# *Appendix 8-A*

*Murray River Coal Project: 2011 to 2013 Hydrology Baseline Report*

HD Mining International Ltd.

# MURRAY RIVER COAL PROJECT
# 2011 to 2013 Hydrology Baseline Report









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March 2014

# MURRAY RIVER COAL PROJECT
# 2011 TO 2013 HYDROLOGY BASELINE REPORT

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**Prepared for:**

HD Mining International Ltd.

**Prepared by:**

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# Executive Summary

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# Executive Summary

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

To support HD Mining's planning and development of the Project, and to contribute to the environmental assessment process, environmental and socio-economic baseline studies were initiated by ERM Consultants Canada Ltd. (ERM Rescan). Project-specific studies began in 2010 and have continued through 2013. As appropriate and available, historical data from government sources and neighbouring projects, as well as traditional use/knowledge information, have been compiled and incorporated into analysis.

This report presents a cumulative summary hydrometric data compiled for the Project from 2011 to 2013. An understanding of the surface hydrology of the area is necessary to conduct a sound assessment of Project effects on the environment, as well as for the design and implementation of an appropriate water management plan. Long-term hydrological records are available from Water Survey of Canada (WSC) stations for Murray River and other large rivers in the region. However, very little hydrological information is available from small watersheds. To fill this gap, ERM Rescan established new stations primarily in small watersheds (4-100 $km^2$).

The annual flow regime in the region is highly influenced by the seasonal distribution of precipitation and temperature. Rivers are predominantly fed by spring snowmelt (freshet), and are often augmented by rain-on-snow events during the melt period. High discharges occur from mid-April through July, with a low flow period during winter and early spring. Large rivers (e.g., Murray River) flow year-round; while small streams (e.g., Twenty Creek) can be ephemeral or intermittent.

Data in this report span from 2011-2013. Rating curves and indices reflect this body of work. Most recently, a newly developed digital elevation model (DEM) constructed with LiDAR data was used to reassess watershed areas in the Project area. The basis for this adjustment was confirmed during a recent field visit.

Annual runoff ranged from 134 mm at MH-3 (Twenty Creek, 2012) to 924 mm at MH-1 (Murray River, 2011). Murray River consistently has much higher runoff than all other monitored rivers and streams in all years. This is likely primarily due to orographic enhancement of precipitation at high elevations within the Murray River catchment.

Analysis of recurrence intervals shows that peak flows in 2011 and 2012 were between 2-and 5-year events at most stations. In 2013, peak flows were below average. Instantaneous peak flow magnitude ranged from 0.2 $m^3/s$ (MH-5 in 2012) to 476 $m^3/s$ (MH-1 in 2011). Peak and daily unit yields are typically highest in the Murray River watershed, indicating that on a unit-area basis, this catchment has the most available water.

All annual 7-day low flows are predicted to be near zero in small catchments (4-7 $km^2$), indicating that these streams likely freeze to their beds. In moderate sized catchments (21-52 $km^2$), winter 7-day low flows are likely less than 10 L/s. In the Murray River catchments, annual 7-day low flow is 7 $m^3/s$.

June to September 7-day low flows are also controlled by watershed size. However, the 7-day low flow usually occurs towards the end of September. This statistic is sensitive to years with Septembers that are warmer, cooler, wetter, or drier than normal.

# Acknowledgements

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# Acknowledgements

This report was prepared for HD Mining International Ltd. by ERM Rescan. The hydrology fieldwork was conducted by ERM Rescan's Eli Heyman (B.Sc.), Craig Hatt (Dip. Tech., Engineering), Cenling Xia (Ph.D., P.Eng.), Natasha Cowie (M.Sc.), Michael Soloducha (BSc), and Emerson Belland (BSc). The report was written by Cenling Xia (Ph.D., P.Eng.), Eli Heyman (B.Sc.), Jaclyn Bowman (BASc, EIT) and Ted Lewis (Ph.D.). It was technically reviewed by Ali Naghibi (Ph.D., P.Eng.). The work was managed by Jason Rempel (M.Sc., P.Geo.) and Korina Houghton (B.Sc.), and was directed by Clem Pelletier (CEO, B.Sc.) and Anne Currie (B.A., MPA).

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# MURRAY RIVER COAL PROJECT
# 2011 TO 2013 HYDROLOGY BASELINE REPORT

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# Glossary and Abbreviations

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# Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

| | |
|---|---|
| **ADCP** | Acoustic Doppler Current Profiler |
| **Annual runoff** | Annual runoff is a measure of the hydrologic response of a watershed. It is often presented as a depth, in mm, over an entire watershed allowing direct comparison with precipitation totals. |
| **Bankfull stage/ discharge** | The stage or discharge of a watercourse in which the stream completely fills its channel and the elevation of the water surface coincides with the bank margins. |
| **BC** | British Columbia |
| **EAO** | Environmental Assessment Office (of British Columbia) |
| **Flood frequency** | The frequency that a flood of a specified magnitude occurs, inversely related to flood return period (see Return Period). |
| **Freshet** | In channels, the high water discharge period resulting from spring/summer meltwater runoff of the snowpack accumulated over the winter. |
| **FWA** | Freshwater Atlas. A standardized dataset for mapping the province's hydrological features, produced by the British Columbia Ministry of Forests, Lands and Natural Resource Operations. |
| **ha** | Hectares |
| **HD** | HD Mining International Ltd. |
| **Hydrograph** | A graphical plot of water discharge versus time. |
| **Hydrologic zone** | An area where hydrologic characteristics are homogeneous and where data collected in the region can be extrapolated to estimate characteristics at ungauged sites to an acceptable degree of accuracy. |
| **ILMB** | Integrated Land Management Bureau (British Columbia) |
| **ISO** | International Organization for Standardization |
| **LiDAR** | A remote sensing technology that measures distance using transmitted and reflected laser light |
| **LSA** | Local Study Area |
| **MFLNRO** | Ministry of Forests, Lands, and Natural Resource Operations (British Columbia) |
| **MOE** | Ministry of Environment (British Columbia) |
| **MSC** | Meteorological Service of Canada |
| **MSDA** | Mine Surface Development Area |
| **Project, the** | Murray River Coal Project |

| | |
|---|---|
| **Rescan** | Rescan Environmental Services Ltd. |
| **Return period** | The average interval at which an event occurs, calculated from the probability of its occurrence in a given year. |
| **RSA** | Regional Study Area |
| **Seven-day low flow** | The minimum average 7-day flow that occurs over a specified period, such as a month, season or year. |
| **Stage** | The depth of water in a water course or channel. |
| **Stage-discharge curve** | A curve derived from concurrently measured stage and discharge data that is used to estimate the discharge for any given observed stage. Often referred to as a rating curve for a hydrometric station. |
| **TRIM** | Terrain Resource Information Management Program. A mapping dataset of British Columbia provided by the Crown Registry and Geographic Base |
| **WSC** | Water Survey of Canada |

# 1. Introduction

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# 1. Introduction

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia (Figure 1-1), and consists of 57 coal licences covering an area of 16,024 hectares. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

In October 2011, HD Mining submitted an application to the BC Ministry of Energy and Mines and Ministry of Environment seeking permission to complete a bulk sampling program as part of exploration of the property. In March 2012, HD Mining received approval to conduct a 100,000 tonne bulk sample for the purpose of conducting testing to assist in developing markets for the coal.

Beyond the bulk sample program, in order to develop a full mine at the proposed 6 Mtpa, the Project is subject to both the BC and Canadian environmental assessment processes. Development of any infrastructure for the full mine is not permitted before the requirements of these processes are met.

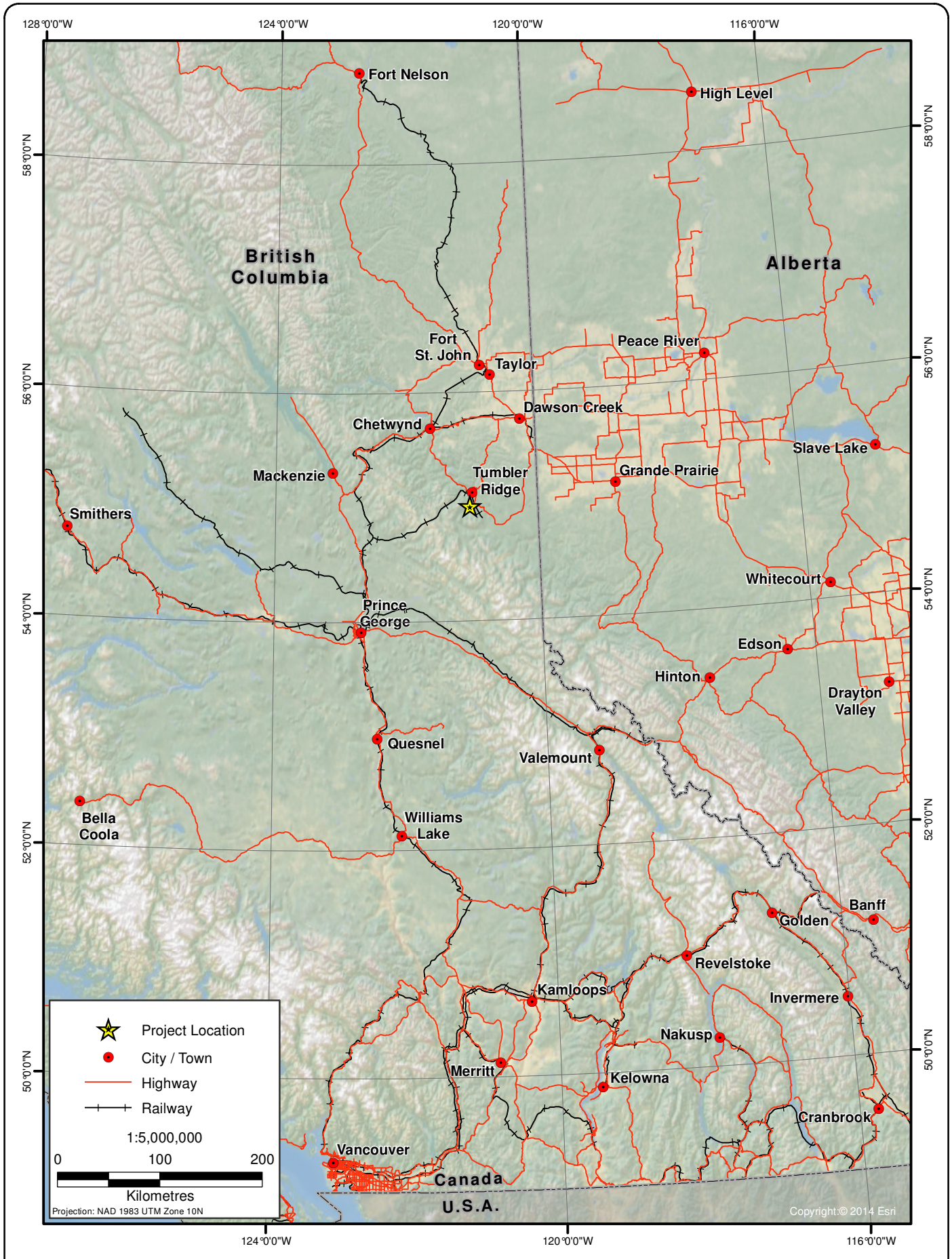
To support HD Mining's planning and development of the Project, and to contribute to the environmental assessment process, environmental and socio-economic baseline studies were initiated by ERM Consultants Canada Ltd. (ERM Rescan). Project-specific studies began in 2010 and have continued through 2013. As appropriate and available, historical data from government sources and neighbouring projects, as well as traditional use/knowledge information, have been compiled and incorporated into analysis.

In order to help guide the scope of baseline studies, regional and local study areas (RSA and LSA, respectively) have been developed (Figures 1-2 and 1-3). The RSA is intended to encompass an area beyond which effects of the Project would not be expected. It is also intended to be ecologically relevant based on the home range of key wildlife species known to inhabit the region. The LSA encompasses an area surrounding the proposed Project infrastructure within which direct effects from the Project may be anticipated. Its boundary has also been developed following natural terrain and drainage boundaries in order to be ecologically and hydrologically relevant. For consistency, the same RSA and LSA are used for all environmental studies.

This report presents a cumulative summary of all hydrology information compiled for the Project to date.

An understanding of the surface hydrology of the area is necessary to conduct a sound assessment of Project effects on the environment, and for the design and implementation of an appropriate water management plan.

Data and analysis presented here supersedes previous Murray River hydrology reports. It includes hydrometric data collected in 2013, and updated watershed areas using digital elevation models constructed with recently acquired LiDAR data. Hydrologic indices reported here use updated watershed areas.




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# Project Location

Figure 1-1

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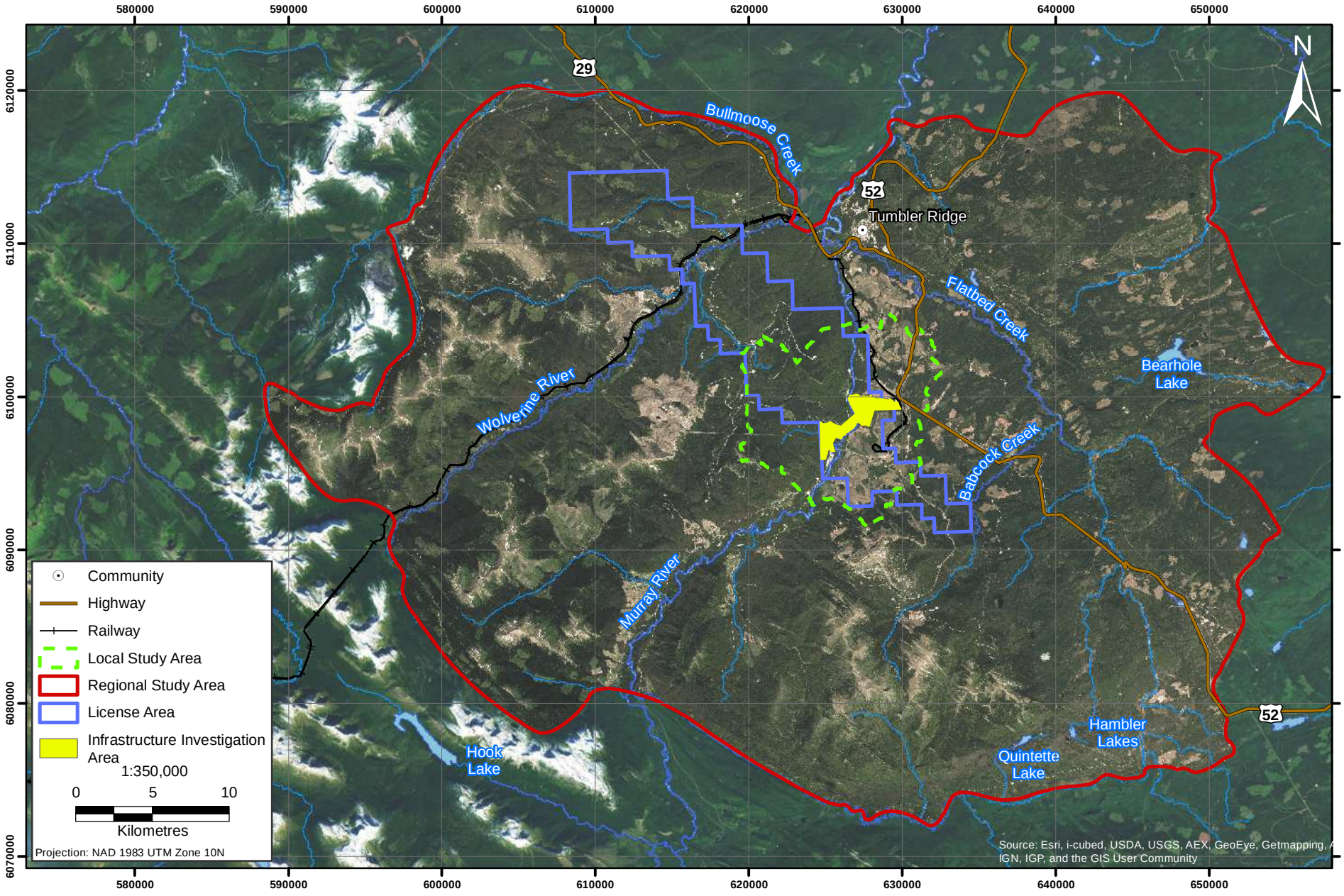



Figure 1-2

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# Project Study Boundaries

Figure 1-2

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The main objectives of the hydrology baseline program are to:

- Collect, analyze, and present hydrometric data from drainage basins and channels that will be affected by the Project;
- collect, analyze, and present hydrometric data from watersheds that are smaller than regional long-term stations operated by the Water Survey of Canada (WSC). With the exception of Murray River, catchments within the Project area tend to be small to moderate in size;
- review historical data relevant to the Project;
- generate daily discharges and annual hydrographs for each hydrometric station;
- calculate hydrological indices such as annual runoff, seasonal runoff distribution, monthly flow rates, and peak and low flows; and
- conduct frequency analyses on hydrologic data for regional WSC stations and for Project area hydrometric stations.

Chapter two presents background information relevant to the Project area and region, including the characteristics of its surface water hydrology. Chapter three details the methodologies used for collection and analysis of hydrometric data collected in the Project area between 2011 and 2013. Chapter four presents results of the surface water monitoring program, and Chapter 5 summarizes these data.

*PROJECT #* 0791-007-01 *GIS #* MUR-15-071 *VERSION #* T0.10 February 18 2013

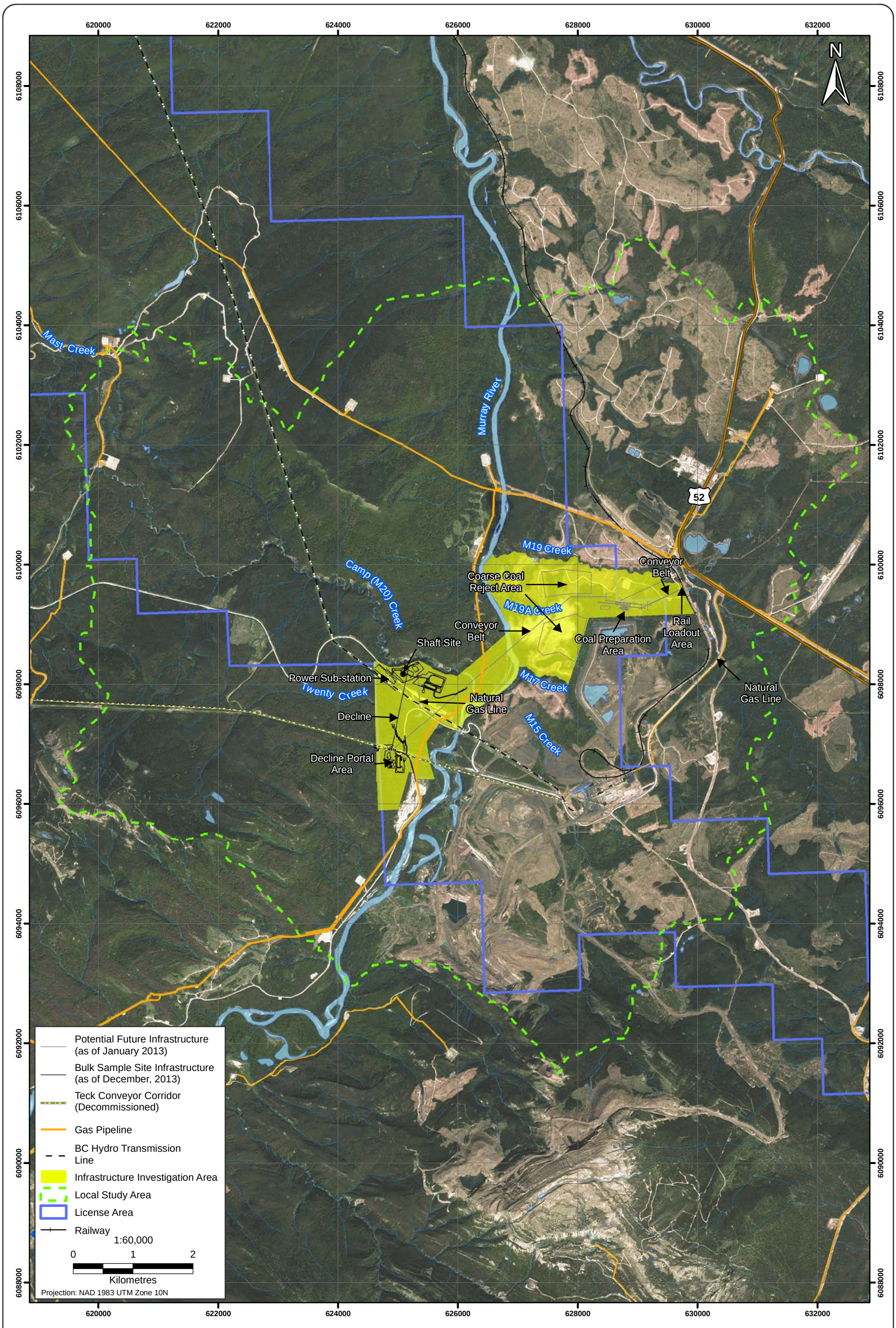



Figure 1-3

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# Preliminary Site Layout

**Figure 1-3**

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# 2. Background Information

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# 2. Background Information

## 2.1 APPLICABLE STANDARDS

To ensure high quality data was collected the installation of hydrometric stations and development of discharge measurements and stage-discharge rating curves were performed in accordance with relevant manuals and guidelines (Terzi 1981; WSC, MSC, and Environment Canada 2004; Land and Water British Columbia Inc. 2005; RISC 2009). These manuals and guidelines have been established to promote standardization and describe practices, procedures, and specifications for the appropriate siting of instruments, to ensure the precision and accuracy of discharge measurements.

The Ministry of Environment's Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MOE Guideline 2012) outlines the baseline study expectations and recommendations to propose a mineral development project in the Province of British Columbia. In the section of Surficial Hydrology, the Guideline states that "the purpose of the hydrologic study for a proposed resource development project is to characterize existing surface water resources and to estimate the impact that resource development is expected to have on these systems."

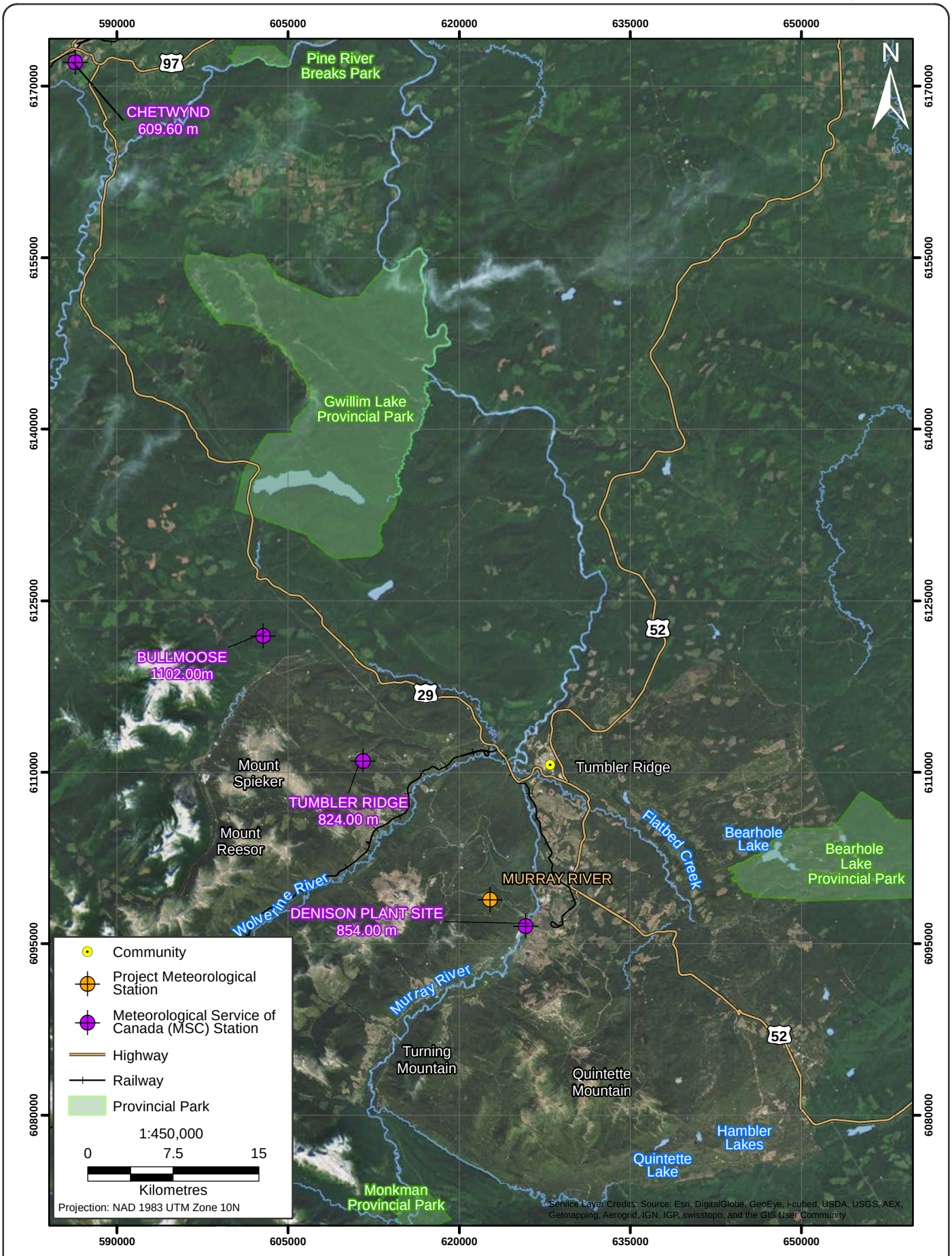
According to BC MOE Guideline (2012), the Resource and Inventory Standards Committee (RISC) Manual of British Columbia Hydrometric Standards — Version 1.0 (RISC 2009) should be used as a reference or guideline for conducting hydrometric surveys to collect baseline data for the EA process. In addition, BC MOE Guideline (2012) indicates a minimum of two years of data should be collected in order to evaluate the accuracy of the rating curves.

## 2.2 REGIONAL SETTING

Regional hydrology and climatology are described in detail in Appendix 7. To summarize, the Project area is located within Hydrologic Zone #7 — British Columbia's Southern Rocky Mountain Foothills (ILMB 2009). This region is characterized by a continental climate with little precipitation, moderately warm summers, and cold winters. There are four Meteorological Service of Canada (MSC) climate stations within or around the Project area (Figure 2.2-1). These stations have registered an average total annual rainfall range of 318.4 to 455.9 mm, and an average total annual precipitation of 447.5 to 788.7 mm (Environment Canada 2012). Their monthly and annual precipitation is presented in Tables 2.2-1 to 2.2-4. The heaviest precipitation typically falls as rainstorms during the summer, with the majority of precipitation occurring from November through April as snow. Approximately 30 to 42% of the annual total precipitation occurs as snowfall.

The average annual temperature observed at these four climate stations ranges from 2.1 to 3.4°C (Environment Canada 2012). The lowest daily average temperature occurs in January, and ranges from -8.0 to -10.7°C. The monthly and annual average temperatures are presented in Tables 2.2-1 to 2.2-4. Temperatures typically rise to above the freezing point in April and reach the highest point in July. The highest daily average temperature ranges from 13.4 to 15.3°C in July.

The hydrologic regime in the Project area is closely related to the seasonal distribution of precipitation and temperature (Figure 2.2-2). Rivers in this area are predominantly fed by spring snowmelt (freshet) and intense rainfall storms in summer. High flows occur from mid-April through July, with a low flow period during winter and early spring.

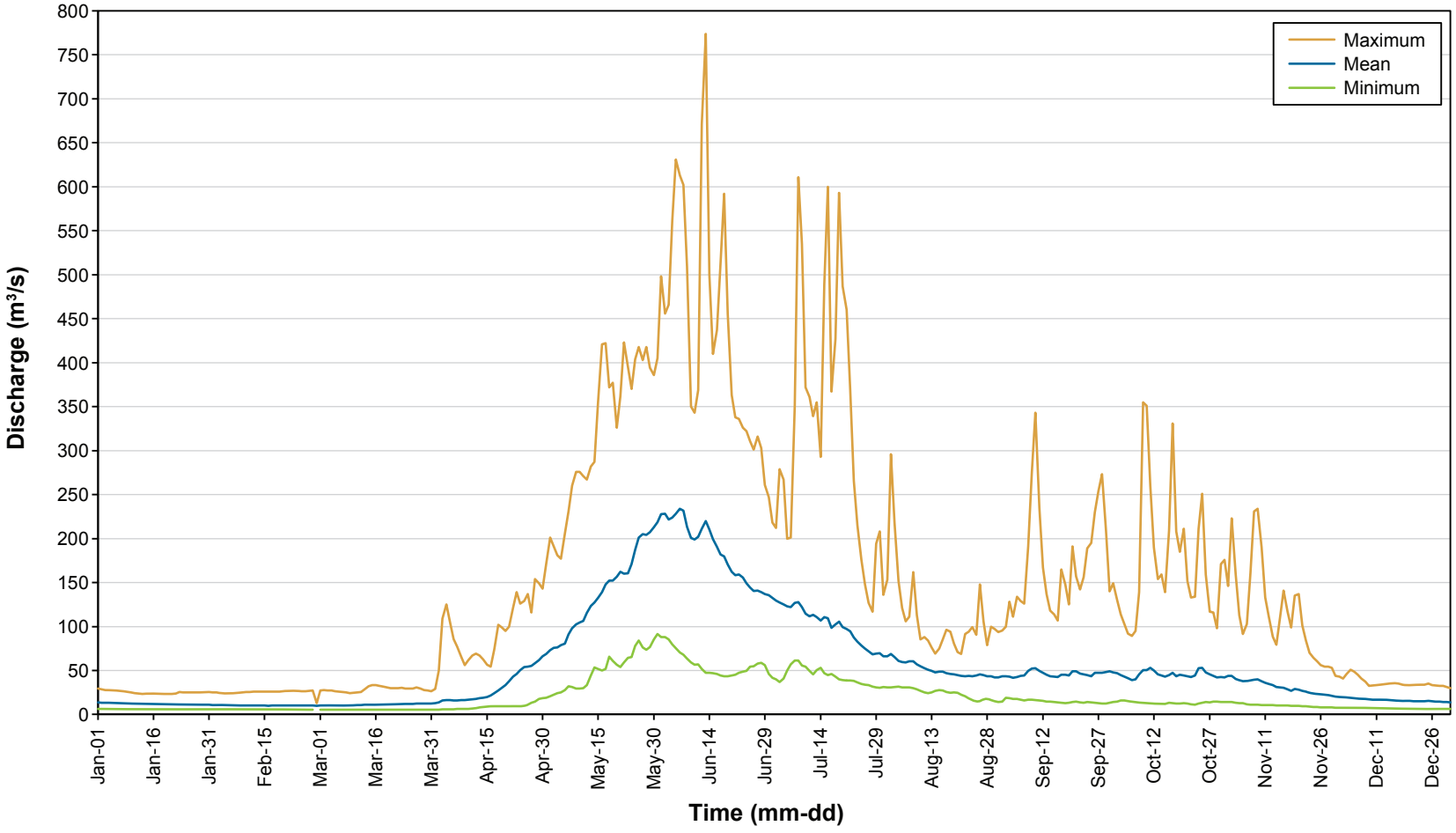



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# Locations of MSC Climate and Meteorological Stations

Figure 2.2-1

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*Note: based on the 1977 – 2010 records of Water Survey of Canada Station Murray River Above Wolverine (07FB006).*

Figure 2.2-2

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## Typical Annual Discharge Hydrograph of the Study Area

Figure 2.2-2

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**Table 2.2-1. Monthly Average Temperature and Precipitation at Chetwynd A Station**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | -10.7 | -7.6 | -2.4 | 4.7 | 9.6 | 13.2 | 15.3 | 14.5 | 10.0 | 3.9 | -5.9 | -9.4 | **3.0** |
| Rainfall (mm) | 0.9 | 0.6 | 1.3 | 10.3 | 33.0 | 76.1 | 79.3 | 53.9 | 42.1 | 16.1 | 3.5 | 1.3 | **318.4** |
| Precipitation (mm) | 21.6 | 16.0 | 19.5 | 18.7 | 37.2 | 76.1 | 79.3 | 53.9 | 44.4 | 30.7 | 29.6 | 20.5 | **447.5** |

*Note: ID# 1181508; UTM 10N; Easting 586339, Northing 6172124; Elevation 609.60 m; Period 1971-2000*

**Table 2.2-2. Monthly Daily Average Temperature and Precipitation at Tumbler Ridge**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | -9.8 | -6.9 | -2.3 | 3.9 | 9.0 | 13.1 | 15.2 | 14.6 | 10.3 | 4.3 | -4.0 | -7.0 | **3.4** |
| Rainfall (mm) | 2.2 | 1.5 | 2.5 | 12.4 | 27.3 | 73.0 | 77.1 | 56.0 | 36.1 | 13.2 | 5.4 | 2.8 | **319.5** |
| Precipitation (mm) | 35.9 | 25.3 | 34.6 | 21.3 | 30.3 | 73.0 | 77.1 | 56.3 | 37.7 | 25.8 | 41.0 | 25.6 | **483.9** |

*Note: ID# 1188297; UTM 10N; Easting 611568, Northing 6110996; Elevation 824 m; Period 1985-2002*

**Table 2.2-3. Monthly Daily Average Temperature and Precipitation at Denison Plant Site**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | -8.0 | -6.1 | -2.2 | 3.9 | 8.9 | 12.8 | 15.0 | 14.2 | 10.2 | 4.0 | -5.0 | -7.0 | **3.4** |
| Rainfall (mm) | 5.8 | 2.6 | 3.2 | 17.5 | 26.8 | 83.0 | 87.9 | 51.6 | 52.1 | 29.8 | 5.7 | 2.9 | **368.9** |
| Precipitation (mm) | 42.0 | 26.3 | 34.8 | 30.3 | 30.8 | 83.0 | 87.9 | 51.7 | 54.5 | 49.4 | 54.1 | 33.1 | **577.9** |

*Note: ID# 1182427; UTM 10N; Easting 625796, Northing 6096560; Elevation 854 m; Period 1982-1998*

**Table 2.2-4. Monthly Daily Average Temperature and Precipitation at Bullmoose Station**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | -8.5 | -6.6 | -3.6 | 2.0 | 7.2 | 11.0 | 13.4 | 12.7 | 8.2 | 2.6 | -5.1 | -7.6 | **2.1** |
| Rainfall (mm) | 5.1 | 7.8 | 5.5 | 12.8 | 36.6 | 94.0 | 89.5 | 73.5 | 59.6 | 52.9 | 12.0 | 6.8 | **455.9** |
| Precipitation (mm) | 68.9 | 49.7 | 48.3 | 33.2 | 41.2 | 94.3 | 89.5 | 74.5 | 66.1 | 83.5 | 82.3 | 57.2 | **788.7** |

*Note: ID# 1181120; UTM 10N; Easting 602810, Northing 6121949; Elevation 1,102 m; Period 1971-2000*

## 2.3 LITERATURE REVIEW

Several research reports regarding the hydrology of the Murray River watershed have been developed by other organizations (e.g. Wagner 2010; EAO 2009). Other relevant reports include streamflow inventory studies that were conducted by BC MOE (Church 1997; Coulson and Obedkoff 2000a and 2000b). However, these reports were completed over 10 years ago, and do not provide site-specific data for the Project and its watersheds. This cumulative baseline report fills the data gap by integrating on-site streamflow data with long-term hydrometric information from regional WSC stations.

## 2.4 DRAINAGE BASINS

The Murray River Coal Project Local Study Area (LSA) lies entirely within the Murray River watershed (Figure 1-2). The Murray River flows north into the Pine River, 40 km downstream from Chetwynd, BC. Both the Pine and Murray Rivers belong to the greater Peace River drainage system, which flows into the Slave River, a tributary of the greater Mackenzie River Watershed. Mackenzie River finally empties into the Beaufort Sea, part of the Arctic Ocean.

The LSA encompasses the mainstream of Murray River, Camp Creek (M20 Creek), Twenty Creek, Mast Creek, M17 Creek, and M19 Creek (Figure 2.4-1). Camp and Twenty creeks on the west side and M17 and M19 creeks on the east side flow into the Murray River. Mast Creek is one of tributaries of the Wolverine River, which confluences with the Bullmoose River at Tumbler Ridge, and continues to flow north-east and downstream into the Murray River.

The mid and headwater regions of Mast, Camp, Twenty, M17, and M19 creeks are densely forested with some rock outcrops (Plates 2.4-1 to 2.4-7). The three types of surficial deposits that have been identified in the LSA include moraine, colluvium and fluvial sediments. Downstream channels mainly consist of fluvial sediments that are prone to erosion. Resource activities within the drainage basins include forestry, mineral exploration and mining, natural gas processing plants, and natural gas pipelines.

Wetlands cover about 5 to 10% of the LSA. Less than 5% of the upper portion of the Murray River Watershed (Natural Resources Canada 2012a) is covered by wetlands. The proposed Murray River Project is wholly located in the Rocky Mountain Foothills physiographic region. The foothills consist of an extensive system of low-elevation ridges. Elevations in the Infrastructure Investigation Area range from 700 to 1,000 masl. The headwater regions of the Murray River Watershed can be as high as 2,000 masl.



*Plate 2.4-1. Looking north along the Murray River, immediately downstream of the Murray River Forest Service bridge crossing. Note the width of the river, the presence of exposed side and mid-channel gravel bars (under low flow conditions), as well as the presence of bedrock along the right bank. Hydrometric station MH-1 is just off to the right side of the photograph. October 17, 2011.*



*Plate 2.4-2. Lower Camp Creek looking upstream along the channel during low flow conditions. Note the high turbidity of the channel, as well as the presence of coarse sands and gravels along the channel reach. Hydrometric station MH-2 (2012-13 location) is present high on the undercut left bank, downstream of the fallen tree. August 8, 2012.*



*Plate 2.4-3. Low angle photograph looking downstream along Twenty Creek in the vicinity of hydrometric station MH-3 (2011-2012). Note the orientation, depth of surface water, width and gradient of the gravel bed stream, as well as presence of the deposition and erosion features along the channel reach. July 4, 2011.*



*Plate 2.4-4. Upper Camp Creek looking downstream along the channel during moderate flow conditions. Note the channel width and gradient, as well as the presence of coarse sands and gravels, as well as woody debris along the channel reach. Hydrometric station MH-4 is present along the left side of the pool that is downstream of woody debris. July 1, 2011.*



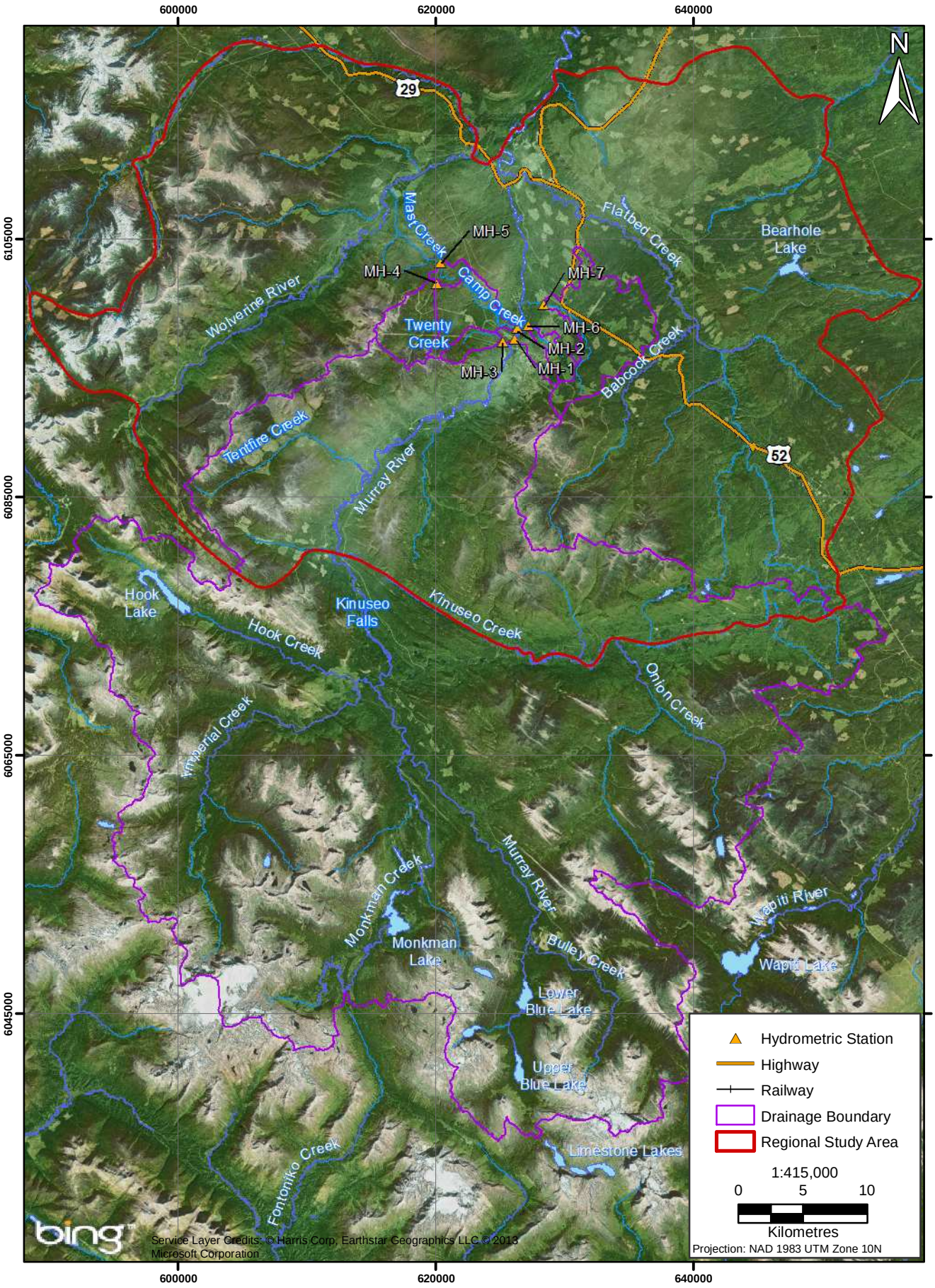

*Plate 2.4-5. Upper Mast Creek looking downstream along the channel during moderate flow conditions. Note the channel width and gradient, as well as the presence of incised and partially undercut channel banks along the stream reach. Hydrometric station MH-5 is present downstream along the left bank within the water pool. July 1, 2011.*




*Plate 2.4-6. Upstream view of the monitored stream reach at hydrometric station MH-6 on M17 Creek during high flow conditions. The station is located on the right-hand side of the photograph (left bank). June 27, 2013.*




*Plate 2.4-7. Downstream view of hydrometric station MH-7 on M19 Creek. Note the very low flow conditions with exposed gravel on the left bank and the exposed bedrock on the right bank. September 30, 2012.*




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# Drainage Basins within the Study Area

Figure 2.4-1

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# 3. Methodology

ERM

# 3. Methodology

## 3.1 HYDROMETRIC MONITORING NETWORK

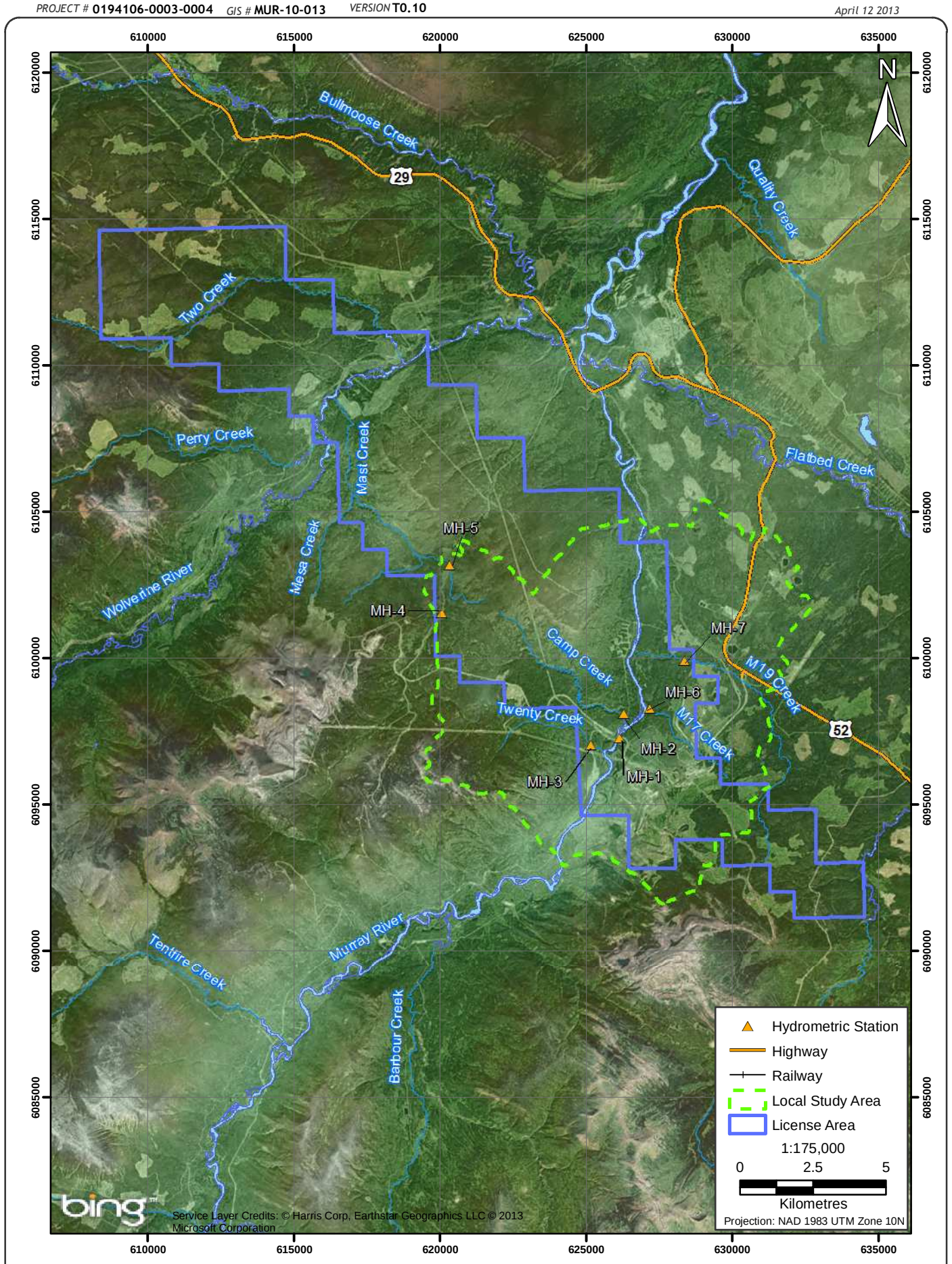
A network of hydrometric monitoring stations was established at selected locations within the LSA (Figures 2.4-1, 3.1-1). The automated stations recorded stream water level data at a ten minute interval during the open water season. The names, locations, drainage areas, median elevations, and the operating period of these monitoring stations are shown in Table 3.1-1. Their watersheds are mapped in Figures 3.1-2 to 3.1-7. Detailed site information for each station is presented in Appendix 1.

**Table 3.1-1. Hydrologic Monitoring Stations within the Project Area**

| Hydrometric Station | Location | UTM Coordinates[1] | | Drainage Area ($km^2$)[4] | Median Elevation (masl) | Period of Operation |
|---|---|---|---|---|---|---|
| | | Easting (m) | Northing (m) | | | |
| MH-1 | Murray River Downstream of Murray River Forest Service Road bridge crossing | 626,091 | 6,097,291 | 2,242 | 1,323 | Jan 1 to Nov 19, 2011; Apr 27 to Nov 7, 2012 |
| MH-2[2] | Lower Camp Creek Upstream of the stream crossing along the local resource road | 626,246 | 6,098,122 | 42.97 | 1,230 | May 15 to Nov 17, 2011; Apr 26 to Nov 5, 2012; May 1 to Nov 6, 2013 |
| MH-3[3] | Twenty Creek Towards the drainage outlet into Murray River | 625,141 | 6,097,069 | 6.62 | 1,126 | May 16 to Nov 16, 2011; Apr 27 to Nov 7, 2012 |
| MH-4 | Upper Camp Creek Upstream of the stream crossing along the local resources road | 620,078 | 6,101,730 | 21.08 | 1,351 | May 14 to Nov 14, 2011; Apr 28 to Nov 8, 2012 |
| MH-5 | Mast Creek Upstream of the stream crossing along the local resources road | 620,306 | 6,103,205 | 4.12 | 1,199 | May 12 to Nov 12, 2011; Apr 29 to Nov 8, 2012 |
| MH-6 | Mile 17 Creek Near the outlet into Murray River | 627,134 | 6,098,319 | 7.36 | 918 | Sep 27 to Nov 6,2012; Apr 30 to Nov 6, 2013 |
| MH-7 | Mile 19 Creek | 628,335 | 6,099,938 | 52.39 | 998 | Sep 30 to Nov 4, 2012 May 1 to Nov 7, 2013 |

*Notes:*
*[1] NAD 83, Zone 10N.*
*[2] At the 2011 site; Easting: 626,256 m, Northing: 6,097,951 m. Drainage area: 43.1 $km^2$.*
*[3] At the 2011 site; Easting: 625,519 m, Northing: 6,096,897 m. Drainage area: 6.8 $km^2$.*

The 2011 hydrometric network consisted of five automated gauging stations. Station MH-1 was located on the mainstem of Murray River, downstream of the Murray River Forest Service Road bridge crossing. The other four stations (MH-2 to MH-5) were located on the west side of the Murray River. Stations MH-2 and MH-3 were located on the mainstream of Camp Creek (M20 Creek) and Twenty Creek that will be potentially affected by the Project. Stations MH-4 and MH-5 were installed on the upper Camp Creek and Mast Creek, respectively, providing reference hydrologic information. All of the hydrometric stations were demobilized in mid-November 2011.

