26.86	13.30	3.14	2233.37
622.00	36.00	1.44	231.02	231.19	0.99	2.38	0.94	2.63	17.63	15.74	3.15	1870.35
622.00	38.00	1.47	231.05	231.21	0.99	2.41	0.96	2.85	18.20	16.95	3.16	1962.75
622.00	40.00	1.49	231.07	231.24	0.97	2.44	0.99	3.09	18.75	18.16	3.16	2054.34
622.00	42.00	1.51	231.09	231.26	0.95	2.46	1.01	3.34	19.29	19.37	3.16	2147.45
622.00	44.00	1.53	231.11	231.29	0.92	2.49	1.03	3.62	19.81	20.56	3.15	2236.57
623.00	36.00	1.44	231.93	232.13	1.01	2.48	0.90	14.12	20.70	1.18	3.17	1872.88
623.00	38.00	1.47	231.96	232.17	1.03	2.53	0.92	15.20	21.53	1.27	3.17	1965.39
623.00	40.00	1.49	231.98	232.19	1.05	2.57	0.94	16.30	22.34	1.36	3.17	2057.08
623.00	42.00	1.51	232.00	232.22	1.07	2.61	0.96	17.46	23.08	1.46	3.17	2150.31
623.00	44.00	1.54	232.03	232.25	1.10	2.64	0.98	18.70	23.74	1.56	3.17	2239.54

TABLE 4.5a-2
HEATHCOTE PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
624.00	36.00	1.31	232.86	233.24	1.17	2.89	1.01	3.89	31.37	0.74	3.18	1874.54
624.00	38.00	1.34	232.89	233.28	1.20	2.96	1.03	4.27	32.92	0.82	3.18	1967.11
624.00	40.00	1.37	232.92	233.33	1.23	3.02	1.06	4.65	34.46	0.89	3.18	2058.87
624.00	42.00	1.39	232.94	233.37	1.26	3.09	1.09	5.03	36.01	0.96	3.18	2152.16
624.00	44.00	1.41	232.96	233.41	1.30	3.16	1.12	5.41	37.55	1.04	3.18	2241.46
625.00	36.00	1.58	234.08	234.50	1.14	3.13	1.23	1.05	29.14	5.81	3.19	1875.81
625.00	38.00	1.62	234.12	234.54	1.13	3.18	1.27	1.16	30.42	6.42	3.19	1968.43
625.00	40.00	1.65	234.15	234.59	1.15	3.21	1.29	1.33	31.58	7.10	3.19	2060.26
625.00	42.00	1.69	234.19	234.63	1.13	3.23	1.31	1.49	32.70	7.80	3.19	2153.60
625.00	44.00	1.73	234.23	234.67	1.12	3.26	1.33	1.67	33.84	8.50	3.19	2242.96

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
2.00	72.72	2.06	231.56	231.60	0.16	1.07	0.20	0.49	47.54	24.69	0.07	30.22
2.00	76.76	2.07	231.57	231.61	0.17	1.11	0.20	0.53	49.59	26.64	0.06	31.19
2.00	80.80	2.10	231.60	231.64	0.17	1.12	0.21	0.59	50.79	29.41	0.06	34.31
2.00	84.84	2.11	231.61	231.65	0.18	1.15	0.22	0.64	52.50	31.70	0.06	34.35
2.00	88.88	2.12	231.62	231.66	0.19	1.18	0.23	0.68	54.38	33.81	0.06	35.46
3.00	72.72	2.37	231.66	231.68	0.13	0.73	0.15	6.45	46.57	19.69	0.15	62.57
3.00	76.76	2.39	231.68	231.70	0.14	0.75	0.15	7.04	48.36	21.36	0.15	64.41
3.00	80.80	2.41	231.70	231.72	0.14	0.77	0.16	7.72	49.80	23.29	0.15	69.04
3.00	84.84	2.43	231.72	231.74	0.15	0.79	0.16	8.35	51.40	25.09	0.15	70.13
3.00	88.88	2.45	231.74	231.76	0.16	0.81	0.17	8.97	53.03	26.88	0.14	72.11
4.00	72.72	2.29	231.73	231.76	0.21	0.94	0.14	14.81	49.65	8.27	0.22	97.86
4.00	76.76	2.30	231.74	231.78	0.22	0.96	0.14	15.88	51.49	9.40	0.21	100.85
4.00	80.80	2.33	231.77	231.80	0.23	0.98	0.15	17.04	52.93	10.83	0.21	107.05
4.00	84.84	2.35	231.79	231.82	0.24	1.00	0.16	18.14	54.55	12.15	0.21	109.39
4.00	88.88	2.37	231.81	231.84	0.24	1.02	0.17	19.23	56.20	13.45	0.21	112.50
5.00	72.72	2.11	231.81	231.82	0.16	0.69	0.19	5.86	32.23	34.63	0.32	130.37
5.00	76.76	2.13	231.83	231.84	0.17	0.70	0.20	6.33	33.27	37.16	0.31	134.52
5.00	80.80	2.16	231.86	231.87	0.18	0.71	0.20	6.83	34.13	39.84	0.31	142.17
5.00	84.84	2.18	231.88	231.89	0.18	0.72	0.21	7.32	35.08	42.44	0.31	145.73
5.00	88.88	2.20	231.90	231.91	0.19	0.73	0.21	7.80	36.05	45.03	0.30	149.95
6.00	72.72	1.46	231.89	231.90	0.18	0.62	0.18	8.80	35.60	28.32	0.47	184.25
6.00	76.76	1.48	231.91	231.92	0.19	0.62	0.19	9.40	36.58	30.79	0.46	190.45
6.00	80.80	1.50	231.93	231.94	0.19	0.62	0.19	10.00	37.41	33.39	0.46	200.44
6.00	84.84	1.53	231.96	231.97	0.20	0.64	0.20	10.56	38.71	35.58	0.46	205.56
6.00	88.88	1.55	231.98	231.99	0.20	0.65	0.20	11.14	39.67	38.07	0.45	211.64

