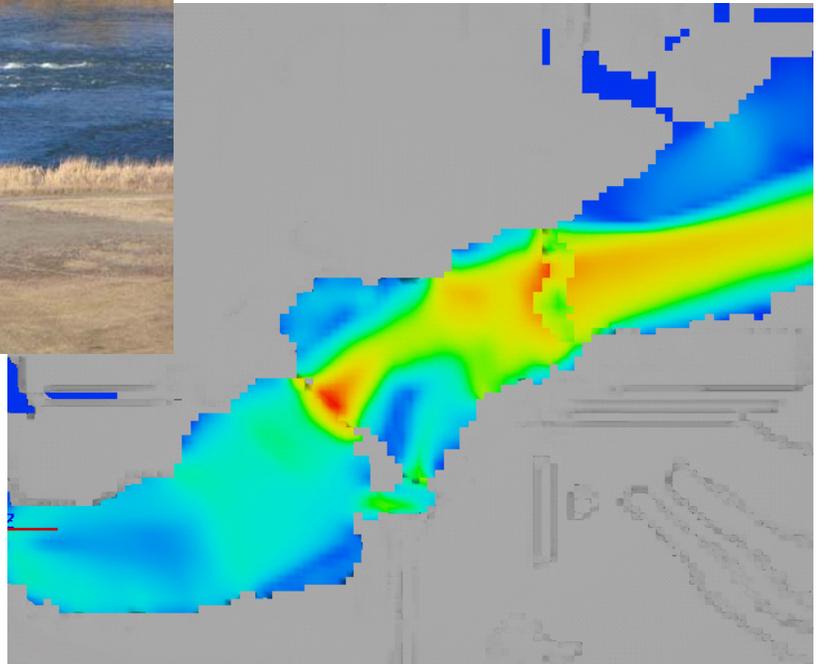


Manitoba Hydro

**VELOCITIES AT THE BRANDON GENERATING STATION
WEIR ON THE ASSINIBOINE RIVER**



REPORT NO. PP&D – 06/07

**WATER RESOURCE DEVELOPMENT & ENGINEERING DEPARTMENT
POWER PLANNING & DEVELOPMENT
August 2006**

REPORT ON

**VELOCITIES AT THE BRANDON GENERATING STATION WEIR
ON THE ASSINIBOINE RIVER**

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TABLE OF CONTENTS

LIST OF FIGURES.....iii

LIST OF TABLES.....iii

1. SUMMARY.....1

2. DATA.....1

 2.1 Discharges.....1

 2.2 Water Levels.....1

 2.3 Bathymetry.....1

3. MODELLING.....1

 3.1 Model Set-up.....1

 3.2 Calibration and Sensitivity.....2

 3.3 Modelled Scenarios2

4. RESULTS.....3

 4.1 Water Surface Profile.3

 4.2 Model Velocity Distribution3

 4.3 Cross Sectional Velocity Distribution3

5. CONCLUSIONS4

LIST OF FIGURES

	<u>Page</u>
Figure 1 - Site Layout	.....5
Figure 2 - Assiniboine River Discharge Duration Curves	.....6
Figure 3 - Brandon GS Weir 1956 Bathymetric Survey	.....7
Figure 4 - Brandon GS Weir 2004 Bathymetric Survey	.....8
Figure 5 - Aerial Photographs of the Weir	.....9
Figure 6 - Brandon GS Weir Modelled Water Surface Profiles	.....10
Figure 7 - Brandon GS Weir Velocity Profiles	.....11
Figure 8 - Cross Section Locations	.....12
Figure 9 - Velocity Distribution at Cross Section A	.....13
Figure 10 - Velocity Distribution at Cross Section B	.....14
Figure 11 - Velocity Distribution at Cross Section C	.....15
Figure 12 - Velocity Distribution at Cross Section D	.....16
Figure 13 - Velocity Distribution at Cross Section E	.....17

LIST OF TABLES

	<u>Page</u>
Table 1 - Modelled Discharges	.....2
Table 2 - Maximum Velocities (m/s)	.....3
Table 3 - Maximum Flow Depth	.....3

1. SUMMARY

At the request of the Generation Maintenance Engineering Department, the velocity distribution was determined at the Brandon Generating Station weir on the Assiniboine River shown in Figure 1. The velocity distribution was modelled with FLOW3D, a three dimension model, using bathymetry from surveys completed in 1956 and 2004. Results of the model will be used to assess the ability for fish passage under a variety of discharges.

2. DATA

2.1 Discharges

Discharge data used in this study was taken from Water Survey of Canada gauge 05MH013 from 1974-2004. The gauge is located approximately 24 km upstream of the Brandon G.S. weir. Figure 2 shows the discharge duration curve with the 5th, 50th and 95th percentile discharges. Duration curves were developed for the entire record, the open water season (May 1 –Oct 31), the ice covered season (Nov 1- Apr 30) and the spring freshet (Apr 15 – Jun 15).

2.2 Water Levels

Water levels at the weir required for calibration were taken from surveys done in September 2004 and July 2006. The 2004 survey only collected water levels directly upstream and downstream of the weir while the 2006 survey captured a complete water surface profile from approximately 150m upstream of the weir to 250 m downstream.

2.3 Bathymetry

Bathymetric information was compiled from two surveys completed in 1956 and 2004. The 1956 survey shown in Figure 3 was commissioned before the weir was constructed and consisted of bathymetry and upbank elevations. The 2004 survey, shown in Figure 4, collected transects only across the weir.

In addition to the survey data collected in 1956 and 204, a number of cross sections were fabricated upstream of the weir to reduce the effects of the model boundary on the weir velocities. Information from both surveys and the fabricated points were incorporated into a single bathymetry file for use in the FLOW3D model.

3. MODELLING

3.1 Model Set-up

The model boundaries included 300 m upstream and 250 m downstream of the weir. This distance was deemed large enough to reduce the effects of the model boundaries on the velocities at the weir. The model was set up with 3 m horizontal modelling elements and 0.2 m vertical elements. Inputs for each modelled scenario included a discharge and its corresponding downstream water level.

3.2 Calibration and Sensitivity

The model was calibrated using the following two runs:

Date Collected	Discharge (m ³ /s)	Downstream Water Level (m)
September 2004	20.2	353.8
July 2006	65	354.25

The modelled downstream water levels were calibrated to within 0.1 m while the upstream water levels were within 0.2 m. The only parameter used in the calibration was the bottom roughness. The sensitivity of the modelled water levels to the modelled bottom roughness was examined. The results indicate the bottom roughness used in the model had less than 0.03 m influence on the water levels.

3.3 Modelled Scenarios

The Generation Maintenance Engineering Department requested the modelling of the velocity distribution for the 5th, 50th and 95th percentile discharges for both the open water season and the spring freshet. Since the 5th percentile flows for both the open water and spring periods were very similar, only one of the flows was modelled. Coincidentally, the two flows used to calibrate the model were very close to the 50th percentile flows for the open water and freshet periods. As a result the calibration runs were used instead of rerunning the model precisely at the defined 50th percentile discharges. The table below shows the five discharges that were modelled and the condition that they represent.

Table 1: Modelled Discharges

Modelled Discharge m ³ /s	Open Water	Spring Freshet
4.8	5%ile (4.8 m ³ /s)	5%ile (7.8 m ³ /s)
20.2	50%ile (17.9 m ³ /s)	-
65	-	50%ile (48.1 m ³ /s)
136	95%ile (136 m ³ /s)	-
294	-	95%ile (294 m ³ /s)

An important parameter needed to model the velocities in the vicinity of the weir is the downstream water levels. Since this data was not available for most of the discharges that were used in the model, a variety of downstream water levels were modelled for each discharge. Comparing the model results to aerial photographs taken at similar discharges, a suitably downstream boundary condition was chosen. For example, the aerial photos shown in Figure 5 show that under high discharges, there does not appear to be any appreciable head loss across the weir. Therefore the downstream boundary condition was chosen to reflect the observations.