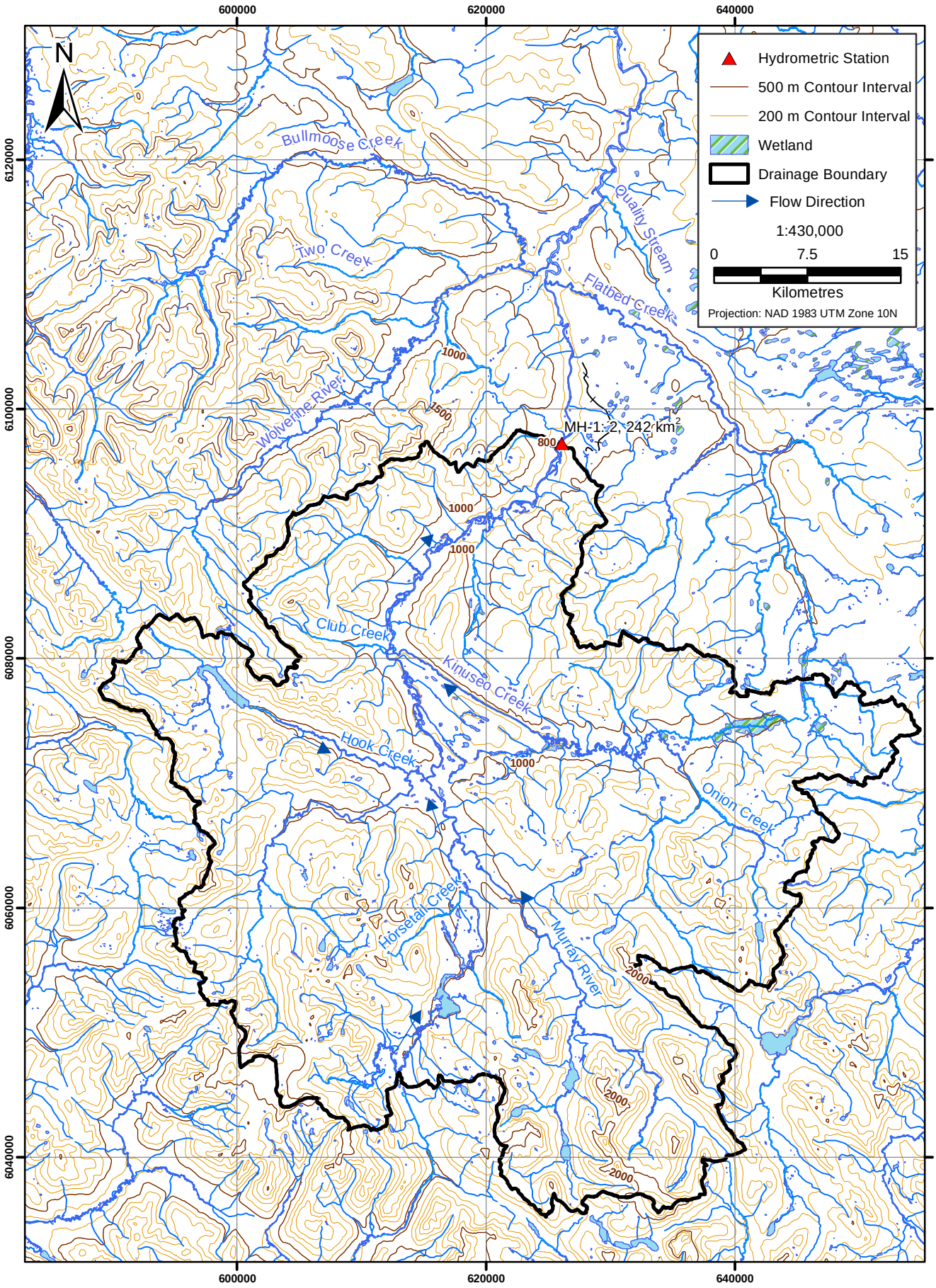



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# Hydrometric Station Locations

Figure 3.1-1

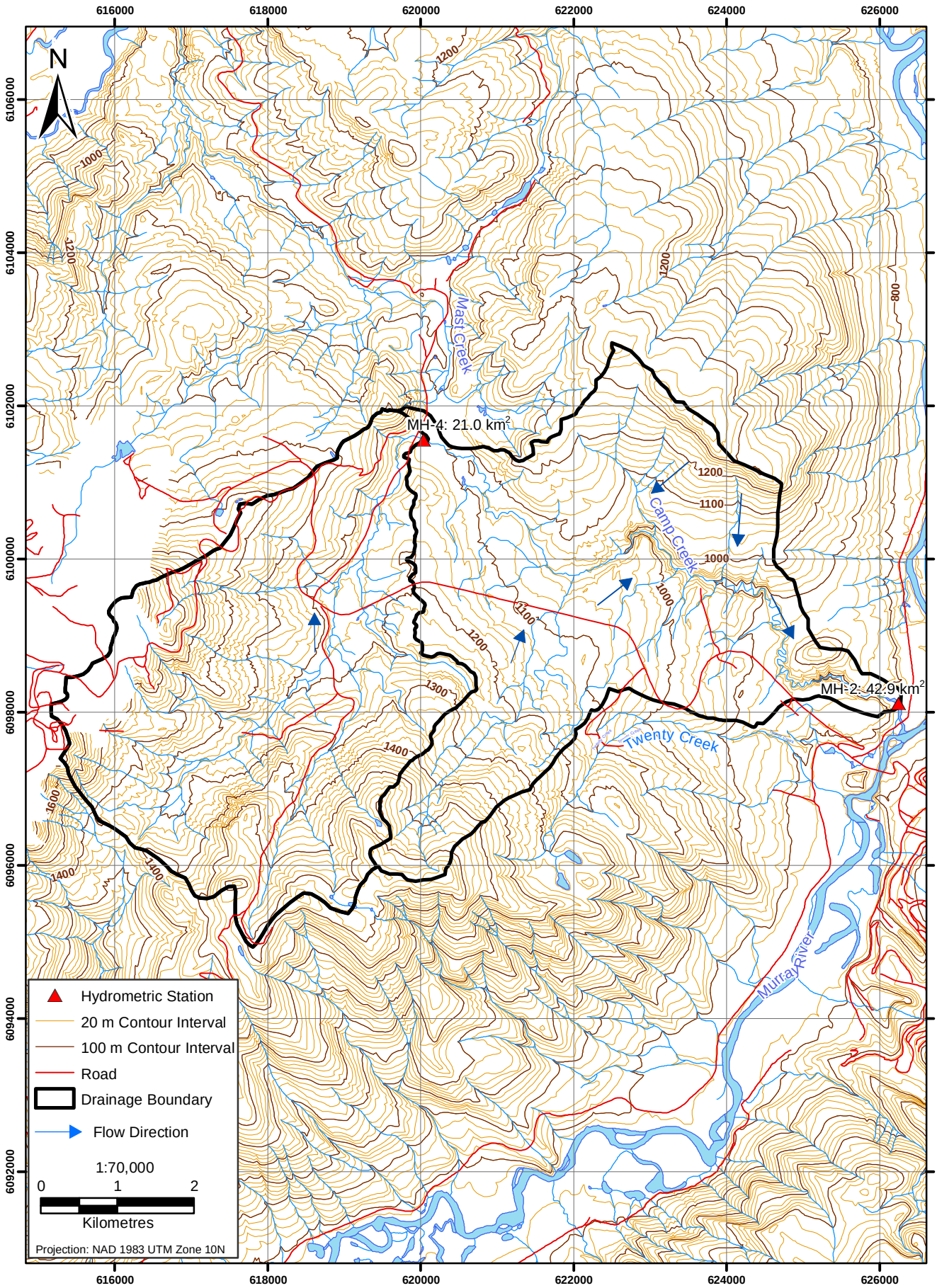
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# Drainage Boundary for Murray River Hydrometric Monitoring Station MH-1

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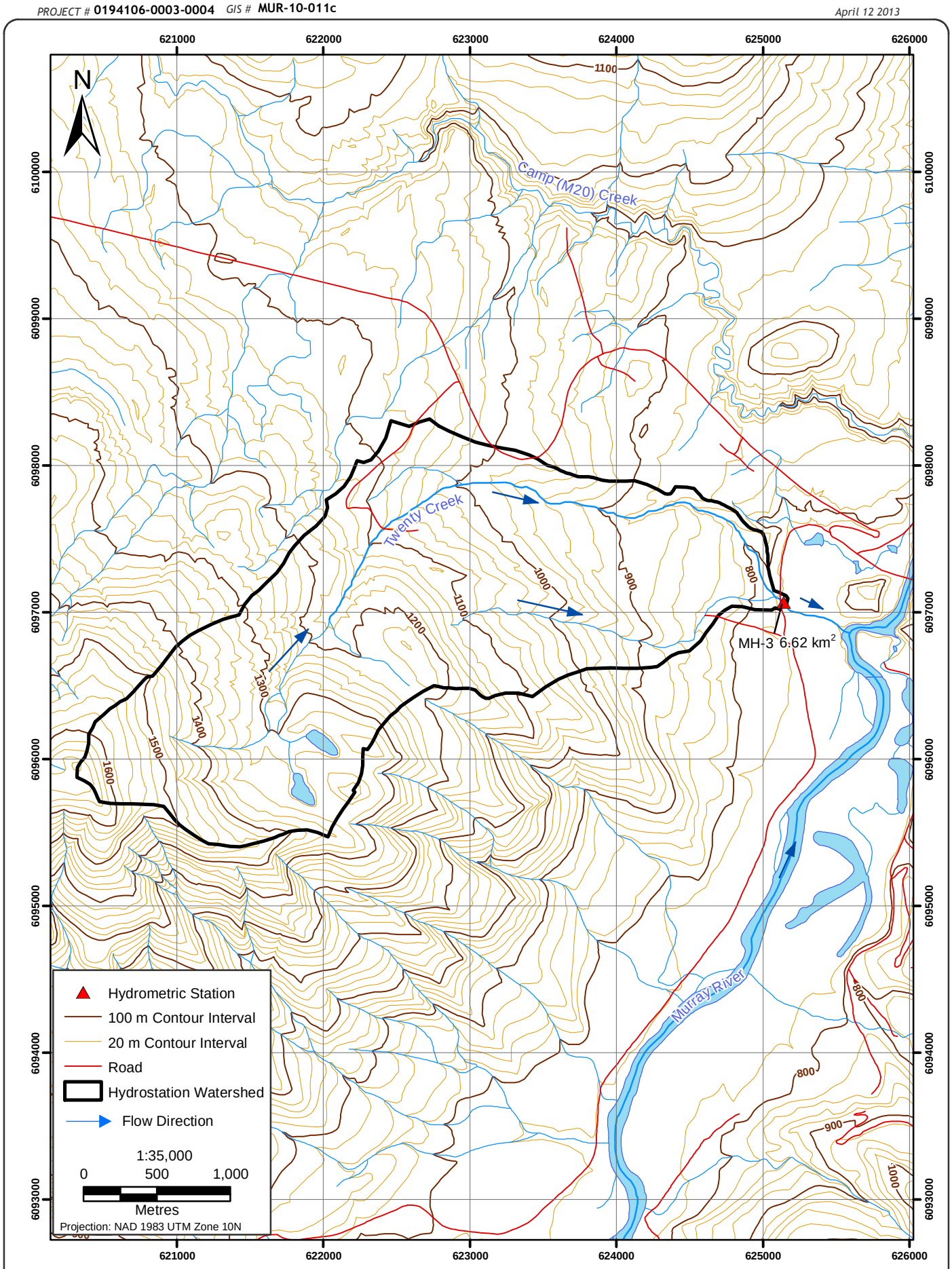
Figure 3.1-2




MURRAY RIVER COAL PROJECT

# Drainage Boundary for Camp Creek Hydrometric Monitoring Station MH-2 and MH-4

Figure 3.1-3

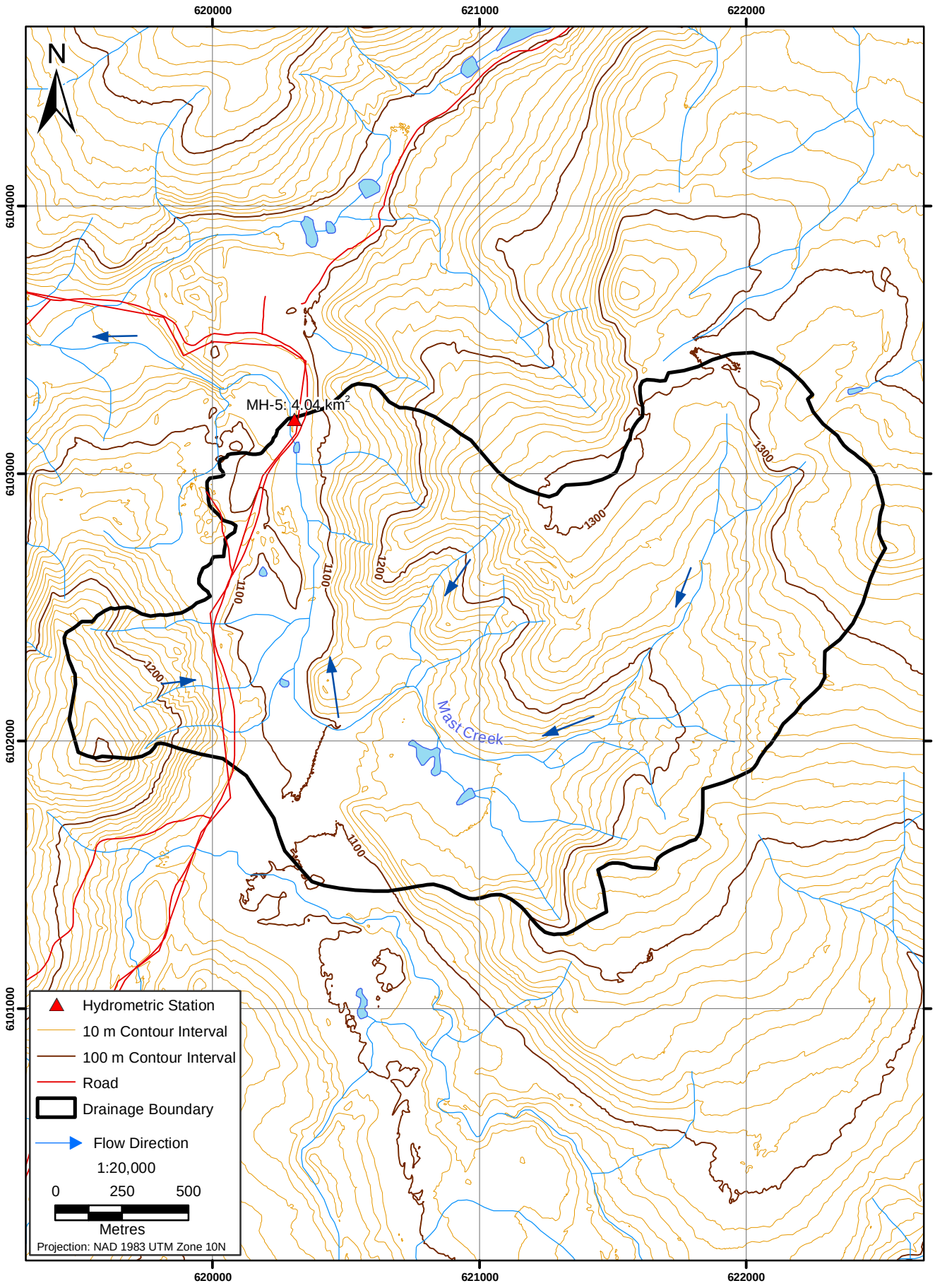



MURRAY RIVER COAL PROJECT

# Drainage Boundary for Twenty Creek Hydrometric Monitoring Station MH-3

Figure 3.1-4

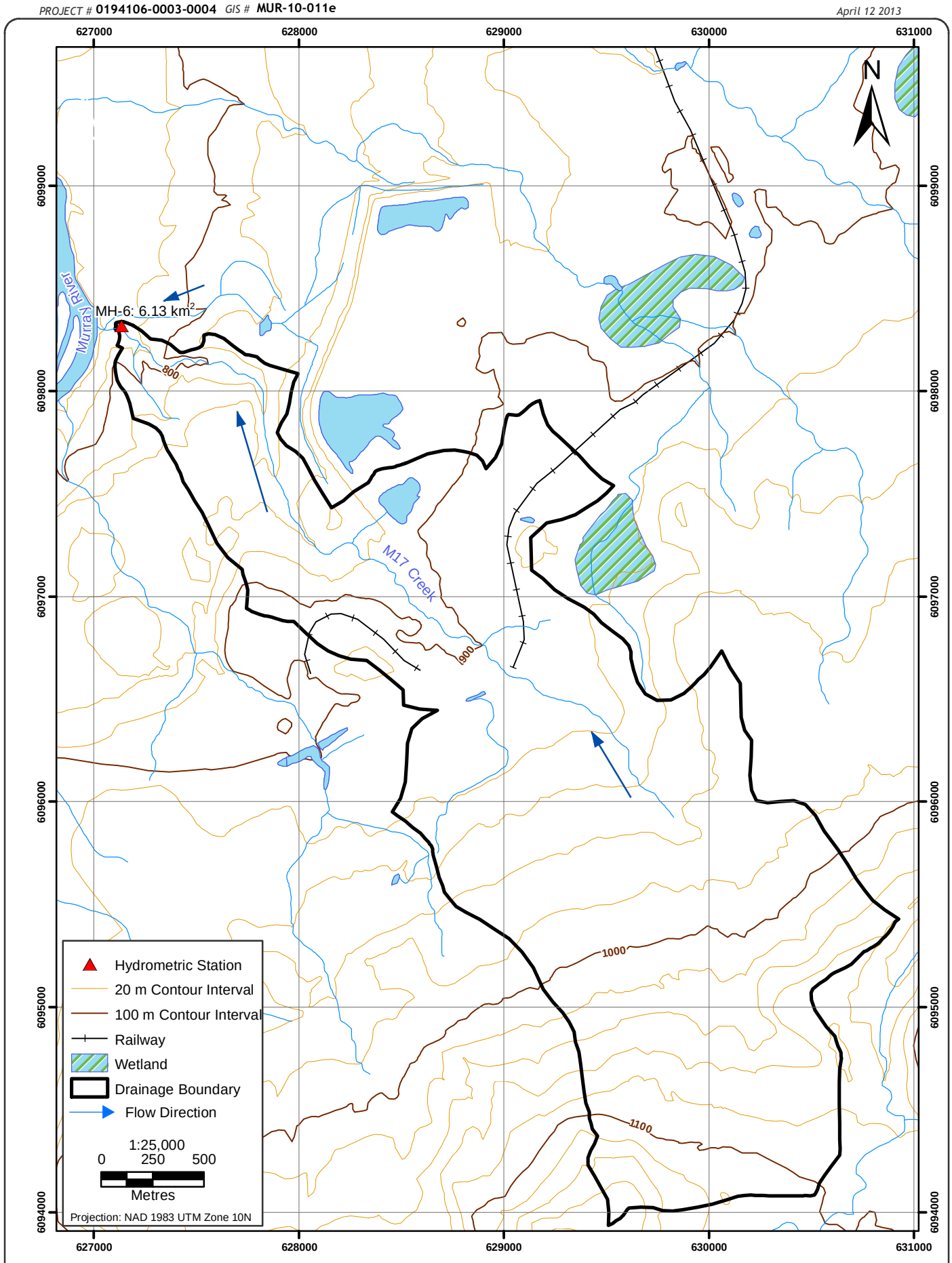
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# Drainage Boundary for Mast Creek Hydrometric Monitoring Station MH-5

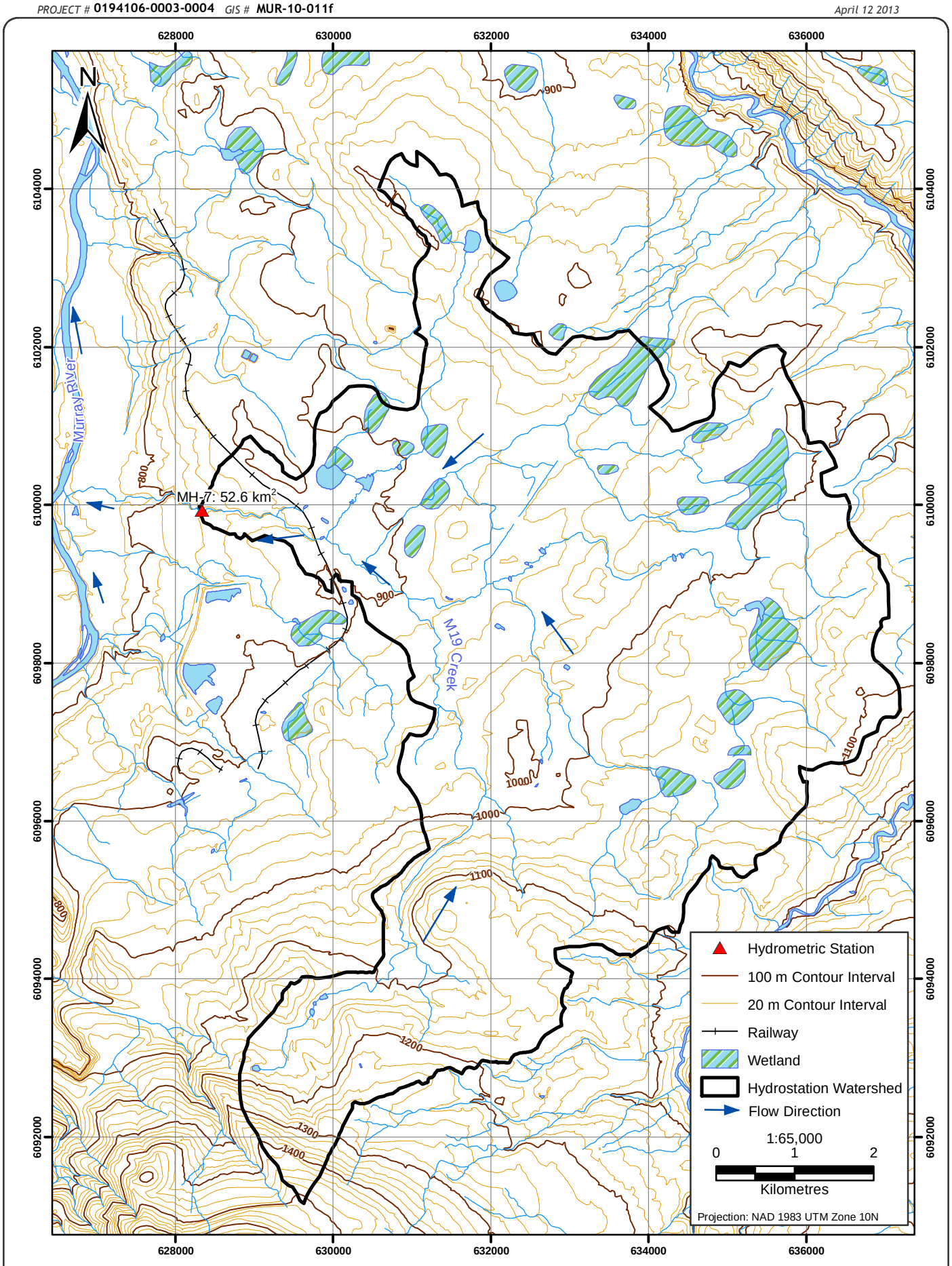
Figure 3.1-5




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# Drainage Boundary for M17 Creek Hydrometric Monitoring Station MH-6

Figure 3.1-6




MURRAY RIVER COAL PROJECT

# Drainage Boundary for M19 Creek Hydrometric Monitoring Station MH-7

Figure 3.1-7

In April 2012, the hydrometric station on Murray River (MH-1) and the four automated hydrometric gauging stations on the west side of Murray River (MH-2 to MH-5) were reinstalled at the 2011 station locations. In 2012, the 2011 station locations for MH-2 and MH-3 became unsuitable for monitoring due to changes in the channel and were relocated upstream about 150 metres, with minor drainage area reductions of 0.46% and 2.6%, respectively. In September, two new stations, MH-6 and MH-7, were installed on M17 Creek and M19 Creek, respectively. Both creeks are on the east side of the Murray River. The expansion of the hydrometric network reflected the updated Project infrastructure plan.

In 2013, three hydrometric stations operated in the Project area: MH-2, MH-6, and MH-7.

## 3.2 HYDROMETRIC STATION SETUP

Hydrometric monitoring stations were set up to obtain water level records at selected streams. Sites were selected to record hydrometric data in watersheds with the potential of being affected by Project infrastructure, and to complement data requirements from other baseline studies (e.g., water quality). Sites were selected to best meet criteria for desirable gauging locations, such as: the ability to obtain accurate water level data and to measure discharge at all stages, a stable natural hydraulic control at the site, and accessibility during the entire operational period.

Each of the automated hydrometric stations consisted of a 0 to 5 psi vented PS-98i pressure transducer (Instrumentation Northwest Inc.; accuracy = 3.5 mm) paired with an Elf-2 datalogger (Terrascience Systems Ltd.) or GDL datalogger (Instrumentation Northwest Inc.). The pressure transducers and dataloggers automatically record water level at a 10-minute interval. Each pressure transducer and its associated cabling were inserted into a flexible aluminum conduit with one end of the conduit attached to a piece of 1.5-m long angle iron (Plate 3.2-1). The angle iron assembly was either weighed down and placed flat on the streambed close to the banks, or bolted to immovable rocks or trees where available. The pressure transducer assembly was positioned as deep as possible to allow for monitoring low flow conditions along the stream channels. Dataloggers were housed in steel waterproof enclosures on channel banks above the high water mark.

## 3.3 HYDROMETRIC SURVEYS

### 3.3.1 Hydrometric Levelling Surveys

Hydrometric levelling surveys were conducted at each monitoring station during each field trip. This was accomplished by installing a minimum of three benchmarks near each hydrometric monitoring station for use as survey control points. Benchmarks consisted of wedge anchors drilled into bedrock or large immovable boulders where available. When not available, benchmarks were placed on large trees. In addition, the elevations of the pressure transducer and water level were surveyed relative to the reference points.

Surveying was completed using an engineer's level and stadia rod during station installation and during subsequent site visits. Surveying allowed assessment of the accuracy and precision of the water level data that were logged between field site visits. Surveying also allowed the pressure transducer to be moved as needed, allowing the stage elevation to be continuously and consistently known.

### 3.3.2 Channel Geometry Surveys

Channel geometry surveys were completed at each hydrometric station once a year to define the channel geometry at the gauged stream section. At the majority of hydrometric stations, a suitable channel reach with a total length of approximately three to six channel widths was selected, using the

hydrometric station as the midpoint of the surveyed section. Three evenly spaced cross-sections, perpendicular to the channel reach, were surveyed using an engineer's level and levelling rod.

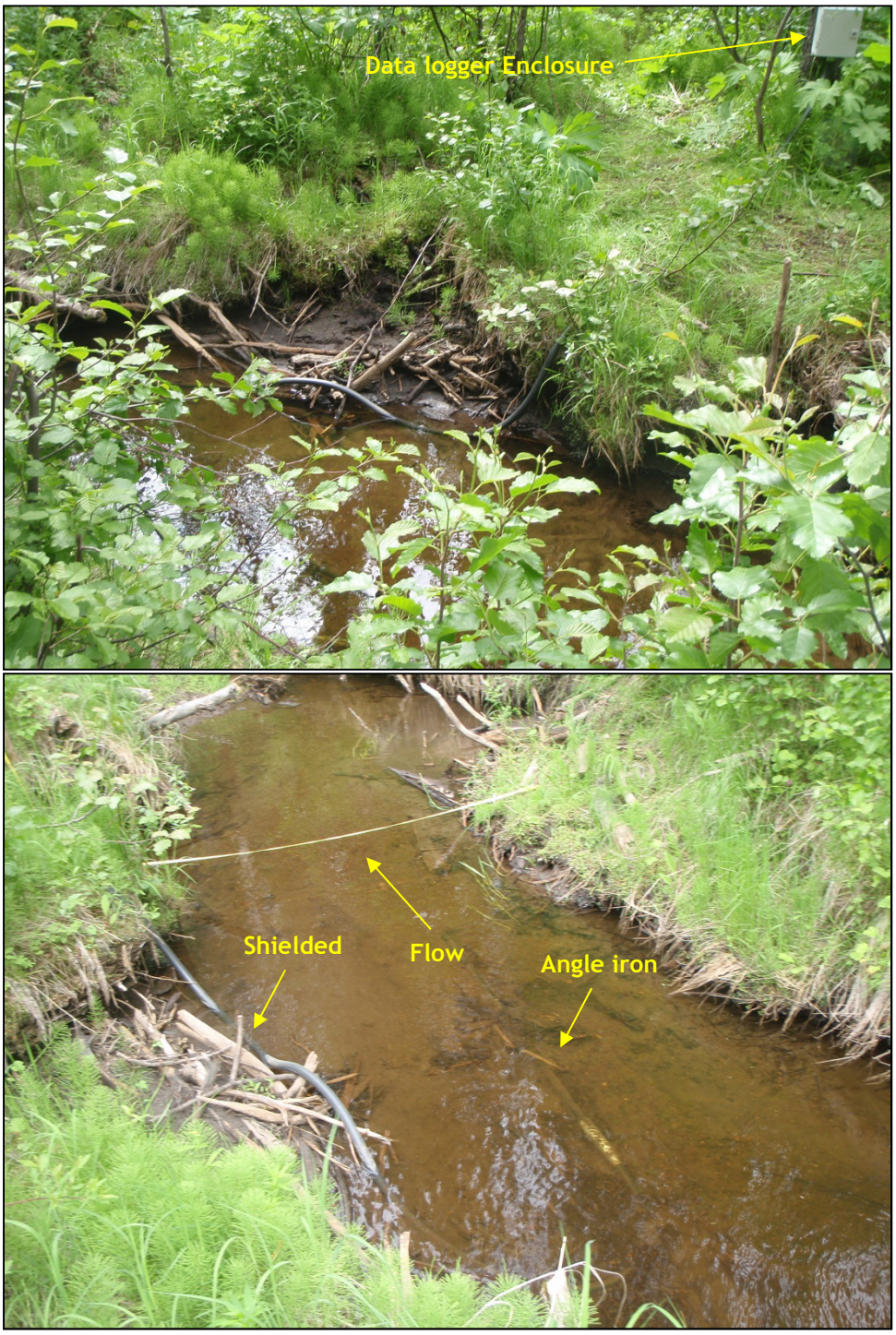



*Plate 3.2-1. Photographs illustrating a typical 'laydown' style hydrometric monitoring station. The pressure transducer is mounted to the angle iron*

At station MH-1, channel bed topography was obtained from an Acoustic Doppler Current Profiler (ADCP), and was merged with topographic information of the adjacent banks, which was surveyed using

an engineer's level and rod. At each station, all surveyed cross-sections were referenced to the established arbitrary local datum.

## 3.4 DISCHARGE MEASUREMENTS

To determine discharge, current velocity and depth were recorded across channel cross sections. Measurements were taken throughout the open water season in order to obtain a wide range of discharges.

The majority of discharge measurements (85% of measurements, n=69) were obtained with a handheld current meter. When stage or velocity were too high for streams to be waded, an Acoustic Doppler Current Profiler (ADCP) was used (12% of measurements, n=10). When stage or velocity were too low for a handheld current meter to be used, discharge was measured volumetrically, by filling a flask to a known volume over a known period of time (2% of measurements, n=2). On five occasions, streams were visited, but were not flowing. Methods of discharge measurement with handheld current meters and ADCP are discussed below.

### 3.4.1 Measurement of Discharge with a Handheld Current Meter

Measurement Technique

Three models of handheld current meters were used between 2011 and 2013 (Table 3.4-1).

**Table 3.4-1. Handheld Current Meters Used in the Murray River Project Area, 2011-2013**

| Flow Meter | Manufacturer | Flow measurement method | Accuracy | Resolution | Number of measurements |
|---|---|---|---|---|---|
| Flo-Mate | Hach | Electromagnetic | ± 2% of reading ±0.01524 m/s | 0.01 m/s | 59 |
| FH950 | Hach | Electromagnetic | ±2% of reading ±0.015 m/s from 0 to 3.04 m/s | Four significant digits | 6 |
| Swoffer Model 2100 | Swoffer Instruments Inc. | 2" propeller and photo-sensor | 1% "with periodic user required calibration tests and adjustments" (Swoffer 2012) | 0.01 m/s | 4 |

The location of the metered section at each site was determined based on channel geometry and flow conditions at the time of measurement. Generally, the stream was measured along a straight reach near the station where the flow was as uniform as possible. Areas with submerged vegetation and/or immovable rocks were avoided where possible.

Water discharges were computed from the stream velocity measurements using the velocity-area method, which determines discharge per unit width for each sounding or vertical. In this method it is assumed that the velocity sampled at each vertical represents the mean velocity in a segment. The segment area extends laterally from half the distance of the preceding vertical to half the distance of the next and vertically from the water surface to the sounded depth. The partial discharges across the channel are then summed to obtain the estimated total discharge measurement. Typically, a minimum of 20 current velocity measurements are taken across the width of a channel with the aim of having each sounding or measurement interval account for less than 10% of the total discharge (Plate 3.4-1).




*Plate 3.4-1. Current velocity measurements at hydrometric station MH-4 using a handheld current velocity meter. Photo taken on May 19, 2012.*

At each sounding point across the channel, if the observed water depth was less than 0.75 m, the current water velocities were measured at 60% of the flow depth of water. The measurement was assumed to be the mean velocity for the vertical water section. When water depths were greater than 0.75 m, current velocities were measured at 20% and 80% of the flow depth of water, and the average of the two readings was taken as the mean velocity for the vertical. In all cases, the adopted methods followed standard WSC operating procedures (Terzi 1981; RISC 2009).

Quantification of Discharge Measurement Error

Total error for each discharge measurement using a handheld current meter was quantified as the sum of errors from the measurement of channel width, depth, and velocity (e.g. current meter averaging interval, calibration errors). Total error also quantifies errors associated with the mean velocity of the channel, number of measured verticals, and number of measurements per vertical. Total error is expressed as a percentage, at a 95% confidence interval (Herschy, 2009). Measurement error is presented in the Results section, and on rating curves as error bars (Appendix 3).

### 3.4.2 Measurement of Discharge with an ADCP

At hydrometric station MH-1, the water depth or current velocity conditions during the open water season limited the ability to safely wade and measure discharge with a handheld current meter. Discharge was therefore measured using a StreamPro® (Teledyne RD Instruments) Acoustic Doppler Current Profiler (ADCP) following standard operating procedures (Rehmel et al. 2003; WSC, MSC, and Environment Canada 2004).

The location of the ADCP measurements was selected following the same general principles as with handled current meters. A cableway was used to manoeuvre the ADCP in controlled transects perpendicular to the direction of flow (Plate 3.4-2). The Murray River bridge (photo in Appendix 1-1,

MH-1 station information sheet) was used to set up the cableway across the channel. The measurement transect was located downstream of the bridge during the visit of June 2012, and upstream of the bridge during all other visits. No significant water inputs or outputs exist between the two gauging sites.

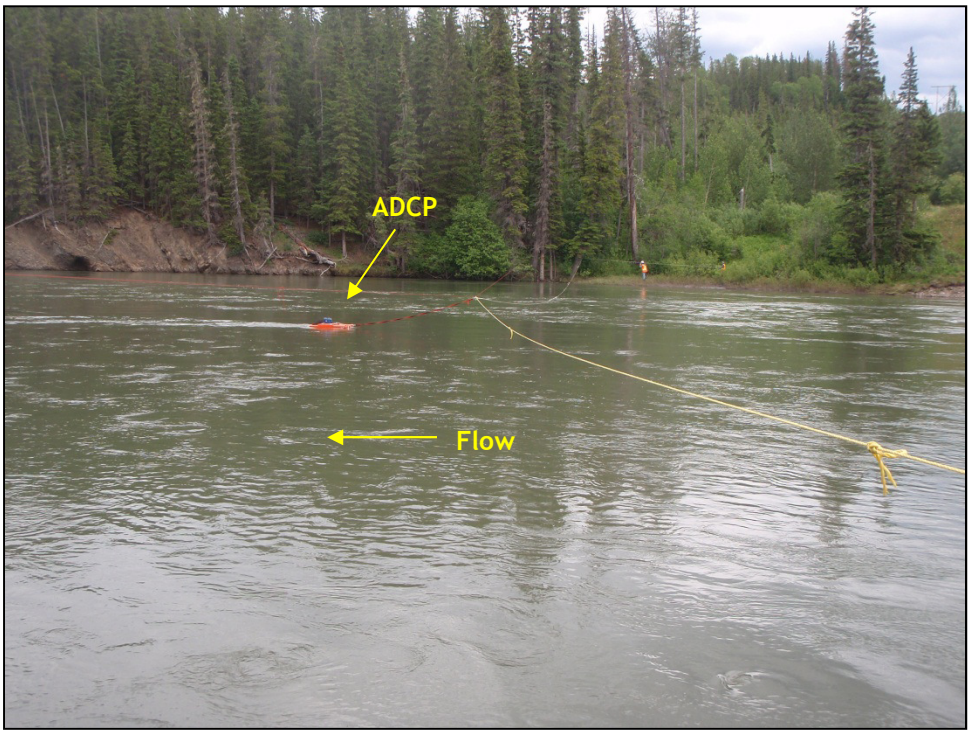



*Plate 3.4-2. Discharge measurements at hydrometric station MH-1 using an acoustic Doppler current profiler (ADCP). Photo taken on June 28, 2012.*

Measurements of current velocity, water depth, and the position of the unit across the channel section were recorded by the ADCP. A single channel section or transect produced one measurement of mean discharge. At least four valid transects were collected during each site visit to reduce the effects of turbulence, directional bias, or other random errors. Results were considered valid if they were within 5% of the measured mean flow discharge. The resulting mean discharge value was reported as the estimated discharge for the river.

## 3.5 STAGE-DISCHARGE RATING CURVES

Rating Curve Development

Stage-discharge relationships were developed for each hydrometric station and are presented as rating curves. Where appropriate, data collected in multiple years were combined in the development of the stage-discharge relationships. Rating curves are used to mathematically convert water level data (stage) recorded by the hydrometric monitoring stations into a continuous discharge time series or hydrograph.

The quality of a rating curve is a function of the number, accuracy, and precision of the individual data points that are used to generate the curve. The stability of the channel geometry between measurements also affect rating curve quality. To develop a robust stage-discharge relationship, six to greater than 15 manual streamflow measurements are recommended (depending on channel stability and the standard: RISC 2009, ISO 2010). Although a rating curve can be developed with as few as

two points (if the point of zero flow is known), each additional point adds increased robustness, particularly if the newly added measurements have a significantly different discharge and stage than preceding measurements. Flow measurements at the higher end of the flow range are especially important as they help define the upper end of the rating curve, and help the quantification of hydrologically important periods such as peak flow and high-magnitude rainfall-runoff events.

Stage-discharge relationships can also change from low flow periods to high flow periods, due to alterations in the geometry of the channel at high and low stages. When this is the case, a two-stage rating relationship was developed. One relationship satisfies low stage conditions, while the other relationship represents high stage conditions.

In the absence of a stage–discharge measurement corresponding to high flow conditions, the rating curve must be extrapolated to a high flow value that is beyond the range of the observed data used to generate the curve. Discharges extrapolated beyond that limit will have higher uncertainty (ISO 2010). In Appendix 5, when calculated discharges are greater than 1.5 times the maximum measured discharge, these values are marked as 'estimated'. These dates are also flagged in the daily discharge tables (Appendix 4).

All three flow measurements at hydrometric station MH-3 in 2012 were conducted under low flow conditions. To improve the rating curve at this site, the Hydraulic Software HEC-RAS 4.1 was used to estimate several high flow points. There is a high degree of uncertainty in the hydrograph for this station.

Rating curves were developed using Aquarius™ Time Series Hydrologic Software (version 3.4.149; Aquatics Informatics Inc.). The software uses standard methods outlined by the United States Geological Survey and the International Organization for Standardization (Kennedy 1984; ISO 2010).

Rating equations are presented in the form:

$$Q = C\,(h - a)^{b} \quad (1)$$

where $Q$ is the discharge (units = $m^3/s$), $C$ and $b$ are coefficients, h is the stage (water level; units = m), and $a$ is the stage at zero flow (datum correction; units = m).

Rating Curve Error

Rating curve error is expressed in two ways:

1. **Error for each rating point**. For each rating point, the percent deviation of modelled discharge from measured discharge is calculated. This statistic is called T.Diff by the Aquarius™ software package, and 'Diff %' in RISC 2009 (form HYD-03). Rating points are colour coded by difference percent on rating curves in Appendix 3.
2. **Overall rating curve error.** The root mean squared (RMS) error describes the overall error in a rating curve. For each discharge measurement, the residual between modelled and measured discharge is calculated. Residuals are summed then normalized by the sample size. The statistic combines both overall bias and lack of precision. There are no thresholds that define a valid or invalid stage-discharge relationship, though generally speaking, the lower the RMS, the better the estimated values provided by the rating relationship. RMS for each rating curve is presented in the results section (Section 4.1).

## 3.6 DISCHARGE HYDROGRAPHS

For the operating period at each station, discharges were calculated by applying the developed rating curve(s) to the recorded stage data using Aquarius™.

Flow estimation was required when pressure transducers were not recording, when channel geometry was influenced by vegetation growth or ice, and backwatering occurred. For these times, flows were estimated using two methods:

1. **Regional analysis.** Discharge from regional WSC stations were used to estimate flows in the Project area when suitable records were available. Details are described in Section 4.3.1.
2. **Logarithmic or exponential growth/decay functions**. The beginning and end of melt seasons are often not monitored. When required, the dates of flow initiation and cessation were estimated by applying a 7-day running average to the air temperature record from the ERM Rescan Murray River meteorologic station. The first and last day of above freezing air temperatures were assumed to represent the date of flow initiation and cessation. Depending on the shape of the hydrograph, logarithmic or exponential growth/decay functions were used to estimate flows between these dates and the dates of first (or last) measured discharge. Regional analysis was used to determine typical winter flow conditions, and the logarithmic or exponential decay was stopped at this level.

Estimated discharges are marked on hydrographs in Appendix 5, and in daily discharge tables in Appendix 4.

## 3.7 WATERSHED DELINEATION

Watershed boundaries, areas, and spatial statistics were calculated in ArcGIS (v.10.0 SP1). In this report, watershed boundaries were modified using recently acquired LiDAR data. LiDAR data are available at 2-meter postings, with horizontal and vertical accuracies of 30 cm and 50 cm respectively. Bare earth data were created from LiDAR data supplied by HD Mining and flown by Valtus Imagery Services. The ArcGIS 'Mosaic' and 'Calculate Statistics' tools were used with the resampling method set to bilinear; missing values were ignored.

The LiDAR DEM identified several areas where roads and other engineering structures could potentially restrict or divert flows. These areas were investigated in field-based surveys to determine whether these diversions or restrictions exist. For example, whether culverts were present under roads, or whether water was diverted in ditches.

As a result of this process, watershed boundaries in Project area watersheds were updated, which affects hydrologic indices that are dependent on area, such as runoff, volumetric outflow, and unit yield. Median watershed elevations were also recalculated. For all watersheds except MH-6 (Mile 17 Creek near the outlet), this process changed watershed area by less than 1.3%. For MH-6, the watershed area was increased by 20% (from 6.1 $km^2$ to 7.4 $km^2$).

## 3.8 HYDROMETRIC INDICES

Calculated annual runoff, seasonal runoff distribution, mean annual discharge (MAD), peak flow, and low flow are important hydrologic indices that provide useful information when undertaking a hydrologic assessment for design of mine Project infrastructure as well as when managing the water resources once a mine has entered operations.

Annual hydrometric indices are presented as calendar year rather than water year throughout this report.

### 3.8.1 Annual Runoff

Calculated annual runoff (expressed as a depth) is measured/estimated volume divided by watershed area. It is a valuable metric for estimating the water available from a basin. It is standardized by watershed area, making it is a useful index for comparing the hydrologic response of basins of different sizes.

### 3.8.2 Seasonal Runoff Distribution

Seasonal runoff distribution was determined by summing the daily runoff by month for each basin. Monthly runoff as a depth and as a percent of the total annual runoff are calculated and presented to illustrate the spatial and temporal distribution of runoff.

### 3.8.3 Mean Annual Discharge

The mean annual discharge (MAD), computed as an average discharge over the year, is an additional variable that gives an indication of the potential amount of water a basin can provide as a function of drainage area, geology, and climate.

### 3.8.4 Annual Peak and Low Flow

Peak flows represent the maximum flow rate of a catchment during a year in response to precipitation events or snowmelt. Peak flows are used in combination with flood frequency analysis techniques to estimate design flows used in the sizing of ditches, diversion channels, or stream crossings.

June to September low flows provide an estimate of the normal baseflow conditions during the open water season, which is important to the sustained health of a stream's aquatic community.

## 3.9 FLOW DURATION ANALYSIS

Flow duration analysis considers the percent of time that a specific discharge level has been exceeded or equalled during a period of record. A flow duration curve is the relationship between the magnitudes of streamflow at a point and the frequency (probability) with which those magnitudes are exceeded over an extended period of time (Dingman 2002).

For each monitored basin, a flow duration curve was generated. The flow duration curve is a useful planning tool in evaluating water discharge, as a function of basin characteristics.

A flow duration curve is constructed by ranking discharge values over a period of record, and then calculating their associated probabilities of exceedance using the following equation:

$$P = [M/(n+1)] \times 100\% \quad (2)$$

where $P$ is the probability that a given flow will be equalled or exceed, $M$ is the ranked position on the listing, and n is the number of events for the period of record (Dingman 2002).

## 3.10 REGIONAL HYDROLOGICAL ANALYSIS

The surface water hydrology of the Project was characterized using both site-specific and regional data. While the local hydrometric monitoring network provided site-specific information for the

Project, regional analysis provides general hydrological characteristics of the region in which the Project is situated.

### 3.10.1 Historical Data Collection

Analyzing regional hydrologic information ensures that locally collected hydrologic data for the Project are evaluated in terms of the recorded pattern and trend for the region. It also allows for the direct comparison of one site to another, and assists the planning and engineering design of surface water-related projects. The regional analysis was based on historical discharge flow data that were collected at the hydrometric monitoring network and stations operated by the WSC. Fourteen WSC hydrometric stations across the north-east region of British Columbia were considered (Table 3.10-1 and Figure 3.10-1).

All the WSC stations are located within Hydrologic Zone 7 that includes the Project (ILMB 2009; Obedkoff 2000ab). Among the stations, two exist along the Murray River mainstream. WSC station 07FB006 is at Tumbler Ridge, upstream of the confluence of Murray and Wolverine rivers. It is located approximately 8 km north of the Project. The second WSC hydrometric station 07FB002 is located about 60 km downstream of the Project. It is near the drainage outlet of where Murray River flows into the Pine River.

Quality Creek Station (WSC station 07FB005) and Flatbed Creek Station (WSC station 07FB009) are stream tributaries that drain into the Murray River from the east side of the river valley. The rest of the WSC stations are on rivers outside the Murray River watershed.

All of the WSC stations that were considered have natural water flowing conditions, with either seasonal or continuous operational schedules. The WSC station at Pine River at East Pine has the longest period of flow record series of over 50 years. In contrast, WSC's Chichouyenily Creek near Mackenzie River station has only four years of incomplete data.

Six of the WSC stations that were considered (i.e., Stations 07FB007, 07FB010, 07FB011, 07GC001, 07EF004, and 07EE004) were not used for frequency and regional analyses because of their short time series of flow discharges (Table 3.10-1). Other stations (07FB001, 07FB002, 07FB003, 07FB004, 07FB005, 07FB006, 07FB008, 07FB009) had a minimum of 18 years of substantially complete monthly flow data, and were used for regional analyses.

### 3.10.2 Regional Analysis

Historical streamflow data were collected, compiled, and verified at the abovementioned WSC stations (Table 3.10.1). Hydrologic characteristics, such as annual and monthly flow and runoff, distribution, peak flows, and low flows were extracted from the annual hydrographs at each station.

Recurrence intervals were calculated for estimation of annual runoff (wet and dry years), peak flow, and 7-day low flows. To provide a sense of the magnitude and frequency of events, recurrence intervals are generally calculated for the 2, 5, 10, 20, 50, and 100-year periods.

Regional analysis conducted here is based on data from regional WSC hydrometric stations. All selected stations have over 18 years of continuous flow records; the latest year of included data is 2010. For comparability and consistency, the analysis was referenced to the BC Ministry of Environment streamflow inventory for this region (Obedkoff 2000b).

**Table 3.10-1. Water Survey of Canada Hydrometric Stations Relevant to the Project**

| Station ID | Station Name | UTM Coordinates (m)[1] | | Distance and Direction from Project | Drainage Area ($km^2$) | Flow Type | Period of Record |
|---|---|---|---|---|---|---|---|
| | | Easting | Northing | | | | |
| 07FB001* | Pine River at East Pine | 612,577 | 6,176,372 | 80 km, N | 12,100 | Natural | 1961 – 1963 seasonal<br>1964 – 2010 continuous |
| 07FB002* | Murray River near the Mouth | 613,275 | 6,158,173 | 61 km, N | 5,550 | Natural | 1977 – 2010 continuous |
| 07FB003* | Sukunka River near the Mouth | 586,797 | 6,156,053 | 70 km, NW | 2,590 | Natural | 1977 – 2010 continuous |
| 07FB004* | Dickebusch Creek near the Mouth | 588,707 | 6,155,256 | 68 km, NW | 82.4 | Natural | 1978 – 2010 continuous |
| 07FB005* | Quality Creek | 632,349 | 6,112,988 | 17 km, N | 29.5 | Natural | 1978 – 2001 continuous |
| 07FB006* | Murray River above Wolverine River | 626,922 | 6,103,861 | 6 km, NE | 2,370 | Natural | 1977 – 2010 continuous |
| 07FB007 | Sukunka River above Chamberlain Creek | 578,877 | 6,116,388 | 51 km, NW | 927 | Natural | 1977 – 1985 continuous |
| 07FB008* | Moberly River near Fort St. John | 602,844 | 6,217,668 | 122 km, N | 1,520 | Natural | 1980 - 2010 continuous |
| 07FB009* | Flatbed Creek at kilometre 110 of the Heritage Highway | 631,473 | 6,106,652 | 11 km, NE | 486 | Natural | 1982 – 1982 seasonal<br>1983 - 2010 continuous |
| 07FB010 | Pine River above Mountain Creek | 526,859 | 6,152,443 | 113 km, NW | 677 | Natural | 1985 – 1988 seasonal<br>1989 - 1989 miscellaneous |
| 07FB011 | Windrem Creek near Chetwynd | 586,111 | 6,173,078 | 86 km, N | 22.9 | Natural | 1986 – 1998 seasonal |
| 07GC001 | Wapiti River above Mistanusk Creek | 689,554 | 6,065,227 | 71 km, SE | 2,400 | Natural | 1977 – 1981 continuous<br>1982 – 1982 seasonal |
| 07EF004 | Carbon Creek near the Mouth | 521,425 | 6,200,166 | 145 km, NW | 741 | Natural | 1998 – 2010 continuous |
| 07EE004 | Chichouyenily Creek near Mackenzie River | 493,830 | 6,130,344 | 137 km, NW | 72.3 | Natural | 1965 – 1967 continuous<br>1968 – 1968 miscellaneous |

*Notes:*
*1 NAD 83, Zone 10N*
** used for regional analyses*

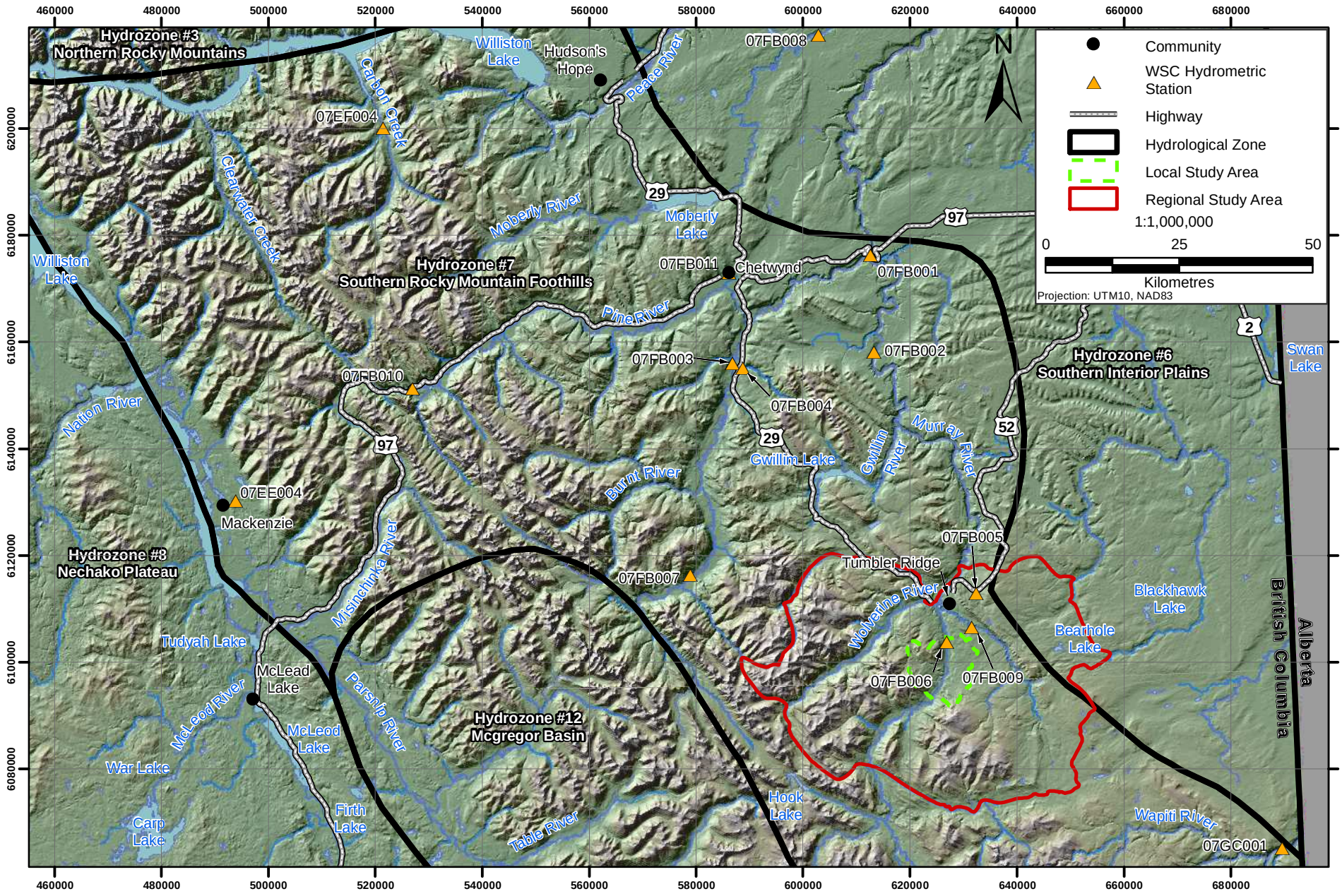



Figure 3.10-1

MURRAY RIVER COAL PROJECT

## Locations of Water Survey of Canada Hydrometric Stations Relevant to the Project

Figure 3.10-1

Rescan Engineers & Scientists

Regional analysis of peak and low flows consisted of correlating the hydrologic index of interest against watershed area. Best-fit equations were constructed based on these correlations, and took the form:

$$Y=aA^b \quad (6)$$

Where $Y$ is the predicted hydrometric index (peak flow, or 7-day low flow), $A$ is the drainage area in $km^2$, and $a$ and $b$ are best-fit coefficients. Based on graphical-fitting and the previous studies (Obedkoff 2000b), Log-Pearson Type III distribution was confirmed to be the best-fit distribution for this region. The distribution parameters for each station were determined using HEC-SSP™ software that provided both analysis and graphical fitting methods.