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
7.00	72.72	1.01	232.06	232.08	0.46	0.95	0.51	6.20	13.26	53.26	0.57	226.43
7.00	76.76	1.03	232.08	232.10	0.46	0.94	0.50	6.58	13.53	56.66	0.56	234.93
7.00	80.80	1.06	232.11	232.12	0.46	0.94	0.50	6.95	13.74	60.11	0.56	247.42
7.00	84.84	1.08	232.13	232.15	0.46	0.92	0.49	7.33	13.84	63.67	0.56	254.57
7.00	88.88	1.10	232.15	232.17	0.46	0.92	0.49	7.70	14.05	67.13	0.56	262.78
8.00	72.72	1.24	232.44	232.46	0.08	0.76	0.20	0.38	59.96	12.38	0.65	254.86
8.00	76.76	1.26	232.46	232.48	0.10	0.78	0.21	0.58	62.35	13.83	0.65	265.04
8.00	80.80	1.28	232.48	232.50	0.11	0.79	0.21	0.80	64.68	15.32	0.65	279.27
8.00	84.84	1.30	232.50	232.52	0.12	0.81	0.22	1.04	66.93	16.87	0.64	288.34
8.00	88.88	1.32	232.52	232.54	0.13	0.82	0.22	1.30	69.14	18.44	0.64	298.22
9.00	72.72	1.43	232.69	232.71	0.38	1.17	0.42	16.06	18.62	38.04	0.74	281.89
9.00	76.76	1.45	232.71	232.74	0.39	1.19	0.43	17.23	19.18	40.35	0.73	293.42
9.00	80.80	1.48	232.74	232.76	0.40	1.21	0.44	18.40	19.74	42.67	0.73	308.96
9.00	84.84	1.50	232.76	232.78	0.41	1.22	0.44	19.56	20.28	44.99	0.73	319.33
9.00	88.88	1.52	232.78	232.80	0.42	1.24	0.45	20.73	20.82	47.33	0.72	330.46
10.00	72.72	1.30	233.89	233.89	0.00	0.42	0.28	0.00	8.22	64.50	0.89	314.81
10.00	76.76	1.31	233.90	233.90	0.00	0.43	0.29	0.00	8.70	68.06	0.88	327.10
10.00	80.80	1.33	233.92	233.92	0.00	0.45	0.30	0.00	9.20	71.60	0.88	343.69
10.00	84.84	1.30	233.89	233.90	0.00	0.49	0.32	0.00	9.59	75.25	0.86	353.77
10.00	88.88	1.29	233.88	233.89	0.00	0.51	0.34	0.00	10.02	78.86	0.85	365.15
11.00	72.72	0.99	233.98	234.02	0.01	1.16	0.69	0.00	11.22	61.50	0.93	331.46
11.00	76.76	1.01	234.00	234.03	0.26	1.19	0.71	0.03	11.74	65.00	0.91	344.02
11.00	80.80	1.03	234.02	234.06	0.27	1.20	0.72	0.03	12.20	68.57	0.91	361.12
11.00	84.84	1.02	234.01	234.05	0.28	1.28	0.76	0.03	12.86	71.95	0.89	370.69
11.00	88.88	1.03	234.02	234.06	0.29	1.33	0.79	0.04	13.42	75.42	0.88	381.99

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
12.10	72.72	1.18	234.11	234.37	0.00	2.29	0.00	0.00	72.72	0.00	0.93	333.42
12.10	76.76	1.20	234.13	234.41	0.00	2.37	0.00	0.00	76.76	0.00	0.92	346.03
12.10	80.80	1.22	234.15	234.45	0.00	2.43	0.00	0.00	80.80	0.00	0.91	363.21
12.10	84.84	1.22	234.15	234.48	0.00	2.53	0.00	0.00	84.84	0.00	0.89	372.77
12.10	88.88	1.24	234.17	234.51	0.00	2.61	0.00	0.00	88.88	0.00	0.88	384.09
12.20	72.72	1.38	234.31	234.48	0.00	1.83	0.00	0.00	72.72	0.00	0.93	333.79
12.20	76.76	1.41	234.34	234.52	0.00	1.88	0.00	0.00	76.76	0.00	0.92	346.42
12.20	80.80	1.44	234.37	234.56	0.00	1.92	0.00	0.00	80.80	0.00	0.92	363.61
12.20	84.84	1.48	234.41	234.60	0.00	1.95	0.00	0.00	84.84	0.00	0.90	373.17
12.20	88.88	1.51	234.44	234.64	0.00	1.99	0.00	0.00	88.88	0.00	0.88	384.51
12.30	72.72	1.59	234.57	234.59	0.22	0.81	0.32	7.22	42.34	23.17	0.95	336.74
12.30	76.76	1.63	234.61	234.63	0.22	0.79	0.32	8.59	42.91	25.27	0.93	349.61
12.30	80.80	1.67	234.65	234.67	0.23	0.77	0.31	10.02	43.42	27.36	0.93	367.05
12.30	84.84	1.71	234.69	234.71	0.23	0.75	0.31	11.51	43.84	29.48	0.91	376.88
12.30	88.88	1.75	234.73	234.75	0.23	0.73	0.31	13.05	44.23	31.60	0.90	388.49
13.00	72.72	1.20	235.06	235.14	0.14	1.78	0.64	0.16	26.80	45.76	1.01	364.28
13.00	76.76	1.22	235.08	235.15	0.15	1.82	0.65	0.23	27.73	48.80	0.99	379.26
13.00	80.80	1.23	235.09	235.16	0.17	1.86	0.66	0.33	28.59	51.88	0.99	398.91
13.00	84.84	1.24	235.10	235.18	0.18	1.88	0.67	0.46	29.39	55.00	0.97	411.06
13.00	88.88	1.25	235.11	235.19	0.20	1.90	0.68	0.62	30.09	58.17	0.96	425.10
14.00	72.72	1.21	235.51	235.52	0.00	0.80	0.42	0.00	15.09	57.63	1.08	380.17
14.00	76.76	1.23	235.53	235.54	0.01	0.81	0.43	0.00	15.74	61.02	1.06	395.76
14.00	80.80	1.25	235.55	235.56	0.01	0.83	0.44	0.00	16.39	64.41	1.06	416.02
14.00	84.84	1.26	235.56	235.58	0.01	0.85	0.44	0.00	17.03	67.81	1.04	428.80
14.00	88.88	1.28	235.58	235.60	0.01	0.86	0.45	0.00	17.67	71.21	1.02	443.48