4. Results

4.1 Water Surface Profile

The water surface profile of each of the modelled discharge is shown in Figure 6. The 2006 surveyed water surface profile is also shown.

4.2 Model Velocity Distribution

The velocity distribution of each of the modelled discharge is shown in Figure 7.

4.3 Cross Sectional Velocity Distribution

The velocity distribution was plotted for each of the cross sections shown in Figure 8. The cross sectional velocities are shown in figures 9 to 13.

The maximum velocities at each cross section are shown in Table 2 and the maximum water depths at each cross section are shown in Table 3.

Table 2: Maximum Velocities (m/s)

Cross Section	Discharge m ³ /s				
	4.8 m ³ /s	20.2 m ³ /s	65 m ³ /s	136 m ³ /s	294 m ³ /s
A	0.3	0.7	1.3	1.7	2.1
B	0.9	1.6	2.0	2.2	2.6
C	1.3	2.1	2.2	2.3	2.8
D	0.5	0.9	1.4	1.7	2.4
E	0.7	1.6	2.1	2.6	2.7

Table 3: Maximum Flow Depth (m)

Cross Section	Maximum Flow Depth (m)				
	4.8 m ³ /s	20.2 m ³ /s	65 m ³ /s	136 m ³ /s	294 m ³ /s
A	0.9	1.1	1.5	2.1	2.7
B	1.7	1.9	2.3	2.9	3.7
C	0.9	1.3	1.7	2.1	2.9
D	1.1	1.3	1.7	2.3	2.9
E	0.7	0.9	1.3	1.9	2.5

5. CONCLUSIONS

At high discharges, the water levels across the weir (and the rest of the study area) are controlled by backwater from downstream (outside the model). As a result of the backwater effect, the weir is

flooded out and the velocities throughout the reach are relatively consistent. This effect was confirmed from the model as well as the aerial photographs.

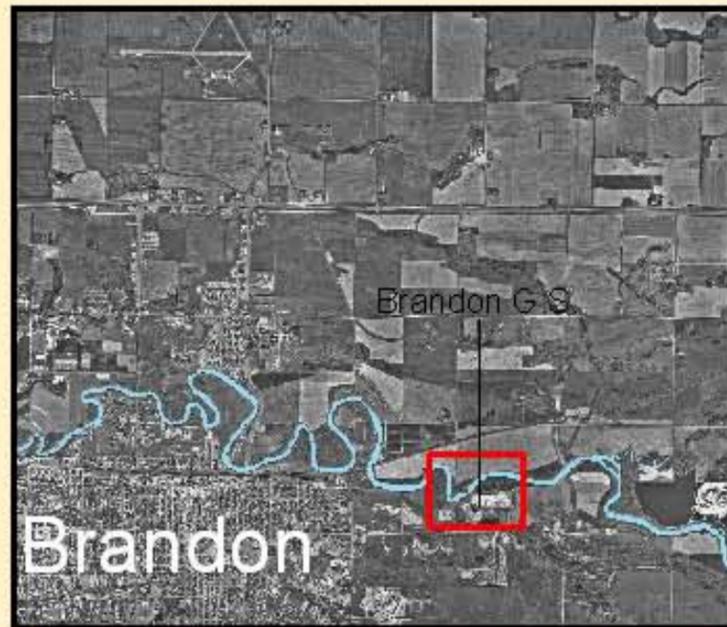
At average discharges, the weir exhibits higher velocity zones than the surrounding area. Although the centre portion of the weir exhibits high velocity, the south section of the weir has a deeper, more tranquil zone. Depths across the weir range from minimal to almost 2 m.

At the extremely low discharges, flow across the weir appears to be limited to the centre portion and the south section. Velocities are extremely low and depths range from minimal to almost 1 m.

Study Area Overview



Brandon G.S. Location



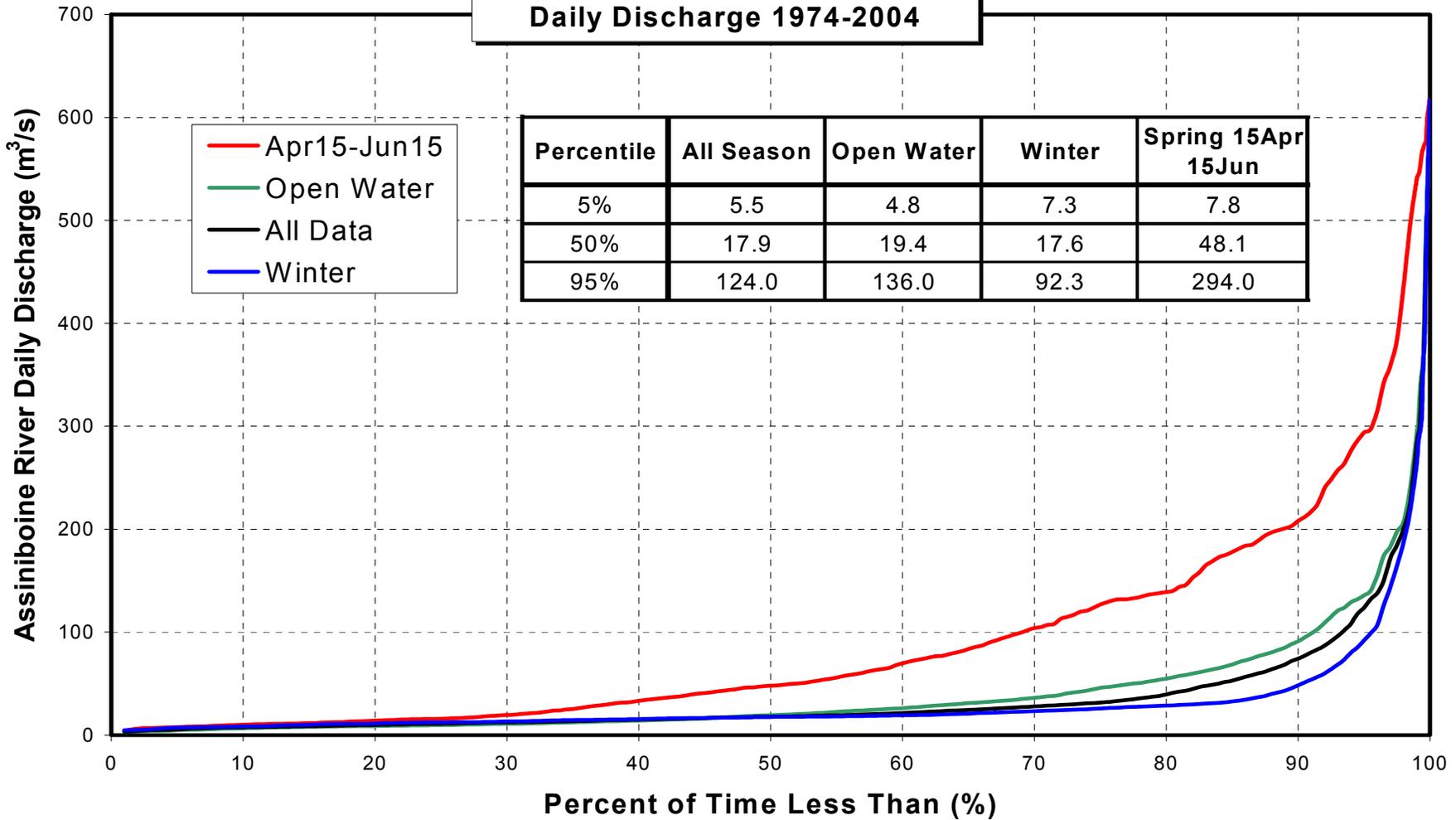
BRANDON GENERATING STATION WEIR SITE MAP

Manitoba Hydro
Water Resource Dev. & Eng. Dept.
Brandon G.S. Weir Velocity Modelling
FIGURE 1