In mountainous regions, orographic enhancement is a strong control on precipitation. Therefore, the regional effect of elevation on annual runoff was investigated using WSC datasets.

## 3.11 QUALITY ASSURANCE AND QUALITY CONTROL

Data collection for this study was conducted in compliance with the BC guidelines for Water and Air Baseline Monitoring (BC MOE 2012). The hydrotechnical standards and methods are based on standards published by the British Columbia Ministry of Environment (RISC 2009). These standards complement the national standards developed by the Water Survey of Canada (Environment Canada 1999). Methods used in rating curve development follow those outlined by both the RISC manual (RISC 2009) and the International Standards Organization (ISO 2010). The RISC (2009) manual outlines four criteria for both water level data and discharge data that are used to assess and grade (i.e. A, B, C, E estimated and U unknown) the overall quality of hydrometric data. The criteria are: instrumentation, stream channel condition, field procedures and data calculation and assessment. The list provided below details the methods that were used in the study, with the aim to achieve high quality data based on the standards in each of the four criteria.

- **Instrumentation.** All instrumentation and procedures related to instrumentation meet Grade A criteria, with the exception of pressure transducers, which meet the Grade B level (the PS98i used in this study are accurate to 3.5 mm). Data loggers and pressure transducers used for the recording and determining of continuous water level at the hydrometric station are checked, and if necessary calibrated by the manufacturer, prior to each field season. Current meters are sent for annual calibration to Environment Canada's laboratory at the National Water Research Institute in Burlington Ontario or to the manufacturer's vendor, as appropriate.
- **Stream Channel Condition.** Channel conditions affecting control of water level and discharge measurements generally meet 'Grade A' quality standards. Channels are stable, measurements are consistent with rating curves, and selected reaches are relatively straight. In the early and late melt season, channel geometry is affected by snow and ice, and measurements are inconsistent with rating curves at these times. These conditions were identified in field notes and photographs, and ice-affected measurements were not considered during rating curve development.
- **Field Procedures.** Field procedures follow the highest standards for four requirements outlined by RISC (2009). These include the use of a minimum of three benchmarks at each station, more than two level checks per year, five or more manual flow measurements, and twenty or more verticals in manual flow measurements. Therefore, the annual data at this station is graded as A.
- **Data Calculation and Assessment.** Provincial and international standards require that a rating curve be composed of a minimum of 10-15 measurements (RISC 2009, ISO 2010). These standards have been met at MH-1, MH-2, MH-4, and MH-5. The remaining stations have been in operation for less than two full melt seasons, so their rating curves and hydrometric indices

should be viewed as preliminary. The aim of the monitoring program is to collect at least five measurements per year to increase the sample size, distribution of measurements, and to assess whether channel geometry changes are occurring. Data assessment in the field took place throughout the hydrometric monitoring process. The following procedures were performed for data assessment in the office:

- data reduction and analysis were carried out by the technologist or project hydrologist. Data were then imported into Aquarius™ software;
- within the Aquarius™ software format the data were examined for integrity and consistency with provincial and federal standards; and
- if needed, a final assessment and rationalization of any data anomalies or shortcomings were discussed and documented.

## 3.12 METEOROLOGY

Meteorological data presented in Appendix 5 are from the ERM Rescan-operated meteorologic station located in the Murray River Project area. The station is located at 55.02 $^{o}$N, 121.08 $^{o}$W, at 1,055 masl, and has been in operation since March 2011 (Recan 2013c). The station records air temperature, precipitation, snow depth, wind speed and direction, solar radiation, barometric pressure, and relative humidity. Only precipitation (tipping bucket rain gauge), and air temperature data are used here. Precipitation was measured with a TE525WS Tipping Bucket Rain Gauge (shielded and fitted with an antifreeze-filled bucket to measure snow), and air temperature was measured with a HMP45C212 Temperature & Relative Humidity Probe.

# 4. Results

ERM

# 4. Results

## 4.1 DISCHARGE MEASUREMENTS

Discharge measurements were conducted at each hydrometric station during site visits in 2011, 2012, and 2013 (Table 4.1-1). Measurements were typically conduced with handheld current meters. An Acoustic Doppler Current Profiler (ADCP) was used when stage or velocity were too high to safely wade the streams. On two occasions, discharge was determined by filling vessels, and noting the length of time to fill a given volume. This technique was only used at MH-3 when stage or velocity were too low to use a handheld current meter. Rating points that were modelled using HEC-RAS at MH-3 are also identified. Detailed discharge measurements and calculations for all measurements are presented in Appendix 2.

**Table 4.1-1. Summary of Discharge Measurements for Project Area Hydrometric Stations**

| Hydrometric Station | Date Measured | Water Stage[a] (m) | Water Discharge ($m^3/s$) | Measurement Error (%) at the 95% Confidence Interval | Method |
|---|---|---|---|---|---|
| MH-1 | 17-Mar-11 | 97.8 | 8.5 | 7.6 | Velocity-Area (Flo-mate) |
| | 13-May-11 | 98.64 | 130 | 1.9[b] | Velocity-Area (ADCP) |
| | 3-Jul-11 | 98.86 | 162.9 | 1.5[b] | Velocity-Area (ADCP) |
| | 3-Aug-11 | 98.38 | 86 | 1.2[b] | Velocity-Area (ADCP) |
| | 6-Sep-11 | 98.02 | 48.9 | 2.3[b] | Velocity-Area (ADCP) |
| | 17-Oct-11 | 97.8 | 34.8 | 3.1[b] | Velocity-Area (ADCP) |
| | 28-Apr-12 | 98.031 | 53.3 | 8.4[b] | Velocity-Area (ADCP) |
| | 20-May-12 | 98.395 | 93.6 | 2.1[b] | Velocity-Area (ADCP) |
| | 28-Jun-12 | 98.984 | 170 | 7.8[b] | Velocity-Area (ADCP) |
| | 17-Aug-12 | 97.943 | 47.7 | 5.9[b] | Velocity-Area (ADCP) |
| | 26-Sep-12 | 97.562 | 20 | 4.5[b] | Velocity-Area (ADCP) |
| MH-2 | 15-Mar-11 | 98.084 | 0.03 | 6.7 | Velocity-Area (Flo-mate) |
| | 15-May-11 | 98.494 | 2.13 | 5.6 | Velocity-Area (Swoffer) |
| | 2-Jul-11 | 98.148 | 0.83 | 5.3 | Velocity-Area (Flo-mate) |
| | 6-Aug-11 | 98.031 | 0.24 | 5.6 | Velocity-Area (Flo-mate) |
| | 5-Sep-11 | 97.948 | 0.065 | 6.8 | Velocity-Area (Flo-mate) |
| | 17-Oct-11 | 97.934 | 0.045 | 6.7 | Velocity-Area (Flo-mate) |
| | 17-Nov-11 | 98.015 | 0.044 | 7.0 | Velocity-Area (Flo-mate) |
| | 26-Apr-12 | 97.323 | 0.318 | 6.1 | Velocity-Area (Flo-Mate) |
| | 21-May-12 | 97.367 | 1.1 | 4.9 | Velocity-Area (Flo-Mate) |
| | 29-Jun-12 | 97.316 | 0.626 | 5.9 | Velocity-Area (Flo-Mate) |
| | 16-Aug-12 | 97.199 | 0.096 | 7.0 | Velocity-Area (Flo-Mate) |
| | 29-Sep-12 | 97.172 | 0.039 | 10.0 | Velocity-Area (Flo-Mate) |
| | 5-Nov-12 | 97.36 | 0.179 | 6.2 | Velocity-Area (Flo-Mate) |
| | 1-May-13 | 97.265 | 0.368 | 5.6 | Velocity-Area (Flo-Mate) |
| | 21-May-13 | 97.444 | 2.281 | 5.4 | Velocity-Area (FH950) |

*(continued)*

**Table 4.1-1. Summary of Discharge Measurements for Project Area Hydrometric Stations (continued)**

| Hydrometric Station | Date Measured | Water Stage[a] (m) | Water Discharge ($m^3/s$) | Measurement Error (%) at the 95% Confidence Interval | Method |
|---|---|---|---|---|---|
| MH-2 (*cont'd*) | 27-Jun-13 | 97.315 | 0.717 | 5.2 | Velocity-Area (Flo-Mate) |
| | 9-Aug-13 | 97.325 | 0.8 | 5.9 | Velocity-Area (FH950) |
| | 10-Oct-13 | 97.222 | 0.179 | 6.4 | Velocity-Area (Flo-Mate) |
| | 6-Nov-13 | 97.192 | 0.092 | 6.5 | Velocity-Area (Flo-Mate) |
| MH-3 | 16-May-11 | 98.498 | 0.326 | 6.1 | Velocity-Area (Swoffer) |
| | 3-Jul-11 | 98.266 | 0.068 | 5.4 | Velocity-Area (Flo-mate) |
| | 4-Jul-11 | 98.397 | 0.064 | 5.8 | Velocity-Area (Flo-mate) |
| | 7-Aug-11 | 98.317 | 0.0003 | 28.0 | Velocity-Area (Flo-mate) |
| | 8-Sep-11 | dry | dry | n/a | n/a |
| | 17-Oct-11 | 98.3 | 0.0001 | n/a[c] | Volumetric |
| | 16-Nov-11 | 98.294 | 0.0001 | n/a[c] | Volumetric |
| | 16-Apr-12 | 97.643 | 0.095 | 6.1 | Velocity-Area (Flo-Mate) |
| | 20-May-12 | 97.673 | 0.094 | 6.2 | Velocity-Area (Flo-Mate) |
| | 29-Jun-12 | 97.633 | 0.042 | 7.1 | Velocity-Area (Flo-Mate) |
| | 15-Aug-12 | dry | dry | n/a | n/a |
| | 29-Sep-12 | dry | dry | n/a | n/a |
| | 5-Nov-12 | dry | dry | n/a | n/a |
| | n/a | 98.330 | 0.5 | n/a | modelled in HEC-RAS |
| | n/a | 98.201 | 0.38 | n/a | modelled in HEC-RAS |
| | n/a | 98.000 | 0.26 | n/a | modelled in HEC-RAS |
| MH-4 | 14-May-11 | 98.644 | 0.838 | 6.5 | Velocity-Area (Swoffer) |
| | 1-Jul-11 | 98.573 | 0.461 | 5.2 | Velocity-Area (Flo-mate) |
| | 6-Aug-11 | 98.445 | 0.138 | 8.1 | Velocity-Area (Flo-mate) |
| | 3-Sep-11 | 98.388 | 0.052 | 8.8 | Velocity-Area (Flo-mate) |
| | 16-Oct-11 | 98.373 | 0.029 | 13.1 | Velocity-Area (Flo-mate) |
| | 16-Nov-11 | 98.445 | 0.047 | 8.9 | Velocity-Area (Flo-mate) |
| | 28-Apr-12 | 98.491 | 0.273 | 5.7 | Velocity-Area (Flo-Mate) |
| | 19-May-12 | 98.606 | 0.645 | 5.7 | Velocity-Area (Flo-Mate) |
| | 30-Jun-12 | 98.54 | 0.35 | 6.6 | Velocity-Area (Flo-Mate) |
| | 15-Aug-12 | 98.419 | 0.086 | 8.9 | Velocity-Area (Flo-Mate) |
| | 28-Sep-12 | 98.344 | 0.02 | 13.8 | Velocity-Area (Flo-Mate) |
| | 8-Nov-12 | 98.597 | 0.079 | 8.9 | Velocity-Area (Flo-Mate) |
| | 9-Nov-12 | 98.542 | Not measured | n/a | n/a |
| MH-5 | 12-May-11 | 98.946 | 0.335 | 6.3 | Velocity-Area (Swoffer) |
| | 1-Jul-11 | 98.615 | 0.072 | 5.1 | Velocity-Area (Flo-mate) |
| | 4-Aug-11 | 98.509 | 0.03 | 6.5 | Velocity-Area (Flo-mate) |
| | 2-Sep-11 | 98.469 | 0.009 | 8.5 | Velocity-Area (Flo-mate) |
| | 15-Oct-11 | 98.456 | 0.004 | 12.0 | Velocity-Area (Flo-mate) |
| | 15-Nov-11 | 98.456 | 0.003 | 14.2 | Velocity-Area (Flo-mate) |
| | 25-Apr-12 | 98.548 | 0.052 | 6.4 | Velocity-Area (Flo-Mate) |

*(continued)*

**Table 4.1-1. Summary of Discharge Measurements for Project Area Hydrometric Stations (completed)**

| Hydrometric Station | Date Measured | Water Stage[a] (m) | Water Discharge ($m^3/s$) | Measurement Error (%) at the 95% Confidence Interval | Method |
|---|---|---|---|---|---|
| MH-5 (*cont'd*) | 18-May-12 | 98.577 | 0.063 | 6.7 | Velocity-Area (Flo-Mate) |
| | 26-Jun-12 | 98.506 | 0.028 | 7.7 | Velocity-Area (Flo-Mate) |
| | 14-Aug-12 | 98.448 | 0.009 | 8.2 | Velocity-Area (Flo-Mate) |
| | 28-Sep-12 | 98.442 | 0.003 | 15.0 | Velocity-Area (Flo-Mate) |
| | 8-Nov-12 | 98.473 | 0.007 | 11.4 | Velocity-Area (Flo-Mate) |
| MH-6 | 27-Sep-12 | 96.381 | 0.002 | 13.4 | Velocity-Area (Flo-Mate) |
| | 6-Nov-12 | 96.451 | 0.028 | 5.8 | Velocity-Area (Flo-Mate) |
| | 30-Apr-13 | 96.524 | 0.288 | 5.7 | Velocity-Area (Flo-Mate) |
| | 21-May-13 | 96.466 | 0.124 | 7.5 | Velocity-Area (FH950) |
| | 27-Jun-13 | 96.438 | 0.074 | 6.0 | Velocity-Area (Flo-Mate) |
| | 27-Jun-13 | 96.434 | 0.065 | 6.1 | Velocity-Area (Flo-Mate) |
| | 8-Aug-13 | 96.4 | 0.019 | 6.9 | Velocity-Area (FH950) |
| | 8-Oct-13 | 96.404 | 0.02 | 7.9 | Velocity-Area (Flo-Mate) |
| | 6-Nov-13 | 96.382 | 0.004 | 11.3 | Velocity-Area (Flo-Mate) |
| MH-7 | 30-Sep-12 | 97.578 | 0.0031 | 10.6 | Velocity-Area (Flo-Mate) |
| | 4-Nov-12 | 97.685 | 0.0391 | 6.8 | Velocity-Area (Flo-Mate) |
| | 1-May-13 | 97.183 | 2.402 | 5.4 | Velocity-Area (Flo-Mate) |
| | 24-May-13 | 96.94 | 0.694 | 6.7 | Velocity-Area (FH950) |
| | 26-Jun-13 | 96.894 | 0.448 | 5.4 | Velocity-Area (Flo-Mate) |
| | 28-Jun-13 | 96.859 | 0.329 | 5.8 | Velocity-Area (Flo-Mate) |
| | 9-Aug-13 | 96.836 | 0.282 | 6.6 | Velocity-Area (FH950) |
| | 8-Oct-13 | 96.739 | 0.052 | 8.1 | Velocity-Area (Flo-Mate) |
| | 7-Nov-13 | 96.689 | 0.018 | 12.0 | Velocity-Area (Flo-Mate) |

*Notes:*
[a] *Stage is referenced to a site-specific arbitrary datum*
[b] *Measurement error for ADCP measurements is calculated as the difference from average transect discharge; when four or more transects are available from at least two matched left to right bank pairs.*
[c] *No method applied to quantify error for volumetric measurements*

In 2011, a total of 33 discharge measurements were attempted (includes times when rivers were not flowing) at five hydrometric monitoring stations during the visits in March, May, July, August, September and November (Table 4.1-1). There was no discharge measurement at MH-1 when it was ice-covered during the November visit and at MH-3 when it was dry during the September visit.

In 2012, a total of 34 discharge measurements were attempted at seven hydrometric monitoring stations during the visits in April, May, June, August, September and November (Table 4.1-1). Two discharge measurements were conducted at MH-6 and MH-7, respectively, since they were installed in September 2012. Station MH-3 was dry after July. Winter flow measurements were conducted in March 2011 at stations MH-1 and MH-2.

In 2013, a total of 20 discharge measurements were made at stations MH-2, MH-6, and MH-7. Discharge measurement visits took place from May to November. By November, flow was very low at all stations.

## 4.2 STAGE-DISCHARGE RELATIONSHIPS

Manual measurements of stage and discharge were correlated to develop stage–discharge relationships and rating curves for each hydrometric station. Stage-discharge rating relationships should not be assumed to remain the same from year-to-year, particularly in the case of high energy, dynamic channels, like many of those in the monitoring network. The stage-discharge relationships were therefore assessed annually. For example, if channel scouring occurs, increasing the channel capacity, the relative stage for a given discharge would decrease, which would alter any previously developed stage-discharge relationships. Rating equations from 2011 to 2013 for each hydrometric station are provided in Table 4.2-1, along with the associated RMS error. Rating curves are presented in Appendix 3.

**Table 4.2-1. Summary of Rating Equations for the Hydrometric Stations**

| Hydrometric Station | Rating Period | High or Low Stage? | Rating Equation[1] $Q = C (h-a)^b$ | Root Mean Square | Number of Rating Points Used |
|---|---|---|---|---|---|
| MH-1 | 2011-2012 | n/a | $Q = 38.737(h-96.856)^{2.022}$ | 3.8 | 10 |
| MH-2 | 2011 | n/a | $Q = 6.520(h-97.871)^{1.779}$ | 5 | 7 |
| | 2012-2013 | Low | $Q = 14.290(h-97.133)^{1.820}$ | 6 | 12 |
| | 2012-2013 | High | $Q = 24.520(h-97.175)^{1.826}$ | | |
| MH-3 | 2012 site | n/a | $Q = 0.546(h-97.379)^{1.417}$ | 20.1 | 6 |
| MH-4 | 2011-2012 | Low | $Q = 1.297(h-98.249)^{1.750}$ | 9.2 | 12 |
| | 2011-2012 | High | $Q = 6.306(h-98.315)^{1.880}$ | | |
| MH-5 | 2011-2012 | n/a | $Q = 1.003(h-98.430)^{1.496}$ | 34.7 | 12 |
| MH-6[3] | 2012-2013 | n/a | $Q = 8.750(h-96.366)^{1.831}$ | 7.1 | 9 |
| MH-7[3] | 2012-2013 | n/a | $Q = 8.399(h-96.654)^{2.016}$ | 5.8 | 9 |

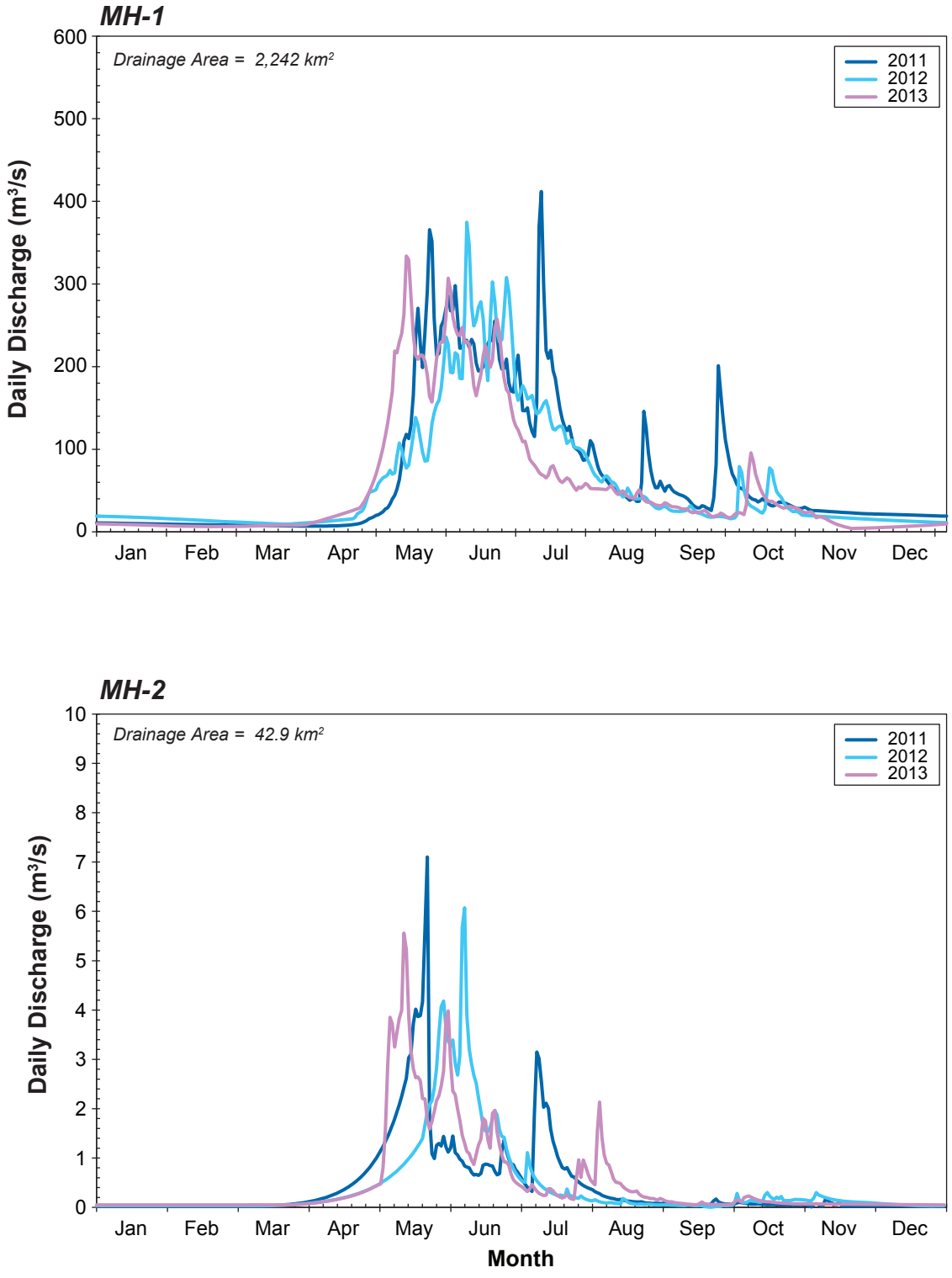
At MH-3, HEC-RAS model was used to estimate several medium and high discharges. These estimated stage-discharge data were used in combination with measured stage/discharge data to develop an estimated rating curve.

Stations MH-6 and MH-7 were established in the fall low-flow period of 2012. As such, very little data from these sites were available prior to this report. Fieldwork in 2013 allowed a range of discharges to be measured, and allowed a rating curve and annual hydrograph to be produced for these stations.

## 4.3 DISCHARGE HYDROGRAPHS

Annual discharge hydrographs were developed for the hydrometric stations by applying the developed stage-discharge relationships to the recorded water level data (Figures 4.3-1 to 4.3-4; Appendices 4 and 5). The annual hydrographs are presented as daily average discharge, calculated over a 24-hour period.

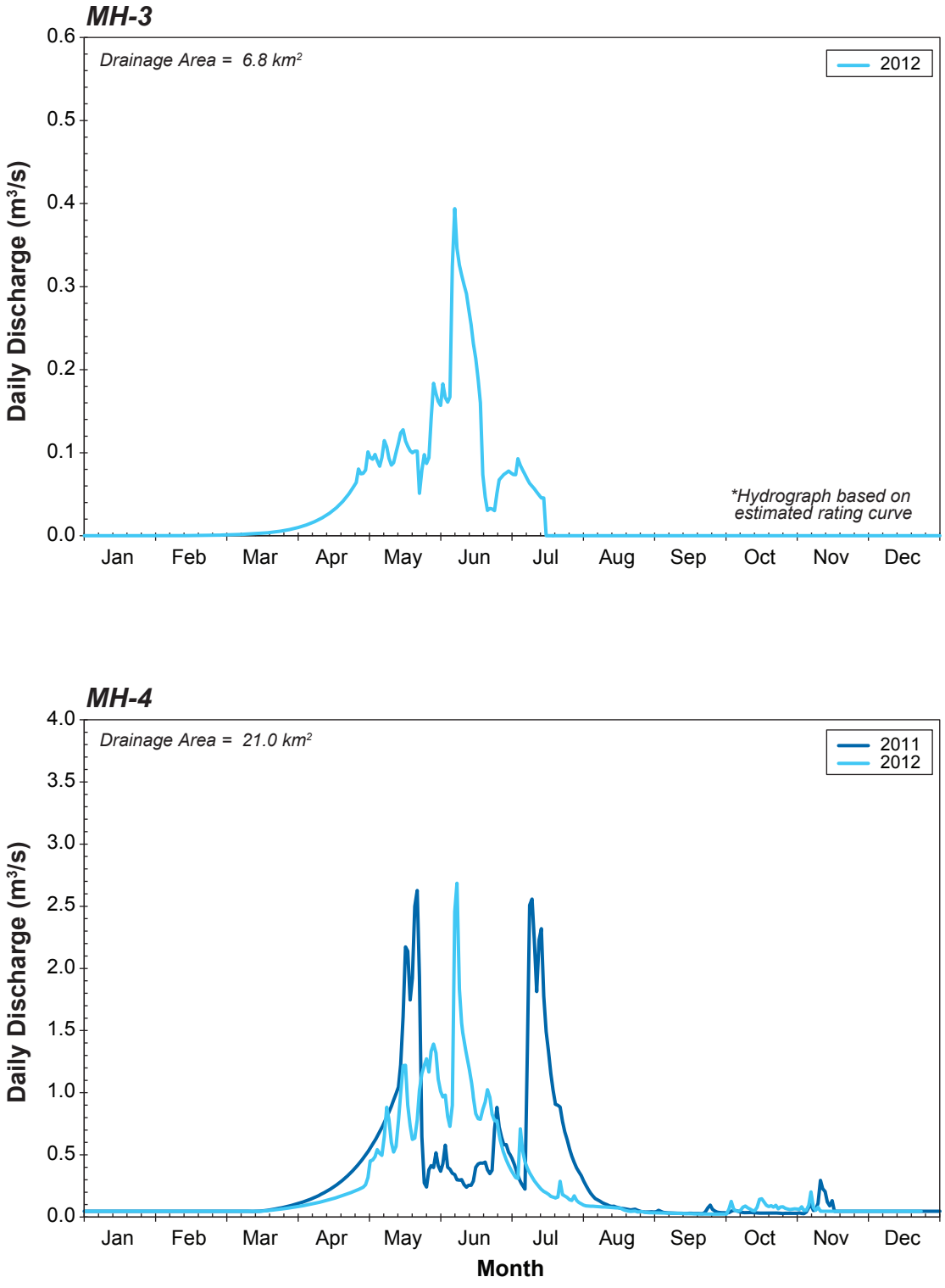
Pressure transducers were removed in the late fall of each monitoring season to prevent damage to pressure transducers from below freezing conditions. Flows were estimated at times when stations were demobilized. Results relating to flow estimation are discussed below, and methods are described in Section 3.6.




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# Annual Hydrographs at MH-1 and MH-2 Hydrometric Monitoring Stations, 2011 to 2013

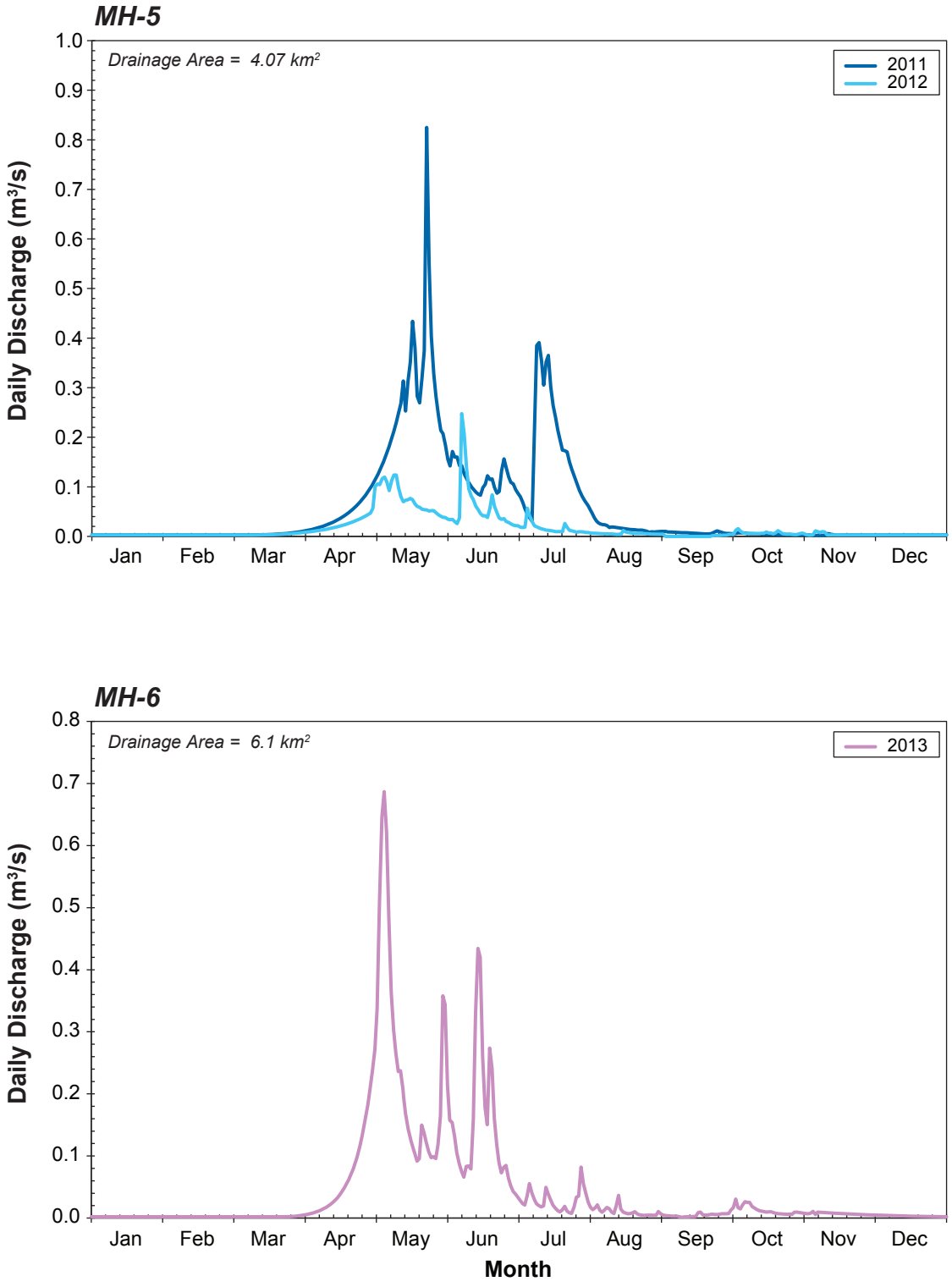
Figure 4.3-1




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# Annual Hydrographs at MH-3 and MH-4 Hydrometric Monitoring Stations, 2011 to 2012

Figure 4.3-2

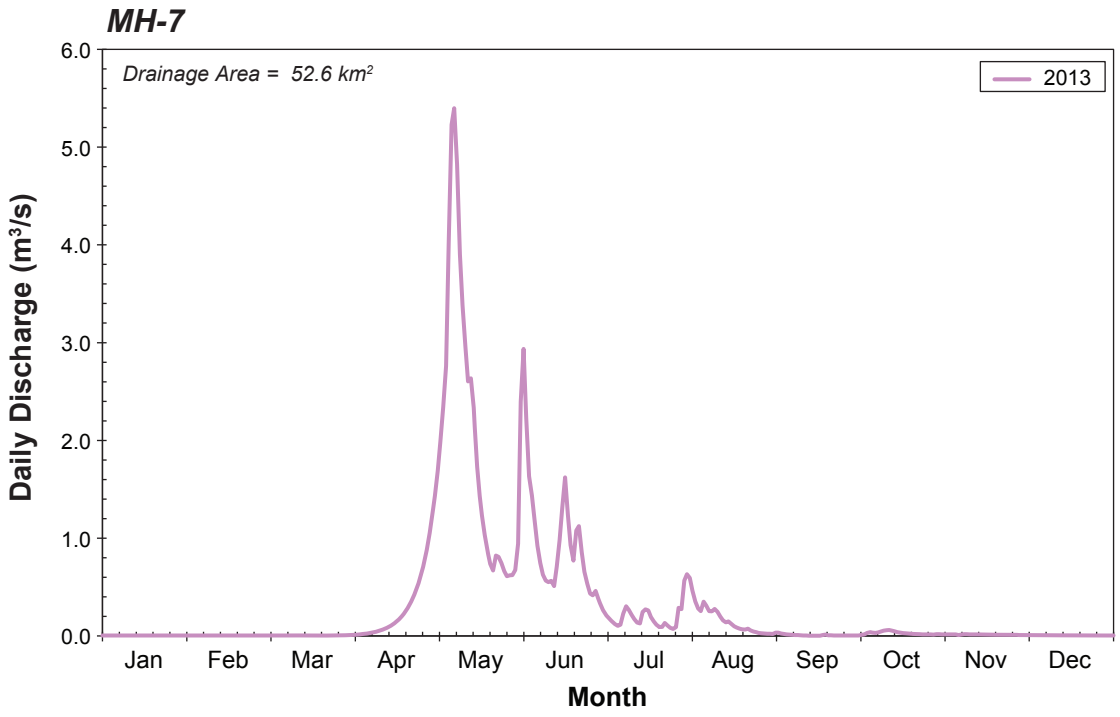



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Figure 4.3-3

Annual Hydrographs at MH-5 and MH-6 Hydrometric Monitoring Stations, 2011 to 2013

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Figure 4.3-4

## Annual Hydrographs at MH-7 Hydrometric Monitoring Stations, 2013

### 4.3.1 Statistical Modelling and Estimation of Flow

MH-1

*2011-2012*

The MH-1 watershed area is large, and as a result it has a similar hydrologic regime to nearby Water Survey of Canada (WSC) hydrometric stations with large watersheds, two of which are located near the Project area on the Murray River (Table 3.10-1).

Depending on data availability, two stations were used to estimate flows at MH-1 from 2011-2012: 07FB003 (Skunka River near the Mouth), and 07FB006 (Murray River above Wolverine River; Figure 4.3-5; Table 3.10-1). Regression analyses between synchronously monitored discharges at the WSC stations and MH-1 are presented below.

For MH-1 and 07FB006:

$$y = 1.001x - 0.019, R^2 = 0.987, n = 205 \quad (3)$$

For MH-1 and 07FB003:

$$y = 0.004\,x^2 - 0.061\,x + 22.317, R^2 = 0.895, n = 140 \quad (4)$$

As expected, a closer relationship exists between MH-1 and 07FB006 than between MH-1 and 07FB003. Therefore, 07FB006 was used to estimate discharges at MH-1 when data were available. When not available, 07FB003 was used.

*2013*

Station MH-1 was not operated in 2013, so all discharge data were estimated or statistically modelled. Station 07FB006 (Murray River above Wolverine River) was not in operation for most of 2013; therefore 07FB002 (Murray River near the Mouth) was used instead. Station 07FB002 is located about 61 km upstream (north) of MH-1 on the Murray River (Figure 3.10-1; Table 3.10-1). These WSC data are preliminary 'real-time' data, so may undergo further QA/QC by the WSC in the future.

Mean daily discharge from 07FB002 and MH-1 were correlated for the 2011 and 2012 open water seasons (Figure 4.3-6). A best-fit second-degree polynomial equation was developed, where:

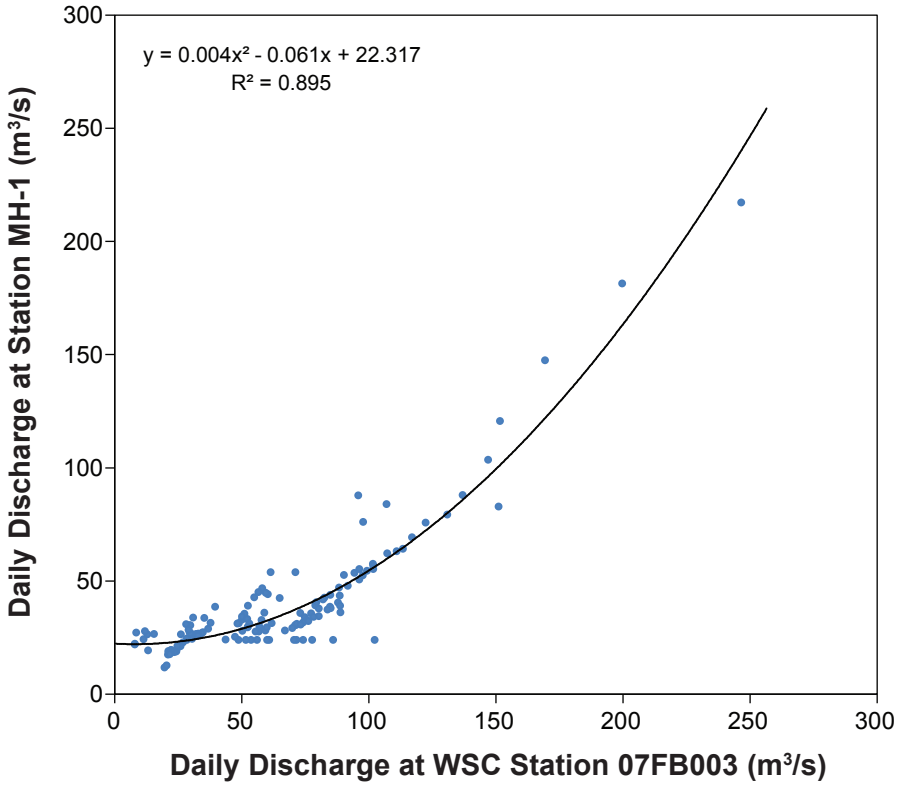
$$y = -0.248 + (0.727 * X) - (0.000296 * x^2),\ R^2 = 0.95,\ n = 690 \quad (5)$$

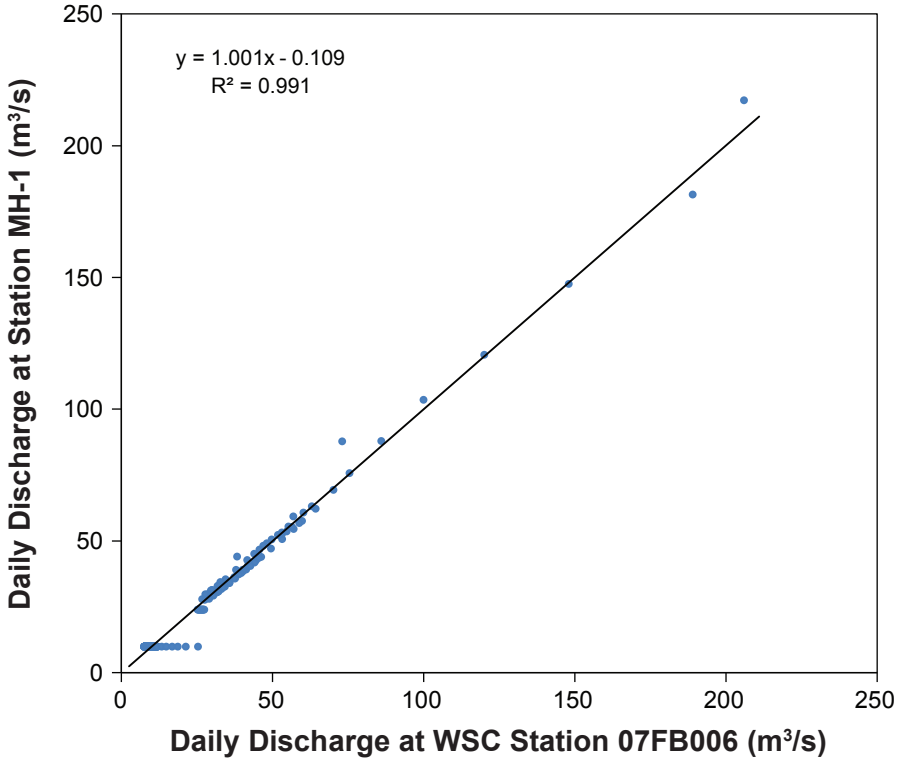
Where 'y' is modelled MH-1 daily discharge, and X is measures 07FB002 discharge. Discharge predicted using this equation is marked as 'modelled' on hydrographs in Appendix 5.

Data from 07FB002 were either missing or obviously ice-affected for the low-flow periods between January 1 and May 8, and November 9 to December 31. To fill these gaps, data for these periods in 2011 and 2012 were used, and are marked as 'estimated' on hydrographs in Appendix 5.

MH-2 to MH-7

Winter discharges at these stations with small upstream watersheds were estimated using a logarithmic or exponential decay function (methods described in Section 3.6).

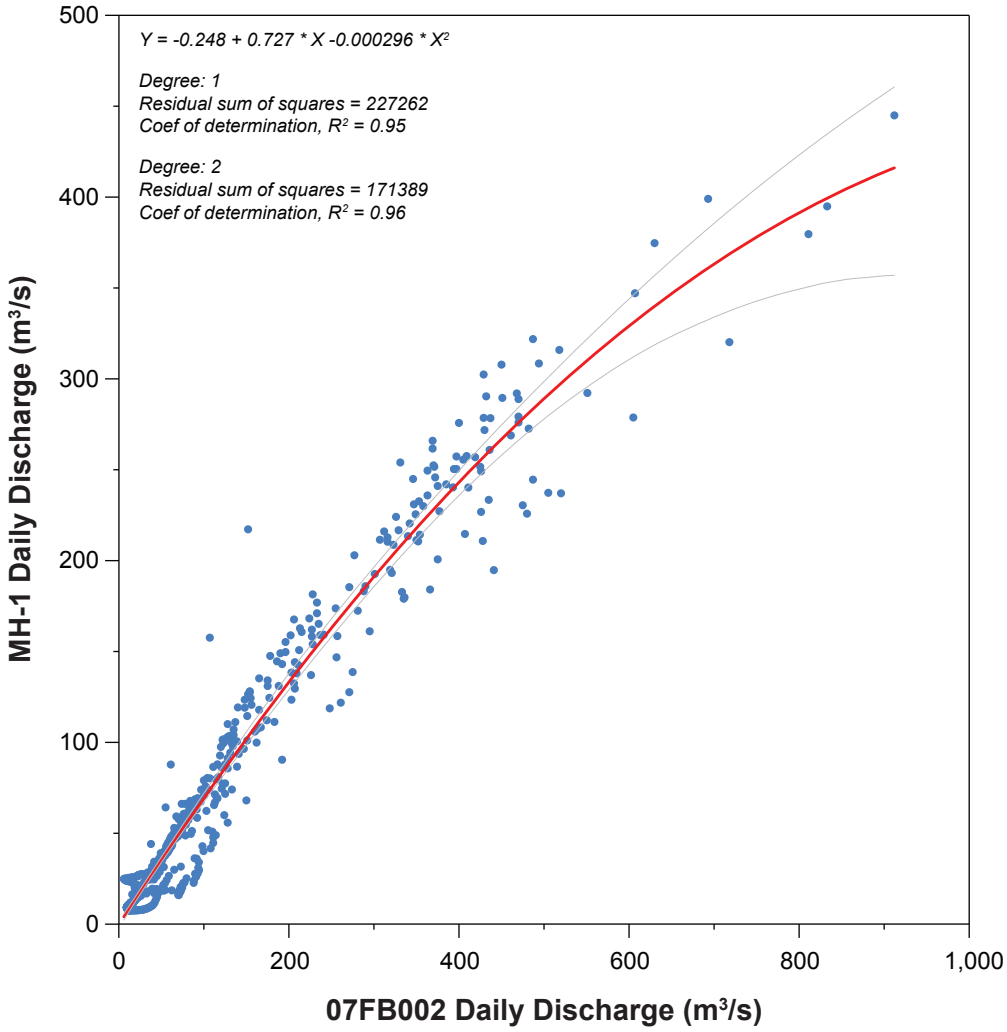



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**Discharge Relationships of Station MH-1 with WSC Stations 07FB006 and 07FB003**

Figure 4.3-5




Notes: Red line is the line of best-fit.
Grey lines are the 95% confidence limits.



Figure 4.3-6

# Discharge Relationships between Station MH-1 and WSC Station 07FB002

## 4.4 HYDROLOGIC STATISTICS

Key hydrologic indices include annual and monthly runoff, peak and low flows. Flow duration curves are also presented here. Local meteorological data are presented to provide spatial and temporal climatic context for interpretation of hydrologic statistics.

### 4.4.1 Annual and Monthly Runoff

Annual and monthly runoff are calculated from the 2011 to 2013 annual discharge hydrographs, which include both measured and modelled/estimated data (Tables 4.4-1 and 4.4-2; Figures 4.4-1 to 4.4-3). The lowest estimated mean annual runoff, 134 mm, occurred at MH-5 (Mast Creek) in 2012, while the highest estimated mean annual runoff, 924 mm, occurred at station MH-1 (Murray River) in 2011.

The mean annual runoff, 837 mm, at MH-1 was significantly larger than the other stations. This is likely because the Murray River watershed has a higher median elevation than the watersheds above the other monitored stations, and a greater proportion of windward slopes, both of which would be expected to result in higher annual precipitation.

Most of the annual runoff at the hydrometric monitoring stations occurred during the period from May to July in all years. Between 69 and 88 percent of total annual runoff occurred in these months. The lowest runoff percentages in this range came from MH-1. Because of the large size of this watershed, flows continue throughout winder, and contribute more of to the annual flow than in smaller watersheds. (Figure 4.4-2; Table 4.4-2).

### 4.4.2 Peak Flow, Low Flows, and Flow Duration Analyses

Peak discharges are summarized in Table 4.4-3. Typically the highest flows occur during the spring period, in response to seasonal freshet-related runoff conditions. However, peak flows are sometimes recorded later in the melt season in response to precipitation events.

The highest peak instantaneous and daily discharges occurred at station MH-1 on Murray River (drainage area 2,242 $km^2$) while the lowest peak instantaneous and daily discharge occurred at station MH-5 on Mast Creek (drainage area: 4.07 $km^2$); these are the stations with the largest and smallest drainage areas, respectively. This is an expected result, as discharge and drainage area are highly correlated.

To allow comparison between watersheds, instantaneous and daily peak unit yield values are also calculated (Table 4.4-3). Peak unit yield is the peak discharge normalized by watershed area, and is expressed here in units of $L/s/km^2$. Similar to annual runoff, the highest peak unit yield occurred at station MH-1 because of the high precipitation amounts in the upper portions of its drainage area. Peak unit yields at the other stations were similar to each other, with the exception of MH-3 and MH-5 which had significantly lower peak unit yields than those of other stations in 2012.

Analyses of low flow were also performed on flows at the hydrometric stations (Table 4.4-4). Annual low flows typically occur during winter, because a large percentage of water inputs are stored as snow or ice. At the majority of hydrometric stations, the pressure transducer is either not active during the winter (to protect the pressure membrane from freezing), or the quality of the data collected is unreliable (ice encroachment and accumulation changes the stage-discharge relationship in the channel). Therefore, manual winter flow measurements were assumed to be representative of baseflow conditions.