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
15.00	72.72	1.21	235.76	235.77	0.00	0.81	0.51	0.00	11.08	61.63	1.15	401.22
15.00	76.76	1.23	235.78	235.80	0.00	0.82	0.52	0.00	11.53	65.23	1.13	417.64
15.00	80.80	1.25	235.80	235.82	0.00	0.83	0.53	0.00	11.97	68.82	1.13	438.71
15.00	84.84	1.27	235.82	235.84	0.00	0.84	0.53	0.00	12.41	72.43	1.11	452.28
15.00	88.88	1.29	235.84	235.86	0.00	0.85	0.54	0.00	12.88	76.00	1.09	467.73
16.00	72.72	1.57	235.88	236.14	0.00	2.28	0.00	0.00	72.72	0.00	1.16	404.12
16.00	76.76	1.59	235.90	236.18	0.00	2.35	0.00	0.00	76.76	0.00	1.14	420.66
16.00	80.80	1.61	235.92	236.22	0.00	2.41	0.00	0.00	80.80	0.00	1.13	441.84
16.00	84.84	1.63	235.94	236.25	0.00	2.47	0.00	0.00	84.84	0.00	1.11	455.53
16.00	88.88	1.65	235.96	236.28	0.00	2.52	0.00	0.00	88.88	0.00	1.10	471.09
16.10	72.72	1.66	235.97	236.47	0.00	3.81	1.13	0.00	47.54	25.18	1.16	404.31
16.10	76.76	1.69	236.00	236.53	0.00	3.91	1.11	0.00	50.03	26.73	1.14	420.86
16.10	80.80	1.73	236.04	236.53	0.00	3.87	0.85	0.00	50.75	30.05	1.13	442.08
16.10	84.84	1.76	236.07	236.51	0.00	3.77	0.77	0.00	50.36	34.47	1.11	455.79
16.10	88.88	1.79	236.10	236.49	0.00	3.66	0.74	0.00	49.77	39.10	1.10	471.39
17.00	72.72	2.22	236.53	236.53	0.10	0.29	0.12	0.56	6.76	65.40	1.18	407.32
17.00	76.76	2.27	236.58	236.59	0.10	0.28	0.12	0.64	6.92	69.20	1.16	424.08
17.00	80.80	2.27	236.58	236.58	0.10	0.30	0.13	0.67	7.29	72.83	1.15	445.35
17.00	84.84	2.25	236.56	236.56	0.11	0.32	0.14	0.68	7.76	76.40	1.13	459.03
17.00	88.88	2.22	236.53	236.53	0.12	0.35	0.15	0.69	8.23	79.95	1.11	474.58
18.00	72.72	1.63	236.55	236.56	0.00	0.68	0.29	0.00	20.64	52.08	1.26	456.02
18.00	76.76	1.68	236.60	236.61	0.08	0.64	0.27	0.01	21.01	55.74	1.25	476.90
18.00	80.80	1.68	236.60	236.61	0.08	0.68	0.29	0.01	22.13	58.66	1.24	498.04
18.00	84.84	1.66	236.58	236.59	0.01	0.74	0.32	0.00	23.56	61.27	1.21	509.97
18.00	88.88	1.64	236.56	236.57	0.01	0.80	0.34	0.00	24.99	63.89	1.19	523.95

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
19.00	72.72	1.05	236.74	236.77	0.38	0.70	0.29	2.09	70.55	0.07	1.31	475.05
19.00	76.76	1.08	236.77	236.79	0.37	0.69	0.29	2.26	74.42	0.08	1.30	497.98
19.00	80.80	1.09	236.78	236.81	0.38	0.70	0.30	2.40	78.31	0.09	1.29	519.35
19.00	84.84	1.10	236.79	236.82	0.39	0.72	0.31	2.54	82.20	0.09	1.26	530.84
19.00	88.88	1.11	236.80	236.83	0.40	0.73	0.31	2.69	86.09	0.10	1.23	544.53
20.00	72.72	1.45	237.44	237.58	0.00	1.67	0.00	0.00	72.72	0.00	1.33	483.29
20.00	76.76	1.45	237.44	237.59	0.00	1.75	0.00	0.00	76.76	0.00	1.32	506.67
20.00	80.80	1.46	237.45	237.61	0.00	1.76	0.00	0.00	80.80	0.00	1.31	528.39
20.00	84.84	1.47	237.46	237.62	0.00	1.75	0.00	0.00	84.84	0.00	1.28	540.18
20.00	88.88	1.49	237.48	237.63	0.00	1.74	0.00	0.00	88.88	0.00	1.25	554.23
21.00	72.72	2.02	238.41	238.43	0.31	0.67	0.25	4.38	64.76	3.58	1.39	495.51
21.00	76.76	2.04	238.43	238.45	0.32	0.68	0.25	4.68	68.20	3.87	1.38	519.32
21.00	80.80	2.05	238.44	238.46	0.32	0.69	0.25	4.99	71.65	4.16	1.37	541.52
21.00	84.84	2.06	238.45	238.48	0.33	0.71	0.26	5.28	75.12	4.44	1.34	553.79
21.00	88.88	2.08	238.47	238.49	0.34	0.72	0.26	5.57	78.59	4.72	1.31	568.30
22.00	62.10	1.51	238.94	239.05	0.09	1.77	0.37	0.02	41.03	21.05	1.43	512.94
22.00	65.55	1.52	238.95	239.06	0.17	1.80	0.39	0.05	42.35	23.15	1.42	537.55
22.00	69.00	1.54	238.97	239.08	0.19	1.83	0.40	0.06	43.56	25.37	1.41	560.47
22.00	72.45	1.56	238.99	239.10	0.20	1.84	0.41	0.08	44.63	27.73	1.37	573.46
22.00	75.90	1.57	239.00	239.11	0.22	1.85	0.42	0.11	45.52	30.27	1.35	588.70
23.00	62.10	1.58	239.53	239.63	0.35	1.60	0.28	2.20	46.42	13.48	1.46	523.94
23.00	65.55	1.60	239.55	239.65	0.35	1.61	0.30	2.51	47.54	15.50	1.45	549.22
23.00	69.00	1.62	239.57	239.67	0.36	1.62	0.31	2.84	48.61	17.55	1.44	572.82
23.00	72.45	1.64	239.59	239.68	0.37	1.64	0.32	3.16	49.74	19.56	1.40	586.47
23.00	75.90	1.65	239.60	239.70	0.38	1.65	0.33	3.48	50.93	21.49	1.38	602.39