Date: August 11, 2006

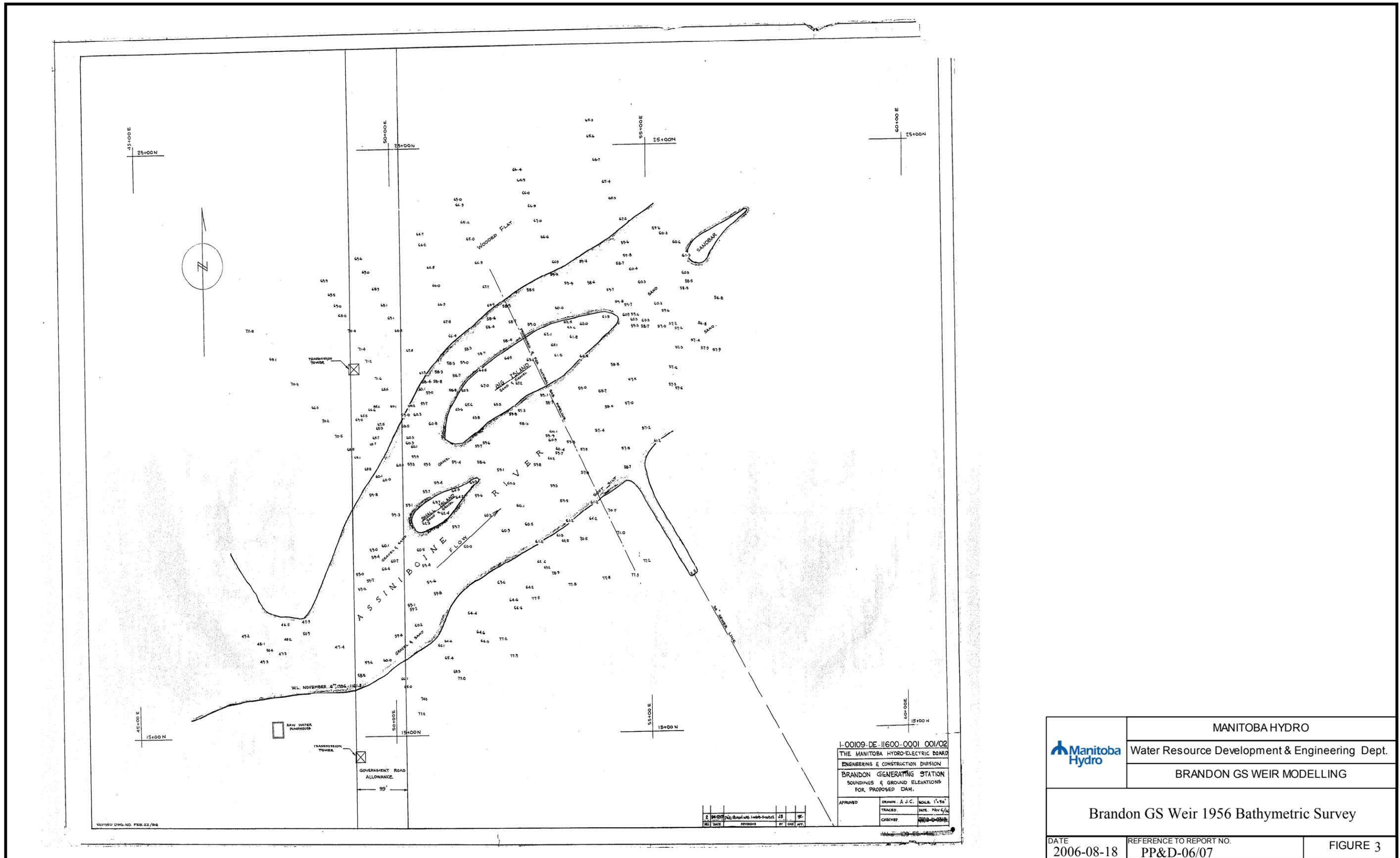
Location: Hydraulic Section Data/Rivers/Assiniboine/Brandon Weir/Brandon Weir Site Map

Assiniboine River at Brandon Daily Discharge 1974-2004



Percentile	All Season	Open Water	Winter	Spring 15Apr 15Jun
5%	5.5	4.8	7.3	7.8
50%	17.9	19.4	17.6	48.1
95%	124.0	136.0	92.3	294.0

	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Assiniboine River Discharge Duration Curves		
DATE	REFERENCE TO REPORT NO.	FIGURE 2
2006-08-18	PP&D-06/07	

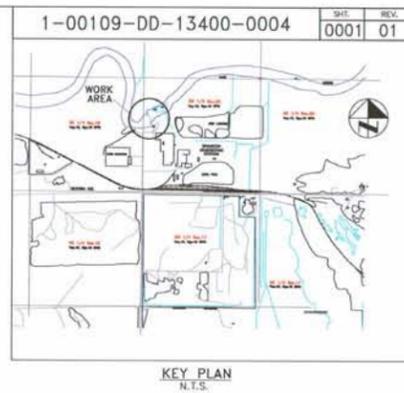
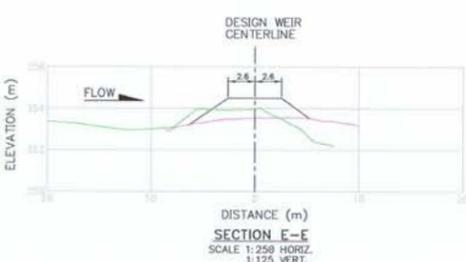
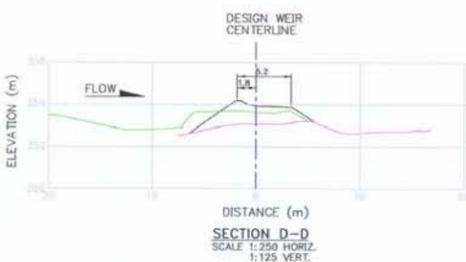
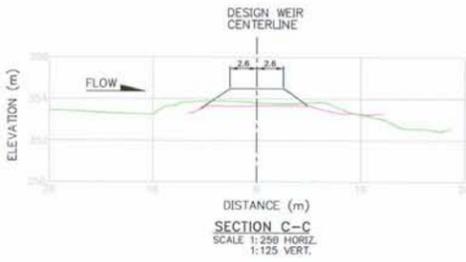
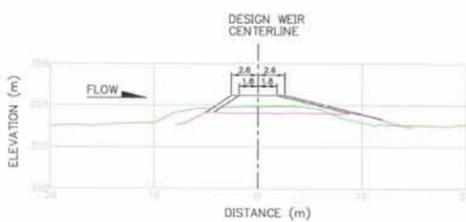


I-00109-DE-11600-0001 001/02
 THE MANITOBA HYDRO-ELECTRIC BOARD
 ENGINEERING & CONSTRUCTION DIVISION
 BRANDON GENERATING STATION
 SOUNDINGS & GROUND ELEVATIONS
 FOR PROPOSED DAM.

2	1957	1957	1957	1957	1957	1957	1957
REV	DATE	BY	CHKD	APPD	DATE	BY	CHKD

	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING
Brandon GS Weir 1956 Bathymetric Survey	
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07
FIGURE 3	

D SIZE - 348 x 481
 SHEET NO. 0001 01
 1-00109-DD-13400-0004



- NOTES:**
1. ALL VALUES SHOWN ARE IN METRES.
 2. ORIGINATING SURVEY CONTROL SHOWN ON PLAN 7-00109-DE-11520-0005.
 3. COORDINATES SHOWN ARE UTM ZONE 14 NAD83. SCALE FACTOR = 0.99959.
 4. ELEVATIONS SHOWN ARE BRANDON G.S. STATION DATUM.
 5. THE LIMITS AND GEOMETRY OF THE SHORELINE EROSION PROTECTION WORKS ARE ASSUMED. PROTECTION INSTALLED POST-SURVEY.
 6. CONTOUR INTERVAL = 0.25 METRES.
 7. SURVEY PERFORMED ON SEPTEMBER 23 & 24, 2004.
 8. RIVER LEVEL WAS 353.98m U/S OF THE WEIR AT THE TIME OF SURVEY.