**Table 4.4-1. 2011-2013 Annual and Monthly Runoff (mm) at Project Area Hydrometric Stations**

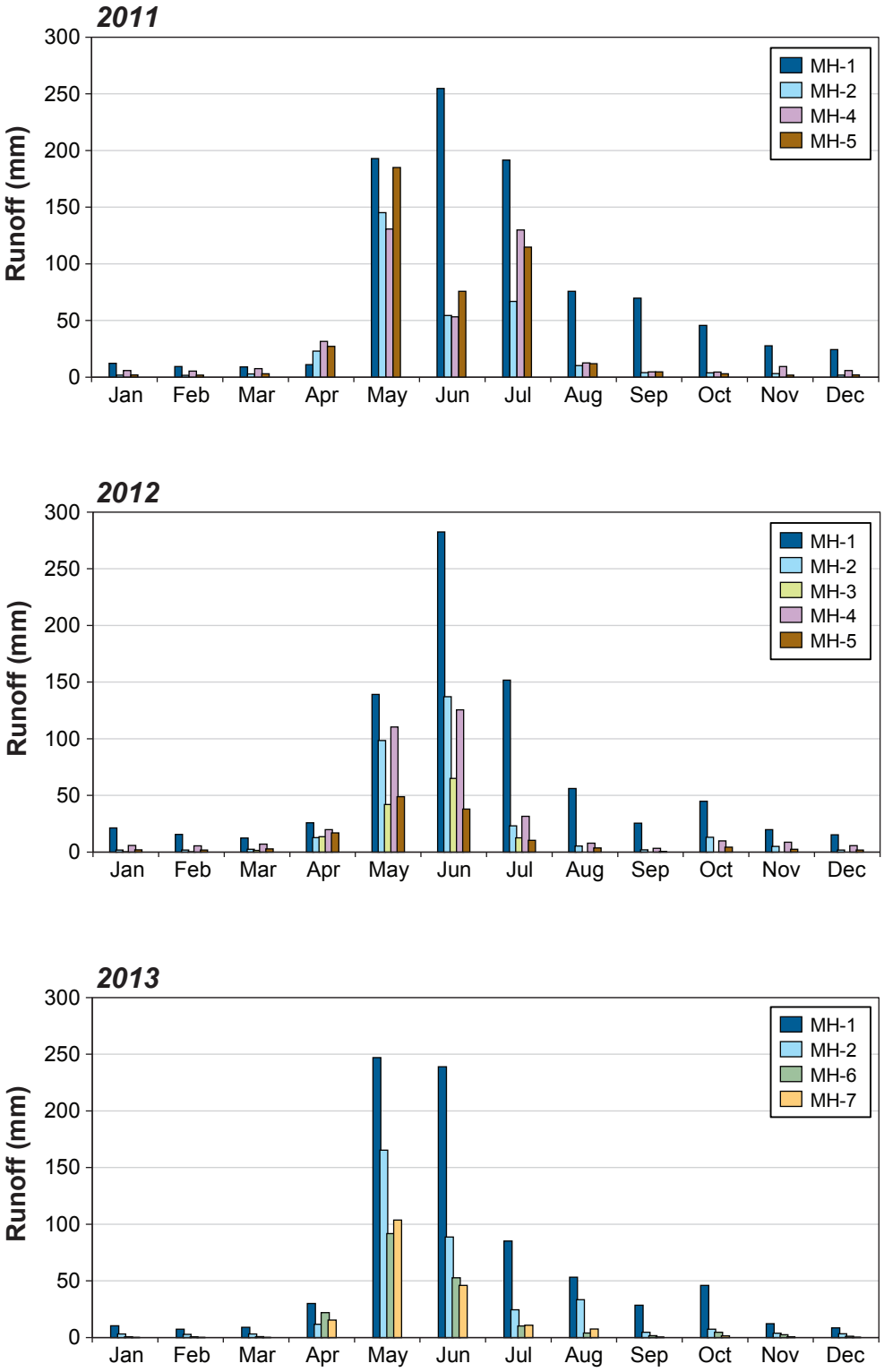
| Hydrometric Station | Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH-1 | 2011 | *12* | *9* | *9* | 11 | 193 | 255 | 192 | 76 | 70 | 46 | *28* | *24* | 924 |
| | 2012 | *21* | *16* | *12* | 26 | 139 | 282 | 152 | 56 | 26 | 45 | *20* | *15* | 810 |
| | 2013 | *10* | *7* | *9* | *30* | *247* | *239* | *85* | *53* | *29* | *46* | *12* | *9* | *777* |
| | Mean | 15 | 11 | 10 | 22 | 193 | 259 | 143 | 62 | 41 | 46 | 20 | 16 | 837 |
| MH-2 | 2011 | *2* | *2* | *3* | 23 | 145 | 54 | 67 | 10 | 4 | 4 | *3* | *2* | *319* |
| | 2012 | *2* | *2* | *3* | *13* | 98 | 137 | 23 | 5 | 2 | 13 | *5* | *2* | *305* |
| | 2013 | *3* | *3* | *3* | *12* | 173 | 82 | 25 | 33 | 5 | 7 | *4* | *3* | *353* |
| | Mean | 2 | 2 | 3 | 16 | 139 | 91 | 38 | 16 | 4 | 8 | 4 | 2 | 326 |
| MH-3 | 2011 | n/d | n/d | n/d | n/d | n/d | n/d | n/d | 67 | n/d | n/d | n/d | n/d | n/d |
| | 2012 | *0* | *0* | *1* | *14* | *42* | *65* | *13* | 0 | 0 | 0 | 0 | 0 | *135* |
| MH-4 | 2011 | *6* | *5* | *7* | 32 | 131 | 53 | 130 | 13 | 5 | 4 | *9* | *6* | *401* |
| | 2012 | *6* | *5* | *7* | *20* | 110 | 126 | 32 | 8 | 3 | 10 | *9* | *6* | *341* |
| | Mean | *6* | *5* | *7* | *26* | 121 | 89 | 81 | 10 | 4 | 7 | *9* | *6* | *371* |
| MH-5 | 2011 | *2* | *2* | *3* | 27 | 185 | 76 | 115 | 12 | 5 | 3 | *2* | *2* | *433* |
| | 2012 | *2* | *2* | *3* | *17* | 49 | 38 | 10 | 4 | 1 | 4 | *3* | *2* | *134* |
| | Mean | *2* | *2* | *3* | *22* | 117 | 57 | 63 | 8 | 3 | 4 | *2* | *2* | *283* |
| MH-6 | 2013 | *1* | *1* | *1* | *22* | 92 | 53 | 10 | 4 | 2 | 5 | *2* | *1* | *193* |
| MH-7 | 2013 | *0* | *0* | *0* | *15* | 104 | 46 | 11 | 8 | 0 | 1 | *1* | *0* | *187* |

*Note:*
*Estimated values are italicized.*

**Table 4.4-2. 2011-2012 Annual and Monthly Runoff (%) of the Hydrometric Stations**

| Hydrometric Station | Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH-1 | 2011 | *1* | *1* | *1* | *1* | 21 | 28 | 21 | 8 | 8 | 5 | *3* | *3* | 100 |
| | 2012 | *3* | *2* | *2* | *3* | 17 | 35 | 19 | 7 | 3 | 6 | *2* | *2* | 100 |
| | 2013 | *1* | *1* | *1* | 4 | 32 | 31 | 11 | 7 | 4 | 6 | *2* | *1* | 100 |
| | Mean | *2* | *1* | *1* | *3* | *23* | *31* | *17* | *7* | *5* | *5* | *2* | *2* | 100 |
| MH-2 | 2011 | *1* | *1* | *1* | 7 | 46 | 17 | 21 | 3 | 1 | 1 | *1* | *1* | 100 |
| | 2012 | *1* | *1* | *1* | *4* | 32 | 45 | 8 | 2 | 1 | 4 | *2* | *1* | 100 |
| | 2013 | *1* | *1* | *1* | 4 | 49 | 23 | 7 | 9 | 1 | 2 | *1* | *1* | 100 |
| | Mean | *1* | *1* | *1* | *5* | *42* | *28* | *12* | *5* | *1* | *2* | *1* | *1* | 100 |
| MH-3 | 2012 | 0 | 0 | *1* | *10* | *31* | *48* | *9* | 0 | 0 | 0 | 0 | 0 | 100 |
| MH-4 | 2011 | *1* | *1* | *2* | 8 | 33 | 13 | 32 | 3 | 1 | 1 | 2 | 1 | 100 |
| | 2012 | *2* | *2* | *2* | *6* | 32 | 37 | 9 | 2 | 1 | 3 | 3 | 2 | 100 |
| | Mean | *1* | *1* | *2* | *8* | *32* | *33* | *17* | *2* | *1* | *1* | *2* | *1* | 100 |
| MH-5 | 2011 | *0* | *0* | *1* | 6 | 43 | 17 | 26 | 3 | 1 | 1 | *0* | *0* | 100 |
| | 2012 | *1* | *1* | *2* | *13* | 36 | 28 | 8 | 3 | 0 | 3 | *2* | *1* | 100 |
| | Mean | *1* | *1* | *2* | *10* | *40* | *23* | *17* | *3* | *1* | *2* | *1* | *1* | 100 |
| MH-6 | 2013 | *0* | *0* | *0* | 11 | 48 | 27 | 5 | 2 | 1 | 2 | *1* | *1* | 100 |
| MH-7 | 2013 | *0* | *0* | *0* | 8 | 55 | 25 | 6 | 4 | 0 | 1 | *0* | *0* | 100 |

*Note: Estimated values are italicized.*

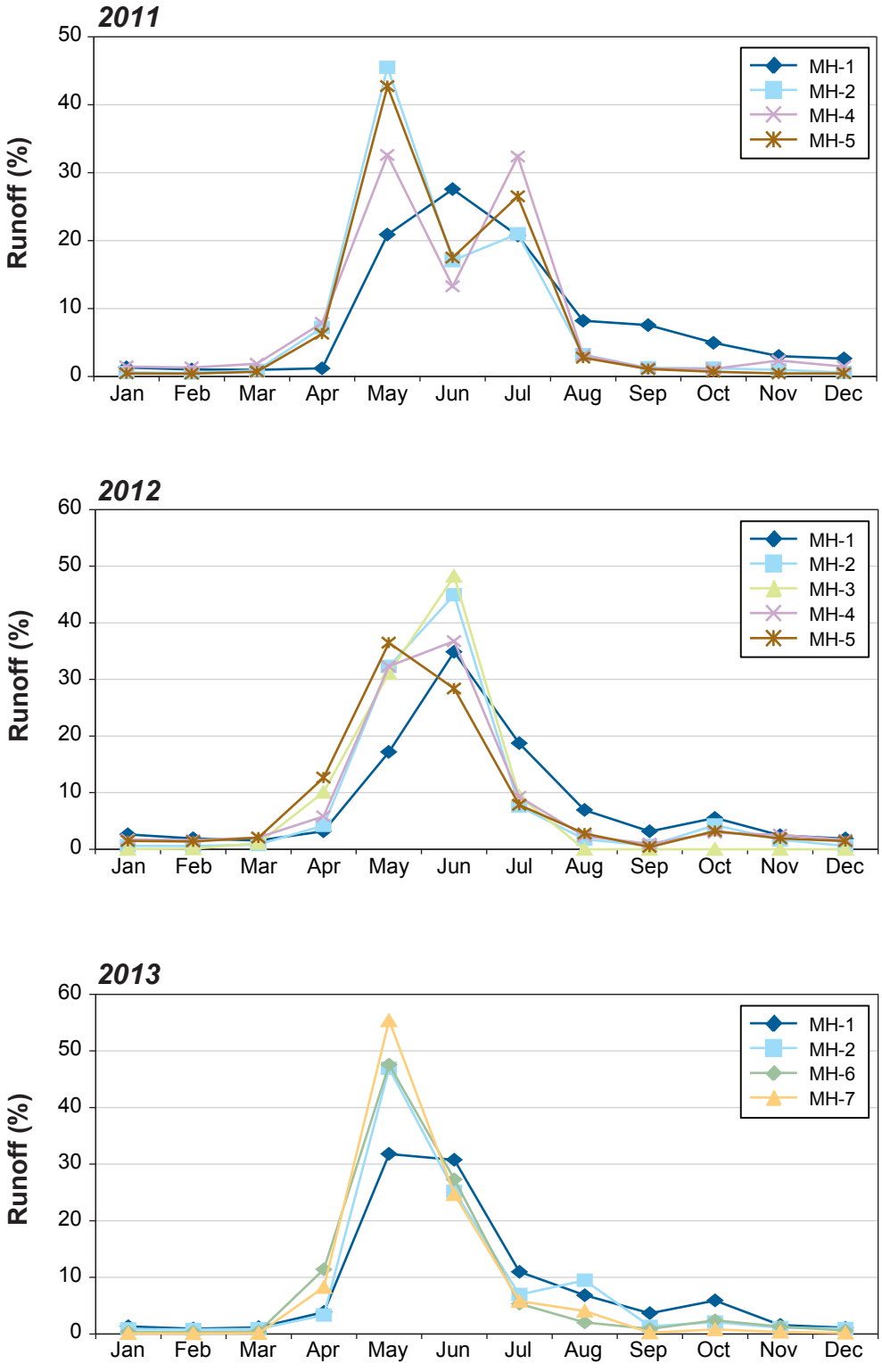



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**2011 to 2013 Monthly Runoff, in Millimetres, at the Project Area Hydrometric Stations**

Figure 4.4-1

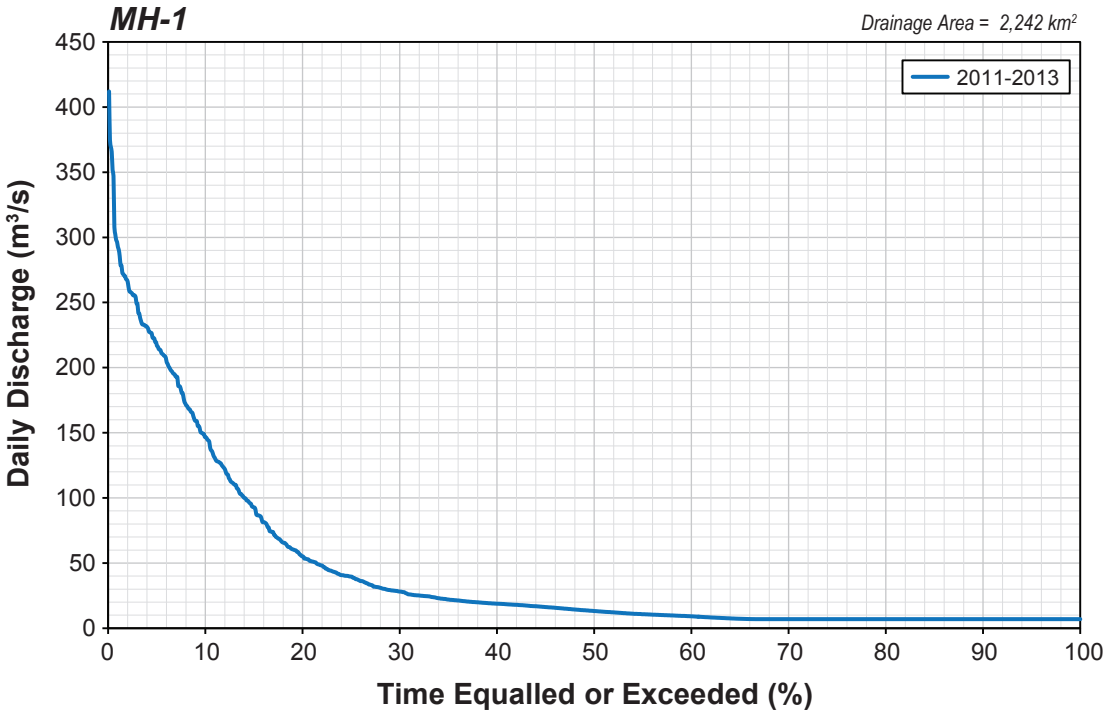
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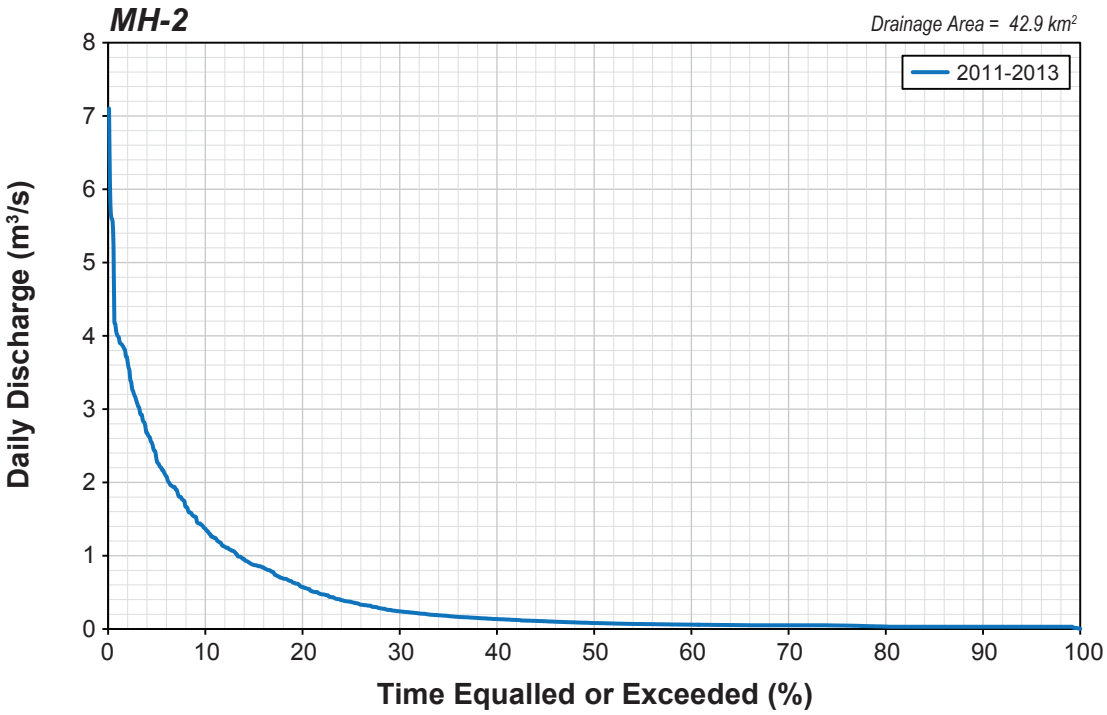



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## 2011 to 2013 Monthly Runoff, in Percent, at the Project Area Hydrometric Stations

Figure 4.4-2




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**Flow Duration Curves for Hydrometric Stations MH-1 and MH-2, 2011 to 2013**

Figure 4.4-3

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**Table 4.4-3. 2011-2013 Peak Discharges and Unit Yields at Project Area Hydrometric Stations**

| Hydrometric Station | Drainage Area ($km^2$) | Year | Peak Flow ($m^3/s$) | | | Peak Unit Yield ($L/s/km^2$) | |
|---|---|---|---|---|---|---|---|
| | | | Instantaneous | Daily | Date | Instantaneous | Daily |
| MH-1 | 2,242 | 2011 | 479 | 412[b] | 11-Jul | 214 | 184 |
| | | 2012 | 426 | 375[b] | 7-Jul | 190 | 167 |
| | | 2013 | n/d | 334[c] | 13-May | n/d | 149[a] |
| | | Mean | 453 | 374 | n/a | 202 | 167 |
| MH-2 | 43.0 | 2011 | 12.3 | 7.1 | 23-May | 286 | 165 |
| | | 2012 | 8.1 | 6.1 | 7-Jun | 189 | 142 |
| | | 2013 | 7.0 | 5.6 | 12-May | 163 | 130 |
| | | Mean | 9.1 | 6.2 | n/a | 213 | 146 |
| MH-3 | 6.6 | 2012 | 0.5 | 0.4 | 7-Jun | 70 | 58 |
| MH-4 | 21.1 | 2011 | 4.3 | 2.6 | 22-May | 203 | 125 |
| | | 2012 | 3.9 | 2.7 | 7-Jun | 186 | 128 |
| | | Mean | 2.9 | 1.9 | n/a | 153 | 104 |
| MH-5 | 4.1 | 2011 | 0.9 | 0.8 | 23-May | 221 | 203 |
| | | 2012 | 0.2 | 0.2 | 6-Jun | 61 | 61 |
| | | Mean | 0.6 | 0.5 | n/a | 141 | 132 |
| MH-6 | 7.4 | 2013 | 0.9 | 0.7 | 5-May | 122 | 95 |
| MH-7 | 52.4 | 2013 | 6.1 | 5.4 | 7-May | 116 | 103 |

Notes:
[a] *Estimated from WSC Station 07FB002 (Section 4.3.1)*

**Table 4.4-4. June to September Low Flows at Project Area Hydrometric Stations, 2011-2013**

| Hydrometric Station | Drainage Area ($km^2$) | Year | Seven-day Low Flow | | Minimum Daily Flow | |
|---|---|---|---|---|---|---|
| | | | Discharge($m^3/s$) | Date | Discharge ($m^3/s$) | Date |
| MH-1 | 2,242 | 2011 | 28.99 | 14-Sep to 21-Sep | 25.86 | 21-Sep |
| | | 2012 | 17.25 | 23-Sep to 30-Sep | 15.96 | 28-Sep |
| | | 2013 | 19.52 | 23-Sep to 30-Sep | 17.23 | 29-Sep |
| | | Mean | 21.92 | n/a | 19.69 | n/a |
| MH-2 | 43.0 | 2011 | 0.04 | 14-Sep to 21-Sep | 0.04 | 21-Sep |
| | | 2012 | 0.01 | 17-Sep to 24-Sep | 0.00 | multiple |
| | | 2013 | 0.06 | 22-Sep to 29-Sep | 0.05 | 16-Sep |
| | | Mean | 0.04 | n/a | 0.03 | n/a |
| MH-3 | 6.6 | 2012 | 0.00 | multiple | 0.00 | multiple |
| MH-4 | 21.1 | 2011 | 0.03 | multiple | 0.03 | multiple |
| | | 2012 | 0.02 | multiple | 0.02 | multiple |
| | | Mean | 0.03 | n/a | 0.03 | n/a |
| MH-5 | 4.1 | 2011 | 0.01 | 14 Sep to 21-Sep | 0.01 | multiple |
| | | 2012 | 0.00 | multiple | 0.00 | multiple |
| | | Mean | 0.00 | n/a | 0.00 | n/a |
| MH-6 | 7.4 | 2013 | 0.00 | multiple | 0.00 | multiple |
| MH-7 | 52.4 | 2013 | 0.00 | multiple | 0.00 | multiple |

Low flows during the summer season (June to September) are important due to increased biological activities during this season. June to September low flows always occurred towards the end of September. This is because flows are receding towards winter low flows at this time. This statistic is therefore sensitive to years with Septembers that are warmer, cooler, wetter, or drier than normal.

Annual flow duration curves (FDC) for the period of record were produced for each of the monitored streams (Figures 4.4-3 through 4.4-6). The trends in the FDC clearly demonstrate the seasonality of these streams. A range of exceedance values and a percentage of time in the open water season during which streams were flowing are presented in Table 4.4-5. The shape of the FDC describes the runoff response of each drainage basin to precipitation or snow melt events. The smaller basins typically produced a steeper FDC as they responded quicker to hydrological inputs. Conversely, larger drainage basins showed a flatter FDC. This reflects a more attenuated response as water was routed through the system.

**Table 4.4-5. Flow Duration Analysis Exceedance Values for Project Area Hydrometric Stations**

| Hydrometric Station | Years of Monitoring | Drainage Area ($km^2$) | Flow Equaled or Exceeded 5% of the Time ($m^3/s$) | Flow Equaled or Exceeded 10% of the Time ($m^3/s$) | Flow Equaled or Exceeded 20% of the Time ($m^3/s$) |
|---|---|---|---|---|---|
| MH-1 | 2011-2013[1] | 2,242 | 217.3 | 146.6 | 55.1 |
| MH-2 | 2011-2013 | 43 | 2.30 | 1.37 | 0.57 |
| MH-3 | 2012 | 6.6 | 0.16 | 0.10 | 0.05 |
| MH-4 | 2011-2012 | 21.1 | 1.19 | 0.74 | 0.34 |
| MH-5 | 2011-2012 | 4.1 | 0.19 | 0.12 | 0.06 |
| MH-6 | 2013 | 7.4 | 0.24 | 0.14 | 0.05 |
| MH-7 | 2013 | 52.4 | 1.67 | 0.90 | 0.35 |

*Note:*
*[1] 2013 Hydrograph based on modelled flows.*

## 4.5 REGIONAL ANALYSIS AND RECURRENCE INTERVALS

In this section, typical annual hydrometric indices are first summarized for WSC hydrometric stations in the region. Next, these data are used to calculate recurrence intervals for annual runoff, peak flow, and 7-day low flow, both at the regional hydrometric stations, and at Project area hydrometric stations. Details of recurrence interval calculations are presented in Appendices 6 and 7.

### 4.5.1 Selected Monthly and Annual Hydrologic Indices for Regional Hydrometric Stations

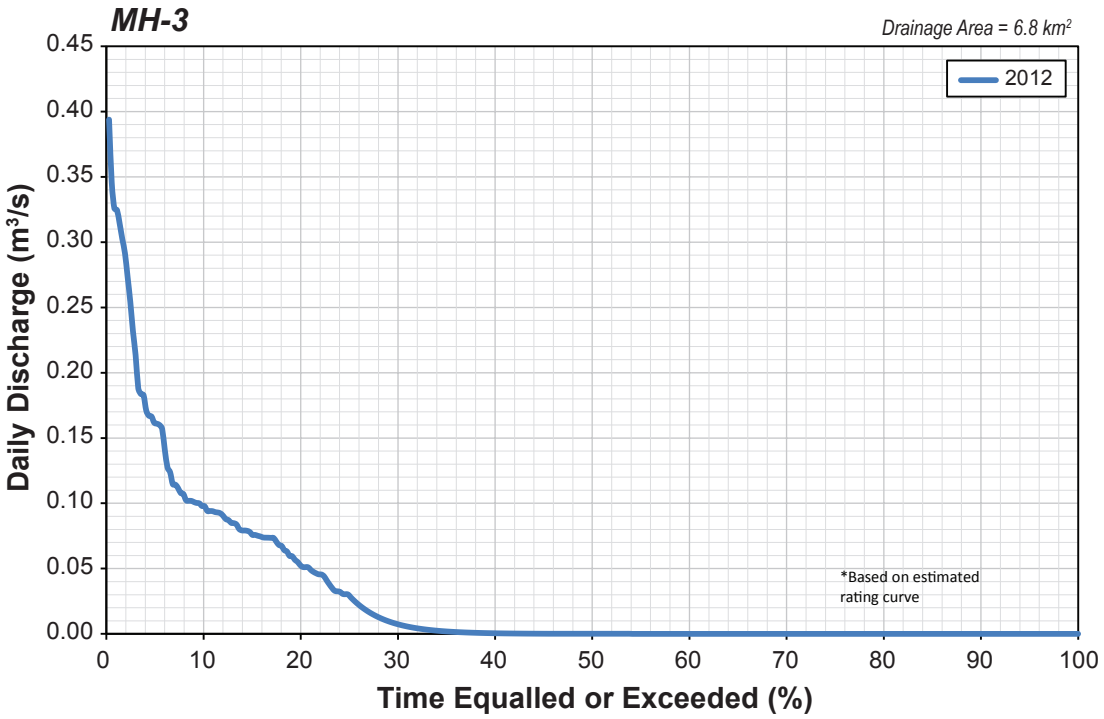
Mean Discharge

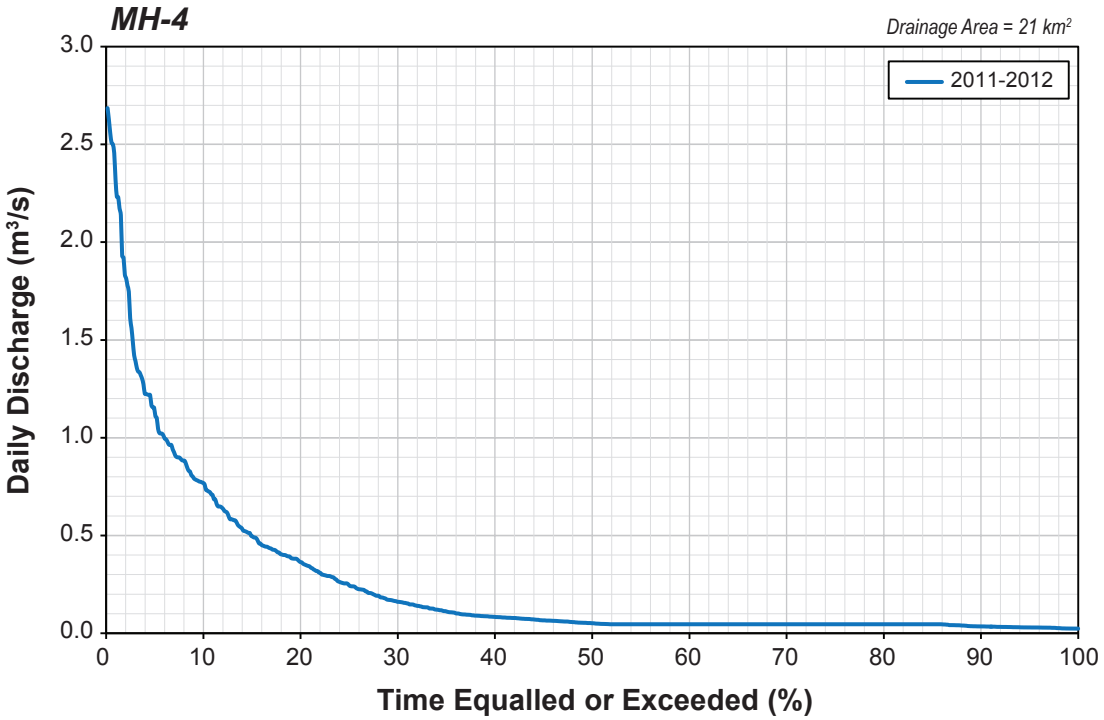
Mean monthly and annual discharges are presented for regional WSC stations in Table 4.5-1. Not all stations have a complete monthly record. For the months with missing values in the period of record, monthly mean values are computed from the available record during the period of record.

In most years, the daily flows at these WSC stations reached peak flow between late May and early June (Figures 4.5-1, 4.5-2). Minimum monthly mean discharges occur in February.

Mean Yield

The mean water yield ($L/s/km^2$) is the flow as a function of the unit drainage area upstream of the hydrometric station. It allows for comparison of discharges between different drainage areas. The annual mean yields within this hydrologic zone ranged from the lowest of 6.64 $L/s/km^2$ at Quality Creek WSC station 07FB005, to the highest of 24.1 $L/s/km^2$ at Murray River above the Wolverine River WSC station 07FB006.



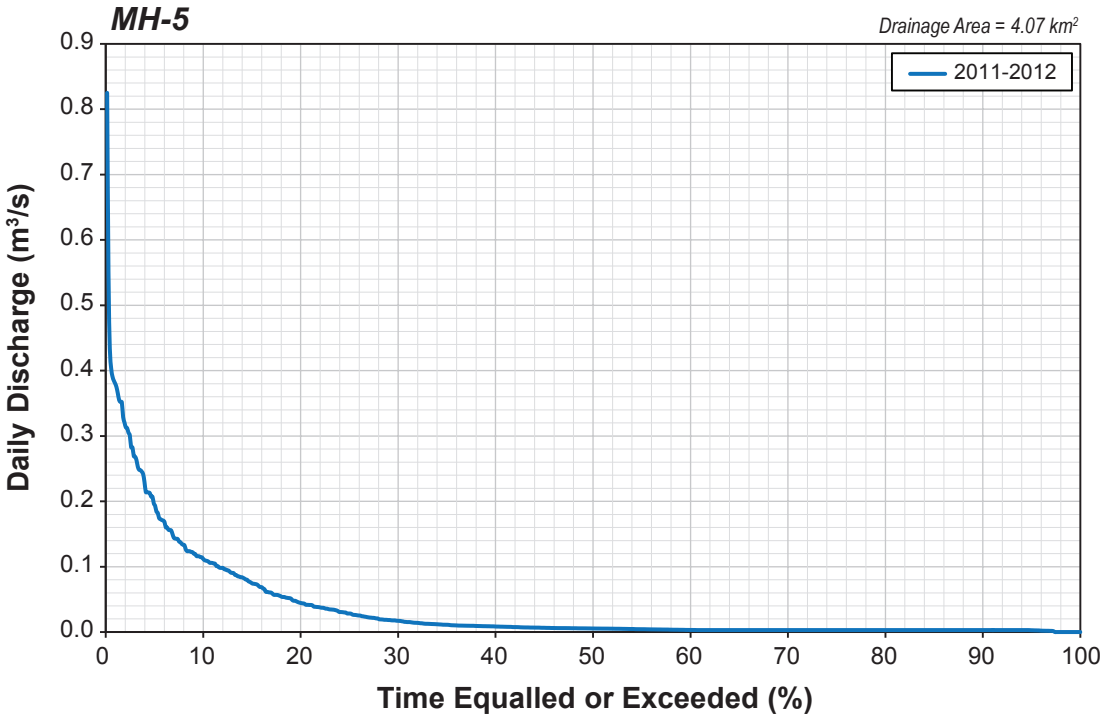



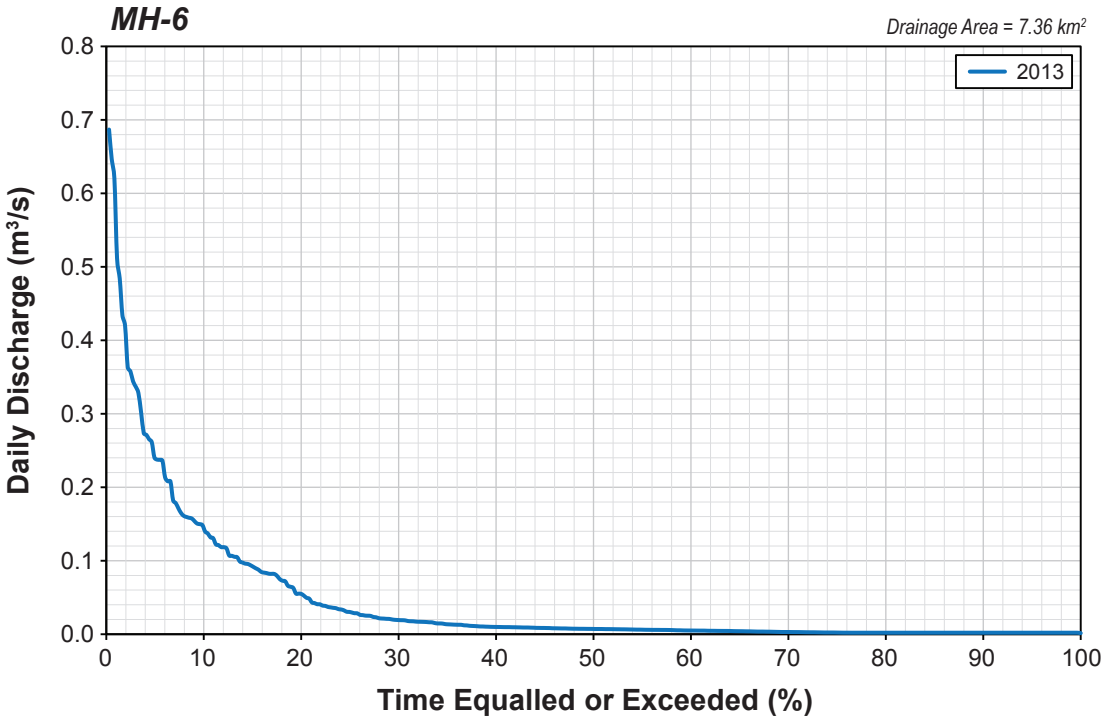

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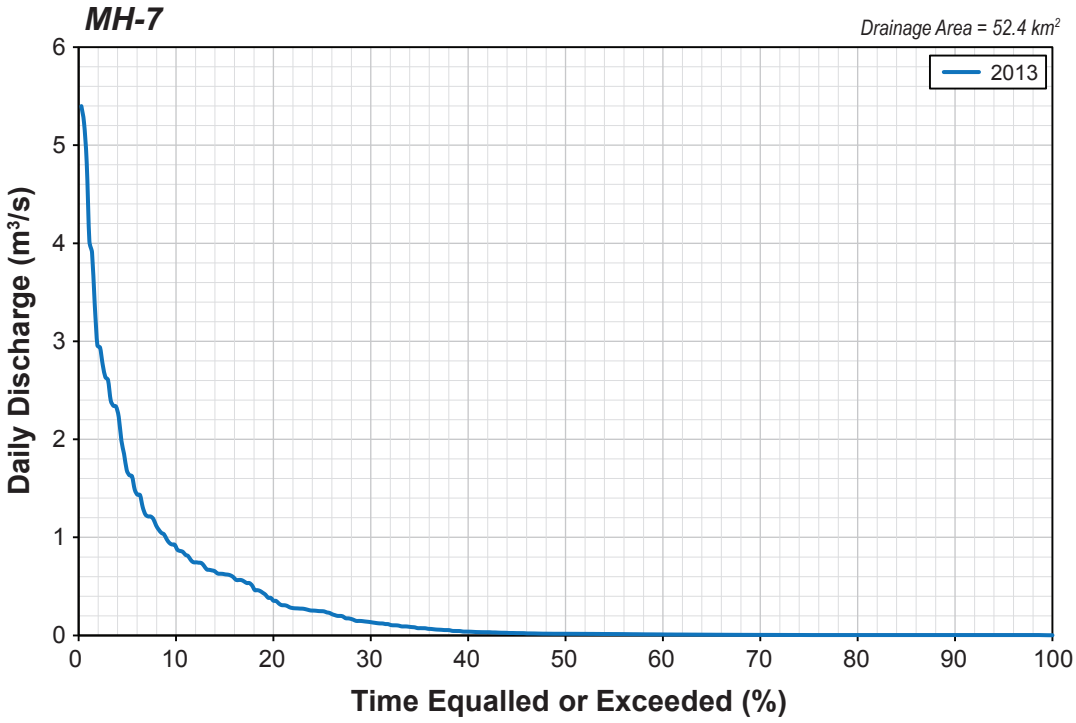
**Flow Duration Curves for Hydrometric Stations MH-3 and MH-4, 2011 to 2012**

Figure 4.4-4

Rescan Engineers & Scientists


MH-5
Drainage Area = 4.07 km²
2011-2012
Daily Discharge (m³/s)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
10
20
30
40
50
60
70
80
90
100
Time Equalled or Exceeded (%)


MH-6
Drainage Area = 7.36 km²
2013
Daily Discharge (m³/s)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
80
90
100
Time Equalled or Exceeded (%)

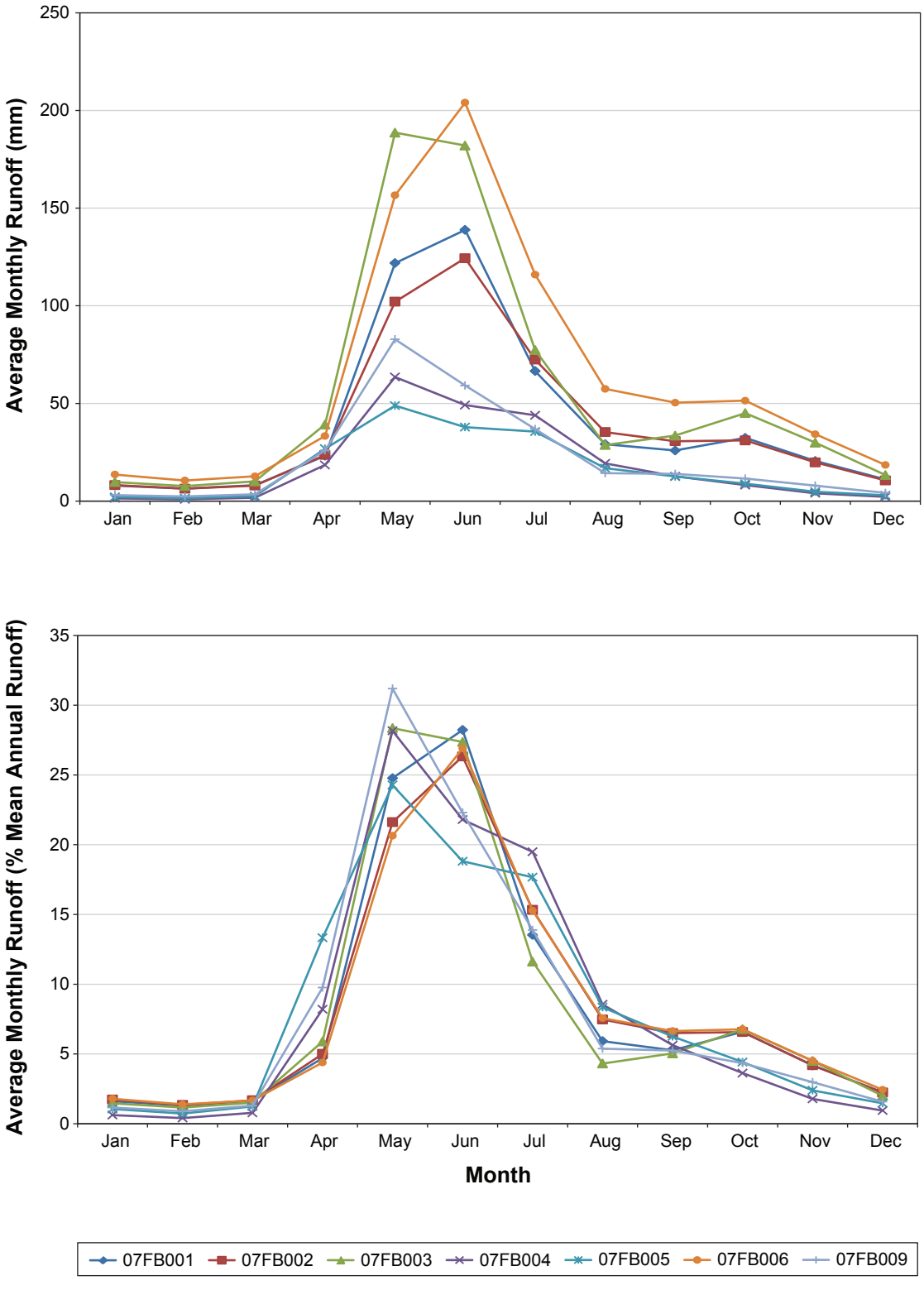



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# Flow Duration Curves for Hydrometric Stations MH-7, 2013

Figure 4.4-6

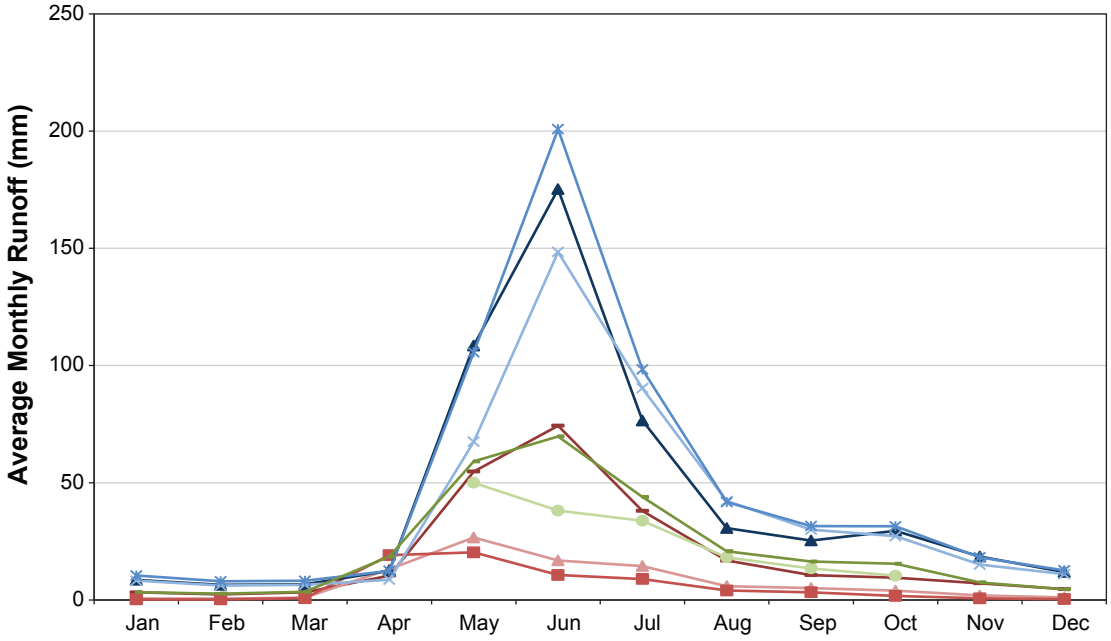
Rescan Engineers & Scientists

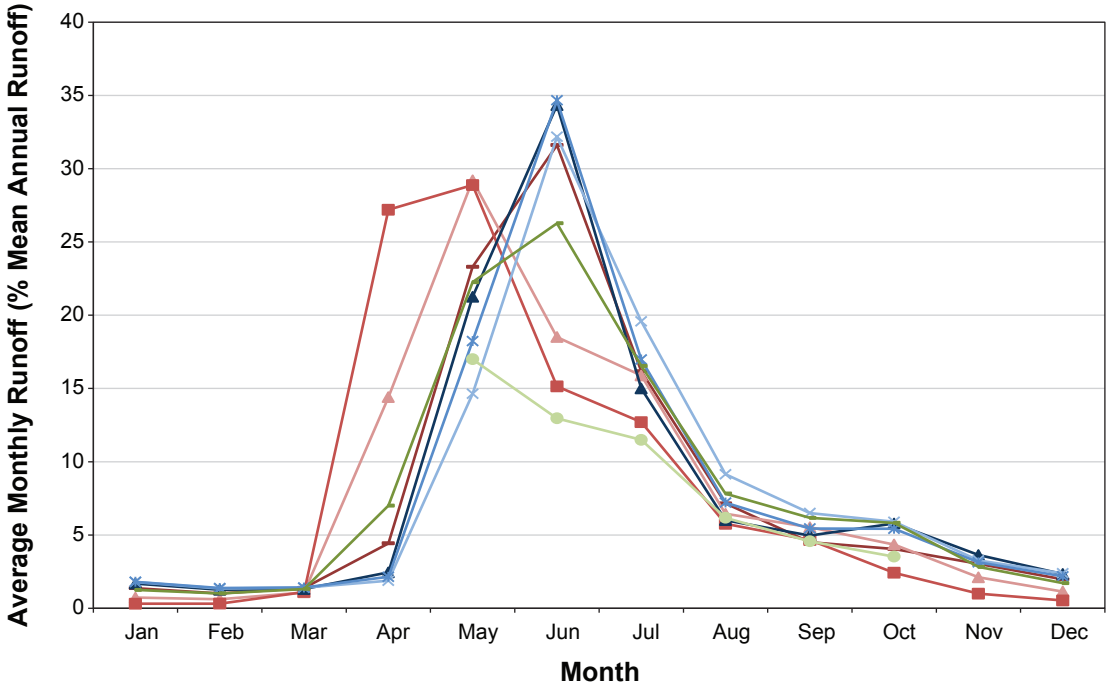



MURRAY RIVER COAL PROJECT

# Mean Monthly Runoff and Runoff Distribution for Selected Stations in BC Hydrologic Zone 7

Figure 4.5-1




MURRAY RIVER COAL PROJECT

# Mean Monthly Runoff and Runoff Distribution for Selected Stations in BC Hydrologic Zones 6, 8, and the Alberta Prairie Region

Figure 4.5-2

**Table 4.5-1. Estimated Monthly and Annual Discharges of Related WSC Hydrometric Stations**

| WSC Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mean Discharge ($m^3/s$)* | | | | | | | | | | | | | |
| 07FB001 | 35.8 | 31.9 | 36.6 | 108 | 551 | 661 | 307 | 139 | 121 | 149 | 96.3 | 50.2 | 189 |
| 07FB002 | 17.0 | 14.6 | 16.4 | 50.6 | 212 | 266 | 150 | 73.1 | 66.4 | 65.5 | 42.5 | 21.8 | 83.1 |
| 07FB003 | 9.43 | 8.22 | 9.73 | 39.2 | 182 | 182 | 74.8 | 27.8 | 34.0 | 44.2 | 30.0 | 12.9 | 54.6 |
| 07FB004 | 0.043 | 0.031 | 0.054 | 0.588 | 1.95 | 1.56 | 1.35 | 0.593 | 0.404 | 0.253 | 0.127 | 0.066 | 0.587 |
| 07FB005 | 0.023 | 0.018 | 0.028 | 0.305 | 0.538 | 0.449 | 0.382 | 0.192 | 0.148 | 0.101 | 0.055 | 0.033 | 0.196 |
| 07FB006 | 12.0 | 10.3 | 11.2 | 30.4 | 139 | 187 | 103 | 50.8 | 46.1 | 45.5 | 31.4 | 16.4 | 57.0 |
| 07FB008 | 1.83 | 1.5 | 1.85 | 6.11 | 31.1 | 43.6 | 21.6 | 9.55 | 6.22 | 5.39 | 4.19 | 2.64 | 11.3 |
| 07FB009 | 0.557 | 0.465 | 0.613 | 4.81 | 15.0 | 11.2 | 7.11 | 3.27 | 2.84 | 2.05 | 1.47 | 0.766 | 4.09 |
| *Mean Yield ($L/s/km^2$)* | | | | | | | | | | | | | |
| 07FB001 | 2.96 | 2.64 | 3.02 | 8.93 | 45.54 | 54.63 | 25.37 | 11.49 | 10.00 | 12.31 | 7.96 | 4.15 | 15.6 |
| 07FB002 | 3.06 | 2.63 | 2.95 | 9.12 | 38.20 | 47.93 | 27.03 | 13.17 | 11.96 | 11.80 | 7.66 | 3.93 | 15.0 |
| 07FB003 | 3.64 | 3.17 | 3.76 | 15.14 | 70.27 | 70.27 | 28.88 | 10.73 | 13.13 | 17.07 | 11.58 | 4.98 | 21.1 |
| 07FB004 | 0.52 | 0.38 | 0.66 | 7.16 | 23.75 | 19.00 | 16.44 | 7.22 | 4.92 | 3.08 | 1.55 | 0.80 | 7.15 |
| 07FB005 | 0.78 | 0.61 | 0.95 | 10.34 | 18.24 | 15.22 | 12.95 | 6.51 | 5.02 | 3.42 | 1.86 | 1.12 | 6.64 |
| 07FB006 | 5.06 | 4.35 | 4.73 | 12.83 | 58.65 | 78.90 | 43.46 | 21.43 | 19.45 | 19.20 | 13.25 | 6.92 | 24.1 |
| 07FB008 | 1.20 | 0.99 | 1.22 | 4.02 | 20.46 | 28.68 | 14.21 | 6.28 | 4.09 | 3.55 | 2.76 | 1.74 | 7.43 |
| 07FB009 | 1.15 | 0.96 | 1.26 | 9.90 | 30.86 | 23.05 | 14.63 | 6.73 | 5.84 | 4.22 | 3.02 | 1.58 | 8.42 |
| *Runoff (mm)* | | | | | | | | | | | | | |
| 07FB001 | 7.9 | 6.4 | 8.1 | 23.1 | 122.0 | 141.6 | 68.0 | 29.8 | 25.9 | 33.0 | 20.6 | 11.1 | 498 |
| 07FB002 | 8.2 | 6.4 | 7.9 | 23.6 | 102.3 | 124.2 | 72.4 | 34.1 | 31.0 | 31.6 | 19.8 | 10.5 | 472 |
| 07FB003 | 9.8 | 7.7 | 10.1 | 39.2 | 188.2 | 182.1 | 77.4 | 27.8 | 34.0 | 45.7 | 30.0 | 13.3 | 665 |
| 07FB004 | 1.4 | 0.9 | 1.8 | 18.6 | 63.6 | 49.3 | 44.0 | 18.7 | 12.8 | 8.3 | 4.0 | 2.2 | 225 |
| 07FB005 | 2.1 | 1.5 | 2.5 | 26.8 | 48.8 | 39.5 | 34.7 | 16.9 | 13.0 | 9.2 | 4.8 | 3.0 | 203 |
| 07FB006 | 13.6 | 10.6 | 12.7 | 33.2 | 157.1 | 204.5 | 116.4 | 55.6 | 50.4 | 51.4 | 34.3 | 18.5 | 758 |
| 07FB008 | 3.2 | 2.4 | 3.3 | 10.4 | 54.8 | 74.3 | 38.1 | 16.3 | 10.6 | 9.5 | 7.1 | 4.7 | 235 |
| 07FB009 | 3.1 | 2.3 | 3.4 | 25.7 | 82.7 | 59.7 | 39.2 | 17.4 | 15.1 | 11.3 | 7.8 | 4.2 | 272 |

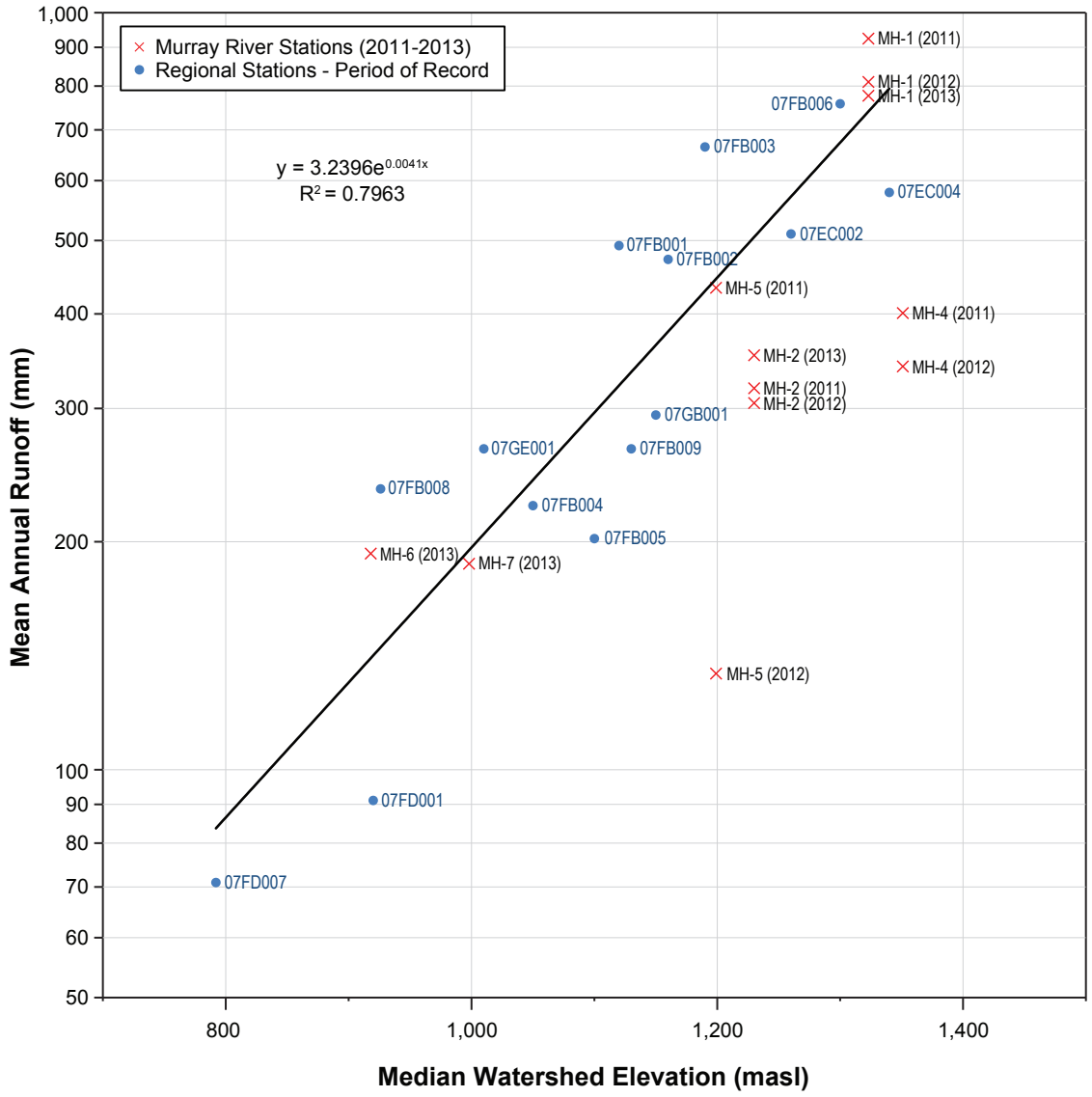
Mean Runoff

Runoff (mm) is the equivalent depth of water flow from each drainage area. Annual runoff is primarily determined by annual inputs (precipitation) and losses (evapo-transpiration), with elevation playing a key role in the amount and type of precipitation received by a drainage basin.