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
24.00	62.10	1.52	240.14	240.22	0.28	1.48	0.33	2.26	44.03	15.81	1.50	538.22
24.00	65.55	1.54	240.16	240.24	0.29	1.51	0.35	2.60	45.48	17.48	1.49	564.40
24.00	69.00	1.55	240.17	240.26	0.30	1.53	0.36	2.95	46.81	19.24	1.48	588.90
24.00	72.45	1.57	240.19	240.27	0.31	1.55	0.37	3.33	48.07	21.06	1.44	603.43
24.00	75.90	1.59	240.21	240.29	0.32	1.56	0.38	3.73	49.23	22.94	1.42	620.20
25.00	62.10	1.48	240.68	240.79	0.00	1.59	0.28	0.00	50.82	11.28	1.53	550.81
25.00	65.55	1.50	240.70	240.81	0.00	1.61	0.29	0.00	52.24	13.31	1.52	577.82
25.00	69.00	1.52	240.72	240.83	0.00	1.62	0.30	0.00	53.64	15.36	1.51	603.12
25.00	72.45	1.54	240.74	240.84	0.00	1.63	0.31	0.00	54.97	17.48	1.48	618.48
25.00	75.90	1.56	240.76	240.86	0.00	1.65	0.32	0.00	56.28	19.62	1.45	636.10
26.00	62.10	1.48	241.03	241.10	0.00	1.31	0.34	0.00	49.72	12.38	1.55	556.66
26.00	65.55	1.50	241.05	241.12	0.00	1.33	0.35	0.00	51.67	13.88	1.54	584.09
26.00	69.00	1.52	241.07	241.14	0.00	1.35	0.35	0.00	53.53	15.47	1.53	609.80
26.00	72.45	1.53	241.08	241.16	0.00	1.36	0.36	0.00	55.29	17.16	1.50	625.58
26.00	75.90	1.55	241.10	241.17	0.00	1.38	0.37	0.00	57.01	18.89	1.47	643.60

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
-21	62.10	2.02	238.41	238.42	0.31	0.57	0.23	4.24	54.65	3.21	1.63	570.94
-21	65.55	2.04	238.43	238.44	0.31	0.58	0.23	4.55	57.51	3.49	1.62	599.23
-21	69.00	2.05	238.44	238.46	0.32	0.58	0.23	4.85	60.40	3.75	1.60	625.64
-21	72.45	2.06	238.45	238.47	0.32	0.60	0.23	5.14	63.30	4.01	1.57	642.08
-21	75.90	2.08	238.47	238.48	0.33	0.60	0.24	5.43	66.19	4.29	1.55	660.80
210.00	12.33	0.84	241.34	241.48	0.49	1.88	0.49	0.89	9.78	1.66	1.65	577.62
210.00	13.01	0.86	241.36	241.50	0.49	1.87	0.49	1.00	10.15	1.87	1.63	606.30
210.00	13.70	0.87	241.37	241.51	0.50	1.91	0.50	1.09	10.58	2.04	1.62	632.97
210.00	14.38	0.88	241.38	241.53	0.52	1.97	0.52	1.17	11.03	2.19	1.59	649.66
210.00	15.07	0.89	241.39	241.54	0.53	1.99	0.53	1.27	11.43	2.37	1.56	668.65
211.00	12.33	1.07	241.67	241.68	0.00	0.57	0.00	0.00	12.33	0.00	1.67	578.43
211.00	13.01	1.08	241.68	241.70	0.00	0.58	0.00	0.00	13.01	0.00	1.66	607.15
211.00	13.70	1.10	241.70	241.71	0.00	0.59	0.00	0.00	13.70	0.00	1.65	633.85
211.00	14.38	1.11	241.71	241.73	0.00	0.59	0.00	0.00	14.38	0.00	1.61	650.57
211.00	15.07	1.12	241.72	241.74	0.00	0.59	0.00	0.00	15.07	0.00	1.59	669.60
212.00	12.33	0.84	242.61	242.77	0.43	2.12	0.48	0.07	8.10	4.16	1.68	579.20
212.00	13.01	0.85	242.62	242.78	0.44	2.19	0.49	0.07	8.45	4.49	1.67	607.95
212.00	13.70	0.87	242.64	242.80	0.45	2.22	0.50	0.08	8.73	4.89	1.65	634.69
212.00	14.38	0.89	242.66	242.82	0.46	2.22	0.51	0.09	8.93	5.36	1.62	651.45
212.00	15.07	0.89	242.66	242.83	0.47	2.28	0.53	0.09	9.28	5.69	1.59	670.52
213.00	12.33	0.68	243.18	243.52	0.00	2.59	0.00	0.00	12.33	0.00	1.68	579.33
213.00	13.01	0.70	243.20	243.56	0.00	2.64	0.00	0.00	13.01	0.00	1.67	608.09
213.00	13.70	0.73	243.23	243.60	0.00	2.69	0.00	0.00	13.70	0.00	1.65	634.83
213.00	14.38	0.75	243.25	243.63	0.00	2.72	0.00	0.00	14.38	0.00	1.62	651.60
213.00	15.07	0.78	243.28	243.67	0.00	2.77	0.00	0.00	15.07	0.00	1.60	670.67

TABLE 4.5b-1
KIMBERLEY PROJECT AREA
100 YEAR SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
213.10	12.33	1.05	243.55	243.69	0.00	1.67	0.00	0.00	12.33	0.00	1.68	579.40
213.10	13.01	1.08	243.58	243.73	0.00	1.71	0.00	0.00	13.01	0.00	1.67	608.15
213.10	13.70	1.12	243.62	243.77	0.00	1.75	0.00	0.00	13.70	0.00	1.66	634.90
213.10	14.38	1.15	243.65	243.81	0.00	1.78	0.00	0.00	14.38	0.00	1.62	651.67
213.10	15.07	1.18	243.68	243.85	0.00	1.81	0.00	0.00	15.07	0.00	1.60	670.74
214.00	12.33	1.09	243.69	244.05	0.00	2.65	0.00	0.00	12.33	0.00	1.68	579.43
214.00	13.01	1.12	243.72	244.09	0.00	2.68	0.00	0.00	13.01	0.00	1.67	608.19
214.00	13.70	1.15	243.75	244.13	0.00	2.71	0.00	0.00	13.70	0.00	1.66	634.93
214.00	14.38	1.18	243.78	244.16	0.00	2.74	0.00	0.00	14.38	0.00	1.62	651.70
214.00	15.07	1.21	243.81	244.20	0.00	2.76	0.00	0.00	15.07	0.00	1.60	670.78
215.00	12.33	0.95	245.59	245.86	0.00	2.34	0.00	0.00	12.33	0.00	1.69	579.68
215.00	13.01	0.97	245.61	245.89	0.00	2.36	0.00	0.00	13.01	0.00	1.68	608.44
215.00	13.70	0.99	245.63	245.92	0.00	2.38	0.00	0.00	13.70	0.00	1.66	635.20
215.00	14.38	1.02	245.66	245.95	0.00	2.40	0.00	0.00	14.38	0.00	1.63	651.98
215.00	15.07	1.04	245.68	245.98	0.00	2.42	0.00	0.00	15.07	0.00	1.60	671.07
216.00	12.33	0.95	247.45	247.72	0.00	2.31	0.00	0.00	12.33	0.00	1.70	580.05
216.00	13.01	0.97	247.47	247.75	0.00	2.34	0.00	0.00	13.01	0.00	1.68	608.83
216.00	13.70	0.99	247.49	247.78	0.00	2.36	0.00	0.00	13.70	0.00	1.67	635.61
216.00	14.38	1.02	247.52	247.80	0.00	2.38	0.00	0.00	14.38	0.00	1.64	652.40
216.00	15.07	1.04	247.54	247.83	0.00	2.40	0.00	0.00	15.07	0.00	1.61	671.51