- LEGEND:**
- 2004 SURVEY
 - 1976 DESIGN
 - 1958 PROFILE
 - 1976 RIVER BOTTOM

- REF. DRAWING:**
- 1-00109-DE-11500-0001 0001/01
 - 1-00109-DC-20350-0001 0001/02
 - 1-00109-DC-13400-0003 0001/00

NO.	DATE	REVISIONS	BY	CHK.	APP.
1	2006 08 04	CORRECTED ELEVATIONS ON SECTIONS AND PROFILE ALIGNMENT			

NOTED		
CIVIL		
GEOTECHNICAL		
ELECTRICAL		
P.P. ENGINEER		
MECHANICAL		
DISTRIBUTION	DRW.	G.L.W.
PROJECT	CHECK	J.T.
CONSTRUCTION	SCALE	AS SHOWN
MANAGER	DATE	2006 06 26

MANITоба HYDRO	
BRANDON GENERATING STATION	
ASSINIBOINE RIVER WEIR	
2004 SURVEY	
PLAN AND SECTIONS	
1-00109-DD-13400-0004	SHT. 0001 REV. 01

	MANITоба HYDRO
	Water Resource Development & Engineering Dept.
BRANDON GS WEIR MODELLING	
Brandon GS Weir 2004 Bathymetric Survey	
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07
FIGURE 4	

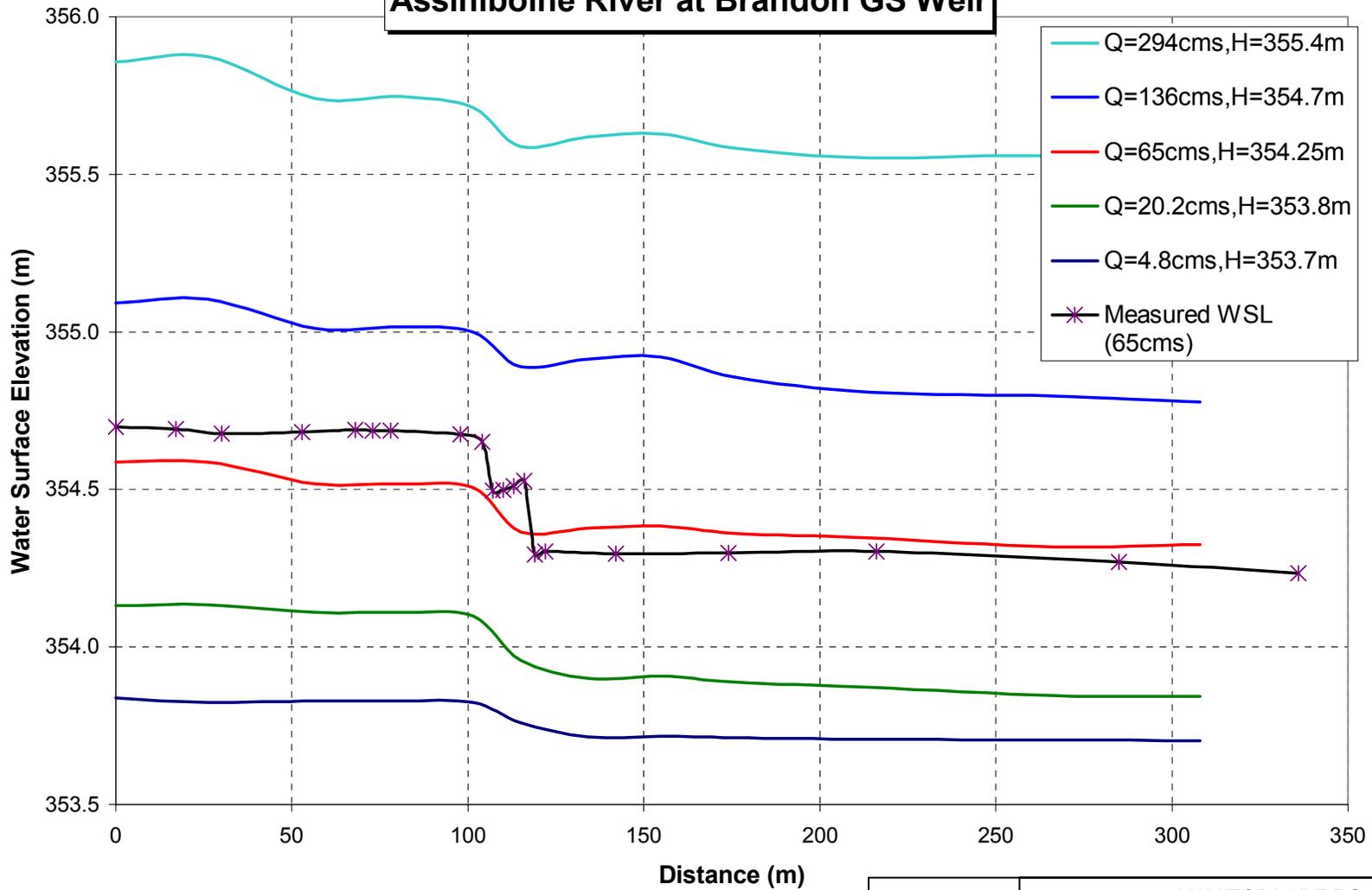


Under high discharge the weir "Disappears"

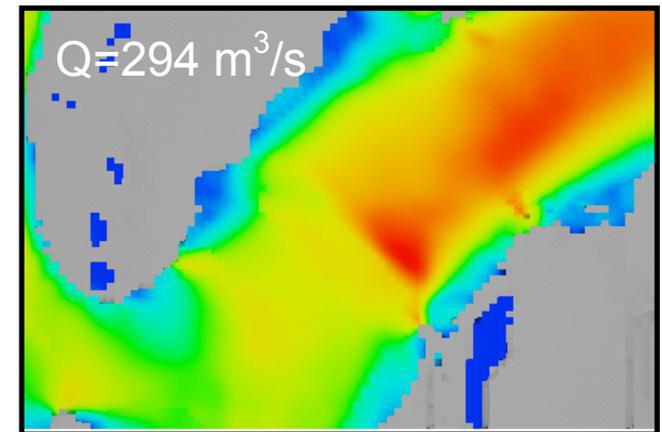
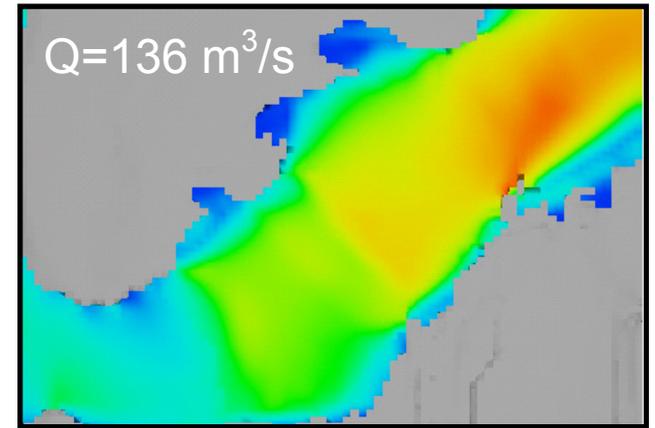
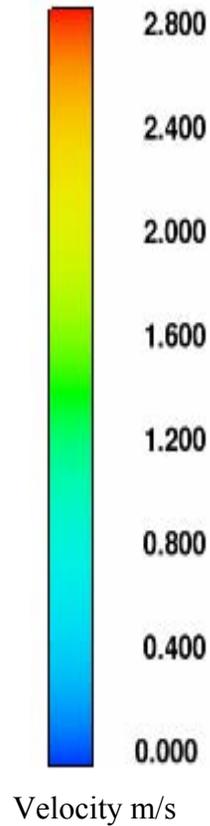
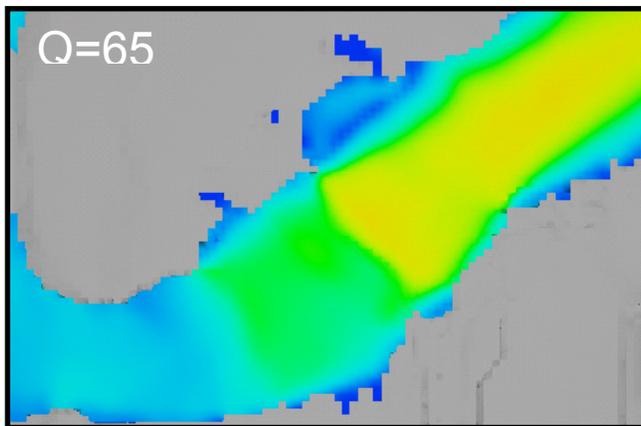
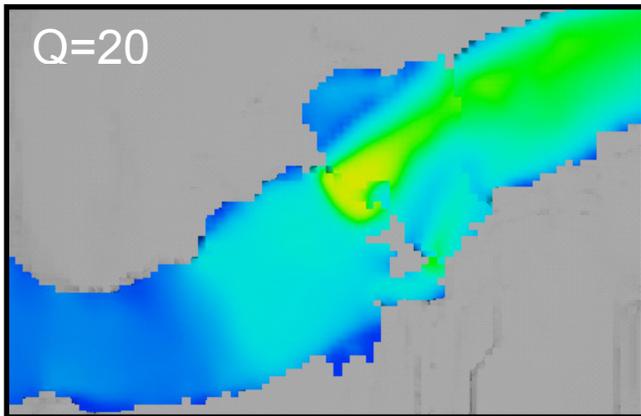
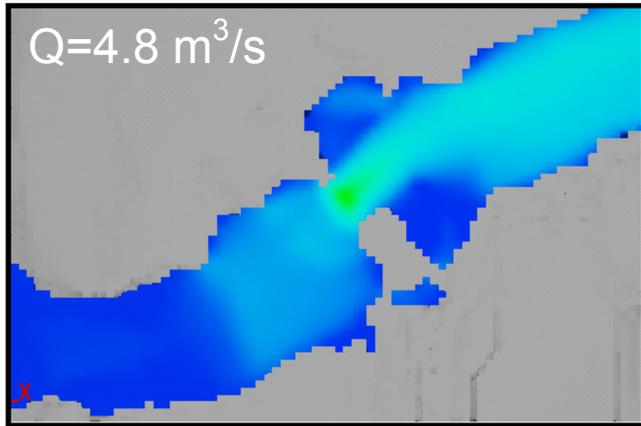