Annual mean runoff was 203 mm at Quality Creek and 758 mm at Murray River above Wolverine River (Table 4.5-1). The majority of annual runoff occurred from May to July for all of the WSC stations. That is, as much as 71% of the runoff occurred during this time period (Table 4.5-1, Figures 4.5-1. 4.5-2). The months from January to March were the annual low discharge period. The percentage of annual runoff estimates during this period was less than 5%.

Mean Runoff and the Role of Watershed Elevation

Figure 4.5-3 shows the relationship between the annual runoff and median basin elevation. The runoff-elevation relationship is commonly used to estimate annual runoff for ungauged drainage basins (Obedkoff 2000b). This is a general trend that shows the correlation between annual runoff and median elevation. However, it cannot be used to precisely estimate the annual runoff in small ungauged watersheds or in small watersheds with limited data (Appendix 7).




MURRAY RIVER COAL PROJECT

# Relationship between Runoff and Elevation in the Project Area and Region

Figure 4.5-3

### 4.5.2 Recurrence Intervals for Annual Runoff

Recurrence intervals of annual runoff quantify the size and frequency of flood and drought events.

For Regional WSC Hydrometric Stations

Annual runoff frequency results for regional WSC stations are summarized in Table 4.5-2.

**Table 4.5-2. Estimated Annual Runoff (mm) Based on Frequency Analysis for Related WSC Hydrometric Stations**

| WSC Station | Recurrence (years) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wet | | | | | Wet/Dry | Dry | | | | |
| | 100 | 50 | 20 | 10 | 5 | 2 | 5 | 10 | 20 | 50 | 100 |
| 07FB001 | 729 | 698 | 653 | 614 | 568 | 485 | 409 | 372 | 344 | 313 | 294 |
| 07FB002 | 672 | 650 | 616 | 586 | 546 | 470 | 392 | 353 | 322 | 287 | 266 |
| 07FB003 | 928 | 896 | 848 | 806 | 757 | 666 | 581 | 539 | 506 | 470 | 447 |
| 07FB004 | 513 | 471 | 410 | 360 | 303 | 211 | 139 | 110 | 88.8 | 69.6 | 58.4 |
| 07FB005 | 613 | 532 | 429 | 354 | 281 | 181 | 117 | 92.0 | 76.0 | 62.0 | 53.5 |
| 07FB006 | 1,012 | 988 | 948 | 911 | 864 | 767 | 664 | 610 | 566 | 517 | 485 |
| 07FB008 | 408 | 380 | 343 | 313 | 281 | 231 | 191 | 174 | 161 | 148 | 140 |
| 07FB009 | 478 | 452 | 411 | 376 | 333 | 256 | 188 | 157 | 134 | 111 | 96.8 |

For Project Area Hydrometric Stations

At regional WSC hydrometric stations with large catchment areas, the mean annual runoff predicted by recurrence interval calculations is similar to recorded mean annual runoff. That is, the ratio predicted runoff to recorded runoff is close to one for large catchments. However, for smaller catchments, the ratio was either greater or less than one. Ratios for WSC stations at various recurrence intervals are presented in Appendix 7. In addition, small watersheds have a much wider range of annual runoff during wet and dry years than large watersheds. This indicates that runoff in small catchments is controlled by different hydrologic processes than in larger catchments.

Therefore, recurrence intervals for the MH-1 catchment can be confidently predicted, given its large watershed area (Table 4.5-3). Recurrence intervals for smaller catchments are highly uncertain, and are not presented here.

### 4.5.3 Recurrence Intervals for Instantaneous Peak Flows

Peak flow recurrence intervals quantify the magnitude and frequency of flooding, and are used for design-related engineering decisions. Annual maximum instantaneous discharges are by definition greater than peak flow from daily average time series. Instantaneous peak flows were analysed here to document short-term, but high-magnitude flood events.

For Regional WSC Hydrometric Stations

Peak flows at regional WSC stations are estimated for various recurrence intervals (Table 4.5-4). No estimates were made for missing years unless maximum daily discharge data were available. If daily peak flow was available, then instantaneous peak flow was estimated using a best-fit regression between peak daily flow and instantaneous peak flow. This process maximized the sample size, which is important given that limited data are available.

For Project Area Hydrometric Stations

The peak discharges for various recurrence intervals are listed for each of the Project area hydrometric stations (Table 4.5-5). The table also summarizes 2011 to 2013 monitored instantaneous peak flows, for comparison to the regional analysis results.

**Table 4.5-3. Annual Runoff (mm) at Various Recurrence Intervals for Hydrometric Station MH-1**

| Hydrometric Station | Watershed Area ($km^2$) | Median Elevation (m) | Annual Runoff (mm) at Various Recurrence Intervals for Hydrometric Station MH-1 | | | | | | | | | | | Monitored Runoff (mm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Wet | | | | | Mean | Dry | | | | | | | |
| | | | 100 | 50 | 20 | 10 | 5 | 2 | 5 | 10 | 20 | 50 | 100 | 2011 | 2012 | 2013 |
| MH-1 | 2,242 | 1,323 | *1,212* | *1,155* | *1,071* | *1,003* | *914* | *764* | *624* | *558* | *506* | *452* | *418* | *924* | *810* | *777*[a] |

*Note:*
[a] *Estimated from WSC Station 07FB002 (Section 4.3.1)*

**Table 4.5-4. Frequency Analyses Summary of Annual Instantaneous Peak Flow Estimates**

| WSC Station | Drainage Area ($km^2$) | Recurrence (years) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 200 | 100 | 50 | 20 | 10 | 5 | 2 |
| 07FB001 | 12,100 | 6,411 | 5,336 | 4,411 | 3,381 | 2,721 | 2,142 | 1,453 |
| 07FB002 | 5,550 | 1,647 | 1,474 | 1,309 | 1,100 | 947 | 794 | 578 |
| 07FB003 | 2,590 | 1,069 | 993 | 917 | 812 | 731 | 643 | 182 |
| 07FB004 | 82.1 | 810 | 471 | 268 | 122 | 64 | 31.3 | 9.82 |
| 07FB005 | 29.5 | 64.3 | 44.4 | 30.2 | 17.5 | 11.2 | 6.74 | 2.91 |
| 07FB006 | 2,370 | 1,167 | 1,020 | 887 | 728 | 617 | 513 | 376 |
| 07FB008 | 1,520 | 173 | 158 | 143 | 123 | 108 | 91.8 | 67.5 |
| 07FB009 | 486.0 | 596 | 438 | 318 | 203 | 141 | 94.9 | 49.9 |

**Table 4.5-5. Peak Instantaneous Discharges ($m^3/s$) at Various Recurrence Intervals for Project Area Hydrometric Stations**

| Hydrometric Station | Drainage Area ($km^2$) | Peak Instantaneous Discharge ($m^3/s$) at Various Recurrence Intervals (years) | | | | | | | Initial or Adjusted Coefficient | Monitored Peak Instantaneous Q ($m^3/s$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 200 | 100 | 50 | 20 | 10 | 5 | 2 | | 2011 | 2012 | 2013 |
| MH-1 | 2,242 | *1,134* | *988* | *856* | *699* | *590* | *488* | *356* | Adjusted | 479 | 426 | *n/d* |
| MH-2 | 42.97 | *145.8* | *99.0* | *66.3* | *37.8* | *23.8* | *14.3* | *7.1* | Adjusted | 12.3 | 8.1 | 7.0 |
| MH-3 | 6.62 | *49.3* | *29.3* | *17.1* | *8.0* | *4.3* | *2.1* | *0.7* | Initial | n/d | 0.5 | n/d |
| MH-4 | 21.08 | *100.7* | *65.4* | *41.8* | *22.3* | *13.4* | *7.5* | *3.5* | Adjusted | 4.3 | 3.9 | n/d |
| MH-5 | 4.12 | *38.3* | *22.1* | *12.5* | *5.6* | *2.9* | *1.4* | *0.4* | Initial | 0.9 | 0.2 | n/d |
| MH-6 | 7.36 | *58.4* | *35.5* | *21.2* | *10.3* | *5.7* | *3.0* | *1.2* | Adjusted | n/d | n/d | 0.9 |
| MH-7 | 52.39 | *161.7* | *111.2* | *75.4* | *43.8* | *28.0* | *17.1* | *8.7* | Adjusted | n/d | n/d | 6.1 |

The same caveats discussed above in relation to annual runoff apply to peak flow recurrence intervals. Namely, recurrence intervals for small catchments are particularly uncertain, since they are calculated using a dataset dominated by large catchments (Figure 4.5-3).

Coefficients for all stations, except MH-6 and MH-7, are presented in Appendix 7. A detailed description of the methodology is presented in Appendix 7. Table 4.5-5 notes which set of coefficients were used for each station.

### 4.5.4 Recurrence Intervals for Seven-day Low Flows

Low flow recurrence intervals are important for quantifying the probability and magnitude of drought, water budgeting, maintaining aquatic ecosystem health, and the availability and quality of fish habitat.

The low flow analysis is based on the seven-day low flow period, which is defined as the minimum running average of discharge over a consecutive 7-day day period. The dates selected for analysis were both the entire calendar year and the June to September summer low flow season, since the months of June through September have special biological values. Data are presented as low flows (units = $m^3/s$) and area-adjusted unit low flows (units = $L/S/km^2$)

For Regional WSC Hydrometric Stations

The annual and summer season regional frequency analyses for regional WSC stations are summarized in Table 4.5-6.

**Table 4.5-6. Frequency Analysis of Seven-Day Low Flow of Related WSC Stations**

| Station Name | Drainage Area ($km^2$) | Recurrence (years) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Annual | | | | | | Seasonal: June to September | | | | | |
| | | 2 | 5 | 10 | 20 | 50 | 100 | 2 | 5 | 10 | 20 | 50 | 100 |
| *Mean Discharge ($m^3/s$)* | | | | | | | | | | | | | |
| 07FB001 | 12,100 | 31.6 | 17.8 | 9.5 | 4.6 | 1.6 | 0.7 | 86.9 | 50.7 | 25.9 | 11.6 | 3.6 | 1.4 |
| 07FB002 | 5,550 | 9.6 | 8.8 | 8.2 | 7.7 | 7.3 | 7.1 | 37.9 | 27.2 | 22.8 | 19.8 | 16.8 | 15.1 |
| 07FB003 | 2,590 | 5.7 | 4.6 | 4.2 | 3.9 | 3.7 | 3.5 | 12.9 | 8.6 | 6.9 | 5.7 | 4.6 | 4.0 |
| 07FB004 | 82.1 | 0.0097 | 0.0031 | 0.0016 | 0.0009 | 0.0005 | 0.0003 | 0.0919 | 0.0496 | 0.0367 | 0.0289 | 0.0223 | 0.0189 |
| 07FB005 | 29.5 | 0.0083 | 0.0024 | 0.0010 | 0.0005 | 0.0002 | 0.0001 | 0.0276 | 0.0088 | 0.0050 | 0.0032 | 0.0020 | 0.0014 |
| 07FB006 | 2,370 | 7.87 | 6.56 | 6.09 | 5.78 | 5.51 | 5.36 | 26.4 | 18.9 | 15.8 | 13.6 | 11.4 | 10.1 |
| 07FB008 | 1,520 | 0.906 | 0.519 | 0.369 | 0.267 | 0.184 | 0.140 | 3.090 | 1.320 | 0.772 | 0.473 | 0.259 | 0.167 |
| 07FB009 | 486 | 0.339 | 0.182 | 0.110 | 0.066 | 0.033 | 0.019 | 0.884 | 0.348 | 0.179 | 0.094 | 0.040 | 0.022 |
| *Unit Low Flow ($L/s/km^2$)* | | | | | | | | | | | | | |
| 07FB001 | 12,100 | 2.61 | 1.47 | 0.79 | 0.38 | 0.13 | 0.06 | 7.18 | 4.19 | 2.14 | 0.96 | 0.30 | 0.12 |
| 07FB002 | 5,550 | 1.73 | 1.59 | 1.48 | 1.39 | 1.32 | 1.28 | 6.83 | 4.90 | 4.11 | 3.57 | 3.03 | 2.72 |
| 07FB003 | 2,590 | 2.20 | 1.78 | 1.62 | 1.51 | 1.43 | 1.35 | 4.98 | 3.32 | 2.66 | 2.20 | 1.78 | 1.54 |
| 07FB004 | 82.1 | 0.12 | 0.04 | 0.02 | 0.01 | 0.01 | 0.00 | 1.12 | 0.60 | 0.45 | 0.35 | 0.27 | 0.23 |
| 07FB005 | 29.5 | 0.28 | 0.08 | 0.03 | 0.02 | 0.01 | 0.00 | 0.94 | 0.30 | 0.17 | 0.11 | 0.07 | 0.05 |
| 07FB006 | 2,370 | 3.32 | 2.77 | 2.57 | 2.44 | 2.32 | 2.26 | 11.14 | 7.97 | 6.67 | 5.74 | 4.81 | 4.26 |
| 07FB008 | 1,520 | 0.60 | 0.34 | 0.24 | 0.18 | 0.12 | 0.09 | 2.03 | 0.87 | 0.51 | 0.31 | 0.17 | 0.11 |
| 07FB009 | 486 | 0.70 | 0.37 | 0.23 | 0.14 | 0.07 | 0.04 | 1.82 | 0.72 | 0.37 | 0.19 | 0.08 | 0.05 |

For Project Area Hydrometric Stations

Summer (June to September) and annual 7-day low flows are presented in Tables 4.5-7 and 4.5-8. Recurrence intervals are presented for 2, 5, 10, and 20 years. Flows approach zero at recurrence intervals greater than 20-years at all stations except MH-1.

**Table 4.5-7. Seven-day Low Flow Discharges ($m^3/s$) of the Hydrometric Stations (June to September)**

| Hydrometric Station | Watershed Area ($km^2$) | Median Elevation (m) | 7-Day Low Flow ($m^3/s$) at Various Recurrence Intervals for Project Area Hydrometric Stations | | | | Monitored 7-day Low Flow ($m^3/s$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 5 | 10 | 20 | 2011 | 2012 | 2013 |
| MH-1 | 2,242 | 1,323 | *25.10* | *17.40* | *14.10* | *11.60* | 28.99 | 17.25 | *19.52*[a] |
| MH-2 | 42.97 | 1,109 | *0.04* | *0.02* | *0.01* | *0.00* | 0.04 | 0.01 | 0.06 |
| MH-3 | 6.62 | 1,126 | *0.00* | *0.00* | *0.00* | *0.00* | n/d | 0.00 | n/d |
| MH-4 | 21.08 | 1,351 | *0.02* | *0.01* | *0.00* | *0.00* | 0.03 | 0.02 | n/d |
| MH-5 | 4.12 | 1,198 | *0.02* | *0.01* | *0.00* | *0.00* | 0.01 | 0.00 | n/d |
| MH-6 | 7.36 | 918 | *0.04* | *0.00* | *0.00* | *0.00* | n/d | n/d | 0.00 |
| MH-7 | 52.39 | 998 | *0.06* | *0.02* | *0.01* | *0.01* | n/d | n/d | 0.00 |

*Note:*
[a] *Estimated from WSC Station 07FB002 (Section 4.3.1)*
*Estimated values are italicized.*

**Table 4.5-8. Seven-day Low Flow Discharges ($m^3/s$) of the Hydrometric Stations (Annual)**

| Hydrometric Station | Watershed Area ($km^2$) | Median Elevation (m) | 7-Day Low Flow ($m^3/s$) at Various Recurrence intervals for Project Area Hydrometric Stations | | | | Monitored 7-day low flow ($m^3/s$)[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 5 | 10 | 20 | 2011 | 2012 | 2013 |
| MH-1 | 2,242 | 1,323 | *7.30* | *6.05* | *5.59* | *5.28* | *6.98* | *9.52* | *4.32*[b] |
| MH-2 | 42.97 | 1,109 | *0.002* | *0.002* | *0.005* | *0.001* | *0.03* | *0.01* | *0.05* |
| MH-3 | 6.62 | 1,126 | *0.000* | *0.000* | *0.000* | *0.000* | *n/d* | *n/d* | *0* |
| MH-4 | 21.08 | 1,351 | *0.005* | *0.001* | *0.000* | *0.000* | *0.03* | *0.02* | *n/d* |
| MH-5 | 4.12 | 1,198 | *0.000* | *0.000* | *0.000* | *0.000* | *0.02* | *0.00* | *n/d* |
| MH-6 | 7.36 | 918 | *0.005* | *0.001* | *0.000* | *0.000* | *n/d* | *n/d* | *0.00* |
| MH-7 | 52.39 | 998 | *0.009* | *0.003* | *0.003* | *0.001* | *n/d* | *n/d* | *0.00* |

*Note:*
[a] *Annual low flows occur in winter, when pressure transducers were removed. Flows were estimated as described in Section 4.3.1.*
[b] *Estimated from WSC Station 07FB002 (Section 4.3.1)*
*Estimated values are italicized.*

### 4.5.5 2011-2013 Runoff in Hydroclimatic Context

Environment Canada subdivides Canada into regions and publishes climatic summaries of these regions (Environment Canada 2014). The Murray River Project area is within the 'South BC Mountains' region, and is close to the border of the 'Northwestern Forest' region.

Over the 66 year period of record, beginning in 1948, the monitoring period was warmer than usual in both regions, by up to 1.4 °C (Table 4.5-9). Annually, 2011 and 2012 were the wettest years, and 2013 was very dry. Since the majority of runoff in the Project area occurs as a result of snowmelt, winter precipitation is also presented here. Overall, the monitoring period occurred over a three-year period where winter precipitation was low (-33 to +6 % deviation).

**Table 4.5-9. Annual Air Temperature and Precipitation Departures from 2011 to 2013 for the South BC Mountains and Northwestern Forest Climatic Regions**

| | Annual Air Temperature Departure (°C) | | Annual Precipitation Departure (%) | | Winter Precipitation Departure (%) | |
|---|---|---|---|---|---|---|
| Year | South BC Mountains | Northwestern Forest | South BC Mountains | Northwestern Forest | South BC Mountains | Northwestern Forest |
| 2011 | 0.0 | 1.3 | 11.9 | 11.0 | -8.0 | 6.0 |
| 2012 | 0.7 | 1.4 | 7.6 | 21.2 | -23.0 | -15.0 |
| 2013 | 1.3 | 0.4 | -19.1 | -15.1 | -33.0 | -2.0 |

Project area hydrometric data are only available for all three years from two stations: MH-1 and MH-2. At MH-1, 2013 had the lowest runoff, which agrees with the regional climatic data presented above. Runoff at MH-2 in 2013 was the highest of the monitoring period, reflecting the influence of watershed-scale hydroclimatic processes.

# 5. Summary

ERM

# 5. Summary

The Murray River Coal Project surface water hydrology baseline program collected hydrometric data during from 2011 to 2013 to support a hydrologic assessment of streams near the Project. The network consisted of seven automated hydrometric stations, one on the mainstream of Murray River, four on the west and two on east side of the Murray River. A total of 81 discharge measurements were performed during the program. Based on these measurements, stage-discharge relationships and rating curves were developed for all hydrometric stations. Daily discharges were derived, and flow statistics were also calculated for all stations.

The monitored open water period extended roughly from mid-May to mid-November. During this period, the mean annual runoff ranged from approximately 134 mm at MH-5 (Mast Creek, 2012) to 924 mm at MH-1 (Murray River, 2011)

The highest flows often occur during the spring period, in response to seasonal freshet-related runoff conditions that are often augmented by rain-on-snow events during the melt period. Peak flow sometimes occurs later in the melt season in response to rainfall events. Between 69% and 88% of the annual runoff occurred during the May to July time period.

The highest peak discharges occurred at MH-1 (479 $m^3/s$ in 2011), and the lowest occurred in MH-5, the stream with the smallest catchment (0.2 $m^3/s$ in 2012).

The lowest June to September 7-day low flows occur in the smallest catchments, MH-2, MH-3, MH-4, and MH-5. In some years, flow ceases or almost ceases in the smallest of these streams. The lowest of the June to September 7-day low flows occur towards the end of September. Annual low flows are also near zero in most project area catchments, with the exception of MH-1, where annual low flows are approximately 7 $m^3/s$.

Regional and hydrological frequency analyses were performed on eight WSC hydrometric stations. This provides predictive relationships for estimates of key hydrological indices for Project area watersheds.

Recurrence intervals for smaller catchments are difficult to predict; however, at MH-1, predicted runoff ranges from 418 mm (100-year dry) to 1,212 (100-year wet). Runoff for other watersheds will be lower.

The magnitude of peak flows at various recurrence intervals varies in relation to watershed size. However, it varies from 1,134 ($m^3/s$) for the 200-year wet event at MH-1, to 0.4 $m^3/s$ for MH-5 in a typical year.

7-day low flow magnitudes approach zero both for June to September and annually in all but the largest catchment beyond the 2-to-5-year event.

# References

ERM

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# Appendix 1

## MH-1 to MH-7 Station Information Sheets

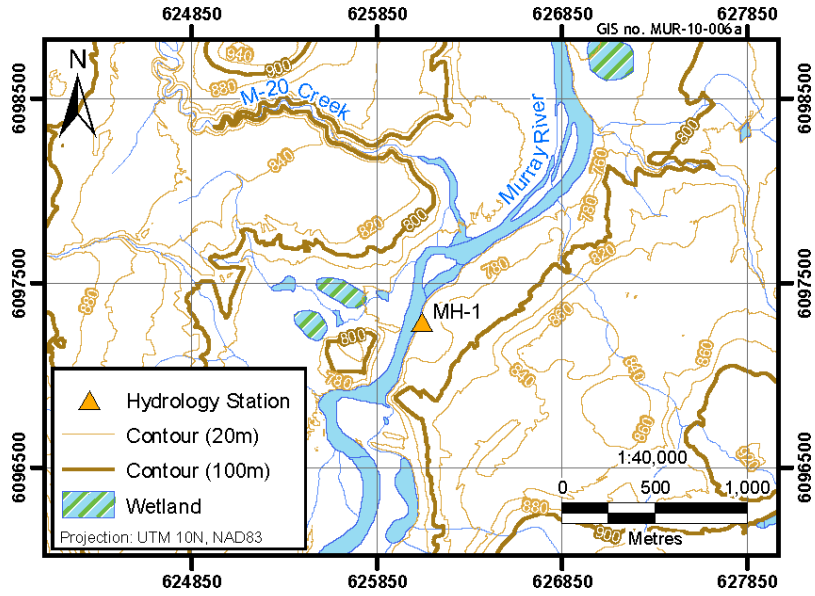
ERM

## Appendix 1-1. Station Information Sheet for Hydrometric Station MH-1 Murray River

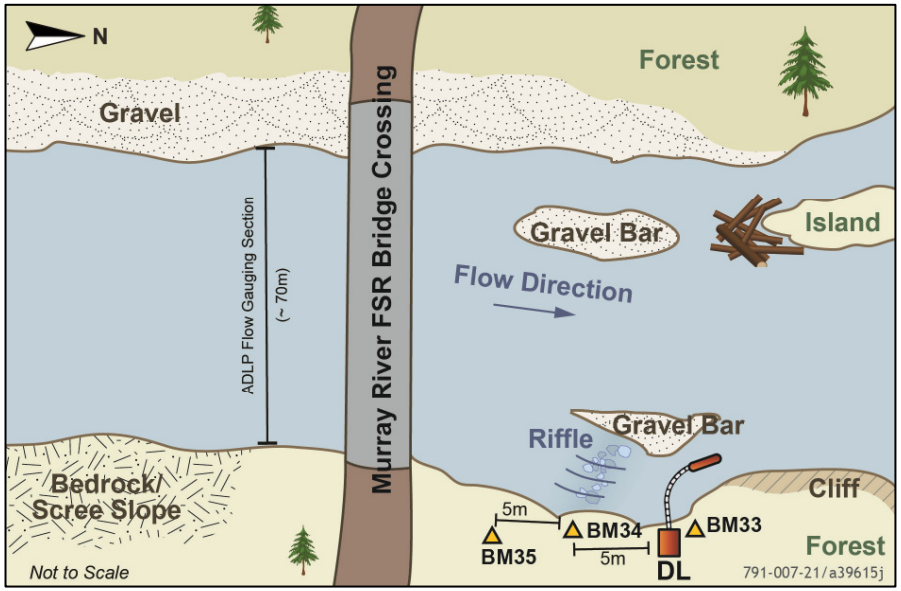
| Site ID: | MH-1 | Drainage Area ($km^2$): | 2242.14 |
|---|---|---|---|
| Site Location: | Approximately 75 m downstream of the bridge crossing. | | |
| UTM: | 10U | 626,091 m E | 6,097,291 m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM33 | 101.112 m | Nail in tree near station | |
| BM34 | 100.885 m | Nail in tree upstream of station | |
| BM35 | 100.614 m | Nail in tree upstream of BM 34 | |
| Transducer: | PS-98i pressure transducer with Elf-2 datalogger | | |
| Operating Periods: | | | |
| 2011 | January 1 – November 19 | | |
| 2012 | April 28 – November 7 | | |
| 2013 | Not Active | | |
| General Comments: | | | |

- Wide channel (70m near station) with relatively high flow. Gravel and cobble bed.
- Pool-Riffle morphology with a point bars upstream and downstream of the station.
- New benchmarks in 2012 keeping same datum as 2011.

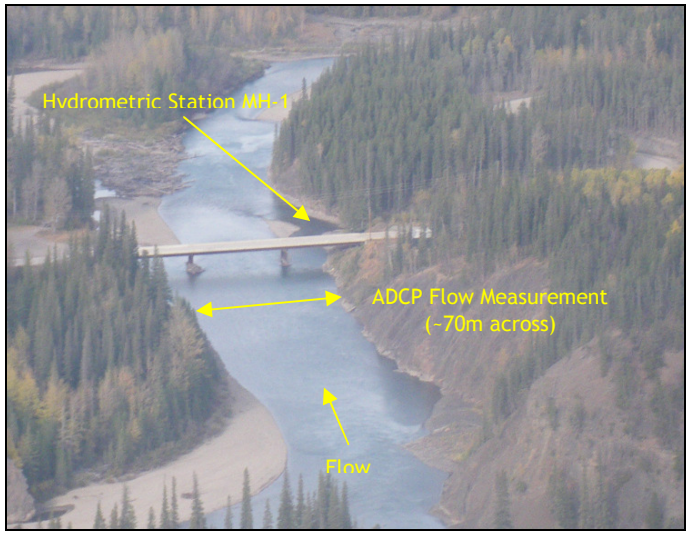
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-1**




*A high angle oblique view facing downstream and north. The location of the ADCP flow measurement is shown ~20m upstream of the Murray FSR Bridge. Photo taken September 27, 2012.*

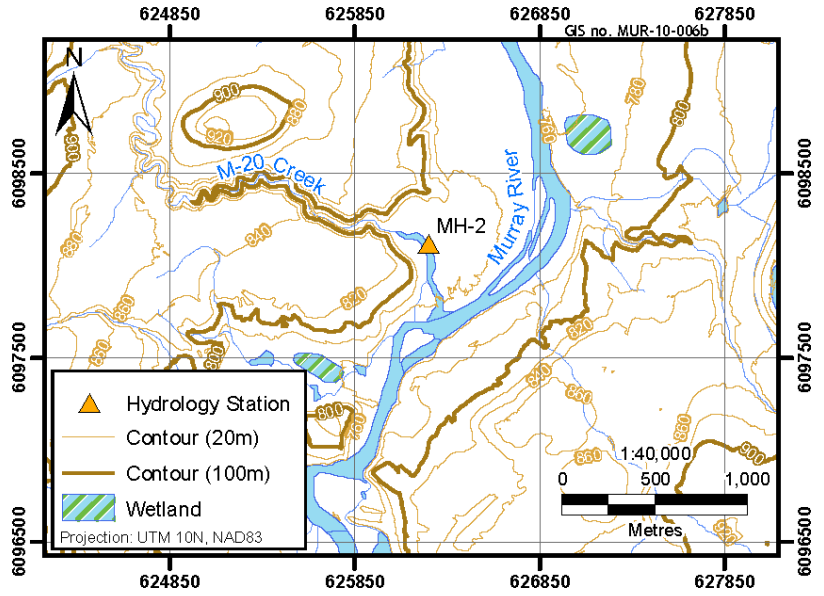
**Site Photo**

## Appendix 1-2. Station Information Sheet for Hydrometric Station MH-2 Lower Camp Creek

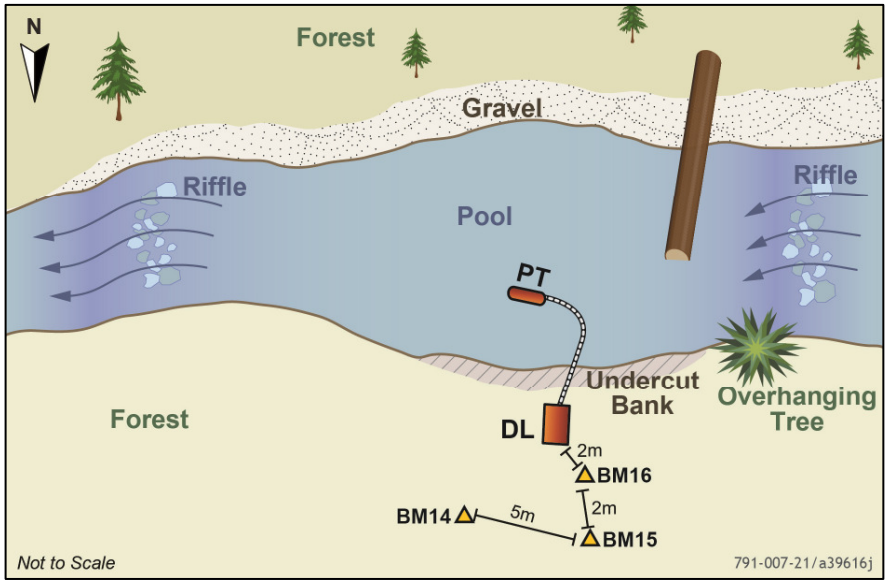
| Site ID: | MH-2 | Drainage Area ($km^2$): | 42.97 |
|---|---|---|---|
| Site Location: | Approximately 150 m upstream of the bridge crossing on River Road. | | |
| UTM: | 10U | 626,246 m E | 6,098,122 m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM16 | 100.000 m | Nail in tree 2m up bank from station | |
| BM15 | 99.871 m | Nail in tree 4m up bank from station | |
| BM14 | 99.026 m | Nail in tree 5m downstream of BM15 | |
| Transducer: | PS-98i pressure transducer with Elf-2 data logger | | |
| Operating Periods: | | | |
| 2011 | January 1 – November 17 (150m downstream of 2012 location) | | |
| 2012 | April 26 – November 5 | | |
| 2013 | May 1 – November 6 | | |
| General Comments: | | | |

- High energy stream with gravel-cobble bed.
- Forced pool-riffle morphology resulting from large woody debris obstructions.
- Station in different location 100 m upstream from 2011.

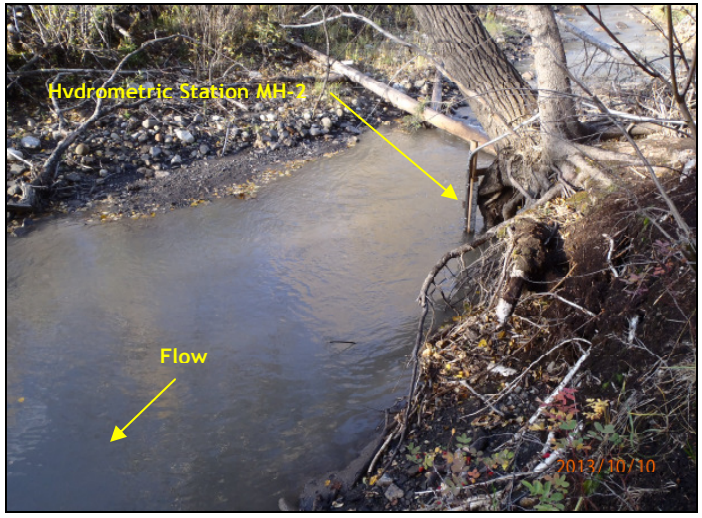
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-2**




*Upstream view of the channel section under low flow conditions indicating the vertically installed pressure transducer and staff gauge on the left bank. October 10, 2013.*

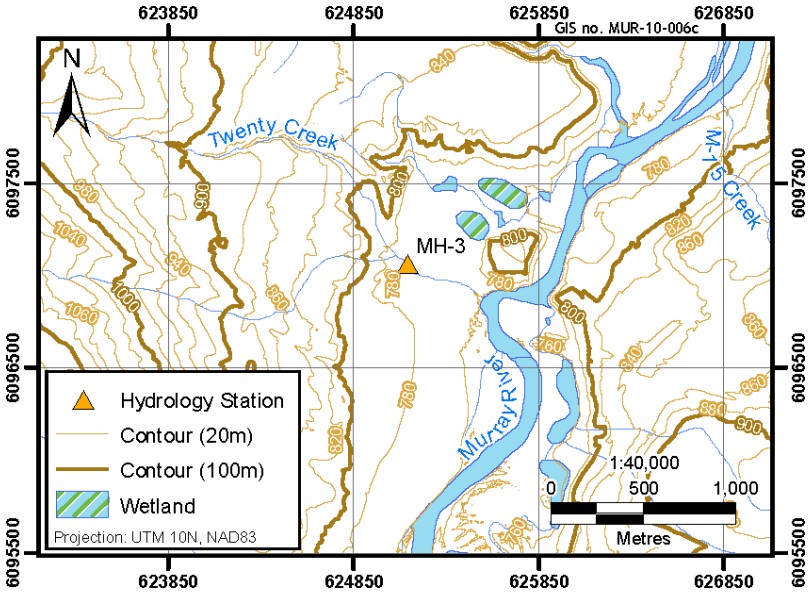
**Site Photo**

## Appendix 1-3. Station Information Sheet for Hydrometric Station MH-3 Twenty Creek

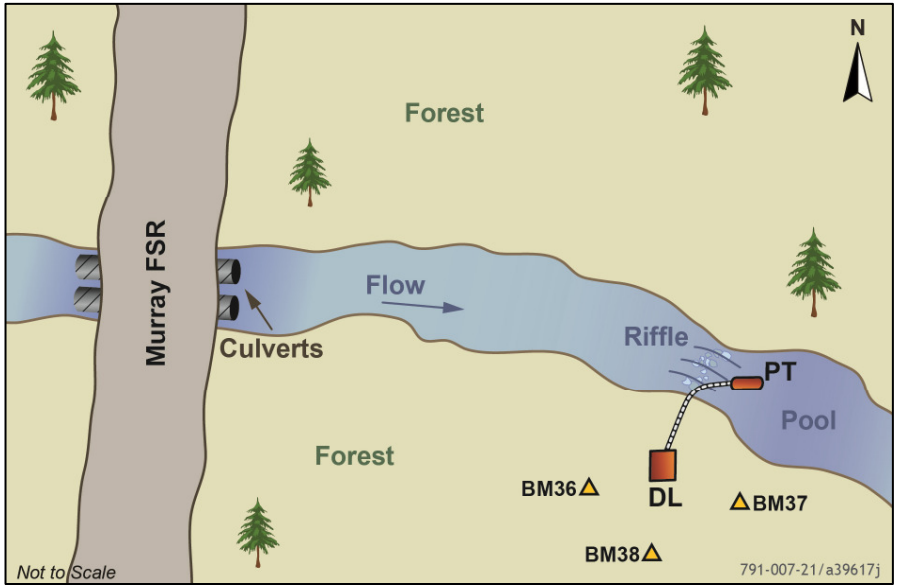
| Site ID: | MH-3 | Drainage Area ($km^2$): | 6.62 |
|---|---|---|---|
| Site Location: | Approximately 25 m upstream of the inflow point into Murray River. | | |
| UTM: | 10U | 625,151 m E | 6,097,069 m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM36 | 100.000 m | Nail in tree | |
| BM37 | 99.491 m | Nail in tree | |
| BM38 | 98.983 m | Nail in tree | |
| Transducer: | PS-98i pressure transducer with Elf-2 data logger | | |
| Operating Periods: | | | |
| 2011 | January 1 – November 16 (100m downstream of 2012 location) | | |
| 2012 | April 27 – November 5 | | |
| 2013 | Not Active | | |
| General Comments: | | | |

- Small channel with a gravel bed.
- Forced pool-riffle morphology resulting from large woody debris obstructions.
- Surface water flow stopped during July.

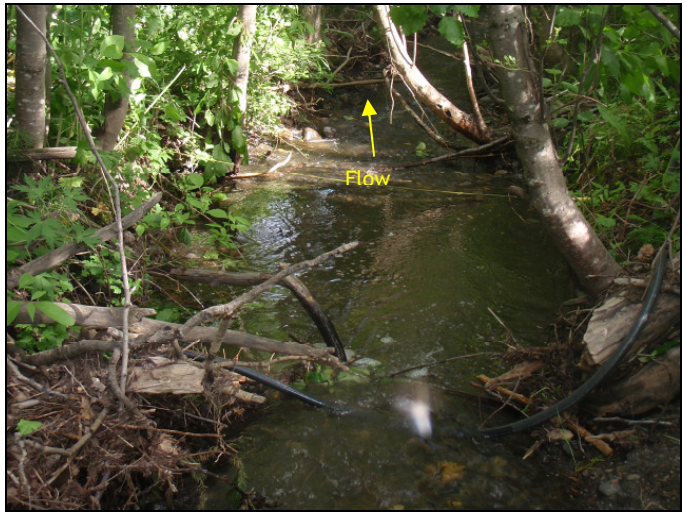
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-3**




*A low angle view facing downstream and east at hydrometric station MH3 at Twenty Creek. The velocity measurement section is marked by the tape. Photo taken June 29, 2012.*

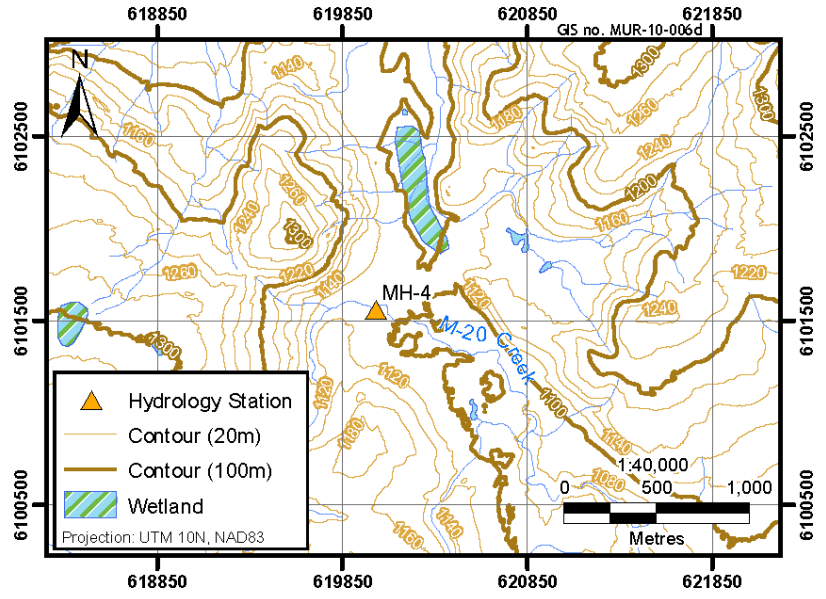
**Site Photo**

## Appendix 1-4. Station Information Sheet for Hydrometric Station MH-4 Upper Camp Creek

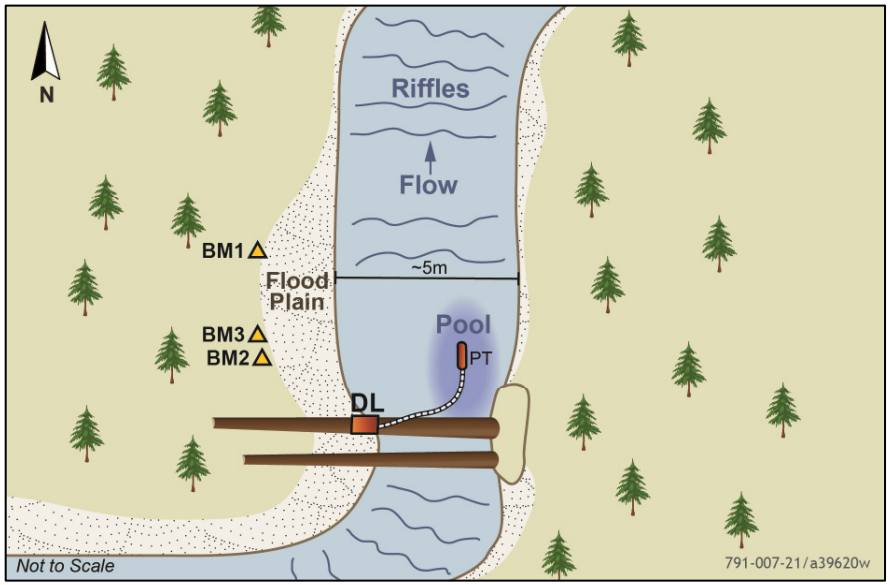
| Site ID: | MH-4 | Drainage Area ($km^2$): | 21.08 |
|---|---|---|---|
| Site Location: | Approx. 50 m downstream from where Camp Creek crosses Mast Road. | | |
| UTM: | 10U | 620,078 m E | 6,101,730 m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM1 | 100.000 m | Nail in tree 10m downstream of station | |
| BM2 | 99.900 m | Nail in tree 4m downstream of station | |
| BM3 | 99.982 m | Nail in tree 7m downstream of station | |
| Transducer: | PS-98i pressure transducer with Elf-2 data logger | | |
| Operating Periods: | | | |
| 2011 | May 14 – November 16 | | |
| 2012 | April 28 – November 9 | | |
| 2013 | Not Active | | |
| General Comments: | | | |

- High energy stream with gravel-cobble bed.
- Forced pool-riffle morphology resulting from large woody debris obstructions.
- Significant about of ice build-up in early November.