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
2.00	114.57	2.21	231.71	231.76	0.22	1.31	0.27	1.05	63.08	50.44	0.06	43.14
2.00	120.94	2.23	231.73	231.78	0.23	1.34	0.28	1.15	65.08	54.71	0.06	44.93
2.00	127.30	2.25	231.75	231.80	0.23	1.37	0.29	1.24	67.09	58.97	0.06	46.56
2.00	133.66	2.27	231.77	231.82	0.24	1.39	0.30	1.34	69.05	63.27	0.06	48.17
2.00	140.03	2.29	231.79	231.84	0.25	1.42	0.31	1.44	70.95	67.63	0.06	49.75
3.00	114.57	2.55	231.84	231.87	0.19	0.90	0.20	13.30	61.95	39.32	0.14	86.74
3.00	120.94	2.58	231.87	231.89	0.20	0.92	0.21	14.40	64.02	42.51	0.14	90.14
3.00	127.30	2.60	231.89	231.92	0.21	0.94	0.22	15.49	66.02	45.79	0.14	93.30
3.00	133.66	2.62	231.91	231.94	0.21	0.96	0.22	16.59	67.95	49.13	0.13	96.41
3.00	140.03	2.65	231.94	231.96	0.22	0.98	0.23	17.69	69.84	52.51	0.13	99.48
4.00	114.57	2.49	231.93	231.96	0.28	1.12	0.21	26.32	64.94	23.30	0.20	134.94
4.00	120.94	2.51	231.95	231.99	0.29	1.14	0.22	28.07	66.93	25.93	0.20	140.15
4.00	127.30	2.54	231.98	232.02	0.30	1.16	0.22	29.80	68.90	28.59	0.20	145.05
4.00	133.66	2.56	232.00	232.04	0.31	1.18	0.23	31.53	70.82	31.31	0.20	149.87
4.00	140.03	2.59	232.03	232.07	0.32	1.20	0.24	33.26	72.70	34.08	0.20	154.62
5.00	114.57	2.32	232.02	232.04	0.22	0.79	0.24	10.91	41.37	62.29	0.29	180.63
5.00	120.94	2.35	232.05	232.07	0.22	0.80	0.24	11.65	42.54	66.74	0.29	187.87
5.00	127.30	2.38	232.08	232.09	0.23	0.82	0.24	12.39	43.69	71.21	0.29	194.72
5.00	133.66	2.41	232.11	232.12	0.24	0.83	0.25	13.13	44.82	75.72	0.29	201.43
5.00	140.03	2.43	232.13	232.15	0.24	0.84	0.25	13.86	45.91	80.26	0.29	208.02
6.00	114.57	1.68	232.11	232.12	0.22	0.68	0.23	14.89	45.33	54.35	0.44	255.07
6.00	120.94	1.71	232.14	232.15	0.23	0.69	0.24	15.82	46.71	58.41	0.44	265.37
6.00	127.30	1.73	232.16	232.18	0.23	0.70	0.24	16.75	48.10	62.46	0.43	275.13
6.00	133.66	1.76	232.19	232.20	0.24	0.71	0.25	17.67	49.48	66.52	0.43	284.66
6.00	140.03	1.79	232.22	232.23	0.24	0.72	0.26	18.61	50.84	70.58	0.42	294.00

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
7.00	114.57	1.23	232.28	232.29	0.46	0.90	0.49	10.08	15.32	89.16	0.55	319.29
7.00	120.94	1.25	232.30	232.32	0.46	0.89	0.49	10.68	15.63	94.63	0.54	332.68
7.00	127.30	1.28	232.33	232.35	0.45	0.89	0.49	11.28	15.92	100.10	0.54	345.53
7.00	133.66	1.31	232.36	232.37	0.45	0.89	0.49	11.89	16.20	105.58	0.54	358.12
7.00	140.03	1.33	232.38	232.40	0.45	0.89	0.49	12.49	16.47	111.07	0.54	370.48
8.00	114.57	1.42	232.62	232.65	0.20	0.89	0.26	3.19	81.31	30.07	0.63	364.89
8.00	120.94	1.44	232.64	232.67	0.21	0.90	0.27	3.69	84.02	33.22	0.62	380.74
8.00	127.30	1.47	232.67	232.70	0.22	0.91	0.27	4.21	86.62	36.47	0.62	396.08
8.00	133.66	1.49	232.69	232.72	0.23	0.92	0.28	4.73	89.18	39.75	0.62	411.13
8.00	140.03	1.51	232.71	232.74	0.24	0.94	0.29	5.26	91.70	43.07	0.62	425.93
9.00	114.57	1.63	232.89	232.92	0.48	1.33	0.49	28.07	24.20	62.30	0.70	404.62
9.00	120.94	1.66	232.92	232.95	0.49	1.36	0.50	29.89	25.00	66.04	0.70	422.19
9.00	127.30	1.69	232.95	232.98	0.50	1.38	0.51	31.70	25.81	69.79	0.70	439.20
9.00	133.66	1.71	232.97	233.00	0.52	1.40	0.52	33.52	26.60	73.55	0.69	455.87
9.00	140.03	1.73	232.99	233.02	0.53	1.42	0.53	35.33	27.37	77.32	0.69	472.27
10.00	114.57	1.31	233.90	233.91	0.00	0.65	0.43	0.00	12.98	101.59	0.80	442.50
10.00	120.94	1.33	233.92	233.93	0.00	0.67	0.45	0.00	13.77	107.16	0.80	461.25
10.00	127.30	1.30	233.89	233.90	0.00	0.73	0.49	0.00	14.40	112.90	0.79	478.08
10.00	133.66	1.31	233.90	233.91	0.00	0.76	0.51	0.00	15.14	118.53	0.78	495.50
10.00	140.03	1.33	233.92	233.93	0.00	0.78	0.52	0.00	15.93	124.10	0.77	512.96
11.00	114.57	1.11	234.10	234.15	0.36	1.49	0.89	0.06	16.56	97.95	0.83	460.38
11.00	120.94	1.14	234.13	234.18	0.37	1.51	0.90	0.07	17.25	103.61	0.82	479.70
11.00	127.30	1.15	234.14	234.19	0.39	1.56	0.93	0.08	18.07	109.15	0.81	496.18
11.00	133.66	1.17	234.16	234.21	0.40	1.59	0.95	0.09	18.78	114.80	0.80	513.91
11.00	140.03	1.19	234.18	234.24	0.41	1.61	0.95	0.10	19.45	120.48	0.80	531.89