	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Aerial Photographs of the Weir		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 5

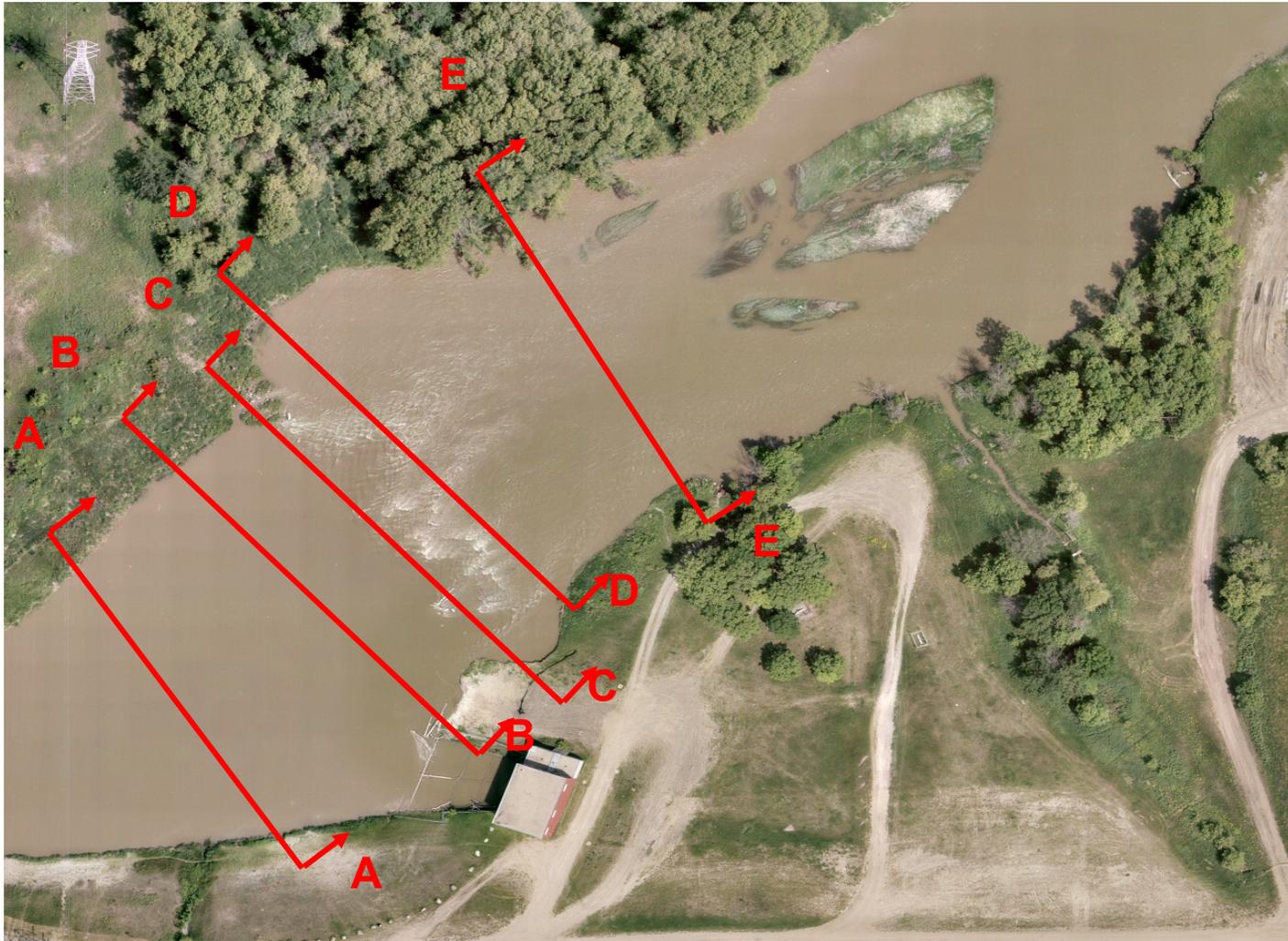
Assiniboine River at Brandon GS Weir



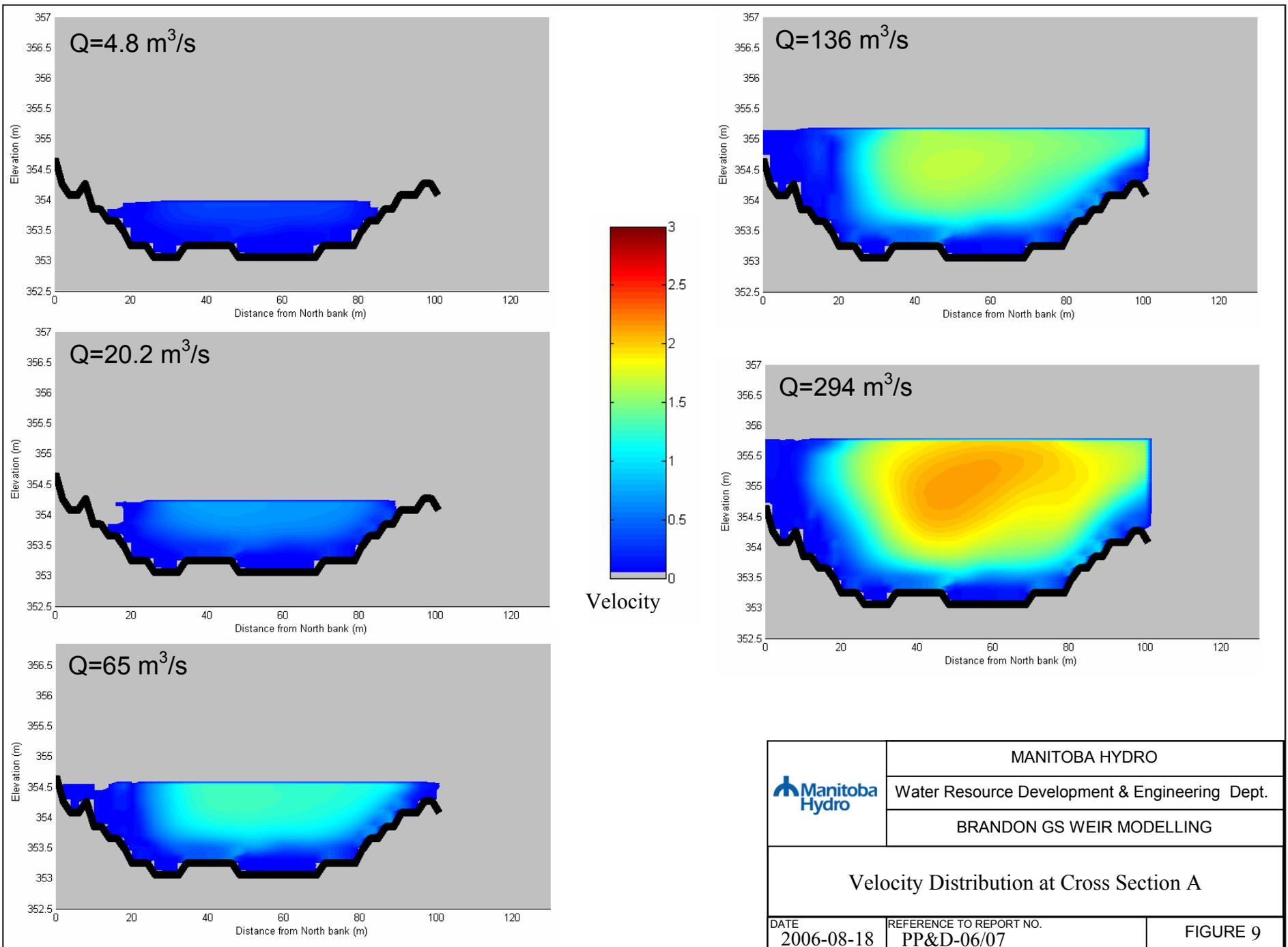
	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Brandon GS Weir Modelled Water Surface Profiles		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 6