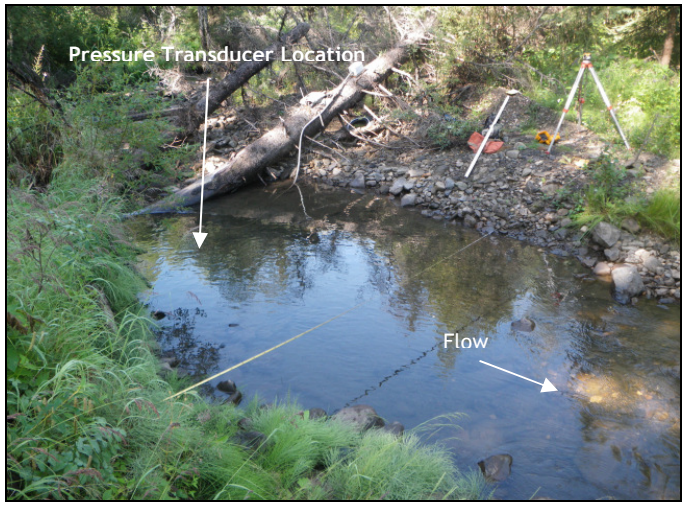
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-4**



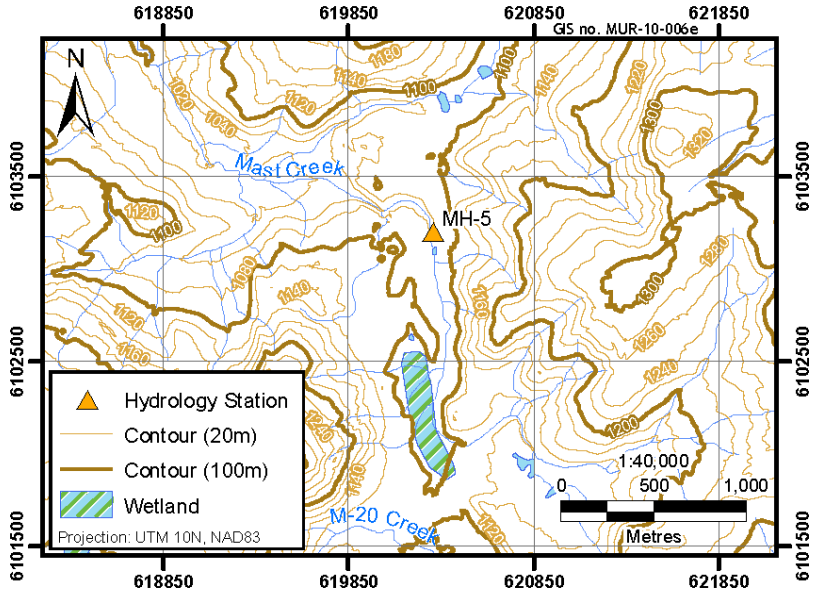

*A low angle view looking towards the hydrometric station. The tape across the channel indicates the flow measurement location. The pressure transducer is located in a pool just downstream of the fallen trees. Photo taken August 15, 2012.*

**Site Photo**

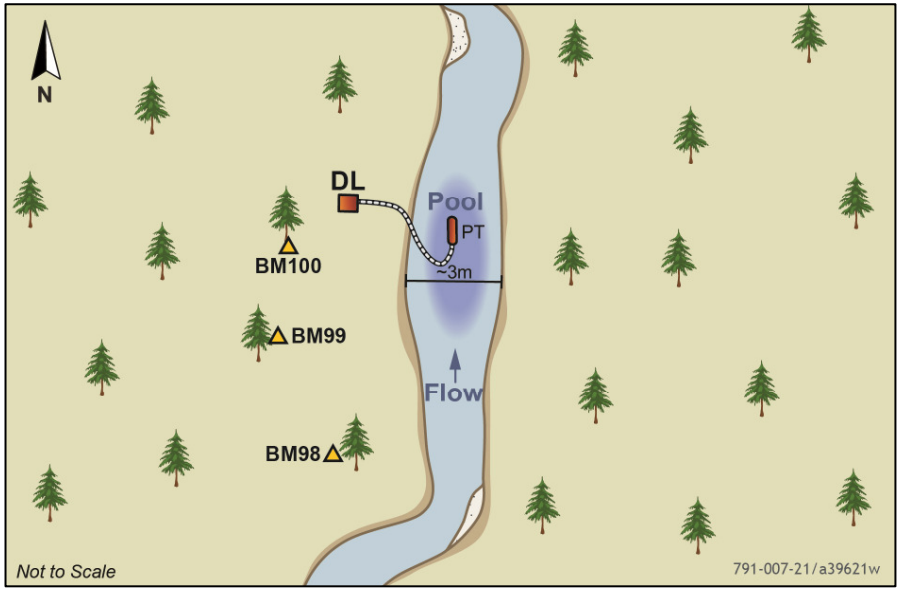
## Appendix 1-5. Station Information Sheet for Hydrometric Station MH-5 Mast Creek

| Site ID: | MH-5 | Drainage Area ($km^2$): | 4.12 |
|---|---|---|---|
| Site Location: | Approximately 20 m west of Mast Road at the north end of the wetland. | | |
| UTM: | 10U | 620,306 m E | 6,103,205 m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM100 | 100.000 m | Nail in tree 5m upstream of station | |
| BM99 | 100.251 m | Nail in tree 10m upstream of station | |
| BM98 | 100.117 m | Nail in tree 20m upstream of station | |
| Transducer: | PS-98i pressure transducer with Elf-2 data logger | | |
| Operating Periods: | | | |
| 2011 | May 12 – November 15 | | |
| 2012 | April 25- November 8 | | |
| 2013 | Not Active | | |
| General Comments: | | | |
| • Small, low energy stream with soft, silt bed.<br>• Very little ice noted in early November likely due to upstream wetland. | | | |

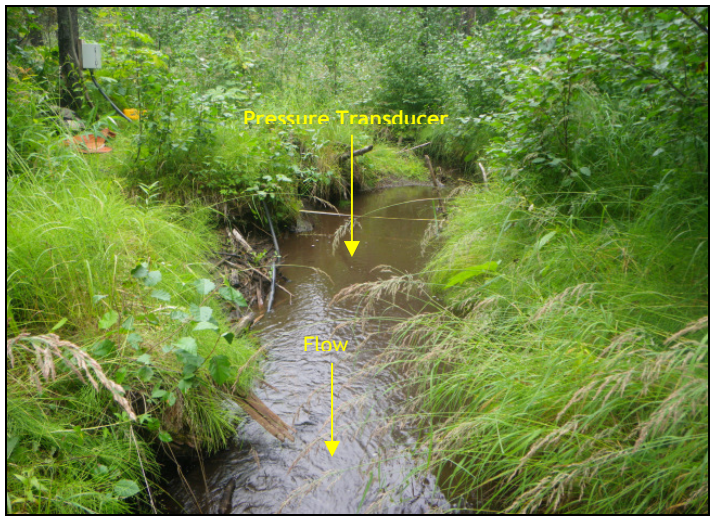
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-5**




*A low angle view facing upstream and north towards the hydrometric station. Note the large amount of vegetation that has established on the banks over the summer. August 14, 2012.*

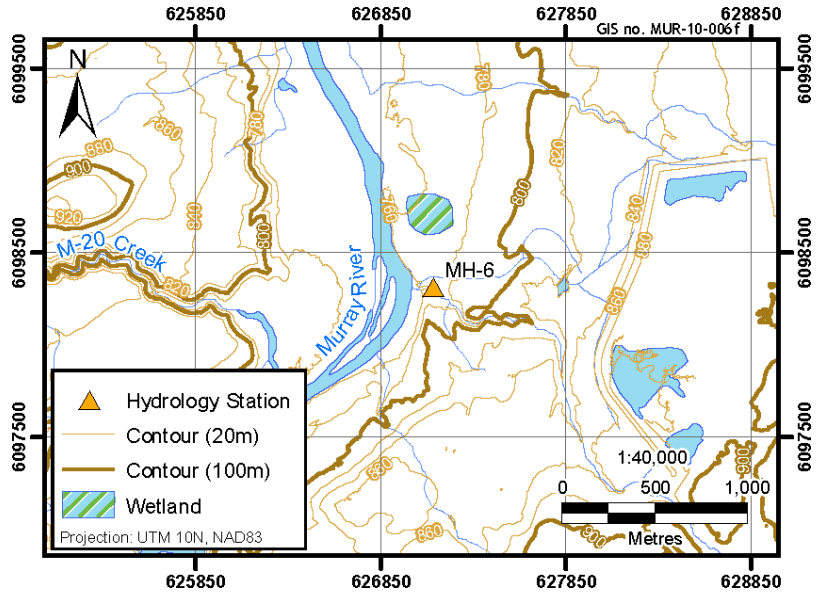
**Site Photo**

## Appendix 1-6. Station Information Sheet for Hydrometric Station MH-6 Mile 17 Creek

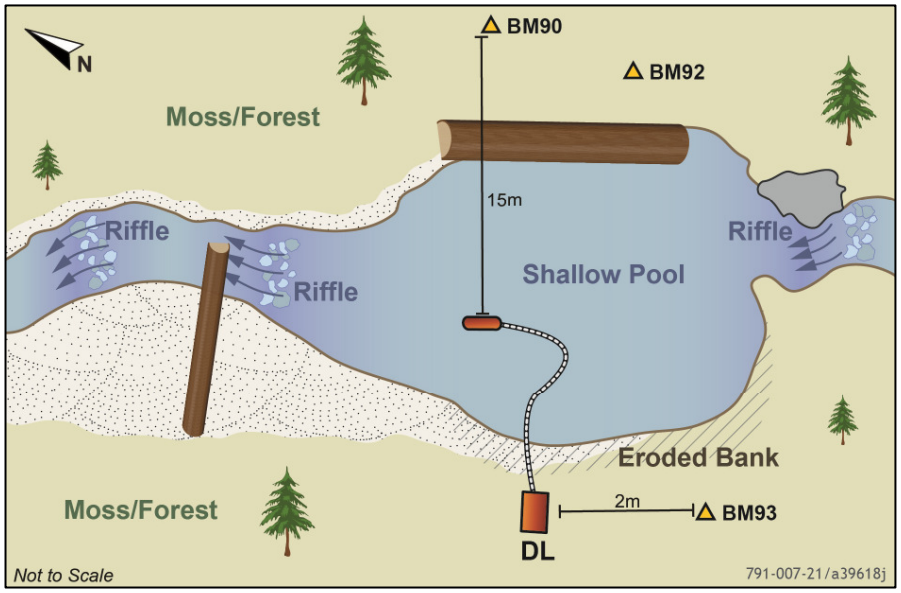
| Site ID: | MH-6 | Drainage Area ($km^2$): | 7.36 |
|---|---|---|---|
| Site Location: | On Mile 17 creek 200m from the inflow to Murray River. | | |
| UTM: | 10U | 627,134m E | 6,098,319m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM 90 | 100.000 m | Nail in tree in high on left bank opposite station | |
| BM 91 | 99.086 m | Nail in tree on tree 2m upstream of station | |
| BM 92 | 97.694 m | Nail in tree near left bank of stream | |
| Transducer: | PS-98i pressure transducer with GDL data logger | | |
| Operating Periods: | | | |
| 2011 | Not Active | | |
| 2012 | September 27- November 6 | | |
| 2013 | April 30 – November 6 | | |
| General Comments: | | | |

- Small, low energy stream, deeply incised into ravine. Cobble and bedrock bed.
- Pool-riffle morphology near station with sections of step-pool morphology upstream.
- Access via UTV from Murray FSR near the top of "The Switches".

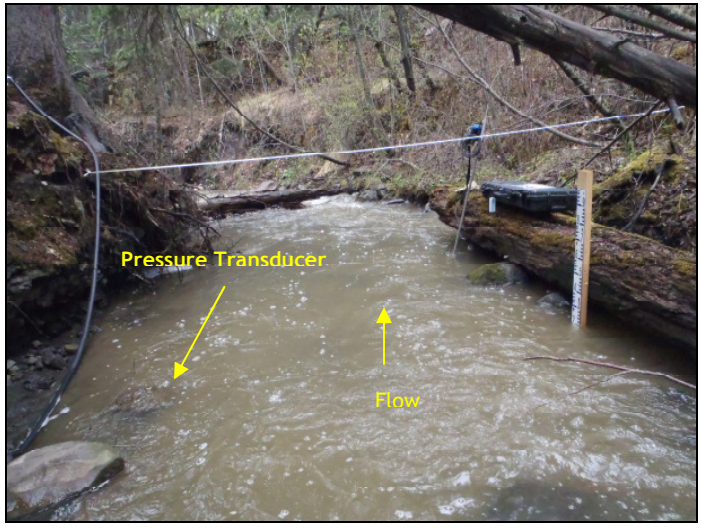
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-6**




*A low angle view facing downstream towards the hydrometric station during a discharge measurement. The staff gauge can also be seen on the right bank. Mat 21 2013.*

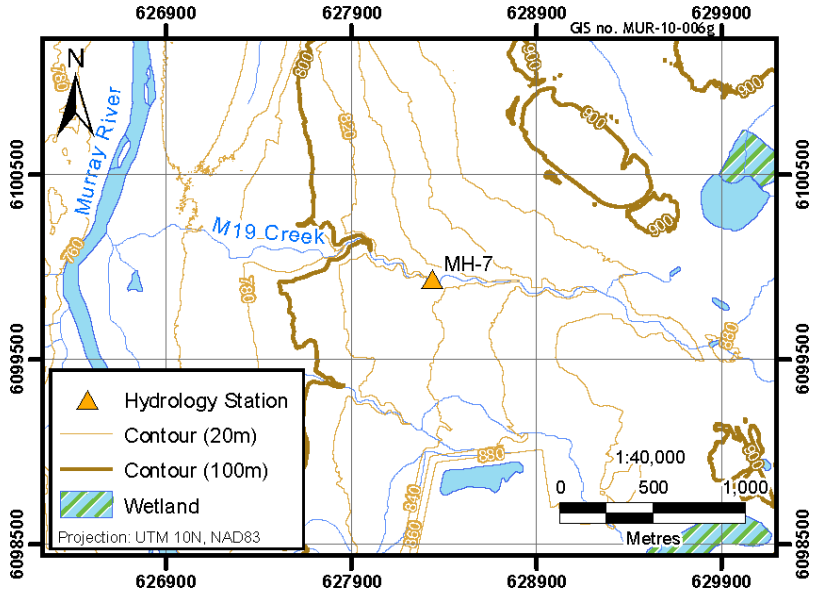
**Site Photo**

## Appendix 1-7. Station Information Sheet for Hydrometric Station MH-7 Mile 19 Creek

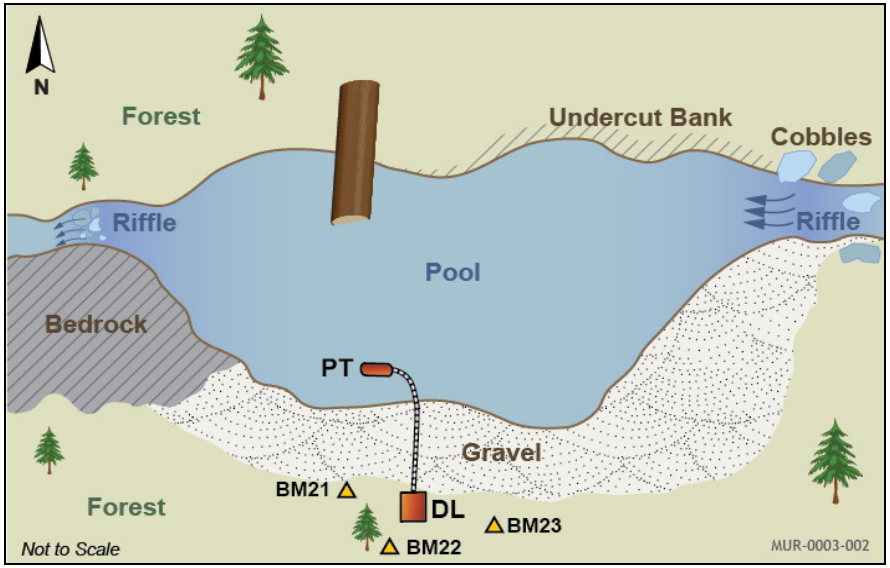
| Site ID: | MH-7 | Drainage Area ($km^2$): | 52.39 |
|---|---|---|---|
| Site Location: | On Mile 19 creek approx. 1.5 km east of Highway 52 along "Goat Path". | | |
| UTM: | 10U | 627,134m E | 6,098,319m N |
| **Benchmarks** | **Elevation** | **Description** | |
| BM 21 | 100.000 m | Nail in tree on left bank 5m DS of station. | |
| BM 22 | 100.449 m | Nail in tree 5m behind station. | |
| BM 23 | 100.698 m | Nail in tree on left bank 3m US of station. | |
| Transducer: | PS-98i pressure transducer with GDL data logger | | |
| Operating Periods: | | | |
| 2011 | Not Active | | |
| 2012 | September 30- November 4 | | |
| 2013 | May 1 – November 7 | | |
| General Comments: | | | |

- Channel deeply incised into ravine. Cobble and bedrock bed.
- At peak flow stream is not wadeable, salt dilution may be necessary.
- Bedrock morphology with sections of pools and riffles in between bedrock steps.
- Truck access via road to the south of channel named "Goat Path" near Highway 52.

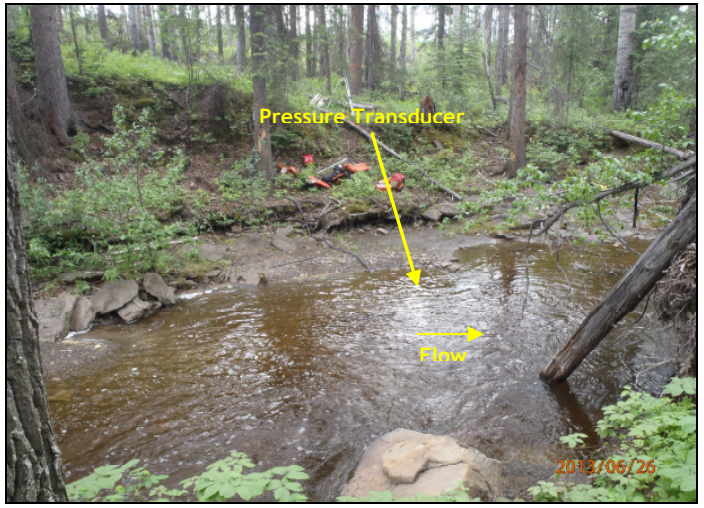
**General Site Information**




**Site Map**




**Plan View of Hydrometric Station MH-7**




*Low angle view looking towards the station, which is located on the left bank, under moderate flow conditions. June 26 2013.*

**Site Photo**

# Appendix 2

## Summary of Discharge Measurements and Levelling Surveys

ERM

## Appendix 2-1a(1). Manual Discharge Measurement and Levelling Survey at MH-1 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-1 | | | |
| **Stream Name** | Murray River | | | |
| **Date Monitored** | Thursday, March 17, 2011 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:00:00 PM | **End Time:** | 4:00:00 PM |
| **Personnel** | Craig Hatt, Vern Solonas | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2425003 |
| **Gain** | 10.471 | **Offset** | 0.0008 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 76 | 2.007 | 102.007 | | 100.000 | Nail in tree |
| BM 75 | | | 0.924 | 101.083 | Nail in tree |
| BM 74 | | | 1.792 | 100.215 | Nail in tree |
| WL | | | 4.206 | 97.801 | |
| BM 75 | 1.072 | 102.155 | | **101.083** | |
| WL | | | 4.349 | 97.806 | |
| BM 74 | | | 1.937 | **100.218** | |
| BM 76 | | | 2.159 | 99.996 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 76 | | 99.998 | | |
| BM 75 | | 101.083 | | |
| BM 74 | | 100.217 | | |

| Summary | |
|---|---|
| **Stage (m)** | 97.804 |
| **Discharge ($m^3$/s)** | 8.545 |
| **Pressure Transducer Reading (m)** | 0.574 |
| **Pressure Transducer Elevation (m)** | 97.230 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:00 | **End** | 14:30 | **Location** | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.574 | **Time** | 13:00 | | | |
| | **End** | **Reading** | | **Time** | 14:30 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| right bank | 0.00 | 0.00 | 2.50 | 1.00 | 0 | | | 0.1500 | 1.8 |
| | 5.00 | 0.80 | 3.50 | 2.80 | 0.15 | | | 0.4200 | 4.9 |
| | 7.00 | 0.67 | 2.50 | 1.68 | 0.12 | | | 0.2010 | 2.4 |
| | 10.00 | 0.41 | 3.50 | 1.44 | 0.07 | | | 0.1005 | 1.2 |
| | 14.00 | 0.62 | 4.00 | 2.48 | 0.04 | | | 0.0992 | 1.2 |
| | 18.00 | 1.46 | 3.50 | 5.11 | 0.1 | | | 0.5110 | 6.0 |
| | 21.00 | 1.52 | 3.00 | 4.56 | 0.31 | | | 1.4136 | 16.5 |
| | 24.00 | 1.35 | 3.00 | 4.05 | 0.45 | | | 1.8225 | 21.3 |
| | 27.00 | 1.07 | 3.00 | 3.21 | 0.42 | | | 1.3482 | 15.8 |
| | 30.00 | 0.93 | 3.00 | 2.79 | 0.41 | | | 1.1439 | 13.4 |
| | 33.00 | 0.67 | 3.00 | 2.01 | 0.3 | | | 0.6030 | 7.1 |
| | 36.00 | 0.53 | 3.00 | 1.59 | 0.28 | | | 0.4452 | 5.2 |
| | 39.00 | 0.35 | 3.00 | 1.05 | 0.2 | | | 0.2100 | 2.5 |
| | 42.00 | 0.18 | 3.00 | 0.54 | 0.11 | | | 0.0594 | 0.7 |
| | 45.00 | 0.12 | 3.00 | 0.36 | 0.05 | | | 0.0180 | 0.2 |
| | 48.00 | 0.10 | 3.00 | 0.30 | 0.01 | | | 0.0030 | 0.0 |
| | 51.00 | 0.05 | 3.00 | 0.15 | 0.02 | | | 0.0030 | 0.0 |
| | 54.00 | 0.03 | 3.00 | 0.09 | 0 | | | 0.0000 | 0.0 |
| | 57.00 | 0.09 | 3.00 | 0.27 | -0.01 | | | -0.0027 | 0.0 |
| | 60.00 | 0.10 | 3.00 | 0.30 | -0.01 | | | -0.0030 | 0.0 |
| left bank | 63.00 | 0.00 | 1.50 | 0.08 | 0 | | | -0.0008 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **8.545** | **100.0** |

**General Notes**

River covered in ice. Measurement taken by cutting holes in ice and regularily spaced intervals and measuring flow beneath ice.

## Appendix 2-1a(2). ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH1 | | | |
| Stream Name | Murray River | | | |
| Date Monitored | 13-May-11 | | | |
| Time at Site (24 hr) | Start Time: | 10:00 | End Time: | 15:00 |
| Personnel | Craig Hatt, Adrian Ang | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2425003 |
| Gain | 10.471 | Offset | 0.0008 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 76 | 2.503 | 102.503 | | 100.000 | Nail in tree |
| BM 75 | | | 1.418 | 101.085 | Nail in tree |
| BM 74 | | | 2.285 | 100.218 | Nail in tree |
| WL | | | 3.865 | **98.638** | |
| BM 75 | 2.246 | 102.464 | | 100.218 | |
| BM 74 | | | 1.376 | **101.088** | |
| WL | | | 3.821 | 98.643 | |
| BM 76 | | | 2.464 | 100.000 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 76 | | 100.000 | | |
| BM 75 | | 100.652 | | |
| BM 74 | | 100.653 | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | | Start | 14:05 | End | 15:30 | Location | | |
| Method | | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | | |
| Flow Meter Type | | ADCP | | | | Water Temp (Therm) (°C) | | |
| Instrument Model | | ASL Stream Pro | | | | Mean Discharge Q ($m^3/s$) | 130.0 | |
| Instrument Serial# | | 767 | | | | Error (Std Dev in $m^3/s$) | 1.26 | |
| Stage (m) | Start | Reading | 1.241 | Time | 13:30 | Mean % of Q Measured | 76.4 | |
| | End | Reading | | Time | | | | |
| File Location | | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| 1 | 14.6 | 99.0 | 14.8 | 0.145 | 0.281 | 129 | 77 | 6 | 5 |
| 2 | 15.9 | 99.8 | 15.7 | 0.043 | 0.148 | 132 | 76 | 2 | 6 |
| 3 | 15.2 | 99.6 | 14.6 | 0.006 | 0.146 | 130 | 77 | 14 | 5 |
| 4 | 16.0 | 98.9 | 14.6 | 0.013 | 0.299 | 130 | 76 | 11 | 3 |
| Mean | 15.4 | 99.3 | 14.9 | 0.052 | 0.219 | 130 | 76 | 8 | 5 |

**General Notes**

| Summary | | | |
|---|---|---|---|
| Stage (m) | 98.641 | | |
| Discharge ($m^3/s$) | 130.0 | | |
| Pressure Transducer Reading (m) | 1.241 | | |
| Pressure Transducer Elevation (m) | 97.400 | | |

## Appendix 2-1a(2). ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH1 | | | |
| Stream Name | Murray River | | | |
| Date Monitored | 3-Jul-11 | | | |
| Time at Site (24 hr) | Start Time: | 14:00 | End Time: | 17:00 |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| Weather Conditions | | | | |

| Transducer Information | | | | | |
|---|---|---|---|---|---|
| PT Model | | PS9800 | Serial # | | 2425003 |
| Gain | | 10.471 | Offset | | 0.0008 |
| Status | | Active | Battery | | |
| # of Records | | | Memory Free | | |
| Date Serviced | | | Crest Gauges | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 76 | 2.423 | 102.423 | | 100.000 | Nail in tree |
| BM 75 | | | 1.331 | 101.092 | Nail in tree |
| BM 74 | | | 2.203 | 100.220 | Nail in tree |
| WL | | | 3.560 | **98.863** | |
| BM 74 | 2.212 | 102.432 | | 100.220 | |
| WL | | | 3.571 | **98.861** | |
| BM 75 | | | 1.338 | 101.094 | |
| BM 76 | | | 2.432 | 100.000 | |

| BM# | Established Elevation (m) | n Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 76 | | 100.000 | | |
| BM 75 | | 101.093 | | |
| BM 74 | | 100.220 | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | | Start | 14:23 | End | 15:30 | Location | Upstream of bridge | |
| Method | | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | | |
| Flow Meter Type | | ADCP | | | | Water Temp (Therm) (°C) | | |
| Instrument Model | | ASL Stream Pro | | | | Mean Discharge Q ($m^3/s$) | 162.9 | |
| Instrument Serial# | | 767 | | | | Error (Std Dev in $m^3/s$) | 1.25 | |
| Stage (m) | Start | Reading | 1.406 | Time | 14:20 | Mean % of Q Measured | 73.3 | |
| | End | Reading | | Time | | | | |
| File Location | | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| 1 | 17.3 | 124.6 | 19.5 | 0.423 | 0.516 | 162.4 | 77 | 0 | 7 |
| 2 | 17.0 | 125.4 | 18.0 | 1.324 | 0.200 | 161.9 | 77 | 0 | 7 |
| 3 | 18.2 | 123.1 | 22.0 | 0.823 | 0.637 | 164.7 | 75 | 10 | 11 |
| 4 | 18.0 | 125.6 | 18.1 | 0.424 | 0.470 | 162.5 | 77 | 0 | 6 |
| Mean | 17.6 | 124.7 | 19.4 | 0.748 | 0.456 | 162.9 | 77 | 2 | 8 |

**General Notes**

| Summary | | | |
|---|---|---|---|
| Stage (m) | 98.862 | | |
| Discharge ($m^3/s$) | 162.9 | | |
| Pressure Transducer Reading (m) | 1.406 | | |
| Pressure Transducer Elevation (m) | 97.456 | | |

## Appendix 2-1a(2). ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH1 | | | |
| Stream Name | Murray River | | | |
| Date Monitored | 3-Aug-11 | | | |
| Time at Site (24 hr) | Start Time: | 13:20 | End Time: | 16:30 |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| Weather Conditions | | | | |

| Transducer Information | | | | | |
|---|---|---|---|---|---|
| PT Model | | PS9800 | Serial # | | 2425003 |
| Gain | | 10.471 | Offset | | 0.0008 |
| Status | | Active | Battery | | |
| # of Records | | | Memory Free | | |
| Date Serviced | | | Crest Gauges | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 76 | 2.414 | 102.414 | | 100.000 | Nail in tree |
| BM 75 | | | 1.324 | 101.090 | Nail in tree |
| BM 74 | | | 2.201 | 100.213 | Nail in tree |
| WL | | | 4.038 | **98.376** | |
| BM 74 | 2.138 | 102.351 | | 100.213 | |
| WL | | | 3.977 | **98.374** | |
| BM 75 | | | 1.262 | 101.089 | |
| BM 76 | | | 2.354 | 99.997 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 76 | | 99.999 | | |
| BM 75 | | 101.090 | | |
| BM 74 | | 100.213 | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | | Start | 15:00 | End | 16:30 | Location | Upstream of bridge | |
| Method | | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | | |
| Flow Meter Type | | ADCP | | | | Water Temp (Therm) (°C) | | |
| Instrument Model | | ASL Stream Pro | | | | Mean Discharge Q ($m^3/s$) | 86.0 | |
| Instrument Serial# | | 767 | | | | Error (Std Dev in $m^3/s$) | 0.51 | |
| Stage (m) | Start | Reading | 0.934 | Time | 15:00 | Mean % of Q Measured | 76.9 | |
| | End | Reading | | Time | | | | |
| File Location | | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| 1 | 9.6 | 66.8 | 8.8 | 0.227 | 0.225 | 85.6 | 78 | 0 | 4 |
| 2 | 9.9 | 65.4 | 10.1 | 0.237 | 0.521 | 86.1 | 76 | 0 | 6 |
| 3 | 9.9 | 65.1 | 9.4 | 0.192 | 0.891 | 85.4 | 76 | 0 | 4 |
| 4 | 10.1 | 66.7 | 9.0 | 0.211 | 0.161 | 86.1 | 77 | 0 | 6 |
| 5 | 9.7 | 66.9 | 9.4 | 0.269 | 0.375 | 86.7 | 77 | 0 | 5 |
| Mean | 9.8 | 66.2 | 9.3 | 0.227 | 0.435 | 86.0 | 77 | 0 | 5 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**General Notes**

**Summary**

| | | | |
|---|---|---|---|
| Stage (m) | 98.375 | | |
| Discharge ($m^3/s$) | 86.0 | | |
| Pressure Transducer Reading (m) | 0.934 | | |
| Pressure Transducer Elevation (m) | 97.441 | | |

## Appendix 2-1a(2). ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2011

| Site Information | | | | | |
|---|---|---|---|---|---|
| Project Name | Murray River | | | | |
| Station Identification | MH1 | | | | |
| Stream Name | Murray River | | | | |
| Date Monitored | 6-Sep-11 | | | | |
| Time at Site (24 hr) | Start Time: | 12:00 | End Time: | 16:00 | |
| Personnel | Craig Hatt, Assistant | | | | |
| Station Cordinates | Easting | Northing | Elevation | | |
| | 626076 | 6097287 | 763 | | |
| Weather Conditions | | | | | |

| Transducer Information | | | | | |
|---|---|---|---|---|---|
| PT Model | | PS9800 | Serial # | | 2425003 |
| Gain | | 10.471 | Offset | | 0.0008 |
| Status | | Active | Battery | | |
| # of Records | | | Memory Free | | |
| Date Serviced | | | Crest Gauges | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 76 | 2.413 | 102.413 | | 100.000 | |
| BM 75 | | | 1.329 | 101.084 | |
| BM 74 | | | 2.192 | 100.221 | |
| WL | | | 4.396 | **98.017** | |
| BM 76 | 2.401 | 102.401 | | 100.000 | |
| BM74 | | | 2.188 | 100.213 | |
| BM75 | | | 1.325 | 101.076 | |
| WL | | | 4.389 | **98.012** | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 76 | | 100.000 | | |
| BM 75 | | 101.080 | | |
| BM 74 | | 100.217 | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | | Start | 12:30 | End | 15:30 | Location | Upstream of bridge | |
| Method | | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | | |
| Flow Meter Type | | ADCP | | | | Water Temp (Therm) (°C) | | |
| Instrument Model | | ASL Stream Pro | | | | Mean Discharge Q ($m^3/s$) | 48.9 | |
| Instrument Serial# | | 767 | | | | Error (Std Dev in $m^3/s$) | 0.56 | |
| Stage (m) | Start | Reading | 0.576 | Time | 12:30 | Mean % of Q Measured | 76.9 | |
| | End | Reading | | Time | | | | |
| File Location | | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| 1 | 5.4 | 37.8 | 5.6 | 0.075 | 0.276 | 49.0 | 77 | 4 | 2 |
| 2 | 5.5 | 38.3 | 5.5 | -0.015 | 0.350 | 49.7 | 77 | 3 | 2 |
| 3 | 5.4 | 37.0 | 5.6 | 0.064 | 0.178 | 48.2 | 77 | 4 | 2 |
| 4 | 5.4 | 37.8 | 5.2 | 0.009 | 0.346 | 48.7 | 78 | 3 | 2 |
| 5 | 5.5 | 37.1 | 5.8 | 0.124 | 0.137 | 48.6 | 76 | 4 | 2 |
| Mean | 5.4 | 37.6 | 5.5 | 0.051 | 0.257 | 48.9 | 77 | 3 | 2 |

| General Notes |
|---|
| |

| Summary | | | |
|---|---|---|---|
| Stage (m) | 98.015 | | |
| Discharge ($m^3/s$) | 48.9 | | |
| Pressure Transducer Reading (m) | 0.576 | | |
| Pressure Transducer Elevation (m) | 97.439 | | |

## Appendix 2-1a(2). ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH1 | | | |
| Stream Name | Murray River | | | |
| Date Monitored | 17-Oct-11 | | | |
| Time at Site (24 hr) | Start Time: | 13:30 | End Time: | 16:00 |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| Weather Conditions | | | | |

| Transducer Information | | | | | |
|---|---|---|---|---|---|
| PT Model | | PS9800 | Serial # | | 2425003 |
| Gain | | 10.471 | Offset | | 0.0008 |
| Status | | Active | Battery | | |
| # of Records | | | Memory Free | | |
| Date Serviced | | | Crest Gauges | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 76 | 2.410 | 102.410 | | 100.000 | |
| BM 75 | | | 1.322 | 101.088 | |
| BM 74 | | | 2.195 | 100.215 | |
| WL | | | 4.605 | **97.805** | |
| BM 75 | 1.259 | 102.347 | | 101.088 | |
| WL | | | 4.545 | **97.802** | |
| BM 74 | | | 2.131 | 100.216 | |
| BM 76 | | | 2.349 | 99.998 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 76 | | 100.000 | | |
| BM 75 | | 101.088 | | |
| BM 74 | | 100.216 | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | | Start | 13:30 | End | 15:00 | Location | | |
| Method | | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | | |
| Flow Meter Type | | ADCP | | | | Water Temp (Therm) (°C) | | |
| Instrument Model | | ASL Stream Pro | | | | Mean Discharge Q ($m^3/s$) | 34.8 | |
| Instrument Serial# | | 767 | | | | Error (Std Dev in $m^3/s$) | 0.54 | |
| Stage (m) | Start | Reading | 0.367 | Time | 13:30 | Mean % of Q Measured | 70.4 | |
| | End | Reading | | Time | | | | |
| File Location | | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| 1 | 4.9 | 24.4 | 4.1 | 0.494 | 0.612 | 34.4 | 71 | 0 | 3 |
| 2 | 4.9 | 24.2 | 4.4 | 0.502 | 0.762 | 34.7 | 70 | 0 | 3 |
| 3 | 5.1 | 25.2 | 4.2 | 0.463 | 0.784 | 35.7 | 71 | 0 | 3 |
| 4 | 4.9 | 24.7 | 4.2 | 0.466 | 0.343 | 34.6 | 71 | 0 | 3 |
| 5 | 4.9 | 24.3 | 4.3 | 0.564 | 0.428 | 34.4 | 71 | 0 | 4 |
| Mean | 4.9 | 24.5 | 4.2 | 0.498 | 0.586 | 34.8 | 70 | 0 | 3 |

**General Notes**

**Summary**

| | | | |
|---|---|---|---|
| Stage (m) | 97.804 | | |
| Discharge ($m^3/s$) | 34.8 | | |
| Pressure Transducer Reading (m) | 0.367 | | |
| Pressure Transducer Elevation (m) | 97.437 | | |

## Appendix 2-1a(2). ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2011

| Site Information | | | | | |
|---|---|---|---|---|---|
| **Project Name** | Murray River | | | | |
| **Station Identification** | MH1 | | | | |
| **Stream Name** | Murray River | | | | |
| **Date Monitored** | 19-Nov-11 | Survey Only | | | |
| **Time at Site (24 hr)** | **Start Time:** | 13:30 | **End Time:** | 16:00 | |
| **Personnel** | Craig Hatt, Assistant | | | | |
| **Station Cordinates** | Easting | Northing | Elevation | | |
| | 626076 | 6097287 | 763 | | |
| **Weather Conditions** | | | | | |

| Transducer Information | | | | | |
|---|---|---|---|---|---|
| **PT Model** | | PS9800 | **Serial #** | | 2425003 |
| **Gain** | | 10.471 | **Offset** | | 0.0008 |
| **Status** | | Active | **Battery** | | |
| **# of Records** | | | **Memory Free** | | |
| **Date Serviced** | | | **Crest Gauges** | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 76 | 2.397 | 102.397 | | 100.000 | |
| BM 75 | | | 1.319 | 101.078 | |
| BM 74 | | | 2.181 | 100.216 | |
| WL | | | 4.643 | **97.754** | |
| BM 75 | 1.194 | 102.272 | | 101.078 | |
| WL | | | 4.518 | **97.754** | |
| BM 74 | | | 2.055 | 100.217 | |
| BM 76 | | | 2.271 | 100.001 | |
| | | | | | |
| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | | **Difference (m)** | **Notes** |
| BM 76 | | 100.000 | | | |
| BM 75 | | 101.078 | | | |
| BM 74 | | 100.217 | | | |

## Appendix 2-1b. ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH1 | | | |
| **Stream Name** | Murray River | | | |
| **Date Monitored** | 28-Apr-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 9:00 | **End Time:** | |
| **Personnel** | Craig Hatt, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| **Weather Conditions** | Partly cloudy, 5.5C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2425003 |
| **Gain** | 10.471 | **Offset** | 0.0008 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | 28-Apr-12 | **Crest Gauges** | no |

| Discharge Measurement ADCP | | | | | | |
|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 11:00 | **End** | 11:50 | **Location** | 25m upstream of bridge |
| **Method** | Velocity-area (ADCP) | | | | **Water Temp (ADCP)(°C)** | \ |
| **Flow Meter Type** | ADCP | | | | **Water Temp (Therm) (°C)** | 4 |
| **Instrument Model** | ASL Stream Pro | | | | **Mean Discharge Q ($m^3/s$)** | 53.3 |
| **Instrument Serial#** | 767 | | | | **Error (Std Dev in $m^3/s$)** | 2.22 |
| **Stage (m)** **Start** | **Reading** | | **Time** | | **Mean % of Q Measured** | 67.6 |
| **Stage (m)** **End** | **Reading** | | **Time** | | | |
| **File Location** | N:\791 Canadian Dehua Int'l\791-002 Murray River Coal Project\Phase 03 - Baseline and EA 2011_2012\04 Water Resources-Hydrology\Data and Documentation\2012\Data Files\April 23-29, 2012 | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| *2* | 6.91 | 34.46 | 8.72 | 0.19 | 0.48 | 50.75 | 67.90 | 5 | 1 |
| *4* | 7.61 | 37.02 | 9.15 | 0.18 | 0.45 | 54.41 | 68.04 | 2 | 1 |
| *5* | 7.28 | 35.59 | 8.53 | 0.14 | 0.69 | 52.22 | 68.15 | 5 | 0 |
| *6* | 7.70 | 36.94 | 10.50 | 0.20 | 0.39 | 55.73 | 66.28 | 1 | 2 |
| **Mean** | **7.37** | **36.00** | **9.22** | **0.18** | **0.50** | **53.28** | **67.6** | **3.3** | **1.0** |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 33 | 1.205 | 102.317 | | 101.112 | |
| BM 34 | | | 1.432 | 100.885 | |
| BM 35 | | | 1.689 | 100.628 | |
| PT | | | \ | | Flow was too strong |
| WL | | | 4.287 | **98.030** | |
| BM 76 | 2.325 | 102.327 | 2.315 | 100.002 | |
| WL | | | 4.296 | **98.031** | |
| PT | | | \ | | Flow was too strong |
| BM 35 | | | 1.700 | 100.627 | |
| BM 34 | | | 1.442 | 100.885 | |
| BM 33 | | | 1.215 | 101.112 | |
| | | | | | |
| | | | | | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 33 | 101.112 | 101.112 | | Established on this date |
| BM 34 | 100.885 | 100.885 | | Established on this date |
| BM 35 | 100.628 | 100.628 | | Established on this date |

**General Notes**

Checked transducer accuracy. Put PT in cooler full of water, measured depth - 20.2cm, PT reading - 19.5cm. Started logging at 11:40. Manual measurement 0.90m(rough) PT reading:0.888. Did not complete flow measurement on April 27 due to connection issues between ADCP and laptop. Left bank estimated distance = 5.1m, Right Bank Estimated distance = 2.5m.

| Summary | | | |
|---|---|---|---|
| **Stage (m)** | 98.031 | | |
| **Discharge ($m^3/s$)** | 53.3 | | |
| **Pressure Transducer Reading (m)** | 0.902 | | |
| **Pressure Transducer Elevation (m)** | 97.128 | | |

## Appendix 2-1b. ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH1 | | | |
| **Stream Name** | Murray River | | | |
| **Date Monitored** | 20-May-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 8:30 | **End Time:** | 12:00 |
| **Personnel** | Craig Hatt, David Moellenbeck | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| **Weather Conditions** | Partly cloudy, 5.5C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2425003 |
| **Gain** | 10.471 | **Offset** | 0.0008 |
| **Status** | okay | **Battery** | 100% |
| **# of Records** | 3311 | **Memory Free** | |
| **Date Serviced** | 20-May-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 33 | 1.346 | 102.458 | | 101.112 | |
| BM 34 | | | 1.573 | 100.885 | |
| BM 35 | | | 1.833 | 100.625 | |
| PT | | | n/a | | Unsafe to measure |
| WL | | | 4.064 | **98.394** | |
| TBM 76 | 2.374 | 102.378 | 2.454 | 100.004 | In 2011 BM 76 used as |
| WL | | | 3.983 | **98.395** | |
| PT | | | n/a | | Unsafe to measure |
| BM 35 | | | 1.752 | 100.626 | |
| BM 34 | | | 1.493 | 100.885 | |
| BM 33 | | | 1.264 | 101.114 | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 33 | 101.112 | 101.113 | 0.001 | |
| BM 34 | 100.885 | 100.885 | 0.000 | |
| BM 35 | 100.6275 | 100.626 | -0.002 | |
| | | | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 9:00 | **End** | 10:30 | **Location** | 50m upstream of bridge | | |
| **Method** | Velocity-area (ADCP) | | | | **Water Temp (ADCP)(°C)** | | | |
| **Flow Meter Type** | ADCP | | | | **Water Temp (Therm) (°C)** | | | |
| **Instrument Model** | ASL Stream Pro | | | | **Mean Discharge Q ($m^3/s$)** | 93.6 | | |
| **Instrument Serial#** | | | | | **Error (Std Dev in $m^3/s$)** | 0.96 | | |
| **Stage (m)** | **Start** | **Reading** | | **Time** | | **Mean % of Q Measured** | 75.9 | |
| | **End** | **Reading** | | **Time** | | | | |
| **File Location** | N:\791 Canadian Dehua Int'l\791-002 Murray River Coal Project\Phase 03 - Baseline and EA 2011_2012\04 Water Resources-Hydrology\Data and Documentation\2012\Data Files\May 17-22, 2012 | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| *1* | 11.20 | 71.60 | 9.90 | 0.51 | 0.80 | 94.01 | 76.2 | 0 | 2 |
| *2* | 11.10 | 70.50 | 10.50 | 0.50 | 0.80 | 93.40 | 75.5 | 0 | 3 |
| *3* | 11.10 | 70.20 | 10.20 | 0.48 | 0.77 | 92.75 | 75.7 | 0 | 2 |
| *4* | 11.30 | 72.10 | 10.40 | 0.53 | 0.77 | 95.10 | 75.8 | 0 | 3 |
| *6* | 11.00 | 70.70 | 9.92 | 0.51 | 0.74 | 92.87 | 76.1 | 0 | 2 |
| **Mean** | **11.14** | **71.02** | **10.18** | **0.51** | **0.78** | **93.62** | **75.9** | **0.0** | **2.4** |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**General Notes**

Completed 5 good transects, 1 test, 1 "bad" transect where rope got tangled and altered boat's path across the river. Motorboats were observed travelling up and down the river from 11:00-11:20. These boats create a large wake that may affect PT readings of water levels.

| Summary | | | |
|---|---|---|---|
| **Stage (m)** | 98.395 | | |
| **Discharge ($m^3/s$)** | 93.6 | | |
| **Pressure Transducer Reading (m)** | 1.261 | | |
| **Pressure Transducer Elevation (m)** | 97.134 | | |

## Appendix 2-1b. ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH1 | | | |
| **Stream Name** | Murray River | | | |
| **Date Monitored** | 28-Jun-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 17:35 | **End Time:** | |
| **Personnel** | Craig Hatt, Calvin Pin | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| **Weather Conditions** | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | | | |
| **Gain** | | | |
| **Status** | | | |
| **# of Records** | | | |
| **Date Serviced** | | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 33 | 1.265 | 102.377 | | 101.112 | |
| BM 34 | | | 1.493 | 100.884 | |
| BM 35 | | | 1.761 | 100.616 | |
| WL | | | 3.393 | 98.984 | |
| BM 76 | 2.191 | 102.190 | 2.378 | **99.999** | |
| WL | | | 3.207 | **98.983** | |
| BM 35 | | | 1.574 | **100.616** | |
| BM 34 | | | 1.305 | **100.885** | |
| BM 33 | | | 1.077 | **101.113** | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 33 | 101.112 | 101.113 | 0.001 | |
| BM 34 | 100.885 | 100.885 | 0.000 | |
| BM 35 | 100.6275 | 100.616 | -0.011 | |
| | | | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 9:00 | **End** | 10:30 | **Location** | 50m upstream of bridge | | |
| **Method** | Velocity-area (ADCP) | | | | **Water Temp (ADCP)(°C)** | 8.2 | | |
| **Flow Meter Type** | ADCP | | | | **Water Temp (Therm) (°C)** | None | | |
| **Instrument Model** | StreamPro/2000kHz | | | | **Mean Discharge Q ($m^3/s$)** | 170.2 | | |
| **Instrument Serial#** | 1175 | | | | **Error (Std Dev in $m^3/s$)** | 6.64 | | |
| **Stage (m)** | **Start** | **Reading** | | **Time** | | **Mean % of Q Measured** | 72.3 | |
| | **End** | **Reading** | | **Time** | | | | |
| **File Location** | N:\791 Canadian Dehua Int'l\791-002 Murray River Coal Project\Phase 03 - Baseline and EA 2011_2012\04 Water Resources-Hydrology\Data and Documentation\2012\Data Files\May 17-22, 2012 | | | | | | | |

| **Transect #** | **Discharge Q ($m^3/s$)** | | | | | | **% Q Measured** | **% Bad** | |
|---|---|---|---|---|---|---|---|---|---|
| | **Top** | **Mid** | **Bottom** | **Left** | **Right** | **Total Q** | | **Ensembles** | **Bins** |
| *Murray001* | 18.90 | 123.00 | 22.60 | 4.41 | 7.76 | 176.67 | 69.6 | 12 | 6 |
| *Murray004* | 18.70 | 122.00 | 18.20 | 4.34 | 7.05 | 170.29 | 71.6 | 13 | 3 |
| *Murray008* | 16.00 | 131.00 | 16.70 | 3.54 | 5.47 | 172.71 | 75.8 | 18 | 2 |
| *Murray013* | 16.90 | 116.00 | 17.50 | 4.84 | 5.78 | 161.02 | 72.0 | 11 | 3 |
| | | | | | | | | | |
| **Mean** | **17.63** | **123.00** | **18.75** | **4.28** | **6.52** | **170.17** | **72.3** | **13.5** | **3.5** |

**General Notes**

Real Stage discharge = 1.8126, 1.8162, 1.81588 @ 14:44. Flow at Murray River was high. Required 3 additional laborers to complete ADCP measurement due to swift current.

| **Summary** | | | |
|---|---|---|---|
| **Stage (m)** | 98.984 | | |
| **Discharge ($m^3/s$)** | 170.2 | | |
| **Pressure Transducer Reading (m)** | 1.815 | | |
| **Pressure Transducer Elevation (m)** | 97.169 | | |

## Appendix 2-1b. ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH1 | | | |
| Stream Name | Murray River | | | |
| Date Monitored | 17-Aug-12 | | | |
| Time at Site (24 hr) | Start Time: | 10:30 | End Time: | |
| Personnel | Craig Hatt | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| Weather Conditions | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | | | |
| Gain | | | |
| Status | | | |
| # of Records | | | |
| Date Serviced | | | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 33 | 1.313 | 102.425 | | 101.112 | |
| BM 34 | | | 1.541 | 100.884 | |
| BM 35 | | | 1.809 | 100.616 | |
| WL | | | 4.483 | **97.942** | |
| BM 76 | 2.370 | 102.367 | 2.428 | 99.997 | |
| WL | | | 4.423 | **97.944** | |
| BM 35 | | | 1.750 | 100.617 | |
| BM 34 | | | 1.481 | 100.886 | |
| BM 33 | | | 1.254 | 101.113 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 33 | 101.112 | 101.113 | 0.001 | |
| BM 34 | 100.885 | 100.885 | 0.000 | |
| BM 35 | 100.6275 | 100.617 | -0.011 | |
| | | | | |

| Discharge Measurement ADCP | | | | | | |
|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 9:00 | End | 10:30 | Location | 50m upstream of bridge |
| Method | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | |
| Flow Meter Type | ADCP | | | | Water Temp (Therm) (°C) | |
| Instrument Model | River Ray | | | | Mean Discharge Q ($m^3/s$) | 47.8 |
| Instrument Serial# | | | | | Error (Std Dev in $m^3/s$) | 1.42 |
| Stage (m) Start | Reading | | Time | | Mean % of Q Measured | 55.7 |
| Stage (m) End | Reading | | Time | | | |
| File Location | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| MH1003 | 10.987 | 25.187 | 8.243 | 0.247 | 0.851 | 45.515 | 55.34 | 1 | 6 |
| MH1009 | 11.777 | 26.860 | 9.134 | 0.293 | 0.583 | 48.647 | 55.21 | 0 | 4 |
| MH1010 | 11.576 | 26.597 | 8.487 | 0.084 | 0.482 | 47.225 | 56.32 | 21 | 9 |
| MH1011 | 11.907 | 27.245 | 9.064 | 0.242 | 0.466 | 48.924 | 55.69 | 2 | 5 |
| MH1012 | 11.772 | 27.045 | 8.706 | 0.312 | 0.663 | 48.497 | 55.77 | 1 | 8 |
| MH1013 | 11.573 | 26.732 | 8.595 | 0.248 | 0.542 | 47.689 | 56.05 | 1 | 5 |
| **Mean** | **11.599** | **26.611** | **8.705** | **0.238** | **0.598** | **47.750** | **55.67** | **4.3** | **6.2** |

**General Notes**

| Summary | | | |
|---|---|---|---|
| Stage (m) | 97.943 | | |
| Discharge ($m^3/s$) | 47.7 | | |
| Pressure Transducer Reading (m) | 0.824 | | |
| Pressure Transducer Elevation (m) | 97.119 | | |

## Appendix 2-1b. ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH1 | | | |
| Stream Name | Murray River | | | |
| Date Monitored | 26-Sep-12 | | | |
| Time at Site (24 hr) | Start Time: | 11:30 | End Time: | 17:00 |
| Personnel | Eli Heyman, Cenling Xia | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| Weather Conditions | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2425003 |
| Gain | 10.471 | Offset | 0.0008 |
| Status | okay | Battery | 100% |
| # of Records | 21887 | Memory Free | 21574 |
| Date Serviced | 26-Sep-12 | Crest Gauges | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 33 | 1.409 | 102.521 | | 101.112 | ations wrong in survey r |
| BM 34 | | | 1.636 | 100.885 | Have adjusted them |
| BM 35 | | | 1.906 | 100.615 | |
| WL | | | 4.959 | **97.562** | |
| TBM | 4.741 | 102.454 | 4.808 | 97.713 | |
| WL | | | 4.893 | **97.561** | |
| BM 35 | | | 1.841 | 100.613 | |
| BM 34 | | | 1.571 | 100.883 | |
| BM 33 | | | 1.343 | 101.111 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 33 | 101.112 | 101.112 | -0.001 | |
| BM 34 | 100.885 | 100.884 | -0.001 | |
| BM 35 | 100.6275 | 100.614 | -0.013 | |
| | | | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 9:00 | End | 10:30 | Location | 50m upstream of bridge | | |
| Method | Velocity-area (ADCP) | | | | Water Temp (ADCP)(°C) | | | |
| Flow Meter Type | ADCP | | | | Water Temp (Therm) (°C) | | | |
| Instrument Model | River Ray | | | | Mean Discharge Q ($m^3/s$) | 20.0 | | |
| Instrument Serial# | | | | | Error (Std Dev in $m^3/s$) | 0.45 | | |
| Stage (m) Start | Reading | | Time | | Mean % of Q Measured | 71.2 | | |
| Stage (m) End | Reading | | Time | | | | | |
| File Location | N:\791 Canadian Dehua Int'l\791-007 Murray River EA\0791-007-20 Hydrology\Data and Documentation\2012\ | | | | | | | |
| | ADCP Measurements\MH1 ADCP Measurement September 26, 2012 | | | | | | | |

| Transect # | Discharge Q ($m^3/s$) | | | | | | % Q Measured | % Bad | |
|---|---|---|---|---|---|---|---|---|---|
| | Top | Mid | Bottom | Left | Right | Total Q | | Ensembles | Bins |
| MH1b008 | 2.813 | 14.333 | 2.697 | 0.096 | 0.016 | 19.955 | 71.83 | 2 | 2 |
| MH1b009 | 2.962 | 14.400 | 2.945 | 0.095 | -0.005 | 20.396 | 70.60 | 2 | 2 |
| MH1b010 | 2.894 | 13.706 | 2.666 | 0.088 | -0.005 | 19.349 | 70.84 | 8 | 4 |
| MH1b011 | 2.874 | 14.388 | 2.749 | 0.073 | 0.070 | 20.155 | 71.39 | 9 | 2 |
| | | | | | | | | | |
| Mean | **2.886** | **14.207** | **2.764** | **0.088** | **0.019** | **19.964** | **71.16** | **5.3** | **2.5** |

**General Notes**

Used transects 8-11 where computer was on the right bank and maintained a connection for the whole length of the transect.

| Summary | | | |
|---|---|---|---|
| Stage (m) | 97.562 | | |
| Discharge ($m^3/s$) | 19.96 | | |
| Pressure Transducer Reading (m) | 0.418 | | |
| Pressure Transducer Elevation (m) | 97.143 | | |

## Appendix 2-1b. ADCP Discharge Measurements and Levelling Surveys at MH-1 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH1 | | | |
| **Stream Name** | Murray River | | | |
| **Date Monitored** | 7-Nov-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 13:30 | **End Time:** | 16:00 |
| **Personnel** | Eli Heyman, Arnold | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626076 | 6097287 | 763 | |
| **Weather Conditions** | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2425003 |
| **Gain** | 10.471 | **Offset** | 0.0008 |
| **Status** | okay | **Battery** | 100% |
| **# of Records** | 27946 | **Memory Free** | 18540 |
| **Date Serviced** | 7-Nov-12 | **Crest Gauges** | no |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 33 | 1.411 | 102.523 | | 101.112 | |
| BM 34 | | | 1.638 | 100.885 | |
| BM 35 | | | 1.908 | 100.615 | |
| WL | | | 4.191 | **98.332** | |
| BM 76 | 2.763 | 102.441 | 2.845 | 99.678 | |
| WL | | | | | Use first measurement |
| BM 35 | | | 1.827 | 100.614 | |
| BM 34 | | | 1.557 | 100.884 | |
| BM 33 | | | 1.330 | 101.111 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 33 | 101.112 | 101.112 | 0.000 | |
| BM 34 | 100.885 | 100.885 | 0.000 | |
| BM 35 | 100.6275 | 100.615 | -0.013 | |
| | | | | |

| Discharge Measurement ADCP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | | **End** | | **Location** | Not taken due to floating ice | | |
| **Method** | No ADCP ischarge Measurement | | | | **Water Temp (ADCP)(°C)** | | | |
| **Flow Meter Type** | | | | | **Water Temp (Therm) (°C)** | | | |
| **Instrument Model** | | | | | **Mean Discharge Q ($m^3/s$)** | | | |
| **Instrument Serial#** | | | | | **Error (Std Dev in $m^3/s$)** | | | |
| **Stage (m)** | **Start** | **Reading** | | **Time** | | **Mean % of Q Measured** | | |
| | **End** | **Reading** | | **Time** | | | | |
| **File Location** | | | | | | | | |

**Manual Discharge Measurment**

NO ADCP Measurement taken on this date.