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
12.10	114.57	1.33	234.26	234.74	0.00	3.05	0.00	0.00	114.57	0.00	0.83	462.77
12.10	120.94	1.35	234.28	234.78	0.00	3.14	0.00	0.00	120.93	0.00	0.83	482.18
12.10	127.30	1.38	234.31	234.84	0.00	3.20	0.00	0.00	127.30	0.00	0.81	498.72
12.10	133.66	1.42	234.35	234.89	0.00	3.25	0.00	0.00	133.66	0.00	0.81	516.53
12.10	140.03	1.45	234.38	234.94	0.00	3.30	0.00	0.00	140.03	0.00	0.80	534.60
12.20	114.57	1.79	234.72	234.90	0.34	1.96	0.00	6.03	108.54	0.00	0.84	463.35
12.20	120.94	1.88	234.81	234.96	0.38	1.82	0.00	12.75	108.19	0.00	0.83	482.87
12.20	127.30	1.95	234.88	235.02	0.40	1.76	0.00	18.12	109.18	0.00	0.82	499.49
12.20	133.66	2.03	234.96	235.07	0.42	1.66	0.00	25.70	107.97	0.00	0.81	517.41
12.20	140.03	2.10	235.03	235.13	0.42	1.54	0.00	34.69	105.34	0.00	0.80	535.62
12.30	114.57	2.00	234.98	234.99	0.22	0.63	0.28	23.62	45.58	45.37	0.86	469.57
12.30	120.94	2.04	235.02	235.03	0.22	0.63	0.28	26.10	46.43	48.40	0.85	489.72
12.30	127.30	2.10	235.08	235.09	0.22	0.61	0.28	29.31	46.50	51.50	0.84	507.03
12.30	133.66	2.14	235.12	235.13	0.22	0.59	0.28	32.43	46.78	54.45	0.83	525.69
12.30	140.03	2.19	235.17	235.18	0.22	0.58	0.28	35.61	47.07	57.35	0.83	544.69
13.00	114.57	1.36	235.22	235.28	0.26	1.86	0.68	2.82	32.63	79.12	0.92	524.19
13.00	120.94	1.39	235.25	235.31	0.27	1.82	0.68	3.78	32.84	84.31	0.91	548.24
13.00	127.30	1.42	235.28	235.34	0.28	1.78	0.67	4.82	33.11	89.36	0.90	570.48
13.00	133.66	1.45	235.31	235.37	0.30	1.75	0.67	6.14	33.33	94.20	0.90	593.76
13.00	140.03	1.48	235.34	235.40	0.32	1.71	0.66	7.73	33.44	98.86	0.90	617.46
14.00	114.57	1.37	235.67	235.69	0.11	0.96	0.50	0.02	21.63	92.91	0.98	547.06
14.00	120.94	1.39	235.69	235.71	0.09	0.98	0.51	0.04	22.57	98.32	0.97	572.40
14.00	127.30	1.41	235.71	235.73	0.09	1.01	0.52	0.08	23.50	103.72	0.96	595.88
14.00	133.66	1.43	235.73	235.75	0.11	1.03	0.53	0.14	24.42	109.10	0.96	620.39
14.00	140.03	1.45	235.75	235.77	0.12	1.05	0.55	0.21	25.35	114.47	0.95	645.32

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
15.00	114.57	1.40	235.95	235.97	0.16	0.93	0.58	0.22	15.75	98.60	1.04	575.85
15.00	120.94	1.42	235.97	235.99	0.18	0.94	0.58	0.31	16.41	104.21	1.04	602.36
15.00	127.30	1.44	235.99	236.01	0.20	0.95	0.59	0.42	17.05	109.83	1.03	627.00
15.00	133.66	1.47	236.02	236.04	0.22	0.96	0.58	0.54	17.65	115.47	1.02	652.92
15.00	140.03	1.49	236.04	236.06	0.24	0.97	0.57	0.66	18.17	121.19	1.02	679.46
16.00	114.57	1.78	236.09	236.32	0.00	2.30	0.61	0.00	98.34	16.23	1.05	580.37
16.00	120.94	1.80	236.11	236.33	0.00	2.29	0.67	0.00	100.17	20.77	1.04	607.13
16.00	127.30	1.82	236.13	236.33	0.00	2.20	0.73	0.00	99.61	27.69	1.03	632.07
16.00	133.66	1.85	236.16	236.33	0.00	2.11	0.77	0.00	98.99	34.68	1.03	658.37
16.00	140.03	1.87	236.18	236.33	0.00	1.98	0.80	0.00	97.11	42.92	1.02	685.38
16.10	114.57	1.89	236.20	236.44	0.00	3.25	0.75	0.00	47.38	67.19	1.05	580.87
16.10	120.94	2.17	236.48	236.50	0.00	1.07	0.54	0.00	15.95	104.99	1.05	607.95
16.10	127.30	2.15	236.46	236.48	0.00	1.20	0.59	0.00	17.87	109.43	1.03	632.90
16.10	133.66	2.13	236.44	236.47	0.00	1.33	0.64	0.00	19.76	113.91	1.03	659.20
16.10	140.03	2.10	236.41	236.45	0.00	1.53	0.70	0.00	22.80	117.23	1.03	686.20
17.00	114.57	2.16	236.47	236.47	0.16	0.49	0.21	0.81	10.99	102.77	1.06	584.04
17.00	120.94	2.19	236.50	236.51	0.17	0.49	0.21	0.90	11.39	108.64	1.06	611.75
17.00	127.30	2.18	236.49	236.49	0.18	0.53	0.22	0.93	12.09	114.28	1.04	636.60
17.00	133.66	2.17	236.48	236.48	0.19	0.56	0.24	0.96	12.76	119.94	1.04	662.84
17.00	140.03	2.15	236.46	236.46	0.20	0.60	0.25	0.98	13.51	125.55	1.04	689.72
18.00	114.57	1.61	236.53	236.55	0.01	1.10	0.47	0.00	32.86	81.71	1.12	629.83
18.00	120.94	1.64	236.56	236.59	0.01	1.08	0.46	0.00	33.87	87.06	1.11	659.98
18.00	127.30	1.64	236.56	236.58	0.01	1.15	0.49	0.00	35.75	91.55	1.10	684.08
18.00	133.66	1.64	236.56	236.59	0.01	1.20	0.51	0.00	37.52	96.14	1.09	709.93
18.00	140.03	1.63	236.55	236.59	0.01	1.27	0.54	0.00	39.40	100.63	1.08	735.93