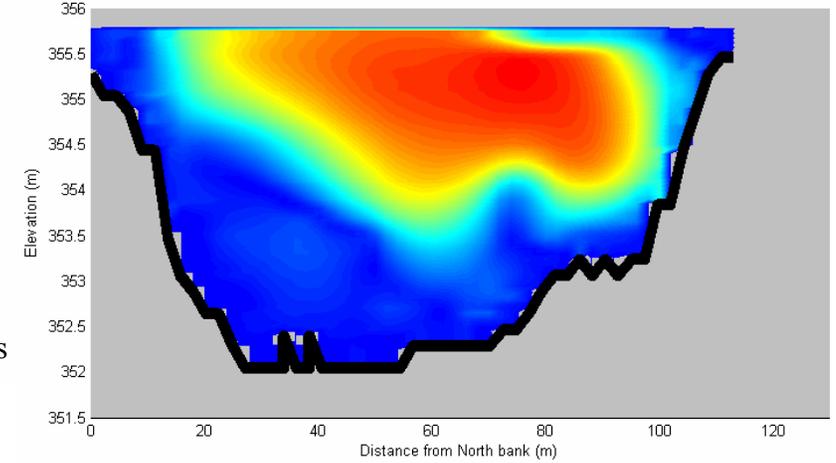
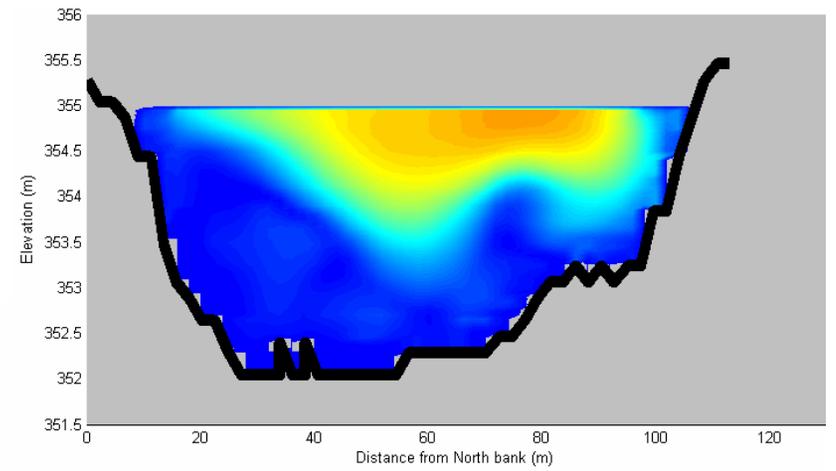
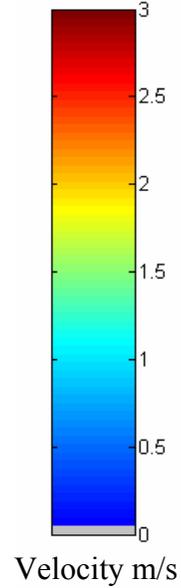
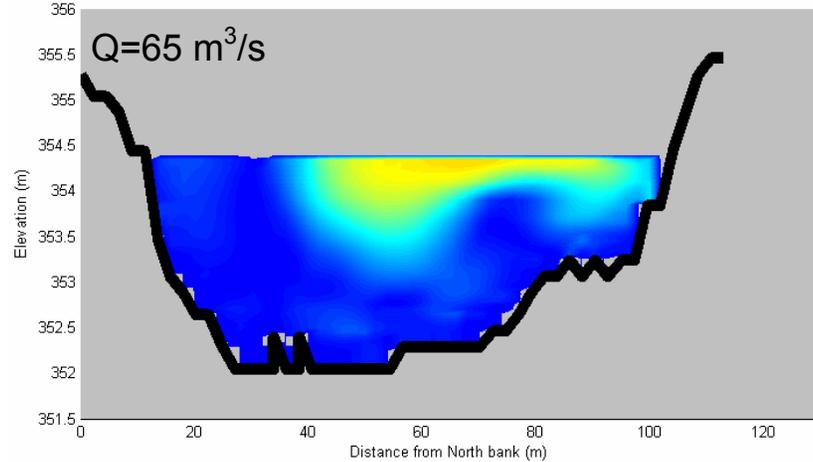
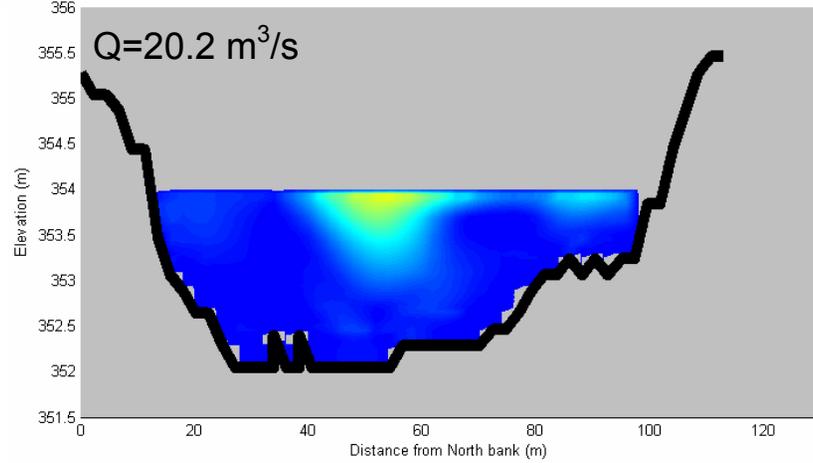
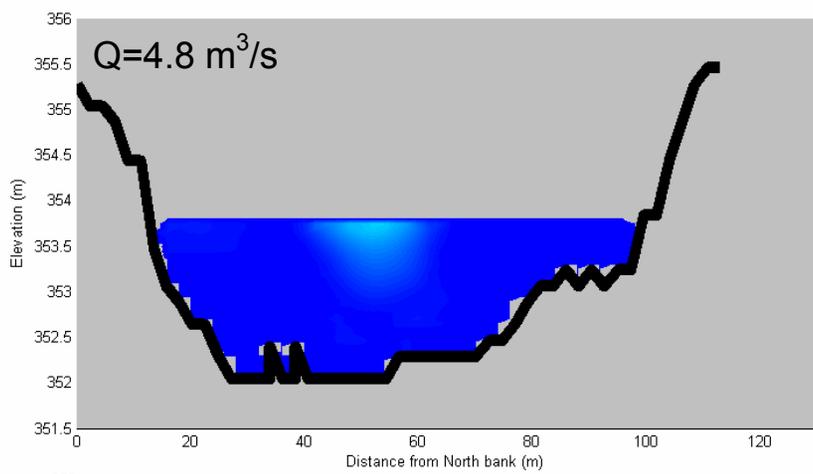
	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Brandon GS Weir Velocity Profiles		
DATE	REFERENCE TO REPORT NO.	FIGURE 7
2006-08-18	PP&D-06/07	