**General Notes**

No ADCP Measurement taken on this date due to large amounts of floating ice on the river.

Carried out a manual measurement by timing floating ice in the thalweg over a distance of 30m downstream of the Murray River FSR Brideg

Large ice-jam that spans entire river downstream of the station likely causing backwater effect at station location

| Summary | | Notes |
|---|---|---|
| **Stage (m)** | 98.332 | |
| **Discharge ($m^3/s$)** | | No ADCP Measurement due to floating ice |
| **Pressure Transducer Reading (m)** | 1.216 | |
| **Pressure Transducer Elevation (m)** | 97.116 | |

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 15-Mar-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 2:00:00 PM | **End Time:** | 17:00 |
| **Personnel** | Craig Hatt, Vern Solonas | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 61 | 0.830 | 100.655 | | 99.825 | Nail in tree |
| BM 60 | | | 1.151 | 99.504 | Nail in tree |
| BM 59 | | | 1.038 | 99.617 | Nail in tree |
| WL | | | 2.573 | 98.082 | |
| BM 60 | 1.135 | 100.639 | | **99.504** | |
| WL | | | 2.553 | 98.086 | |
| BM 61 | | | 0.815 | **99.824** | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.825 | | |
| BM 60 | | 99.504 | | |
| BM 59 | | 99.617 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.084 |
| **Discharge ($m^3/s$)** | 0.0344 |
| **Pressure Transducer Reading (m)** | 0.091 |
| **Pressure Transducer Elevation (m)** | 97.993 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:25 | **End** | 14:45 | **Location** | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.091 | **Time** | 14:25 | | | |
| | **End** | **Reading** | | **Time** | 14:45 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| left bank | 2.70 | 0.00 | 0.15 | 0.00 | 0 | | | 0.0002 | 0.5 |
| | 3.00 | 0.03 | 0.25 | 0.01 | 0.1 | | | 0.0006 | 1.8 |
| | 3.20 | 0.03 | 0.20 | 0.01 | -0.03 | | | -0.0002 | -0.5 |
| | 3.40 | 0.05 | 0.20 | 0.01 | 0.09 | | | 0.0009 | 2.6 |
| | 3.60 | 0.03 | 0.20 | 0.01 | 0.14 | | | 0.0008 | 2.4 |
| | 3.80 | 0.06 | 0.20 | 0.01 | 0.23 | | | 0.0028 | 8.0 |
| | 4.00 | 0.05 | 0.20 | 0.01 | 0.21 | | | 0.0021 | 6.1 |
| | 4.20 | 0.07 | 0.20 | 0.01 | 0.01 | | | 0.0001 | 0.4 |
| | 4.40 | 0.10 | 0.20 | 0.02 | 0.02 | | | 0.0004 | 1.2 |
| | 4.60 | 0.11 | 0.15 | 0.02 | 0.02 | | | 0.0003 | 1.0 |
| | 4.70 | 0.11 | 0.10 | 0.01 | 0.16 | | | 0.0018 | 5.1 |
| | 4.80 | 0.13 | 0.10 | 0.01 | 0.2 | | | 0.0026 | 7.6 |
| | 4.90 | 0.13 | 0.10 | 0.01 | 0.07 | | | 0.0009 | 2.6 |
| | 5.00 | 0.15 | 0.10 | 0.01 | 0.08 | | | 0.0012 | 3.5 |
| | 5.10 | 0.15 | 0.10 | 0.02 | 0.32 | | | 0.0048 | 13.9 |
| | 5.20 | 0.13 | 0.10 | 0.01 | 0.05 | | | 0.0007 | 1.9 |
| | 5.30 | 0.08 | 0.10 | 0.01 | 0.47 | | | 0.0038 | 10.9 |
| | 5.40 | 0.10 | 0.10 | 0.01 | 0.32 | | | 0.0032 | 9.3 |
| | 5.50 | 0.10 | 0.10 | 0.01 | 0.34 | | | 0.0034 | 9.9 |
| | 5.60 | 0.10 | 0.10 | 0.01 | 0.09 | | | 0.0009 | 2.6 |
| | 5.70 | 0.10 | 0.10 | 0.01 | 0 | | | 0.0000 | 0.0 |
| | 5.80 | 0.07 | 0.10 | 0.01 | 0.1 | | | 0.0007 | 2.0 |
| | 5.90 | 0.06 | 0.10 | 0.01 | 0.15 | | | 0.0009 | 2.6 |
| | 6.00 | 0.07 | 0.10 | 0.01 | 0.07 | | | 0.0005 | 1.4 |
| | 6.10 | 0.06 | 0.10 | 0.01 | 0.06 | | | 0.0004 | 1.0 |
| | 6.20 | 0.04 | 0.30 | 0.01 | 0.04 | | | 0.0005 | 1.4 |
| right bank (est., ice) | 6.70 | 0.00 | 0.25 | 0.01 | 0 | | | 0.0002 | 0.6 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0344** | **100.0** |

**General Notes**

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 15-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 2:00:00 PM | **End Time:** | 17:00 |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 61 | 1.110 | 100.935 | | 99.825 | Nail in tree |
| BM 60 | | | 1.446 | 99.489 | Nail in tree |
| BM 59 | | | 1.373 | 99.562 | Nail in tree |
| BM 4 | | | 0.935 | 100.000 | Nail in tree |
| WL | | | 2.441 | **98.494** | |
| BM 60 | 1.455 | 100.944 | | 99.489 | |
| BM 59 | | | 1.384 | 99.560 | |
| BM 4 | | | 0.948 | 99.996 | |
| WL | | | 2.429 | **98.515** | Error, use first |
| BM 61 | | | 1.123 | 99.821 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.823 | | |
| BM 60 | | 99.489 | | |
| BM 59 | | 99.561 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.494 |
| **Mean Discharge ($m^3/s$)** | 2.130 |
| **Pressure Transducer Reading (m)** | 0.544 |
| **Pressure Transducer Elevation (m)** | 97.950 |

**Discharge Measurement - Mid-Section Method (5/15/11 #1)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:20 | **End** | 14:40 | **Location** | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | | |
| **Stage (m)** | **Start** | **Reading** | 0.544 | **Time** | 14:20 | Measurement #1 | |
| | **End** | **Reading** | | **Time** | 14:45 | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | (m/s) | (m/s) | | % |
| Right Bank | 2.65 | 0.00 | 0.23 | 0.009 | 0.00 | 0.00 | 0.000 | 0.0 |
| | 3.10 | 0.08 | 0.43 | 0.03 | 0.07 | 0.07 | 0.002 | 0.1 |
| | 3.50 | 0.18 | 0.40 | 0.07 | 1.07 | 0.74 | 0.052 | 2.7 |
| | 3.90 | 0.37 | 0.40 | 0.15 | 1.23 | 0.85 | 0.128 | 6.4 |
| | 4.30 | 0.40 | 0.40 | 0.16 | 1.28 | 0.89 | 0.142 | 7.2 |
| | 4.70 | 0.48 | 0.40 | 0.19 | 1.64 | 1.13 | 0.215 | 11.0 |
| | 5.10 | 0.52 | 0.40 | 0.21 | 1.47 | 1.02 | 0.213 | 10.7 |
| | 5.50 | 0.36 | 0.40 | 0.14 | 2.10 | 1.44 | 0.202 | 10.5 |
| | 5.90 | 0.40 | 0.40 | 0.16 | 1.94 | 1.33 | 0.213 | 10.8 |
| | 6.30 | 0.41 | 0.40 | 0.16 | 1.52 | 1.05 | 0.168 | 8.7 |
| | 6.70 | 0.35 | 0.40 | 0.14 | 0.92 | 0.64 | 0.090 | 4.6 |
| | 7.10 | 0.29 | 0.40 | 0.12 | 1.84 | 1.27 | 0.152 | 7.4 |
| | 7.50 | 0.33 | 0.40 | 0.13 | 1.32 | 0.91 | 0.119 | 6.1 |
| | 7.90 | 0.20 | 0.40 | 0.08 | 0.68 | 0.48 | 0.038 | 2.0 |
| | 8.30 | 0.15 | 0.40 | 0.06 | 0.41 | 0.30 | 0.018 | 0.9 |
| | 8.70 | 0.11 | 0.40 | 0.04 | 0.69 | 0.49 | 0.020 | 1.1 |
| | 9.10 | 0.10 | 0.40 | 0.04 | 0.55 | 0.39 | 0.016 | 0.8 |
| | 9.50 | 0.11 | 0.40 | 0.04 | 1.05 | 0.73 | 0.029 | 1.6 |
| | 9.90 | 0.14 | 0.40 | 0.06 | 1.04 | 0.72 | 0.043 | 2.1 |
| | 10.30 | 0.11 | 0.40 | 0.04 | 0.76 | 0.54 | 0.021 | 1.2 |
| | 10.70 | 0.12 | 0.40 | 0.05 | 0.79 | 0.56 | 0.028 | 1.4 |
| | 11.10 | 0.12 | 0.40 | 0.05 | 0.57 | 0.41 | 0.020 | 1.0 |
| | 11.50 | 0.09 | 0.40 | 0.04 | 0.24 | 0.18 | 0.007 | 0.3 |
| | 11.90 | 0.10 | 0.50 | 0.05 | 0.54 | 0.39 | 0.019 | 1.0 |
| Left Bank | 12.50 | 0.00 | 0.30 | 0.02 | 0.00 | 0.00 | 0.000 | 0.3 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **1.956** | **100.0** |

**General Notes**

Use average of two discharge measurements

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 15-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 2:00:00 PM | **End Time:** | 17:00 |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 61 | 1.110 | 100.935 | | 99.825 | Nail in tree |
| BM 60 | | | 1.446 | 99.489 | Nail in tree |
| BM 59 | | | 1.373 | 99.562 | Nail in tree |
| BM 4 | | | 0.935 | 100.000 | Nail in tree |
| WL | | | 2.441 | **98.494** | |
| BM 60 | 1.455 | 100.944 | | 99.489 | |
| BM 59 | | | 1.384 | 99.560 | |
| BM 4 | | | 0.948 | 99.996 | |
| WL | | | 2.429 | **98.515** | error, use first |
| BM 61 | | | 1.123 | 99.821 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.823 | | |
| BM 60 | | 99.489 | | |
| BM 59 | | 99.561 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.494 |
| **Mean Discharge ($m^3/s$)** | 2.130 |
| **Pressure Transducer Reading (m)** | 0.544 |
| **Pressure Transducer Elevation (m)** | 97.950 |

| Discharge Measurement - Mid-Section Method (5/15/11 #2) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:20 | **End** | 14:40 | **Location** | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.544 | **Time** | 14:20 | Measurement #2 | | |
| | **End** | **Reading** | | **Time** | 14:45 | | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | (m/s) | (m/s) | | % |
| Left Bank | 12.50 | 0.00 | 0.15 | 0.005 | 0.00 | 0.00 | 0.000 | 0.0 |
| | 12.20 | 0.07 | 0.40 | 0.03 | 0.13 | 0.11 | 0.003 | 0.1 |
| | 11.70 | 0.11 | 0.45 | 0.05 | 0.31 | 0.23 | 0.011 | 0.5 |
| | 11.30 | 0.08 | 0.40 | 0.03 | 0.82 | 0.58 | 0.018 | 0.8 |
| | 10.90 | 0.15 | 0.40 | 0.06 | 0.87 | 0.61 | 0.037 | 1.6 |
| | 10.50 | 0.16 | 0.40 | 0.06 | 0.55 | 0.39 | 0.025 | 1.1 |
| | 10.10 | 0.15 | 0.40 | 0.06 | 0.44 | 0.32 | 0.019 | 0.8 |
| | 9.70 | 0.12 | 0.40 | 0.05 | 0.66 | 0.47 | 0.022 | 1.0 |
| | 9.30 | 0.13 | 0.40 | 0.05 | 0.70 | 0.49 | 0.026 | 1.1 |
| | 8.90 | 0.12 | 0.40 | 0.05 | 0.77 | 0.54 | 0.026 | 1.1 |
| | 8.50 | 0.13 | 0.40 | 0.05 | 0.55 | 0.39 | 0.020 | 0.9 |
| | 8.10 | 0.20 | 0.40 | 0.08 | 1.03 | 0.72 | 0.057 | 2.5 |
| | 7.70 | 0.26 | 0.40 | 0.10 | 0.94 | 0.66 | 0.068 | 3.0 |
| | 7.30 | 0.25 | 0.40 | 0.10 | 1.76 | 1.21 | 0.121 | 5.3 |
| | 6.90 | 0.35 | 0.40 | 0.14 | 1.74 | 1.20 | 0.168 | 7.3 |
| | 6.50 | 0.40 | 0.40 | 0.16 | 1.83 | 1.26 | 0.201 | 8.8 |
| | 6.10 | 0.38 | 0.40 | 0.15 | 2.32 | 1.59 | 0.242 | 10.6 |
| | 5.70 | 0.37 | 0.40 | 0.15 | 2.11 | 1.45 | 0.214 | 9.4 |
| | 5.30 | 0.42 | 0.40 | 0.17 | 2.47 | 1.69 | 0.284 | 12.5 |
| | 4.90 | 0.50 | 0.40 | 0.20 | 1.79 | 1.23 | 0.246 | 10.8 |
| | 4.50 | 0.45 | 0.40 | 0.18 | 2.06 | 1.41 | 0.255 | 11.2 |
| | 4.10 | 0.37 | 0.40 | 0.15 | 1.08 | 0.75 | 0.111 | 4.9 |
| | 3.70 | 0.29 | 0.40 | 0.12 | 1.22 | 0.85 | 0.098 | 4.3 |
| | 3.30 | 0.15 | 0.53 | 0.08 | 0.06 | 0.06 | 0.005 | 0.2 |
| Right Bank | 2.65 | 0.00 | 0.33 | 0.02 | 0.00 | 0.00 | 0.000 | 0.1 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **2.280** | **100.0** |

| General Notes |
|---|
| Use average of two discharge measurements |

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 2-Jul-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 3:30:00 PM | **End Time:** | 5:30:00 PM |
| **Personnel** | Craig Hatt, assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 61 | 1.038 | 100.866 | | 99.828 | Nail in tree |
| BM 4 | | | 0.866 | 100.000 | Nail in tree |
| BM 59 | | | 1.300 | 99.566 | Nail in tree |
| WL 1 | | | 2.717 | 98.149 | Submerged 0.56 (Old) |
| WL 2 | | | 2.711 | **98.155** | Submerged 0.35 (New) |
| BM 4 | 0.852 | 100.852 | | 100.000 | |
| BM 59 | | | 1.287 | 99.565 | |
| WL 1 | | | 2.705 | 98.147 | Submerged 0.55 (Old) |
| WL 2 | | | 2.700 | **98.152** | Submerged 0.35 (New) |
| BM 61 | | | 1.024 | 99.828 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.828 | | |
| BM 4 | | 100.000 | | |
| BM 59 | | 99.566 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.148 |
| **Discharge ($m^3/s$)** | 0.833 |
| **Pressure Transducer Reading (m)** | 0.408 |
| **Pressure Transducer Elevation (m)** | 97.740 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 16:00 | **End** | 16:30 | **Location** | | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | 2000 | | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.408 | **Time** | 16:00 | | | | |
| | **End** | **Reading** | | **Time** | 16:30 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| Left Bank | 4.40 | 0.00 | 0.10 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 4.60 | 0.04 | 0.20 | 0.01 | 0.17 | | | 0.001 | 0.2 |
| 0.2 | 4.80 | 0.10 | 0.20 | 0.02 | 0.23 | | | 0.005 | 0.6 |
| | 5.00 | 0.12 | 0.20 | 0.02 | 0.48 | | | 0.012 | 1.4 |
| | 5.20 | 0.16 | 0.20 | 0.03 | 0.69 | | | 0.022 | 2.6 |
| | 5.40 | 0.10 | 0.20 | 0.02 | 0.74 | | | 0.015 | 1.8 |
| | 5.60 | 0.16 | 0.20 | 0.03 | 0.59 | | | 0.019 | 2.3 |
| | 5.80 | 0.21 | 0.20 | 0.04 | 0.84 | | | 0.035 | 4.2 |
| | 6.00 | 0.25 | 0.20 | 0.05 | 0.73 | | | 0.036 | 4.4 |
| | 6.20 | 0.26 | 0.20 | 0.05 | 0.76 | | | 0.040 | 4.7 |
| | 6.40 | 0.26 | 0.20 | 0.05 | 0.49 | | | 0.025 | 3.1 |
| | 6.60 | 0.30 | 0.20 | 0.06 | 0.81 | | | 0.049 | 5.8 |
| | 6.80 | 0.28 | 0.20 | 0.06 | 0.86 | | | 0.048 | 5.8 |
| | 7.00 | 0.30 | 0.20 | 0.06 | 1.13 | | | 0.068 | 8.1 |
| | 7.20 | 0.34 | 0.20 | 0.07 | 0.76 | | | 0.052 | 6.2 |
| | 7.40 | 0.33 | 0.20 | 0.07 | 0.82 | | | 0.054 | 6.5 |
| | 7.60 | 0.26 | 0.18 | 0.05 | 1.02 | | | 0.046 | 5.6 |
| | 7.75 | 0.32 | 0.15 | 0.05 | 1.11 | | | 0.053 | 6.4 |
| | 7.90 | 0.31 | 0.15 | 0.05 | 1.07 | | | 0.050 | 6.0 |
| | 8.05 | 0.30 | 0.15 | 0.05 | 1.12 | | | 0.050 | 6.0 |
| | 8.20 | 0.33 | 0.15 | 0.05 | 1.02 | | | 0.050 | 6.1 |
| | 8.35 | 0.33 | 0.15 | 0.05 | 0.62 | | | 0.031 | 3.7 |
| | 8.50 | 0.33 | 0.17 | 0.06 | 0.41 | | | 0.024 | 2.8 |
| | 8.70 | 0.30 | 0.20 | 0.06 | 0.67 | | | 0.040 | 4.8 |
| 0.35 | 8.90 | 0.14 | 0.20 | 0.03 | 0.22 | | | 0.006 | 0.7 |
| CF = | 9.10 | 0.10 | 0.2 | 0.02 | 0.1 | | | 0.002 | 0.2 |
| Left Bank | 9.30 | 0.00 | 0.1 | 0.01 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.833** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 6-Aug-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 5:00:00 PM | **End Time:** | 6:45:00 PM |
| **Personnel** | Craig Hatt, assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 61 | 1.034 | 100.861 | | 99.827 | |
| BM 4 | | | 0.861 | 100.000 | |
| BM 59 | | | 1.298 | 99.563 | |
| WL 1 | | | 2.842 | 98.019 | Before movng transducer |
| WL 2 | | | 2.830 | **98.031** | After Moving transducer |
| BM 4 | 0.860 | 100.860 | | 100.000 | |
| BM 59 | | | 1.297 | 99.563 | |
| WL 2 | | | 2.829 | **98.031** | |
| WL 1 | | | 2.843 | 98.017 | |
| BM 61 | | | 1.033 | 99.827 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.827 | | |
| BM 4 | | 100.000 | | |
| BM 59 | | 99.563 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.031 |
| **Discharge ($m^3/s$)** | 0.238 |
| **Pressure Transducer Reading (m)** | 0.289 |
| **Pressure Transducer Elevation (m)** | 97.742 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 17:10 | **End** | 17:35 | **Location** | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | 2000 | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | |
| **Stage (m)** | **Start** | **Reading** | 0.289 | **Time** | 17:10 | | |
| | **End** | **Reading** | | **Time** | 17:35 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| Right Bank | 1.65 | 0.00 | 0.08 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 1.80 | 0.08 | 0.15 | 0.01 | -0.02 | | | 0.000 | -0.1 |
| 1 | 1.95 | 0.12 | 0.15 | 0.02 | 0.11 | | | 0.002 | 0.8 |
| | 2.10 | 0.16 | 0.15 | 0.02 | 0.06 | | | 0.001 | 0.6 |
| | 2.25 | 0.15 | 0.15 | 0.02 | 0.2 | | | 0.005 | 1.9 |
| | 2.40 | 0.06 | 0.15 | 0.01 | 0.29 | | | 0.003 | 1.1 |
| | 2.55 | 0.21 | 0.15 | 0.03 | 0.34 | | | 0.011 | 4.5 |
| | 2.70 | 0.20 | 0.15 | 0.03 | 0.36 | | | 0.011 | 4.5 |
| | 2.85 | 0.28 | 0.11 | 0.03 | 0.36 | | | 0.011 | 4.8 |
| | 2.93 | 0.28 | 0.08 | 0.02 | 0.44 | | | 0.009 | 3.9 |
| | 3.00 | 0.27 | 0.11 | 0.03 | 0.5 | | | 0.015 | 6.4 |
| | 3.15 | 0.26 | 0.15 | 0.04 | 0.57 | | | 0.022 | 9.4 |
| | 3.30 | 0.27 | 0.11 | 0.03 | 0.62 | | | 0.019 | 7.9 |
| | 3.38 | 0.29 | 0.08 | 0.02 | 0.56 | | | 0.012 | 5.1 |
| | 3.45 | 0.28 | 0.08 | 0.02 | 0.2 | | | 0.004 | 1.8 |
| | 3.53 | 0.29 | 0.08 | 0.02 | 0.21 | | | 0.005 | 1.9 |
| | 3.60 | 0.31 | 0.11 | 0.03 | 0.34 | | | 0.012 | 5.0 |
| | 3.75 | 0.25 | 0.15 | 0.04 | 0.47 | | | 0.018 | 7.4 |
| | 3.90 | 0.34 | 0.15 | 0.05 | 0.36 | | | 0.018 | 7.7 |
| | 4.05 | 0.33 | 0.15 | 0.05 | 0.35 | | | 0.017 | 7.3 |
| | 4.20 | 0.36 | 0.15 | 0.05 | 0.25 | | | 0.014 | 5.7 |
| | 4.35 | 0.36 | 0.15 | 0.05 | 0.19 | | | 0.010 | 4.3 |
| | 4.50 | 0.30 | 0.15 | 0.05 | 0.14 | | | 0.006 | 2.7 |
| | 4.65 | 0.32 | 0.15 | 0.05 | 0.12 | | | 0.006 | 2.4 |
| | 4.80 | 0.18 | 0.15 | 0.03 | 0.13 | | | 0.004 | 1.5 |
| 1 | 4.95 | 0.20 | 0.2 | 0.03 | 0.08 | | | 0.002 | 1.0 |
| CF = | 5.10 | 0.16 | 0.2 | 0.02 | 0.04 | | | 0.001 | 0.4 |
| Left Bank | 5.25 | 0.00 | 0.1 | 0.01 | 0 | | | 0.000 | 0.1 |
| **Total Q** | | | | | | | | **0.238** | **100.0** |

**General Notes**

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-2 | | | |
| Stream Name | Lower Camp Creek | | | |
| Date Monitored | 5-Sep-11 | | | |
| Time at Site (24 hr) | Start Time: | 1:50:00 PM | End Time: | 3:00:00 PM |
| Personnel | Craig Hatt, assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2721018 |
| Gain | 3.5161 | Offset | -0.0067 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 4 | 0.872 | 100.872 | | 100.000 | |
| BM 61 | | | 1.044 | 99.828 | |
| BM 59 | | | 1.305 | 99.567 | |
| WL 1 | | | 2.923 | **97.949** | |
| WL 2 | | | 2.943 | **97.946** | |
| BM 59 | 1.322 | 100.889 | | 99.567 | |
| BM 61 | | | 1.060 | 99.829 | |
| BM 4 | | | 0.888 | 100.001 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.829 | | |
| BM 4 | | 100.001 | | |
| BM 59 | | 99.567 | | |

| Summary | |
|---|---|
| Stage (m) | 97.948 |
| Discharge ($m^3/s$) | 0.064 |
| Pressure Transducer Reading (m) | 0.217 |
| Pressure Transducer Elevation (m) | 97.731 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:50 | End | 14:35 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.217 | Time | 13:50 | | | | |
| | End | Reading | | Time | 14:35 | | | | |
| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| Right Bank | 0.45 | 0.00 | 0.08 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 0.60 | 0.04 | 0.20 | 0.01 | 0.01 | | | 0.000 | 0.1 |
| 1 | 0.85 | 0.08 | 0.15 | 0.01 | 0.01 | | | 0.000 | 0.2 |
| | 0.90 | 0.11 | 0.10 | 0.01 | 0.05 | | | 0.001 | 0.8 |
| | 1.05 | 0.14 | 0.15 | 0.02 | 0.05 | | | 0.001 | 1.6 |
| | 1.20 | 0.20 | 0.15 | 0.03 | 0.08 | | | 0.002 | 3.7 |
| | 1.35 | 0.19 | 0.11 | 0.02 | 0.14 | | | 0.003 | 4.6 |
| | 1.43 | 0.22 | 0.08 | 0.02 | 0.19 | | | 0.003 | 4.8 |
| | 1.50 | 0.20 | 0.08 | 0.02 | 0.24 | | | 0.004 | 5.6 |
| | 1.58 | 0.22 | 0.08 | 0.02 | 0.29 | | | 0.005 | 7.4 |
| | 1.65 | 0.22 | 0.08 | 0.02 | 0.31 | | | 0.005 | 7.9 |
| | 1.73 | 0.22 | 0.08 | 0.02 | 0.29 | | | 0.005 | 7.4 |
| | 1.80 | 0.29 | 0.08 | 0.02 | 0.19 | | | 0.004 | 6.4 |
| | 1.88 | 0.28 | 0.08 | 0.02 | 0.15 | | | 0.003 | 4.9 |
| | 1.95 | 0.26 | 0.08 | 0.02 | 0.17 | | | 0.003 | 5.1 |
| | 2.03 | 0.25 | 0.08 | 0.02 | 0.15 | | | 0.003 | 4.3 |
| | 2.10 | 0.28 | 0.08 | 0.02 | 0.17 | | | 0.004 | 5.5 |
| | 2.18 | 0.25 | 0.08 | 0.02 | 0.16 | | | 0.003 | 4.6 |
| | 2.25 | 0.30 | 0.11 | 0.03 | 0.13 | | | 0.004 | 6.8 |
| | 2.40 | 0.28 | 0.15 | 0.04 | 0.1 | | | 0.004 | 6.5 |
| | 2.55 | 0.30 | 0.15 | 0.05 | 0.05 | | | 0.002 | 3.5 |
| | 2.70 | 0.26 | 0.15 | 0.04 | 0.05 | | | 0.002 | 3.0 |
| | 2.85 | 0.22 | 0.15 | 0.03 | 0.05 | | | 0.002 | 2.5 |
| | 3.00 | 0.20 | 0.15 | 0.03 | 0.04 | | | 0.001 | 1.9 |
| 1 | 3.15 | 0.12 | 0.15 | 0.02 | 0.01 | | | 0.000 | 0.3 |
| CF = | 3.30 | 0.10 | 0.2 | 0.02 | 0.02 | | | 0.000 | 0.5 |
| Left Bank | 3.50 | 0.00 | 0.1 | 0.00 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.064** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-2 | | | |
| Stream Name | Lower Camp Creek | | | |
| Date Monitored | 17-Oct-11 | | | |
| Time at Site (24 hr) | Start Time: | 10:00:00 AM | End Time: | 12:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2721018 |
| Gain | 3.5161 | Offset | -0.0067 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 4 | 0.847 | 100.847 | | 100.000 | |
| BM 61 | | | 1.018 | 99.829 | |
| BM 59 | | | 1.280 | 99.567 | |
| WL 1 | | | 2.914 | **97.933** | |
| WL 1 | | | 2.860 | 97.934 | |
| BM 61 | 0.965 | 100.794 | | **99.829** | |
| BM 59 | | | 1.227 | 99.567 | |
| BM 4 | | | 0.793 | 100.001 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.829 | | |
| BM 4 | | 100.001 | | |
| BM 59 | | 99.567 | | |

| Summary | | |
|---|---|---|
| Stage (m) | 97.934 | |
| Discharge ($m^3/s$) | 0.048 | |
| Pressure Transducer Reading (m) | 0.215 | Manual measurement |
| Pressure Transducer Elevation (m) | 97.719 | |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:36 | End | 14:01 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.215 | Time | 13:36 | | | | |
| | End | Reading | | Time | 14:01 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| Right Bank | 1.88 | 0.00 | 0.14 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 2.15 | 0.06 | 0.21 | 0.01 | -0.02 | | | 0.000 | -0.6 |
| 1 | 2.30 | 0.14 | 0.15 | 0.02 | 0 | | | 0.000 | 0.0 |
| | 2.45 | 0.18 | 0.15 | 0.03 | 0.03 | | | 0.001 | 1.8 |
| | 2.60 | 0.20 | 0.15 | 0.03 | 0.03 | | | 0.001 | 2.0 |
| | 2.75 | 0.20 | 0.15 | 0.03 | 0.06 | | | 0.002 | 4.0 |
| | 2.90 | 0.24 | 0.10 | 0.02 | 0.16 | | | 0.004 | 8.6 |
| | 2.95 | 0.24 | 0.05 | 0.01 | 0.19 | | | 0.002 | 5.1 |
| | 3.00 | 0.26 | 0.05 | 0.01 | 0.22 | | | 0.003 | 6.4 |
| | 3.05 | 0.25 | 0.05 | 0.01 | 0.24 | | | 0.003 | 6.7 |
| | 3.10 | 0.26 | 0.05 | 0.01 | 0.24 | | | 0.003 | 7.0 |
| | 3.15 | 0.26 | 0.05 | 0.01 | 0.23 | | | 0.003 | 6.7 |
| | 3.20 | 0.26 | 0.05 | 0.01 | 0.2 | | | 0.003 | 5.8 |
| | 3.25 | 0.27 | 0.05 | 0.01 | 0.19 | | | 0.003 | 5.7 |
| | 3.30 | 0.27 | 0.05 | 0.01 | 0.19 | | | 0.003 | 5.7 |
| | 3.35 | 0.27 | 0.05 | 0.01 | 0.16 | | | 0.002 | 4.8 |
| | 3.40 | 0.26 | 0.05 | 0.01 | 0.17 | | | 0.002 | 4.9 |
| | 3.45 | 0.23 | 0.05 | 0.01 | 0.19 | | | 0.002 | 4.9 |
| | 3.50 | 0.24 | 0.05 | 0.01 | 0.15 | | | 0.002 | 4.0 |
| | 3.55 | 0.25 | 0.05 | 0.01 | 0.12 | | | 0.002 | 3.3 |
| | 3.60 | 0.26 | 0.08 | 0.02 | 0.1 | | | 0.002 | 4.4 |
| | 3.70 | 0.28 | 0.10 | 0.03 | 0.03 | | | 0.001 | 1.9 |
| | 3.80 | 0.29 | 0.13 | 0.04 | 0.02 | | | 0.001 | 1.6 |
| | 3.95 | 0.22 | 0.15 | 0.03 | 0.05 | | | 0.002 | 3.7 |
| | 4.10 | 0.24 | 0.15 | 0.04 | 0.02 | | | 0.001 | 1.6 |
| | 4.25 | 0.20 | 0.2 | 0.03 | 0 | | | 0.000 | 0.0 |
| | 4.40 | 0.08 | 0.2 | 0.01 | -0.02 | | | 0.000 | -0.5 |
| 1 | 4.55 | 0.10 | 0.2 | 0.02 | 0 | | | 0.000 | 0.0 |
| CF = | 4.70 | 0.16 | 0.1 | 0.02 | 0.01 | | | 0.000 | 0.4 |
| Left Bank | 4.80 | 0.00 | 0.1 | 0.00 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.048** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-2a. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 17-Nov-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 1:00:00 PM | **End Time:** | 3:00:00 PM |
| **Personnel** | Craig Hatt, Max Taylor | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 626256 | 6097951 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 4 | 0.852 | 100.852 | | 100.000 | |
| BM 61 | | | 1.025 | 99.827 | |
| BM 59 | | | 1.283 | 99.569 | |
| WL | | | 2.836 | **98.016** | |
| BM 61 | 1.017 | 100.844 | | 99.827 | |
| WL | | | 2.831 | **98.013** | |
| BM 59 | | | 1.277 | 99.567 | |
| BM 4 | | | 0.845 | 99.999 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 61 | | 99.827 | | |
| BM 4 | | 100.000 | | |
| BM 59 | | 99.568 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.015 |
| **Discharge ($m^3/s$)** | 0.047 |
| **Pressure Transducer Reading (m)** | 0.285 |
| **Pressure Transducer Elevation (m)** | 97.730 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:36 | **End** | 14:01 | **Location** | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | 2000 | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | |
| **Stage (m)** | **Start** | **Reading** | 0.285 | **Time** | 13:36 | | |
| | **End** | **Reading** | | **Time** | 14:01 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| Right Bank | 2.10 | 0.00 | 0.10 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 2.30 | 0.16 | 0.15 | 0.02 | 0.02 | | | 0.000 | 1.1 |
| 1 | 2.40 | 0.16 | 0.10 | 0.02 | 0.04 | | | 0.001 | 1.4 |
| | 2.50 | 0.20 | 0.10 | 0.02 | 0.03 | | | 0.001 | 1.4 |
| | 2.60 | 0.22 | 0.10 | 0.02 | 0 | | | 0.000 | 0.0 |
| | 2.70 | 0.24 | 0.10 | 0.02 | -0.02 | | | 0.000 | -1.1 |
| | 2.80 | 0.28 | 0.10 | 0.03 | -0.01 | | | 0.000 | -0.6 |
| | 2.90 | 0.30 | 0.10 | 0.03 | 0.05 | | | 0.002 | 3.4 |
| | 3.00 | 0.28 | 0.10 | 0.03 | 0.11 | | | 0.003 | 7.0 |
| | 3.10 | 0.28 | 0.08 | 0.02 | 0.17 | | | 0.004 | 8.1 |
| | 3.15 | 0.26 | 0.05 | 0.01 | 0.21 | | | 0.003 | 6.2 |
| | 3.20 | 0.26 | 0.05 | 0.01 | 0.27 | | | 0.004 | 7.9 |
| | 3.25 | 0.28 | 0.05 | 0.01 | 0.29 | | | 0.004 | 9.2 |
| | 3.30 | 0.29 | 0.05 | 0.01 | 0.3 | | | 0.004 | 9.8 |
| | 3.35 | 0.28 | 0.05 | 0.01 | 0.29 | | | 0.004 | 9.2 |
| | 3.40 | 0.22 | 0.05 | 0.01 | 0.3 | | | 0.003 | 7.5 |
| | 3.45 | 0.22 | 0.05 | 0.01 | 0.18 | | | 0.002 | 4.5 |
| | 3.50 | 0.22 | 0.08 | 0.02 | 0.13 | | | 0.002 | 4.9 |
| | 3.60 | 0.22 | 0.10 | 0.02 | 0.06 | | | 0.001 | 3.0 |
| | 3.70 | 0.20 | 0.10 | 0.02 | 0.05 | | | 0.001 | 2.3 |
| | 3.80 | 0.18 | 0.10 | 0.02 | 0.04 | | | 0.001 | 1.6 |
| | 3.90 | 0.18 | 0.10 | 0.02 | 0.06 | | | 0.001 | 2.4 |
| | 4.00 | 0.25 | 0.10 | 0.03 | 0.1 | | | 0.003 | 5.7 |
| | 4.10 | 0.20 | 0.10 | 0.02 | 0.09 | | | 0.002 | 4.1 |
| | 4.20 | 0.22 | 0.10 | 0.02 | 0.06 | | | 0.001 | 3.0 |
| 1 | 4.30 | 0.18 | 0.1 | 0.02 | -0.02 | | | 0.000 | -0.8 |
| CF = | 4.40 | 0.18 | 0.1 | 0.02 | -0.02 | | | 0.000 | -1.0 |
| Left Bank | 4.55 | 0.00 | 0.1 | 0.00 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.047** | **100.0** |

**General Notes**

**Appendix 2-2b. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2012**

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Camp Creek | | | |
| **Date Monitored** | 26-Apr-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 11:00:00 AM | **End Time:** | |
| **Personnel** | Craig Hatt, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Overcast, Temp: 6.1 degC | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | 26-Apr-12 | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 16 | 0.917 | 100.917 | | 100.000 | Nail in tree |
| BM 15 | | | 1.047 | 99.870 | Nail in tree |
| BM 14 | | | 0.890 | 100.027 | Nail in tree |
| PT | | | 3.960 | 96.957 | .-2.5 cm under pipe |
| WL | | | 3.595 | **97.322** | 15:00 PDT |
| TBM | 3.077 | 100.943 | 3.051 | 97.866 | |
| WL | | | 3.619 | **97.324** | |
| PT | | | 3.987 | 96.956 | |
| BM 14 | | | 0.917 | 100.026 | |
| BM 15 | | | 1.073 | 99.870 | |
| BM 16 | | | 0.944 | 99.999 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.870 | 99.870 | | Established on this date |
| BM 14 | 100.027 | 100.027 | | Established on this date |
| PT | 96.957 | 96.957 | | Established on this date |

| Summary | |
|---|---|
| **Stage (m)** | 97.323 |
| **Discharge ($m^3/s$)** | 0.318 |
| **Pressure Transducer Reading (m)** | 0.416 |
| **Pressure Transducer Elevation (m)** | 96.907 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:08 | **End** | 14:10 | **Location** | 1.5m downstream of PT | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate | | |
| **Flow Meter Type** | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.411 | **Time** | 13:08 | | | |
| | **End** | **Reading** | 0.414 | **Time** | 14:10 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| RB | 1.75 | 0.00 | 0.00 | 0.006 | 0 | | | 0.000 | 0.0 |
| | 2.00 | 0.05 | 0.25 | 0.011 | 0.07 | | | 0.001 | 0.2 |
| | 2.20 | 0.08 | 0.20 | 0.016 | 0.17 | | | 0.003 | 0.9 |
| Top Rock | 2.40 | 0.00 | 0.20 | 0.000 | 0 | | | 0.000 | 0.0 |
| | 2.70 | 0.10 | 0.30 | 0.030 | 0.2 | | | 0.006 | 1.9 |
| | 3.00 | 0.12 | 0.30 | 0.036 | 0.55 | | | 0.020 | 6.2 |
| | 3.30 | 0.14 | 0.30 | 0.042 | 0.45 | | | 0.019 | 5.9 |
| | 3.60 | 0.18 | 0.30 | 0.054 | 0.32 | | | 0.017 | 5.4 |
| | 3.90 | 0.22 | 0.30 | 0.066 | 0.47 | | | 0.031 | 9.8 |
| | 4.20 | 0.22 | 0.30 | 0.066 | 0.33 | | | 0.022 | 6.9 |
| | 4.50 | 0.26 | 0.30 | 0.078 | 0.25 | | | 0.020 | 6.1 |
| | 4.80 | 0.24 | 0.30 | 0.072 | 0.39 | | | 0.028 | 8.8 |
| | 5.10 | 0.26 | 0.30 | 0.078 | 0.38 | | | 0.030 | 9.3 |
| | 5.40 | 0.31 | 0.30 | 0.078 | 0.23 | | | 0.018 | 5.6 |
| | 5.60 | 0.28 | 0.20 | 0.056 | 0.11 | | | 0.006 | 1.9 |
| | 5.80 | 0.30 | 0.20 | 0.075 | 0.14 | | | 0.011 | 3.3 |
| | 6.10 | 0.26 | 0.30 | 0.078 | 0.18 | | | 0.014 | 4.4 |
| | 6.40 | 0.27 | 0.30 | 0.081 | 0.17 | | | 0.014 | 4.3 |
| | 6.70 | 0.28 | 0.30 | 0.084 | 0.18 | | | 0.015 | 4.8 |
| | 7.00 | 0.22 | 0.30 | 0.066 | 0.14 | | | 0.009 | 2.9 |
| | 7.30 | 0.14 | 0.30 | 0.042 | 0.2 | | | 0.008 | 2.6 |
| | 7.60 | 0.10 | 0.30 | 0.030 | 0.54 | | | 0.016 | 5.1 |
| | 7.90 | 0.06 | 0.30 | 0.018 | 0.46 | | | 0.008 | 2.6 |
| | 8.20 | 0.03 | 0.30 | 0.008 | 0.35 | | | 0.003 | 0.8 |
| LB | 8.40 | 0.00 | 0.20 | 0.003 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.318** | **100.0** |

**General Notes**

Found new location 100m or so upstream of 2010-11 location. Location is on fairly straight reach.

It is a pool with a riffle control section downstream. Large overhanging tree may fall into stream during peak Q.

Cross section survey was also completed. BM's need to be tied in relative to last year's BM's.

Started PT at 13:10 PDT

## Appendix 2-2b. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 21-May-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 9:15 | **End Time:** | 13:00 |
| **Personnel** | Craig Hatt, David Moellenbeck | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Partly Cloudy, Temp: 14 degC | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | ok | **Battery** | 100% |
| **# of Records** | 3598 | **Memory Free** | |
| **Date Serviced** | 26-Apr-12 | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 16 | 0.988 | 100.988 | | 100.000 | |
| BM 15 | | | 1.118 | 99.870 | BM 15 used as 100m reference in field notes |
| BM 14 | | | 0.963 | 100.025 | |
| PT(Old location) | | | 3.936 | 97.052 | |
| WL | | | 3.621 | **97.367** | **.10:45 PDT** |
| TBM | 0.901 | 100.898 | 0.991 | 99.997 | |
| WL | | | 3.531 | **97.367** | |
| PT(Old location) | | | 3.848 | 97.050 | |
| BM 14 | | | 0.873 | 100.025 | |
| BM 15 | | | 1.028 | 99.870 | BM 15 used as 100m reference in field notes |
| BM 16 | | | 0.899 | 99.999 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.870 | 99.870 | 0.000 | |
| BM 14 | 100.027 | 100.025 | -0.001 | |
| PT (new loaction) | 96.990 | 96.990 | 0.000 | New PT Elevation on this date |

| Summary | | |
|---|---|---|
| **Stage (m)** | 97.367 | |
| **Discharge ($m^3/s$)** | 1.10 | |
| **Pressure Transducer Reading (m) (when at old location)** | 0.343 | |
| **Pressure Transducer Elevation (m) (old Location)** | 97.024 | |
| **Pressure Transducer Reading (m) (when at new location)** | 0.416 | 12:00pm |
| **Pressure Transducer Elevation (m) (New Location Surveyed)** | 96.951 | |

**Hydrometric Leveling Survey - New PT Location**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 16 | 0.899 | 100.899 | | 100.000 | |
| BM 15 | | | 1.028 | 99.871 | BM 15 used as 100m reference in field notes |
| BM 14 | | | 0.873 | 100.026 | |
| PT(New location) | | | 3.909 | 96.990 | |
| BM 15 | 0.960 | 100.831 | | 99.871 | BM 15 used as 100m reference in field notes |
| BM 14 | | | 0.805 | 100.026 | |
| BM 16 | | | 0.831 | 100.000 | |
| PT (New Location) | | | 3.841 | 96.990 | |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 9:50 | **End** | 10:30 | **Location** | 0.5m downstream of PT | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | FH950 | | |
| **Flow Meter Type** | | | | **Instrument Serial #** | | 121181001061 | | |
| **Stage (m)** | **Start** | **Reading** | 0.346 | **Time** | 9:40 | | | |
| | **End** | **Reading** | 0.345 | **Time** | 10:37 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| RB | 2.15 | 0.00 | 0.00 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| | 2.30 | 0.10 | 0.15 | 0.02 | 0.64 | | | 0.013 | 1.2 |
| | 2.55 | 0.11 | 0.25 | 0.03 | 0.83 | | | 0.023 | 2.1 |
| | 2.80 | 0.15 | 0.25 | 0.04 | 0.10 | | | 0.004 | 0.3 |
| | 3.05 | 0.19 | 0.25 | 0.05 | 0.75 | | | 0.036 | 3.3 |
| | 3.30 | 0.19 | 0.25 | 0.05 | 0.87 | | | 0.041 | 3.7 |
| | 3.55 | 0.22 | 0.25 | 0.06 | 0.90 | | | 0.050 | 4.5 |
| | 3.80 | 0.20 | 0.25 | 0.05 | 0.95 | | | 0.047 | 4.3 |
| | 4.05 | 0.21 | 0.25 | 0.05 | 0.83 | | | 0.043 | 4.0 |
| | 4.30 | 0.22 | 0.25 | 0.05 | 1.02 | | | 0.051 | 4.6 |
| | 4.50 | 0.24 | 0.20 | 0.05 | 0.85 | | | 0.041 | 3.7 |
| | 4.70 | 0.26 | 0.20 | 0.05 | 0.91 | | | 0.048 | 4.3 |
| | 4.90 | 0.26 | 0.20 | 0.05 | 0.85 | | | 0.044 | 4.0 |
| | 5.10 | 0.32 | 0.20 | 0.06 | 0.70 | | | 0.045 | 4.1 |
| | 5.30 | 0.34 | 0.20 | 0.07 | 0.71 | | | 0.048 | 4.4 |
| | 5.50 | 0.36 | 0.20 | 0.07 | 0.67 | | | 0.049 | 4.4 |
| | 5.70 | 0.39 | 0.20 | 0.08 | 0.74 | | | 0.058 | 5.3 |
| | 5.90 | 0.41 | 0.20 | 0.08 | 0.74 | | | 0.060 | 5.5 |
| | 6.10 | 0.41 | 0.20 | 0.08 | 0.55 | | | 0.045 | 4.1 |
| | 6.30 | 0.43 | 0.20 | 0.09 | 0.56 | | | 0.049 | 4.4 |
| | 6.50 | 0.44 | 0.20 | 0.09 | 0.60 | | | 0.053 | 4.8 |
| | 6.70 | 0.46 | 0.20 | 0.09 | 0.55 | | | 0.051 | 4.6 |
| | 6.90 | 0.44 | 0.20 | 0.09 | 0.56 | | | 0.049 | 4.5 |
| | 7.10 | 0.41 | 0.20 | 0.08 | 0.53 | | | 0.044 | 4.0 |
| | 7.30 | 0.38 | 0.20 | 0.09 | 0.54 | | | 0.046 | 4.2 |
| | 7.55 | 0.26 | 0.25 | 0.07 | 0.48 | | | 0.031 | 2.8 |
| | 7.80 | 0.28 | 0.25 | 0.07 | 0.27 | | | 0.019 | 1.7 |
| | 8.05 | 0.18 | 0.25 | 0.05 | 0.18 | | | 0.008 | 0.7 |
| | 8.30 | 0.12 | 0.25 | 0.03 | 0.15 | | | 0.005 | 0.4 |
| | 8.60 | 0.05 | 0.30 | 0.01 | 0.05 | | | 0.001 | 0.0 |
| LB | 8.75 | 0.00 | 0.15 | 0.00 | 0.00 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **1.099** | **100.0** |

**General Notes**

Moved PT at 11:53 PDT. Data was not recording when we arrived on site. Top of pipe to centre of PT = 23 mm

**Appendix 2-2b. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2012**

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 (Transducer moved to new location) | | | |
| **Stream Name** | Camp Creek | | | |
| **Date Monitored** | 29-Jun-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 13:20 | **End Time:** | |
| **Personnel** | Craig Hatt, Calvin Pin | | | |
| **Station Cordinates** | **Easting** | **Northing** | **Elevation** | |
| | | | | |
| **Weather Conditions** | Overcast | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | | **Serial #** | |
| **Gain** | | **Offset** | |
| **Status** | | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey (Before moving PT)**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM16 | 0.860 | 100.860 | | 100.000 | |
| BM15 | | | 0.988 | 99.872 | |
| BM14 | | | 0.834 | 100.026 | |
| WL | | | 3.544 | **97.316** | 10:52 PDT |
| TBM1 | 0.870 | 100.864 | 0.866 | 99.994 | Box Corner |
| WL | | | 3.549 | **97.315** | |
| BM14 | | | 0.838 | 100.026 | |
| BM15 | | | 0.992 | 99.872 | |
| BM16 | | | 0.864 | 100.000 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM15 | 99.870 | 99.872 | 0.002 | |
| BM14 | 100.027 | 100.026 | 0.000 | |
| PT | 96.922 | 96.922 | 0.000 | New PT Elevation on this date |

**Summary**

| | |
|---|---|
| **Stage (m)** | 97.316 |
| **Discharge ($m^3/s$)** | 0.626 |
| **Pressure Transducer Reading (m)** | 0.365 |
| **Pressure Transducer Elevation (m) (old location)** | 96.951 |
| **Pressure Transducer Elevation (m) (new location)** | 96.899 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | | **End** | | **Location** | MH-2 on Camp Creek |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | |
| **Flow Meter Type** | FH950 | | | **Instrument Serial #** | | |
| **Stage (m)** | **Start** | **Reading** | | **Time** | 9:20 | |
| | **End** | **Reading** | | **Time** | 10:15 | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| RB | 2.45 | 0.00 | 0.00 | 0.01 | 0.000 | | | 0.000 | 0.0 |
| | 2.70 | 0.06 | 0.25 | 0.02 | 0.324 | | | 0.006 | 0.9 |
| | 3.05 | 0.12 | 0.35 | 0.04 | 0.262 | | | 0.011 | 1.8 |
| | 3.40 | 0.17 | 0.35 | 0.06 | 0.485 | | | 0.029 | 4.6 |
| | 3.75 | 0.20 | 0.35 | 0.06 | 0.510 | | | 0.031 | 4.9 |
| | 4.00 | 0.21 | 0.25 | 0.05 | 0.638 | | | 0.033 | 5.3 |
| | 4.25 | 0.23 | 0.25 | 0.06 | 0.706 | | | 0.041 | 6.5 |
| | 4.50 | 0.20 | 0.25 | 0.05 | 0.641 | | | 0.032 | 5.1 |
| | 4.75 | 0.22 | 0.25 | 0.06 | 0.601 | | | 0.033 | 5.3 |
| | 5.00 | 0.19 | 0.25 | 0.05 | 0.582 | | | 0.028 | 4.4 |
| | 5.25 | 0.22 | 0.25 | 0.06 | 0.615 | | | 0.034 | 5.4 |
| | 5.50 | 0.21 | 0.25 | 0.05 | 0.622 | | | 0.033 | 5.2 |
| | 5.75 | 0.23 | 0.25 | 0.06 | 0.586 | | | 0.034 | 5.4 |
| | 6.00 | 0.25 | 0.25 | 0.06 | 0.542 | | | 0.034 | 5.4 |
| | 6.25 | 0.25 | 0.25 | 0.06 | 0.435 | | | 0.027 | 4.3 |
| | 6.50 | 0.22 | 0.25 | 0.06 | 0.540 | | | 0.030 | 4.7 |
| | 6.75 | 0.24 | 0.25 | 0.06 | 0.518 | | | 0.031 | 5.0 |
| | 7.00 | 0.22 | 0.25 | 0.06 | 0.504 | | | 0.028 | 4.4 |
| | 7.25 | 0.20 | 0.25 | 0.06 | 0.486 | | | 0.029 | 4.7 |
| | 7.60 | 0.23 | 0.35 | 0.08 | 0.312 | | | 0.025 | 4.0 |
| | 7.95 | 0.27 | 0.35 | 0.09 | 0.373 | | | 0.035 | 5.6 |
| | 8.30 | 0.28 | 0.35 | 0.10 | 0.291 | | | 0.029 | 4.6 |
| | 8.65 | 0.23 | 0.35 | 0.08 | 0.166 | | | 0.013 | 2.1 |
| | 9.00 | 0.07 | 0.35 | 0.02 | 0.087 | | | 0.002 | 0.3 |
| LB | 9.30 | 0.00 | 0.30 | 0.01 | 0.000 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.626** | **100.0** |

**General Notes**

Transducer moved at 13:42, at new location at 13:45. Transducer buried under 6 in of gravel, Moderate flow rate observed. Reak Time Stage measured at 10:40.