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
19.00	114.57	1.19	236.88	236.91	0.42	0.75	0.34	3.69	110.74	0.15	1.16	651.50
19.00	120.94	1.21	236.90	236.93	0.43	0.76	0.34	3.92	116.85	0.16	1.16	682.95
19.00	127.30	1.23	236.92	236.95	0.44	0.77	0.35	4.17	122.96	0.17	1.14	707.40
19.00	133.66	1.24	236.93	236.96	0.44	0.77	0.35	4.42	129.06	0.18	1.13	733.75
19.00	140.03	1.26	236.95	236.98	0.44	0.77	0.36	4.68	135.16	0.19	1.13	760.13
20.00	114.57	1.55	237.54	237.72	0.00	1.87	0.00	0.00	114.57	0.00	1.18	663.52
20.00	120.94	1.57	237.56	237.74	0.00	1.86	0.00	0.00	120.93	0.00	1.17	695.45
20.00	127.30	1.58	237.57	237.76	0.00	1.89	0.00	0.00	127.30	0.00	1.16	720.48
20.00	133.66	1.59	237.58	237.77	0.00	1.94	0.00	0.00	133.66	0.00	1.15	747.34
20.00	140.03	1.60	237.59	237.79	0.00	1.99	0.00	0.00	140.03	0.00	1.14	774.25
21.00	114.57	2.14	238.53	238.56	0.38	0.79	0.28	7.48	100.32	6.77	1.23	680.40
21.00	120.94	2.16	238.55	238.58	0.39	0.80	0.29	7.94	105.70	7.29	1.23	713.00
21.00	127.30	2.19	238.58	238.61	0.40	0.82	0.30	8.41	111.03	7.87	1.21	738.60
21.00	133.66	2.20	238.59	238.62	0.40	0.83	0.31	8.88	116.17	8.62	1.20	766.11
21.00	140.03	2.21	238.60	238.63	0.41	0.84	0.31	9.35	121.35	9.33	1.19	793.62
22.00	87.57	1.62	239.05	239.16	0.26	1.91	0.46	0.22	49.21	38.15	1.27	704.31
22.00	92.44	1.64	239.07	239.18	0.27	1.91	0.47	0.28	50.24	41.91	1.26	737.93
22.00	97.30	1.67	239.10	239.20	0.29	1.89	0.48	0.37	50.84	46.09	1.25	764.66
22.00	102.17	1.67	239.10	239.21	0.30	1.96	0.50	0.41	52.95	48.80	1.24	792.97
22.00	107.03	1.69	239.12	239.23	0.30	1.99	0.52	0.49	54.43	52.12	1.23	821.40
23.00	87.57	1.71	239.66	239.75	0.40	1.68	0.36	4.71	54.15	28.71	1.30	720.12
23.00	92.44	1.72	239.67	239.77	0.41	1.71	0.37	5.19	55.68	31.57	1.30	754.57
23.00	97.30	1.74	239.69	239.78	0.42	1.74	0.39	5.64	57.44	34.22	1.28	782.15
23.00	102.17	1.76	239.71	239.80	0.42	1.73	0.40	6.26	58.24	37.67	1.27	811.15
23.00	107.03	1.78	239.73	239.82	0.43	1.75	0.41	6.81	59.47	40.74	1.26	840.31

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
24.00	87.57	1.63	240.25	240.34	0.35	1.62	0.41	5.08	53.07	29.43	1.34	740.86
24.00	92.44	1.65	240.27	240.36	0.36	1.63	0.42	5.70	54.44	32.30	1.34	776.40
24.00	97.30	1.67	240.29	240.38	0.37	1.64	0.43	6.37	55.64	35.30	1.32	804.99
24.00	102.17	1.69	240.31	240.40	0.38	1.68	0.44	6.90	57.49	37.78	1.31	835.04
24.00	107.03	1.70	240.32	240.41	0.39	1.69	0.45	7.58	58.71	40.73	1.30	865.29
25.00	87.57	1.61	240.81	240.91	0.00	1.69	0.36	0.00	60.38	27.19	1.38	759.38
25.00	92.44	1.63	240.83	240.93	0.00	1.70	0.37	0.00	61.86	30.58	1.37	796.02
25.00	97.30	1.64	240.84	240.95	0.00	1.73	0.38	0.00	63.60	33.69	1.36	825.64
25.00	102.17	1.67	240.87	240.96	0.00	1.72	0.39	0.00	64.57	37.59	1.35	856.67
25.00	107.03	1.69	240.89	240.99	0.00	1.76	0.41	0.00	66.60	40.43	1.34	887.75
26.00	87.57	1.60	241.15	241.22	0.00	1.42	0.40	0.00	62.25	25.32	1.40	768.17
26.00	92.44	1.61	241.16	241.24	0.00	1.45	0.41	0.00	64.64	27.80	1.39	805.28
26.00	97.30	1.63	241.18	241.26	0.00	1.46	0.42	0.00	66.58	30.71	1.38	835.37
26.00	102.17	1.65	241.20	241.27	0.00	1.49	0.43	0.00	68.91	33.26	1.37	866.90
26.00	107.03	1.67	241.22	241.30	0.00	1.48	0.44	0.00	70.37	36.66	1.36	898.44