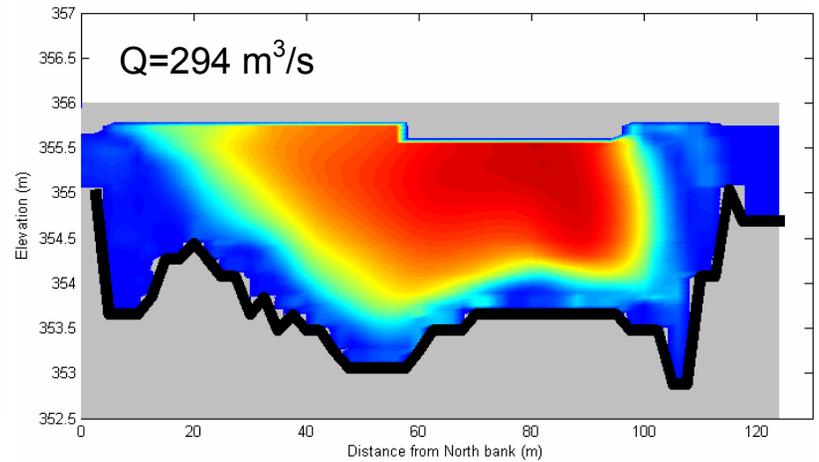
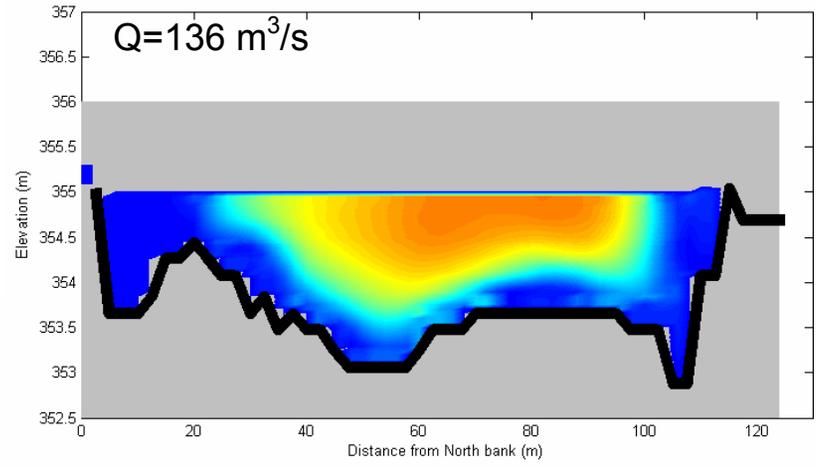
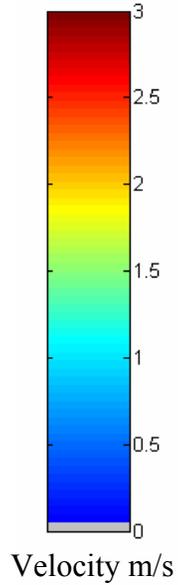
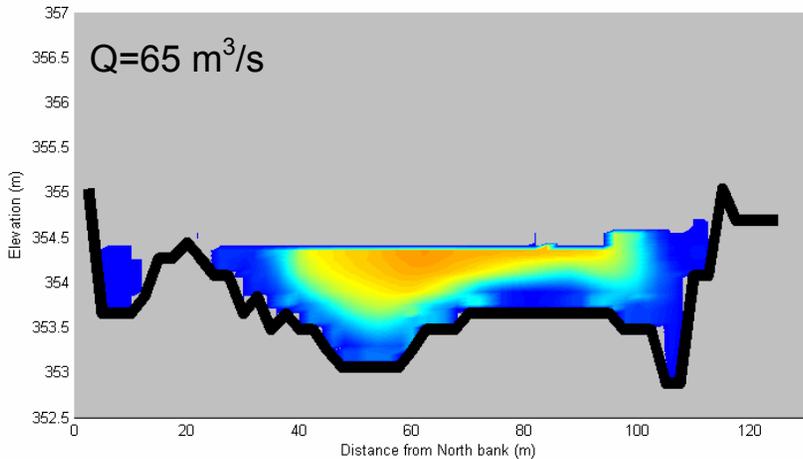
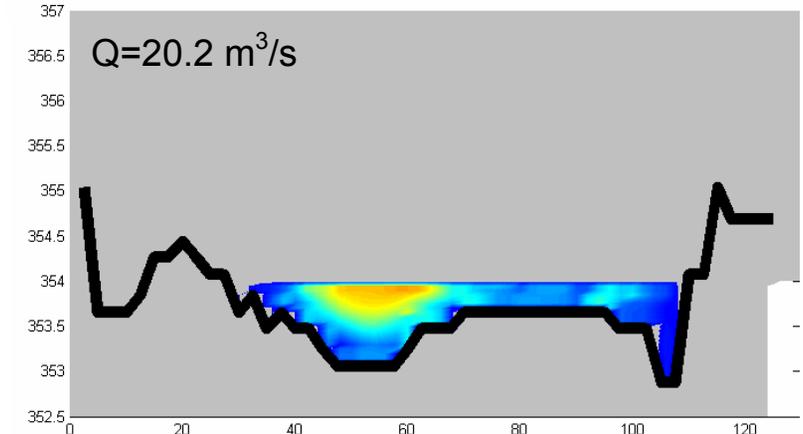
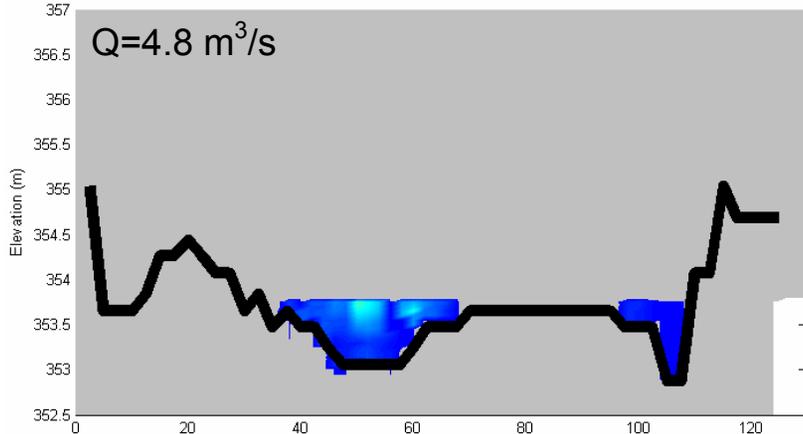
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	BRANDON GS WEIR MODELLING	
Cross Section Locations		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 8



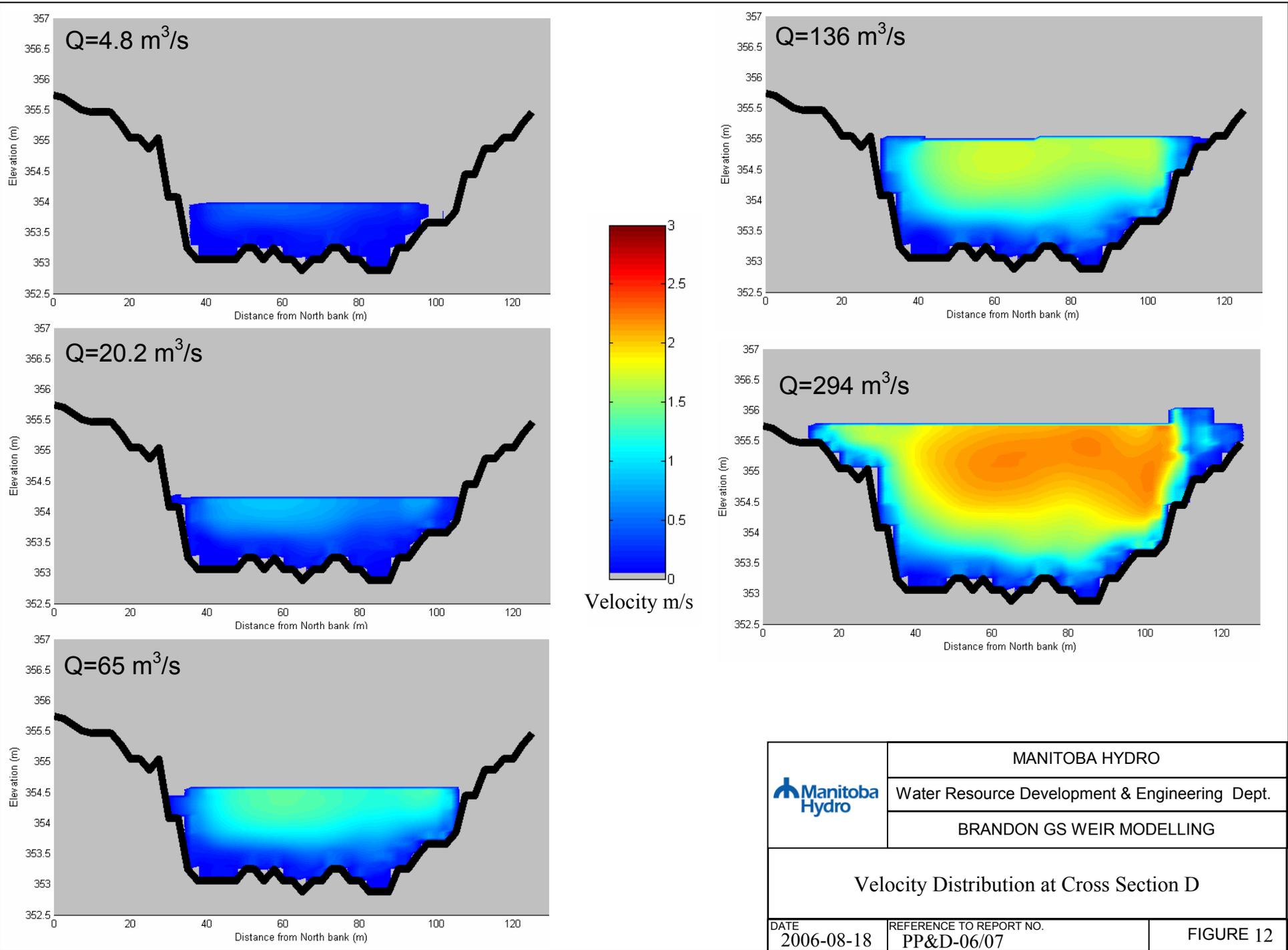
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	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Velocity Distribution at Cross Section A		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 9



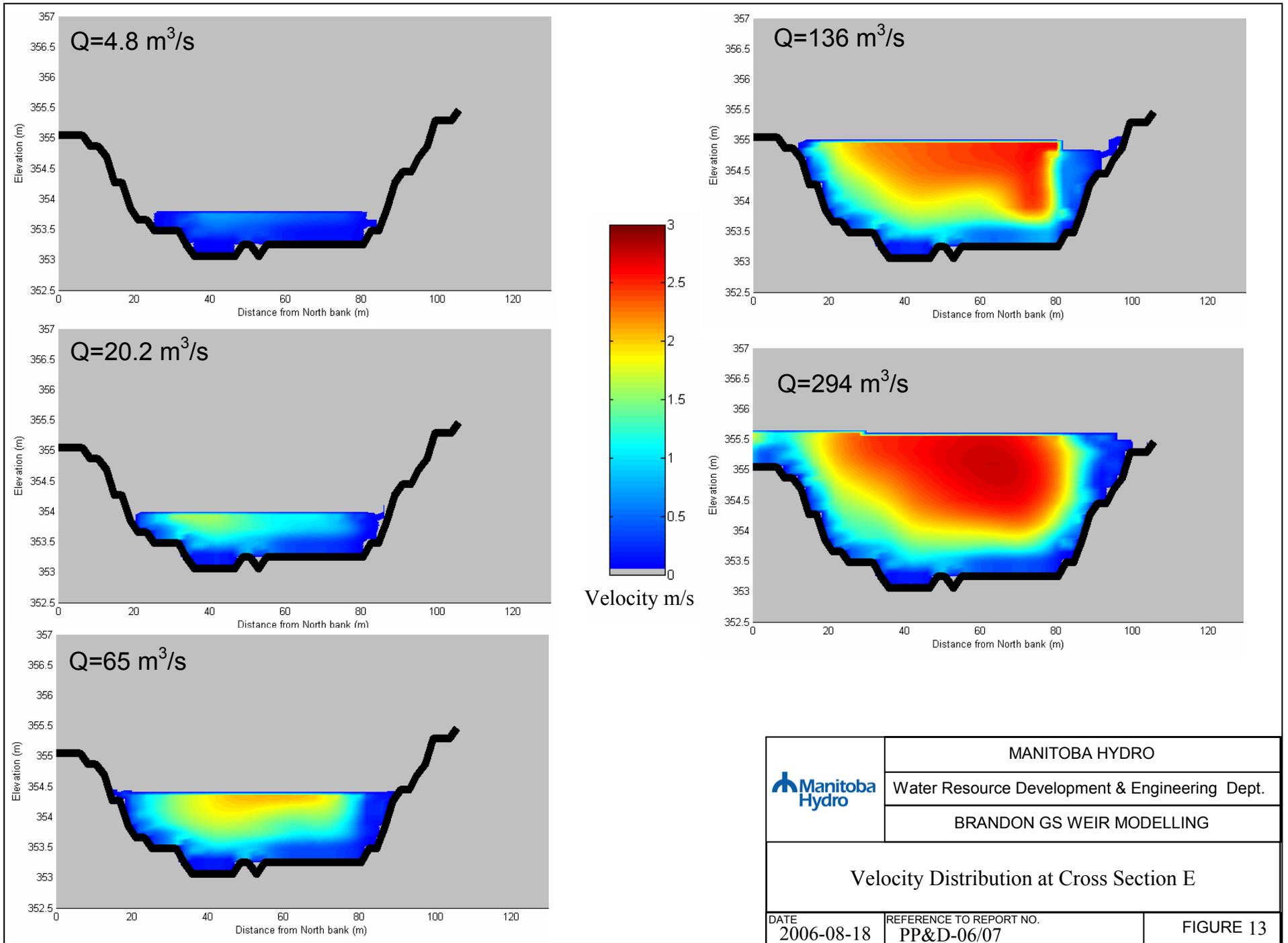
	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Velocity Distribution at Cross Section B		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 10



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	BRANDON GS WEIR MODELLING	
Velocity Distribution at Cross Section C		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 11



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	BRANDON GS WEIR MODELLING	
Velocity Distribution at Cross Section D		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 12



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	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Velocity Distribution at Cross Section E		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 13