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
-21.00	87.57	2.14	238.53	238.55	0.33	0.60	0.23	6.49	75.63	5.44	1.47	788.34
-21.00	92.44	2.16	238.55	238.57	0.34	0.61	0.23	6.90	79.65	5.88	1.46	826.26
-21.00	97.30	2.19	238.58	238.59	0.34	0.61	0.24	7.33	83.48	6.49	1.45	857.48
-21.00	102.17	2.20	238.59	238.60	0.35	0.63	0.25	7.71	87.51	6.94	1.44	889.57
-21.00	107.03	2.21	238.60	238.62	0.36	0.64	0.25	8.12	91.40	7.51	1.43	922.13
210.00	48.78	1.25	241.75	242.00	0.82	2.82	0.82	7.39	27.54	13.85	1.48	798.65
210.00	51.49	1.27	241.77	242.02	0.83	2.87	0.83	7.95	28.63	14.91	1.48	836.98
210.00	54.20	1.29	241.79	242.05	0.85	2.91	0.85	8.52	29.71	15.97	1.46	868.75
210.00	56.91	1.31	241.81	242.07	0.86	2.95	0.86	9.09	30.77	17.05	1.45	901.11
210.00	59.62	1.33	241.83	242.09	0.87	2.99	0.87	9.67	31.81	18.14	1.44	934.06
211.00	48.78	1.57	242.17	242.21	0.40	0.85	0.10	2.25	46.46	0.06	1.50	801.06
211.00	51.49	1.60	242.20	242.23	0.39	0.87	0.11	2.40	49.00	0.09	1.50	839.49
211.00	54.20	1.62	242.22	242.26	0.39	0.89	0.12	2.55	51.53	0.12	1.48	871.37
211.00	56.91	1.64	242.24	242.28	0.38	0.91	0.13	2.71	54.05	0.15	1.47	903.82
211.00	59.62	1.66	242.26	242.31	0.38	0.93	0.13	2.87	56.55	0.19	1.46	936.87
212.00	48.78	1.31	243.08	243.27	0.69	2.93	0.81	0.47	18.09	30.21	1.51	803.42
212.00	51.49	1.33	243.10	243.29	0.71	2.98	0.84	0.50	18.66	32.32	1.50	841.94
212.00	54.20	1.35	243.12	243.31	0.72	3.03	0.86	0.53	19.22	34.44	1.49	873.90
212.00	56.91	1.37	243.14	243.33	0.73	3.07	0.88	0.56	19.75	36.60	1.47	906.44
212.00	59.62	1.39	243.16	243.35	0.74	3.11	0.90	0.59	20.27	38.76	1.47	939.59
213.00	48.78	1.48	243.98	245.13	0.00	4.74	0.00	0.00	48.78	0.00	1.51	803.83
213.00	51.49	1.49	243.99	245.25	0.00	4.96	0.00	0.00	51.49	0.00	1.50	842.36
213.00	54.20	1.49	243.99	245.38	0.00	5.23	0.00	0.00	54.20	0.00	1.49	874.34
213.00	56.91	2.04	244.54	244.59	0.01	0.90	0.95	0.00	9.68	47.23	1.48	907.26
213.00	59.62	2.04	244.54	244.59	0.01	0.95	1.00	0.00	10.14	49.48	1.47	940.42

TABLE 4.5b-2
KIMBERLEY PROJECT AREA
REGIONAL DESIGN SUMMARY OF SENSITIVITY TESTING
ON FLOOD MODEL FOR VARIATION IN FLOWS

SECNO	Q	DEPTH	CWSEL	EG	VLOB	VCH	VROB	QLOB	QCH	QROB	TIME	VOL
213.10	48.78	1.95	244.45	245.57	0.00	4.69	0.00	0.00	48.78	0.00	1.51	803.93
213.10	51.49	2.00	244.50	245.74	0.00	4.95	0.00	0.00	51.49	0.00	1.50	842.47
213.10	54.20	1.96	244.46	245.84	0.00	5.21	0.00	0.00	54.20	0.00	1.49	874.44
213.10	56.91	2.09	244.59	244.63	0.01	0.86	0.91	0.00	9.42	47.49	1.48	907.91
213.10	59.62	2.09	244.59	244.64	0.01	0.89	0.95	0.00	9.84	49.78	1.47	941.07
214.00	48.78	3.08	245.68	245.68	0.15	0.49	0.23	3.57	11.93	33.28	1.51	804.43
214.00	51.49	3.26	245.86	245.87	0.15	0.46	0.22	4.32	12.33	34.84	1.51	843.03
214.00	54.20	3.38	245.98	245.98	0.14	0.46	0.22	4.90	12.82	36.48	1.49	875.04
214.00	56.91	2.27	244.87	245.44	0.83	3.49	0.00	4.71	52.20	0.00	1.48	908.12
214.00	59.62	2.30	244.90	245.49	0.86	3.55	0.00	5.25	54.37	0.00	1.47	941.28
215.00	48.78	1.67	246.31	246.44	0.31	1.95	0.83	0.36	29.19	19.23	1.52	810.16
215.00	51.49	1.66	246.30	246.45	0.33	2.08	0.88	0.36	30.88	20.25	1.52	849.34
215.00	54.20	1.68	246.32	246.47	0.35	2.15	0.91	0.41	32.40	21.38	1.50	881.74
215.00	56.91	1.68	246.32	246.49	0.36	2.23	0.95	0.45	33.96	22.50	1.49	909.64
215.00	59.62	1.66	246.30	246.50	0.38	2.41	1.02	0.41	35.76	23.44	1.48	942.79
216.00	48.78	1.72	248.22	248.36	0.98	1.89	0.32	15.17	33.49	0.12	1.54	812.72
216.00	51.49	1.70	248.20	248.37	1.07	2.04	0.33	16.05	35.33	0.11	1.53	851.84
216.00	54.20	1.75	248.25	248.40	1.02	1.99	0.35	16.79	37.24	0.17	1.51	884.38
216.00	56.91	1.76	248.26	248.42	1.04	2.04	0.37	17.60	39.11	0.20	1.50	912.33
216.00	59.62	1.75	248.25	248.44	1.11	2.17	0.39	18.45	40.97	0.20	1.49	945.41

4.7 Structures Affected by Flooding

4.7.1 Heathcote Mapping Area

In the Heathcote mapping area there is only 1 structure located within the 100 year floodplain (floodway). This is the Community Centre building. In the main Beaver River floodplain, there are 4 residences and their associated outbuildings located in the Regional floodplain (flood fringe area). On the tributary, there are 5 outbuildings located in the Regional floodplain (flood fringe area).

4.7.2 Kimberley Mapping Area

In the Kimberley mapping area, there is 1 cottage and its associated outbuildings located in the 100 year floodplain (floodway). There is one motel located on the Regional floodplain (flood fringe area) as well as 3 houses with their associated outbuildings located in the Regional floodplain (flood fringe area). One house is located in the main river floodplain and the remaining two are located on the tributary flood fringe area.

There is a spill area resulting from uncontained flood waters spilling away from the spill berm area on the north side of the old mill pond on the east tributary. The waters leaving the natural flow direction along the watercourse will flow northerly along the east side of County Road #13 until they reach the existing Beaver River floodplain in Lot 6. The spill area is located in Lot 5, Concession 4. The depth of flooding in the spill area would be relatively shallow with velocities near 1 metre per second. The flow route of the spill should be preserved by some form of zoning or bylaw in order to ensure localized flooding is not increased by filling in the spill area route.

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