**Appendix 2-2b. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2012**

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-2 | | | |
| Stream Name | Camp Creek | | | |
| Date Monitored | 16-Aug-12 | | | |
| Time at Site (24 hr) | Start Time: | 13:30 | End Time: | |
| Personnel | Craig Hatt | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | | | | |
| Weather Conditions | Overcast | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | | Serial # | |
| Gain | | Offset | |
| Status | | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

**Hydrometric Leveling Survey (Before moving PT)**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM16 | 0.903 | 100.903 | | 100.000 | |
| BM15 | | | 1.032 | 99.871 | |
| BM14 | | | 0.878 | 100.025 | |
| WL | | | 3.705 | **97.198** | Time: 14:40 |
| PT | | | 3.983 | **96.920** | Error on shot (?) |
| BM 14 | 0.834 | 100.859 | | **100.025** | |
| PT | | | 3.982 | 96.877 | Error on shot (?) |
| WL | | | 3.660 | **97.199** | |
| BM 15 | | | 0.987 | 99.872 | |
| BM 16 | | | 0.858 | 100.001 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM15 | 99.870 | 99.872 | 0.002 | |
| BM14 | 100.027 | 100.025 | -0.001 | |
| PT | 96.922 | 96.920 | -0.002 | used 1st measurement |

| Summary | |
|---|---|
| Stage (m) | 97.199 |
| Discharge ($m^3/s$) | 0.0965 |
| Pressure Transducer Reading (m) | 0.317 |
| Pressure Transducer Elevation (m) | 96.881 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:44 | End | 14:29 | Location | | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | | | | | |
| Flow Meter Type | FH950 | | | Instrument Serial # | | | | | | |
| Stage (m) | Start | Reading | 0.318 | Time | 13:44 | | | | | |
| | End | Reading | 0.317 | Time | 14:29 | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| RB | 2.00 | 0.00 | 0.00 | 0.01 | 0.000 | | | 0.0000 | 0.0 |
| | 2.35 | 0.08 | 0.35 | 0.02 | 0.155 | | | 0.0037 | 3.9 |
| | 2.60 | 0.09 | 0.25 | 0.02 | 0.131 | | | 0.0029 | 3.1 |
| | 2.85 | 0.10 | 0.25 | 0.03 | 0.121 | | | 0.0030 | 3.1 |
| | 3.10 | 0.09 | 0.25 | 0.02 | 0.248 | | | 0.0056 | 5.8 |
| | 3.35 | 0.08 | 0.25 | 0.02 | 0.247 | | | 0.0049 | 5.1 |
| | 3.60 | 0.10 | 0.25 | 0.03 | 0.256 | | | 0.0064 | 6.6 |
| | 3.85 | 0.08 | 0.25 | 0.02 | 0.250 | | | 0.0050 | 5.2 |
| | 4.10 | 0.11 | 0.25 | 0.03 | 0.235 | | | 0.0065 | 6.7 |
| | 4.35 | 0.12 | 0.25 | 0.03 | 0.225 | | | 0.0068 | 7.0 |
| | 4.60 | 0.14 | 0.25 | 0.04 | 0.208 | | | 0.0073 | 7.5 |
| | 4.85 | 0.13 | 0.25 | 0.03 | 0.220 | | | 0.0072 | 7.4 |
| | 5.10 | 0.11 | 0.25 | 0.03 | 0.192 | | | 0.0053 | 5.5 |
| | 5.35 | 0.13 | 0.25 | 0.03 | 0.089 | | | 0.0029 | 3.0 |
| | 5.60 | 0.17 | 0.25 | 0.04 | 0.168 | | | 0.0071 | 7.4 |
| | 5.85 | 0.19 | 0.25 | 0.05 | 0.152 | | | 0.0072 | 7.5 |
| | 6.10 | 0.16 | 0.25 | 0.04 | 0.103 | | | 0.0041 | 4.3 |
| | 6.35 | 0.14 | 0.25 | 0.04 | 0.089 | | | 0.0031 | 3.2 |
| | 6.60 | 0.14 | 0.25 | 0.04 | 0.076 | | | 0.0027 | 2.8 |
| | 6.85 | 0.13 | 0.25 | 0.03 | 0.063 | | | 0.0020 | 2.1 |
| | 7.10 | 0.13 | 0.25 | 0.03 | 0.064 | | | 0.0021 | 2.2 |
| | 7.35 | 0.10 | 0.25 | 0.03 | 0.020 | | | 0.0005 | 0.5 |
| | 7.60 | 0.05 | 0.25 | 0.01 | 0.011 | | | 0.0002 | 0.2 |
| LB | 7.90 | 0.00 | 0.30 | 0.01 | 0.000 | | | 0.0000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.0965** | **100.0** |

**General Notes**

**Appendix 2-2b. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2012**

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 29-Sep-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 11:35:00 AM | **End Time:** | 14:30 |
| **Personnel** | Eli Heyman, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | 22455 | **Memory Free** | 21137 |
| **Date Serviced** | 29-Sep-12 | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 16 | 0.916 | 100.916 | | 100.000 | |
| BM 15 | | | 1.045 | 99.871 | BM 15 used at 100m in notes |
| BM 14 | | | 0.892 | 100.024 | |
| PT | | | 3.995 | 96.921 | |
| WL | | | 3.744 | **97.172** | |
| TBM | 3.547 | 100.994 | 3.469 | 97.447 | |
| WL | | | 3.823 | **97.171** | |
| PT | | | 4.072 | 96.922 | |
| BM 14 | | | 0.969 | 100.025 | |
| BM 15 | | | 1.123 | 99.871 | |
| BM 16 | | | 0.995 | 99.999 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.87 | 99.871 | 0.001 | |
| BM 14 | 100.0265 | 100.025 | -0.002 | |
| PT | 96.922 | 96.922 | -0.001 | |

| Summary | |
|---|---|
| **Stage (m)** | 97.172 |
| **Discharge ($m^3/s$)** | 0.0392 |
| **Pressure Transducer Reading (m)** | 0.287 |
| **Pressure Transducer Elevation (m)** | 96.885 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 11:40 | **End** | 12:15 | **Location** | In line with PT | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.288 | **Time** | 11:40 | | | |
| | **End** | **Reading** | 0.287 | **Time** | 12:15 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| LB | 0.60 | 0.00 | 0.00 | 0.00 | 0 | | | 0.000 | 0.0 |
| | 0.70 | 0.06 | 0.10 | 0.01 | -0.01 | | | 0.000 | -0.2 |
| | 0.80 | 0.10 | 0.10 | 0.02 | 0.01 | | | 0.000 | 0.4 |
| | 1.00 | 0.16 | 0.20 | 0.03 | 0.02 | | | 0.001 | 1.6 |
| | 1.20 | 0.18 | 0.20 | 0.04 | 0.02 | | | 0.001 | 1.8 |
| | 1.40 | 0.22 | 0.20 | 0.04 | 0.03 | | | 0.001 | 3.4 |
| | 1.60 | 0.27 | 0.20 | 0.05 | 0.04 | | | 0.002 | 5.5 |
| | 1.80 | 0.28 | 0.20 | 0.06 | 0.04 | | | 0.002 | 5.7 |
| | 2.00 | 0.30 | 0.20 | 0.05 | 0.05 | | | 0.002 | 5.7 |
| | 2.10 | 0.30 | 0.10 | 0.03 | 0.04 | | | 0.001 | 3.1 |
| | 2.20 | 0.28 | 0.10 | 0.03 | 0.06 | | | 0.002 | 4.3 |
| | 2.30 | 0.30 | 0.10 | 0.03 | 0.04 | | | 0.001 | 3.1 |
| | 2.40 | 0.30 | 0.10 | 0.03 | 0.05 | | | 0.002 | 3.8 |
| | 2.50 | 0.30 | 0.10 | 0.03 | 0.06 | | | 0.002 | 4.6 |
| | 2.60 | 0.30 | 0.10 | 0.03 | 0.07 | | | 0.002 | 5.4 |
| | 2.70 | 0.28 | 0.10 | 0.03 | 0.07 | | | 0.002 | 5.0 |
| | 2.80 | 0.29 | 0.10 | 0.04 | 0.07 | | | 0.003 | 7.8 |
| | 3.00 | 0.28 | 0.20 | 0.06 | 0.07 | | | 0.004 | 10.0 |
| | 3.20 | 0.18 | 0.20 | 0.04 | 0.09 | | | 0.003 | 8.3 |
| | 3.40 | 0.16 | 0.20 | 0.03 | 0.09 | | | 0.003 | 7.4 |
| | 3.60 | 0.12 | 0.20 | 0.02 | 0.08 | | | 0.002 | 4.9 |
| | 3.80 | 0.12 | 0.20 | 0.02 | 0.07 | | | 0.002 | 4.3 |
| | 4.00 | 0.09 | 0.20 | 0.02 | 0.07 | | | 0.001 | 3.2 |
| | 4.20 | 0.06 | 0.20 | 0.01 | 0.03 | | | 0.000 | 0.9 |
| | 4.40 | 0.06 | 0.20 | 0.01 | 0.02 | | | 0.000 | 0.6 |
| | 4.60 | 0.05 | 0.20 | 0.01 | -0.01 | | | 0.000 | -0.3 |
| | 4.90 | 0.02 | 0.30 | 0.00 | -0.03 | | | 0.000 | -0.3 |
| RB | 5.00 | 0.00 | 0.10 | 0.00 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0392** | **100.0** |

**General Notes**

**Appendix 2-2b. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2012**

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 5-Nov-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:45:00 PM | **End Time:** | 16:00 |
| **Personnel** | Eli Heyman, Arnold | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5161 | **Offset** | -0.0067 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | 27790 | **Memory Free** | 18466 |
| **Date Serviced** | 5-Nov-12 | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 16 | 0.938 | 100.938 | | 100.000 | |
| BM 15 | | | 1.068 | 99.870 | |
| BM 14 | | | 0.913 | 100.025 | |
| PT | | | | | Not Surveyed (ice, silty water) |
| WL | | | 3.578 | **97.360** | |
| TBM | 3.477 | 100.845 | 3.570 | 97.368 | |
| WL | | | 3.485 | **97.360** | |
| PT | | | | | Not Surveyed (ice, silty water) |
| BM 14 | | | 0.818 | 100.027 | |
| BM 15 | | | 0.973 | 99.872 | |
| BM 16 | | | 0.844 | 100.001 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.870 | 99.871 | 0.001 | |
| BM 14 | 100.027 | 100.026 | 0.000 | |
| PT | 96.922 | | | Not Surveyed (ice, silty water) |

| Summary | |
|---|---|
| **Stage (m)** | 97.360 |
| **Discharge ($m^3/s$)** | 0.179 |
| **Pressure Transducer Reading (m)** | 0.482 |
| **Pressure Transducer Elevation (m)** | 96.878 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 12:45 | **End** | 14:45 | **Location** | 25m upstream of PT | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.477 | **Time** | 12:45 | Cleared 3m-wide section of ice (11.5cm thick) | | |
| | **End** | **Reading** | 0.482 | **Time** | 14:45 | for measurement | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| RB | 8.10 | 0.00 | 0.00 | 0.00 | 0 | | | 0.000 | 0.0 |
| | 8.20 | 0.03 | 0.10 | 0.00 | -0.02 | | | 0.000 | 0.0 |
| | 8.30 | 0.22 | 0.10 | 0.03 | -0.03 | | | -0.001 | -0.6 |
| | 8.50 | 0.22 | 0.20 | 0.04 | 0.05 | | | 0.002 | 1.2 |
| | 8.70 | 0.18 | 0.20 | 0.04 | 0.08 | | | 0.003 | 1.6 |
| | 8.90 | 0.29 | 0.20 | 0.06 | 0 | | | 0.000 | 0.0 |
| | 9.10 | 0.28 | 0.20 | 0.06 | 0.03 | | | 0.002 | 0.9 |
| | 9.30 | 0.44 | 0.20 | 0.09 | 0.06 | | | 0.005 | 3.0 |
| | 9.50 | 0.42 | 0.20 | 0.08 | 0.15 | | | 0.013 | 7.0 |
| | 9.70 | 0.40 | 0.20 | 0.08 | 0.22 | | | 0.018 | 9.8 |
| | 9.90 | 0.31 | 0.20 | 0.06 | 0.21 | | | 0.013 | 7.3 |
| | 10.10 | 0.26 | 0.20 | 0.05 | 0.2 | | | 0.010 | 5.8 |
| | 10.30 | 0.22 | 0.20 | 0.04 | 0.26 | | | 0.011 | 6.4 |
| | 10.50 | 0.29 | 0.20 | 0.04 | 0.37 | | | 0.016 | 9.0 |
| | 10.60 | 0.37 | 0.10 | 0.04 | 0.21 | | | 0.008 | 4.3 |
| | 10.70 | 0.32 | 0.10 | 0.03 | 0.27 | | | 0.009 | 4.8 |
| | 10.80 | 0.32 | 0.10 | 0.03 | 0.22 | | | 0.007 | 3.9 |
| | 10.90 | 0.32 | 0.10 | 0.03 | 0.19 | | | 0.006 | 3.4 |
| | 11.00 | 0.38 | 0.10 | 0.06 | 0.13 | | | 0.007 | 4.1 |
| | 11.20 | 0.27 | 0.20 | 0.04 | 0.25 | | | 0.010 | 5.7 |
| | 11.30 | 0.28 | 0.10 | 0.03 | 0.21 | | | 0.006 | 3.3 |
| | 11.40 | 0.31 | 0.10 | 0.03 | 0.34 | | | 0.011 | 5.9 |
| | 11.50 | 0.28 | 0.10 | 0.03 | 0.26 | | | 0.007 | 4.1 |
| | 11.60 | 0.29 | 0.10 | 0.04 | 0.19 | | | 0.007 | 3.8 |
| | 11.75 | 0.34 | 0.15 | 0.05 | 0.13 | | | 0.007 | 3.7 |
| | 11.90 | 0.31 | 0.15 | 0.04 | 0.04 | | | 0.002 | 0.9 |
| | 12.00 | 0.31 | 0.10 | 0.04 | 0.01 | | | 0.000 | 0.2 |
| | 12.15 | 0.22 | 0.15 | 0.03 | 0.02 | | | 0.001 | 0.3 |
| LB | 12.25 | 0.00 | 0.10 | 0.01 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.179** | **100.0** |

**General Notes**

Significant flow on top of ice, with moderate flow beneath ice near centre of the stream. Banks were frozen to bed before recent warm-up. Pool where PT was located was filled with ice (11cm thick), likely affected stage value.

## Appendix 2-2c. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 1-May-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:00 | **End Time:** | 15:50 |
| **Personnel** | Eli Heyman, Natasha Cowie | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Mix Sun | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 7050119 |
| **Gain** | 3.5522 | **Offset** | -0.0508 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | 1 | **Memory Free** | 32534 |
| **Date Serviced** | 1-May-13 | **Crest Gauges** | No |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 16 | 1.003 | 101.003 | | 100.000 | |
| BM 15 | | | 1.132 | 99.871 | |
| BM 14 | | | 0.977 | 100.026 | |
| PT | | | 4.171 | 96.832 | Difficult to survey |
| PT (2) | | | 3.111 | 97.892 | Top hose clamp |
| WL | | | 3.716 | **97.287** | |
| TBM | 3.552 | 100.968 | 3.587 | 97.416 | |
| WL | | | 3.682 | **97.286** | |
| PT (2) | | | 3.080 | 97.888 | Top hose clamp |
| PT | | | 4.122 | 96.846 | |
| BM 14 | | | 0.943 | 100.025 | |
| BM 15 | | | 1.099 | 99.869 | |
| BM 16 | | | 0.969 | 99.999 | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.87 | 99.870 | 0.000 | |
| BM 14 | 100.026 | 100.026 | -0.001 | |
| PT (2) | 97.89 | 97.890 | | |

| Summary | | |
|---|---|---|
| **Stage (m)** | 97.287 | 97.265 |
| **Discharge ($m^3/s$)** | 0.368 | |
| **Pressure Transducer Reading (m)** | 0.423 | |
| **Pressure Transducer Elevation (m)** | 96.864 | 96.843 |

| Discharge Measurement - Mid-Section Method | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:25 | **End** | 14:55 | **Location** | 8m DS of PT | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 6592 | |
| **Stage (m)** | **Start** | **Reading** | 0.423 | **Time** | 14:25 | | |
| | **End** | **Reading** | 0.423 | **Time** | 14:55 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| LB | 1.90 | 0.00 | 0.00 | 0.004 | 0 | | | 0.000 | 0.0 |
| | 2.1 | 0.04 | 0.20 | 0.007 | 0.01 | | | 0.000 | 0.0 |
| | 2.25 | 0.05 | 0.15 | 0.010 | 0.25 | | | 0.003 | 0.7 |
| | 2.5 | 0.06 | 0.25 | 0.017 | 0.27 | | | 0.004 | 1.2 |
| | 2.80 | 0.07 | 0.30 | 0.021 | 0.36 | | | 0.008 | 2.1 |
| | 3.10 | 0.11 | 0.30 | 0.033 | 0.39 | | | 0.013 | 3.5 |
| | 3.40 | 0.14 | 0.30 | 0.042 | 0.23 | | | 0.010 | 2.6 |
| On rock | 3.70 | 0.10 | 0.30 | 0.030 | 0.2 | | | 0.006 | 1.6 |
| | 4.00 | 0.16 | 0.30 | 0.048 | 0.51 | | | 0.024 | 6.7 |
| | 4.30 | 0.14 | 0.30 | 0.042 | 0.38 | | | 0.016 | 4.3 |
| | 4.60 | 0.15 | 0.30 | 0.045 | 0.26 | | | 0.012 | 3.2 |
| | 4.90 | 0.21 | 0.30 | 0.063 | 0.38 | | | 0.024 | 6.5 |
| | 5.20 | 0.22 | 0.30 | 0.066 | 0.59 | | | 0.039 | 10.6 |
| | 5.50 | 0.18 | 0.30 | 0.045 | 0.55 | | | 0.025 | 6.7 |
| | 5.70 | 0.19 | 0.20 | 0.038 | 0.41 | | | 0.016 | 4.2 |
| | 5.90 | 0.19 | 0.20 | 0.048 | 0.47 | | | 0.022 | 6.1 |
| | 6.20 | 0.15 | 0.30 | 0.045 | 0.57 | | | 0.026 | 7.0 |
| | 6.50 | 0.15 | 0.30 | 0.045 | 0.66 | | | 0.030 | 8.1 |
| | 6.80 | 0.14 | 0.30 | 0.049 | 0.54 | | | 0.026 | 7.2 |
| | 7.20 | 0.17 | 0.40 | 0.060 | 0.6 | | | 0.036 | 9.7 |
| | 7.50 | 0.14 | 0.30 | 0.042 | 0.43 | | | 0.018 | 4.9 |
| | 7.80 | 0.09 | 0.30 | 0.027 | 0.31 | | | 0.008 | 2.3 |
| | 8.10 | 0.06 | 0.30 | 0.015 | 0.18 | | | 0.003 | 0.7 |
| | 8.30 | 0.03 | 0.20 | 0.005 | 0.06 | | | 0.000 | 0.1 |
| RB | 8.40 | 0.00 | 0.10 | 0.001 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.368** | **100.0** |

| General Notes |
|---|
| Bottom of pipe difficult to measure due to silty water. Will survey top hose clamp on future surveys to track elevation of PT. Installed screw in tree to track PT elevation as well. |

## Appendix 2-2c. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 27-Jun-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:20 | **End Time:** | 15:50 |
| **Personnel** | Eli Heyman, Tyson Logan | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Mix Sun + Cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721018 |
| **Gain** | 3.5522 | **Offset** | -0.0508 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | 1 | **Memory Free** | 32534 |
| **Manual Gauge** | Yes | **Crest Gauges** | No |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 16 | 0.374 | 100.374 | | 100.000 | |
| BM 15 | | | 0.504 | 100.499 | |
| BM 14 | | | 0.349 | 100.654 | |
| PT | | | 3.656 | 97.347 | Bot ABS (error) |
| PT (2) | | | 2.516 | 98.487 | Top hose clamp |
| WL | | | 3.636 | 97.367 | (+0.575 to WL) |
| WL2 | | | 3.052 | **97.951** | **3m DS of PT** |
| TBM | 0.672 | 100.945 | 0.730 | 100.273 | |
| WL2 | | | 2.993 | **-2.993** | **3m DS of PT** |
| WL3 | | | 2.999 | -2.999 | RB in line with PT |
| PT (2) | | | 2.458 | -2.458 | Tope Hose clamp |
| PT | | | 3.535 | -3.535 | Bot ABS (use this) |
| BM 14 | | | 0.292 | -0.292 | |
| BM 15 | | | 0.446 | -0.446 | |
| BM 16 | | | 0.317 | -0.317 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.87 | 50.027 | -49.844 | |
| BM 14 | 100.0265 | 50.181 | -49.846 | |
| PT | 97.89 | 48.015 | -49.876 | |

| Summary | |
|---|---|
| **Stage (m)** | 47.472 |
| **Discharge ($m^3/s$)** | 0.717 |
| **Pressure Transducer Reading (m)** | 0.477 |
| **Pressure Transducer Elevation (m)** | 46.995 |

| Discharge Measurement - Mid-Section Method | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:42 | **End** | 14:33 | **Location** | 6m DS of PT | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 6592 | |
| **Stage (m)** | **Start** | **Reading** | 0.477 | **Time** | 13:42 | | |
| | **End** | **Reading** | 0.472 | **Time** | 14:33 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| LB | 2.20 | 0.00 | 0.00 | 0.001 | 0 | | | 0.000 | 0.0 |
| | 2.3 | 0.03 | 0.10 | 0.005 | 0.06 | | | 0.000 | 0.1 |
| | 2.5 | 0.06 | 0.20 | 0.015 | 0.25 | | | 0.004 | 1.0 |
| | 2.8 | 0.07 | 0.30 | 0.021 | 0.33 | | | 0.007 | 1.9 |
| | 3.10 | 0.09 | 0.30 | 0.027 | 0.42 | | | 0.011 | 3.1 |
| | 3.40 | 0.13 | 0.30 | 0.039 | 0.4 | | | 0.016 | 4.2 |
| | 3.70 | 0.16 | 0.30 | 0.048 | 0.47 | | | 0.023 | 6.1 |
| | 4.00 | 0.22 | 0.30 | 0.066 | 0.5 | | | 0.033 | 9.0 |
| | 4.30 | 0.25 | 0.30 | 0.075 | 0.52 | | | 0.039 | 10.6 |
| | 4.60 | 0.25 | 0.30 | 0.075 | 0.63 | | | 0.047 | 12.9 |
| | 4.90 | 0.27 | 0.30 | 0.081 | 0.64 | | | 0.052 | 14.1 |
| | 5.20 | 0.27 | 0.30 | 0.081 | 0.73 | | | 0.059 | 16.1 |
| | 5.50 | 0.28 | 0.30 | 0.084 | 0.64 | | | 0.054 | 14.6 |
| | 5.80 | 0.26 | 0.30 | 0.078 | 0.72 | | | 0.056 | 15.3 |
| | 6.10 | 0.23 | 0.30 | 0.069 | 0.7 | | | 0.048 | 13.1 |
| | 6.40 | 0.27 | 0.30 | 0.081 | 0.52 | | | 0.042 | 11.5 |
| | 6.70 | 0.23 | 0.30 | 0.069 | 0.79 | | | 0.055 | 14.8 |
| | 7.00 | 0.18 | 0.30 | 0.054 | 0.72 | | | 0.039 | 10.6 |
| | 7.30 | 0.21 | 0.30 | 0.063 | 0.62 | | | 0.039 | 10.6 |
| | 7.60 | 0.20 | 0.30 | 0.060 | 0.54 | | | 0.032 | 8.8 |
| | 7.90 | 0.19 | 0.30 | 0.057 | 0.42 | | | 0.024 | 6.5 |
| | 8.20 | 0.19 | 0.30 | 0.057 | 0.23 | | | 0.013 | 3.6 |
| | 8.50 | 0.14 | 0.30 | 0.042 | 0.33 | | | 0.014 | 3.8 |
| | 8.80 | 0.10 | 0.30 | 0.030 | 0.26 | | | 0.008 | 2.1 |
| | 9.10 | 0.06 | 0.30 | 0.011 | 0.22 | | | 0.002 | 0.6 |
| | 9.15 | 0.09 | 0.05 | 0.004 | -0.02 | | | 0.000 | 0.0 |
| RB | 9.20 | 0.00 | 0.05 | 0.002 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.717** | **194.9** |

| General Notes |
|---|
| Bottom of pipe difficult to measure due to silty water. Will survey top hose clamp on future surveys to track elevation of PT. |

## Appendix 2-2c. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-2 | | | |
| Stream Name | Lower Camp Creek | | | |
| Date Monitored | 9-Aug-13 | | | |
| Time at Site (24 hr) | Start Time: | 12:30:00 PM | End Time: | |
| Personnel | Mike S., Dan H. | | | |
| Station Coordinates | Easting | Northing | Elevation | |
| | 0626246 | 6098122 | 755 | |
| Weather Conditions | 25 C sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | | Serial # | 2721018 |
| Gain | | Offset | |
| Status | logging | Battery | 100% |
| # of Records | 14402 | Memory Free | 24392 |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 16 | 0.983 | 100.983 | | 100.000 | |
| TBM1 | | | 3.089 | 97.914 | |
| BM14 | | | 0.956 | 100.047 | |
| BM 15 | | | 1.111 | 99.892 | |
| TP1 | 1.122 | 101.014 | 1.111 | 99.892 | |
| BM 16 | | | 0.993 | -0.993 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.87 | 99.892 | 0.022 | |
| BM14 | 100.026 | 100.047 | 0.021 | |

| Summary | |
|---|---|
| Stage (m) | 97.325 |
| Discharge ($m^3/s$) | 0.8 |
| Pressure Transducer Reading (m) | 0.482 |
| Pressure Transducer Elevation (m) | 96.843 from June 27 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 12:45 | End | 13:10 | Location | at cross section 3 (d.s.) | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | | | | |
| Flow Meter Type | | | | Instrument Serial # | | 12921 | | | |
| Stage (m) | Start | Reading | 0.48 | SG | 0.44 | Time | 12:45 | Gauge Correction: | |
| | End | Reading | 0.48 | SG | 0.44 | Time | 13:10 | | 96.885 |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| RB | 3.40 | 0.00 | 0.0 | 0.01 | 0 | | | 0.000 | 0.0 |
| | 3.75 | 0.08 | 0.4 | 0.03 | 0.11 | | | 0.003 | 0.8 |
| | 4.10 | 0.10 | 0.4 | 0.04 | 0.28 | | | 0.010 | 2.7 |
| | 4.45 | 0.15 | 0.4 | 0.05 | 0.28 | | | 0.015 | 4.0 |
| | 4.80 | 0.16 | 0.4 | 0.06 | 0.55 | | | 0.031 | 8.4 |
| | 5.15 | 0.22 | 0.4 | 0.08 | 0.63 | | | 0.049 | 13.2 |
| | 5.50 | 0.22 | 0.4 | 0.08 | 0.83 | | | 0.064 | 17.4 |
| | 5.85 | 0.26 | 0.4 | 0.09 | 0.74 | | | 0.067 | 18.3 |
| | 6.20 | 0.26 | 0.4 | 0.09 | 0.89 | | | 0.081 | 22.0 |
| | 6.55 | 0.23 | 0.4 | 0.08 | 0.59 | | | 0.047 | 12.9 |
| | 6.90 | 0.28 | 0.4 | 0.10 | 0.57 | | | 0.056 | 15.2 |
| | 7.25 | 0.28 | 0.4 | 0.10 | 0.74 | | | 0.073 | 19.7 |
| | 7.60 | 0.22 | 0.4 | 0.08 | 0.59 | | | 0.045 | 12.4 |
| | 7.95 | 0.24 | 0.4 | 0.08 | 0.66 | | | 0.055 | 15.1 |
| | 8.30 | 0.26 | 0.4 | 0.09 | 0.65 | | | 0.059 | 16.1 |
| | 8.65 | 0.28 | 0.4 | 0.10 | 0.3 | | | 0.029 | 8.0 |
| | 9.00 | 0.18 | 0.4 | 0.06 | 0.39 | | | 0.025 | 6.7 |
| | 9.35 | 0.20 | 0.4 | 0.07 | 0.61 | | | 0.043 | 11.6 |
| | 9.70 | 0.15 | 0.4 | 0.05 | 0.29 | | | 0.015 | 4.1 |
| | 10.05 | 0.12 | 0.4 | 0.04 | 0.56 | | | 0.020 | 5.5 |
| | 10.30 | 0.11 | 0.3 | 0.03 | 0.43 | | | 0.013 | 3.5 |
| LB | 10.60 | 0.00 | 0.3 | 0.02 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | 0.800 | 217.6 |

| General Notes |
|---|
| no screw on cable end. Duck taped shut. |

## Appendix 2-2c. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 9-Oct-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 7:10:00 AM | **End Time:** | 9:00:00 AM |
| **Personnel** | Eli H., Jem M. | | | |
| **Station Coordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Clear, 3C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 2721018 |
| **Gain** | 3.5522 | **Offset** | -0.0508 |
| **Status** | logging | **Battery** | 100% |
| **# of Records** | 23294 | **Memory Free** | 19944 |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 16 | 0.901 | 100.901 | | 100.000 | |
| BM 15 | | | 1.029 | 99.974 | |
| BM 14 | | | 0.874 | 100.129 | |
| PT 1 | | | 3.058 | 97.945 | top Hose Clamp |
| PT 2 | | | 4.095 | 96.908 | |
| WL | | | 3.679 | 97.324 | |
| SG | | | 2.972 | 98.031 | |
| TBM | 1.160 | 100.984 | 1.179 | 99.824 | |
| SG | | | 2.953 | -2.953 | |
| WL | | | 3.660 | -3.660 | |
| PT 2 | | | 4.084 | -4.084 | |
| **PT 1** | | | 3.038 | -3.038 | **top Hose Clamp** |
| BM 14 | | | 0.856 | -0.856 | |
| BM 15 | | | 1.011 | -1.011 | |
| BM 16 | | | 0.882 | -0.882 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 15 | 99.87 | 49.482 | -50.389 | |
| BM 14 | 100.026 | 49.637 | -50.390 | |
| PT 2 | 97.89 | 47.454 | -50.437 | |

| Summary | |
|---|---|
| **Stage (m)** | 46.832 |
| **Discharge ($m^3/s$)** | 0.179 |
| **Pressure Transducer Reading (m)** | 0.386 |
| **Pressure Transducer Elevation (m)** | 46.446 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 7:32 | **End** | 7:55 | **Location** | 2.5m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate | | | |
| **Flow Meter Type** | Electromagnetic | | | **Instrument Serial #** | | 14614 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.386 | **SG** | 0.346 | **Time** | 7:20 | **Gauge correction:** | |
| | **End** | **Reading** | 0.386 | **SG** | 0.346 | **Time** | 7:50 | | 46.486 |

| | Station | Depth | Depth | Distance | Area | Velocity (m/s) | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (ft) | (m) | (m) | ($m^2$) | 60% | | (m3/s) | % |
| LB | 0.40 | 0.00 | 0.00 | 0.0 | 0.01 | 0 | | 0.000 | 0.0 |
| | 0.60 | 0.23 | 0.07 | 0.2 | 0.01 | 0.03 | | 0.000 | 0.1 |
| | 0.80 | 0.40 | 0.12 | 0.2 | 0.02 | 0.06 | | 0.001 | 0.4 |
| | 1.00 | 0.50 | 0.15 | 0.2 | 0.03 | 0.08 | | 0.002 | 0.7 |
| | 1.20 | 0.69 | 0.21 | 0.2 | 0.04 | 0.1 | | 0.004 | 1.1 |
| | 1.40 | 0.82 | 0.25 | 0.2 | 0.05 | 0.14 | | 0.007 | 1.9 |
| | 1.60 | 0.90 | 0.27 | 0.2 | 0.05 | 0.16 | | 0.009 | 2.4 |
| | 1.80 | 0.87 | 0.27 | 0.2 | 0.05 | 0.17 | | 0.009 | 2.5 |
| | 2.00 | 1.00 | 0.30 | 0.2 | 0.06 | 0.17 | | 0.010 | 2.8 |
| | 2.20 | 0.99 | 0.30 | 0.2 | 0.06 | 0.16 | | 0.010 | 2.6 |
| | 2.40 | 1.07 | 0.33 | 0.2 | 0.07 | 0.13 | | 0.008 | 2.3 |
| | 2.60 | 1.10 | 0.34 | 0.2 | 0.07 | 0.16 | | 0.011 | 2.9 |
| | 2.80 | 1.05 | 0.32 | 0.2 | 0.06 | 0.19 | | 0.012 | 3.3 |
| | 3.00 | 1.00 | 0.30 | 0.2 | 0.06 | 0.22 | | 0.013 | 3.6 |
| | 3.20 | 0.90 | 0.27 | 0.2 | 0.05 | 0.27 | | 0.015 | 4.0 |
| | 3.40 | 0.85 | 0.26 | 0.2 | 0.05 | 0.33 | | 0.017 | 4.7 |
| | 3.60 | 0.65 | 0.20 | 0.2 | 0.04 | 0.33 | | 0.013 | 3.6 |
| | 3.80 | 0.61 | 0.19 | 0.2 | 0.04 | 0.36 | | 0.013 | 3.6 |
| | 4.00 | 0.46 | 0.14 | 0.2 | 0.03 | 0.34 | | 0.010 | 2.6 |
| | 4.20 | 0.43 | 0.13 | 0.2 | 0.03 | 0.29 | | 0.008 | 2.1 |
| | 4.40 | 0.27 | 0.08 | 0.2 | 0.02 | 0.21 | | 0.003 | 0.9 |
| | 4.60 | 0.18 | 0.05 | 0.2 | 0.01 | 0.12 | | 0.001 | 0.4 |
| | 4.80 | 0.10 | 0.03 | 0.2 | 0.01 | 0.03 | | 0.000 | 0.1 |
| | 5.10 | 0.08 | 0.02 | 0.3 | 0.01 | 0.02 | | 0.000 | 0.0 |
| | 5.25 | 0.00 | 0.0 | 0.2 | 0.00 | 0 | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.179** | **48.6** |

**General Notes**

## Appendix 2-2c. Manual Discharge Measurements and Levelling Surveys at MH-2 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-2 | | | |
| **Stream Name** | Lower Camp Creek | | | |
| **Date Monitored** | 6-Nov-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:00:00 AM | **End Time:** | 11:30:00 AM |
| **Personnel** | Eli H., Tyler G. | | | |
| **Station Coordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0626246 | 6098122 | 755 | |
| **Weather Conditions** | Clear, 3C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 2721018 |
| **Gain** | 3.5522 | **Offset** | -0.0508 |
| **Status** | logging | **Battery** | 100% |
| **# of Records** | 27200 | **Memory Free** | 17987 |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 16 | 0.954 | 100.954 | | 100.000 | |
| BM 15 | | | 1.082 | 99.921 | |
| BM 14 | | | 0.929 | 100.074 | |
| PT 1 | | | 3.113 | 97.890 | Top Hose clamp |
| PT 2 | | | 4.258 | 96.745 | **error** |
| WL | | | 3.762 | 97.241 | |
| SG | | | 3.029 | 97.974 | |
| TBM | 1.347 | 101.041 | 1.309 | 99.694 | |
| SG | | | 3.066 | -3.066 | |
| WL | | | 3.801 | -3.801 | |
| PT 2 | | | 4.211 | -4.211 | |
| **PT 1** | | | 3.151 | -3.151 | Top Hose clamp |
| BM 14 | | | 0.967 | -0.967 | |
| BM 15 | | | 1.121 | -1.121 | |
| BM 16 | | | 0.993 | -0.993 | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 15 | 99.87 | 49.400 | -50.470 | |
| BM 14 | 100.026 | 49.554 | -50.473 | |
| PT 2 | 97.89 | 47.370 | -50.521 | |

| Summary | |
|---|---|
| **Stage (m)** | 46.720 |
| **Discharge ($m^3/s$)** | 0.092 |
| **Pressure Transducer Reading (m)** | 0.354 |
| **Pressure Transducer Elevation (m)** | 46.366 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 10:25 | **End** | 11:33 | **Location** | 2.5m DS of PT | | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate | | | | |
| **Flow Meter Type** | Electromagnetic | | | **Instrument Serial #** | | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.36 | **SG** | 0.317 | **Time** | 10:30 | **Gauge correction:** | | |
| | **End** | **Reading** | 0.354 | **SG** | 0.314 | **Time** | 11:00 | -0.04 | 46.403 | |

| | **Station** | **Depth** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(ft)** | **(m)** | **(m)** | **($m^2$)** | **60%** | | **(m3/s)** | **%** |
| LB | 3.55 | 0.00 | 0.00 | 0.0 | 0.00 | 0 | | 0.000 | 0.0 |
| | 3.60 | 0.20 | 0.06 | 0.1 | 0.01 | -0.04 | | 0.000 | -0.1 |
| | 3.75 | 0.10 | 0.03 | 0.2 | 0.01 | 0.02 | | 0.000 | 0.0 |
| | 4.00 | 0.20 | 0.06 | 0.3 | 0.02 | 0.02 | | 0.000 | 0.1 |
| | 4.25 | 0.28 | 0.09 | 0.3 | 0.02 | 0.04 | | 0.001 | 0.2 |
| | 4.50 | 0.41 | 0.12 | 0.3 | 0.03 | 0.13 | | 0.004 | 1.1 |
| | 4.75 | 0.45 | 0.14 | 0.3 | 0.03 | 0.17 | | 0.006 | 1.6 |
| | 5.00 | 0.50 | 0.15 | 0.3 | 0.04 | 0.21 | | 0.008 | 2.2 |
| | 5.25 | 0.43 | 0.13 | 0.3 | 0.03 | 0.2 | | 0.007 | 1.8 |
| | 5.50 | 0.42 | 0.13 | 0.3 | 0.03 | 0.21 | | 0.007 | 1.8 |
| | 5.75 | 0.38 | 0.12 | 0.3 | 0.03 | 0.19 | | 0.006 | 1.5 |
| | 6.00 | 0.50 | 0.15 | 0.3 | 0.04 | 0.24 | | 0.009 | 2.5 |
| | 6.25 | 0.40 | 0.12 | 0.3 | 0.03 | 0.22 | | 0.007 | 1.8 |
| | 6.50 | 0.54 | 0.16 | 0.3 | 0.04 | 0.21 | | 0.009 | 2.4 |
| | 6.75 | 0.47 | 0.14 | 0.3 | 0.04 | 0.25 | | 0.009 | 2.4 |
| | 7.00 | 0.34 | 0.10 | 0.3 | 0.03 | 0.25 | | 0.006 | 1.8 |
| | 7.25 | 0.28 | 0.09 | 0.3 | 0.02 | 0.29 | | 0.006 | 1.7 |
| | 7.50 | 0.25 | 0.08 | 0.3 | 0.02 | 0.21 | | 0.004 | 1.1 |
| | 7.75 | 0.26 | 0.08 | 0.3 | 0.02 | 0.14 | | 0.003 | 0.8 |
| | 8.00 | 0.22 | 0.07 | 0.3 | 0.02 | 0.07 | | 0.001 | 0.3 |
| | 8.25 | 0.15 | 0.05 | 0.3 | 0.01 | 0.03 | | 0.000 | 0.1 |
| | 8.50 | 0.18 | 0.05 | 0.3 | 0.01 | -0.01 | | 0.000 | 0.0 |
| | 8.70 | 0.10 | 0.03 | 0.2 | 0.00 | -0.05 | | 0.000 | -0.1 |
| | 8.75 | 0.00 | 0.00 | 0.1 | 0.00 | 0 | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0918** | **25.0** |

| General Notes |
|---|
| Drop on stage due to water flushing through system following ice breakup. Use value @ 11:00 |

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 16-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 5:00:00 PM | **End Time:** | 6:30:00 PM |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 94 | 1.189 | 101.189 | | 100.000 | |
| BM 93 | | | 1.666 | 99.523 | |
| BM95 | | | 0.861 | 100.328 | |
| TP 1 | | | 1.414 | 99.775 | |
| WL | | | 2.691 | **98.498** | |
| TP 1 | 1.365 | 101.140 | | 99.775 | |
| BM 93 | | | 1.609 | 99.531 | |
| BM 95 | | | 0.801 | 100.339 | |
| WL | | | 2.642 | **98.498** | |
| BM 94 | | | 1.130 | 100.010 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 94 | | 100.005 | | |
| BM 93 | | 99.527 | | |
| BM 95 | | 100.334 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.498 |
| **Mean Discharge ($m^3/s$)** | 0.311 |
| **Pressure Transducer Reading (m)** | 0.372 |
| **Pressure Transducer Elevation (m)** | 98.126 |

**Discharge Measurement - Mid-Section Method (5/15/11 #1)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 17:15 | **End** | 17:45 | **Location** | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | | |
| **Stage (m)** | **Start** | **Reading** | 0.372 | **Time** | 17:15 | Measurement #1 | |
| | **End** | **Reading** | | **Time** | 17:45 | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **(m/s)** | **(m/s)** | **(m3/s)** | **%** |
| Right bank | 1.40 | 0.00 | 0.05 | 0.01 | 0.00 | 0.02 | 0.000 | 0.0 |
| | 1.50 | 0.28 | 0.10 | 0.03 | 0.03 | 0.04 | 0.001 | 0.4 |
| | 1.60 | 0.28 | 0.10 | 0.03 | 1.16 | 0.80 | 0.024 | 7.3 |
| | 1.70 | 0.31 | 0.10 | 0.03 | 1.67 | 1.15 | 0.035 | 11.6 |
| | 1.80 | 0.32 | 0.10 | 0.03 | 1.41 | 0.97 | 0.029 | 10.1 |
| | 1.90 | 0.33 | 0.10 | 0.03 | 1.54 | 1.06 | 0.032 | 11.4 |
| | 2.00 | 0.28 | 0.10 | 0.03 | 1.24 | 0.86 | 0.026 | 7.8 |
| | 2.10 | 0.26 | 0.10 | 0.03 | 1.29 | 0.89 | 0.027 | 7.5 |
| | 2.20 | 0.24 | 0.10 | 0.02 | 1.19 | 0.82 | 0.016 | 6.4 |
| | 2.30 | 0.21 | 0.08 | 0.02 | 1.06 | 0.73 | 0.015 | 3.8 |
| | 2.35 | 0.14 | 0.05 | 0.01 | 1.43 | 0.98 | 0.010 | 2.2 |
| | 2.40 | 0.20 | 0.08 | 0.02 | 1.12 | 0.78 | 0.016 | 3.8 |
| | 2.50 | 0.18 | 0.10 | 0.02 | 1.28 | 0.88 | 0.018 | 5.2 |
| | 2.60 | 0.13 | 0.10 | 0.01 | 1.28 | 0.88 | 0.009 | 3.7 |
| | 2.70 | 0.12 | 0.10 | 0.01 | 1.16 | 0.80 | 0.008 | 3.1 |
| | 2.80 | 0.10 | 0.10 | 0.01 | 0.98 | 0.68 | 0.007 | 2.2 |
| | 2.90 | 0.11 | 0.10 | 0.01 | 1.09 | 0.75 | 0.008 | 2.7 |
| | 3.00 | 0.10 | 0.10 | 0.01 | 1.92 | 1.31 | 0.013 | 4.3 |
| | 3.10 | 0.12 | 0.10 | 0.01 | 0.72 | 0.51 | 0.005 | 2.0 |
| | 3.20 | 0.14 | 0.10 | 0.01 | 0.62 | 0.44 | 0.004 | 2.0 |
| | 3.30 | 0.15 | 0.10 | 0.02 | 0.69 | 0.49 | 0.010 | 2.4 |
| Left bank | 3.40 | 0.00 | 0.05 | 0.00 | 0.00 | 0.02 | 0.000 | 0.0 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **0.311** | **100.0** |

**General Notes**

Use average of two discharge measurements

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 16-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 5:00:00 PM | **End Time:** | 6:30:00 PM |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 94 | 1.189 | 101.189 | | 100.000 | |
| BM 93 | | | 1.666 | 99.523 | |
| BM95 | | | 0.861 | 100.328 | |
| TP 1 | | | 1.414 | 99.775 | |
| WL | | | 2.691 | **98.498** | |
| TP 1 | 1.365 | 101.140 | | 99.775 | |
| BM 93 | | | 1.609 | 99.531 | |
| BM 95 | | | 0.801 | 100.339 | |
| WL | | | 2.642 | **98.498** | |
| BM 94 | | | 1.130 | 100.010 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 94 | | 100.005 | | |
| BM 93 | | 99.527 | | |
| BM 95 | | 100.334 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.498 |
| **Mean Discharge ($m^3/s$)** | 0.353 |
| **Pressure Transducer Reading (m)** | 0.372 |
| **Pressure Transducer Elevation (m)** | 98.126 |

**Discharge Measurement - Mid-Section Method (5/15/11 #2)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 17:15 | **End** | 17:45 | **Location** | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | | |
| **Stage (m)** | **Start** | **Reading** | 0.372 | **Time** | 17:15 | Measurement #2 | |
| | **End** | **Reading** | | **Time** | 17:45 | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **(m/s)** | **(m/s)** | **(m3/s)** | **%** |
| Left bank | 3.40 | 0.00 | 0.02 | 0.00 | 0.00 | 0.02 | 0.000 | 0.0 |
| | 3.35 | 0.09 | 0.08 | 0.01 | 1.00 | 0.69 | 0.007 | 1.4 |
| | 3.25 | 0.16 | 0.10 | 0.02 | 0.74 | 0.52 | 0.010 | 2.4 |
| | 3.15 | 0.15 | 0.10 | 0.02 | 0.71 | 0.50 | 0.010 | 2.2 |
| | 3.05 | 0.13 | 0.10 | 0.01 | 0.99 | 0.69 | 0.007 | 2.6 |
| | 2.95 | 0.12 | 0.10 | 0.01 | 1.22 | 0.84 | 0.008 | 2.9 |
| | 2.85 | 0.12 | 0.10 | 0.01 | 1.33 | 0.92 | 0.009 | 3.2 |
| | 2.75 | 0.12 | 0.10 | 0.01 | 1.33 | 0.92 | 0.009 | 3.2 |
| | 2.65 | 0.13 | 0.10 | 0.01 | 1.41 | 0.97 | 0.010 | 3.6 |
| | 2.55 | 0.15 | 0.10 | 0.02 | 1.52 | 1.04 | 0.021 | 4.5 |
| | 2.45 | 0.15 | 0.10 | 0.02 | 1.44 | 0.99 | 0.020 | 4.3 |
| | 2.35 | 0.19 | 0.08 | 0.01 | 1.30 | 0.90 | 0.009 | 3.7 |
| | 2.30 | 0.22 | 0.05 | 0.01 | 1.01 | 0.70 | 0.007 | 2.2 |
| | 2.25 | 0.25 | 0.08 | 0.02 | 1.40 | 0.96 | 0.019 | 5.2 |
| | 2.15 | 0.23 | 0.10 | 0.02 | 1.30 | 0.90 | 0.018 | 6.0 |
| | 2.05 | 0.25 | 0.10 | 0.03 | 1.46 | 1.00 | 0.030 | 7.3 |
| | 1.95 | 0.27 | 0.10 | 0.03 | 1.39 | 0.96 | 0.029 | 7.5 |
| | 1.85 | 0.29 | 0.10 | 0.03 | 1.69 | 1.16 | 0.035 | 9.7 |
| | 1.75 | 0.32 | 0.10 | 0.03 | 1.63 | 1.12 | 0.034 | 10.3 |
| | 1.65 | 0.32 | 0.10 | 0.03 | 1.62 | 1.11 | 0.033 | 10.3 |
| | 1.55 | 0.30 | 0.13 | 0.04 | 0.99 | 0.69 | 0.028 | 7.5 |
| Right bank | 1.40 | 0.00 | 0.08 | 0.01 | 0.00 | 0.02 | 0.000 | 0.1 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **0.353** | **100.0** |

| General Notes |
|---|
| Use average of two discharge measurements |

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-3 | | | |
| Stream Name | Twenty Creek | | | |
| Date Monitored | 3-Jul-11 | | | |
| Time at Site (24 hr) | Start Time: | 12:50:00 PM | End Time: | 2:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS 9800 | Serial # | 2721022 |
| Gain | 3.4573 | Offset | -0.0054 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 95 | 0.754 | 101.082 | | 100.328 | |
| BM 94 | | | 1.082 | 100.000 | |
| BM 93 | | | 1.628 | 99.454 | |
| PT | | | 2.948 | 98.134 | |
| WL 1 | | | 2.816 | **98.266** | |
| WL 2 | | | 2.932 | 98.150 | |
| BM 93 | 1.599 | 101.053 | | 99.454 | |
| BM 94 | | | 1.055 | 99.998 | |
| WL 1 | | | 2.788 | **98.265** | |
| WL 2 | | | 2.899 | 98.154 | |
| PT | | | 2.918 | 98.135 | |
| **BM 95** | | | 0.726 | 100.327 | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 94 | | 99.999 | | |
| BM 93 | | 99.454 | | |
| BM 95 | | 100.328 | | |

| Summary | |
|---|---|
| Stage (m) | 98.266 |
| Mean Discharge ($m^3/s$) | 0.0680 |
| Pressure Transducer Reading (m) | 0.252 |
| Pressure Transducer Elevation (m) | 98.014 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 15:30 | End | 16:02 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.252 | Time | 12:30 | | | | |
| | End | Reading | | Time | 13:05 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 0.90 | 0.00 | 0.05 | 0.001 | 0 | | | 0.000 | 0.0 |
| CF = | 1.00 | 0.04 | 0.10 | 0.004 | -0.02 | | | 0.000 | -0.1 |
| 1 | 1.10 | 0.08 | 0.10 | 0.008 | 0.21 | | | 0.002 | 2.5 |
| | 1.20 | 0.09 | 0.07 | 0.006 | 0.61 | | | 0.004 | 5.6 |
| | 1.24 | 0.12 | 0.04 | 0.005 | 0.47 | | | 0.002 | 3.3 |
| | 1.28 | 0.11 | 0.04 | 0.004 | 0.71 | | | 0.003 | 4.6 |
| | 1.32 | 0.12 | 0.04 | 0.005 | 0.76 | | | 0.004 | 5.4 |
| | 1.36 | 0.12 | 0.06 | 0.007 | 0.63 | | | 0.005 | 6.7 |
| | 1.44 | 0.12 | 0.08 | 0.010 | 0.46 | | | 0.004 | 6.5 |
| | 1.52 | 0.13 | 0.08 | 0.010 | 0.37 | | | 0.004 | 5.6 |
| | 1.60 | 0.10 | 0.08 | 0.008 | 0.36 | | | 0.003 | 4.2 |
| | 1.68 | 0.12 | 0.08 | 0.010 | 0.38 | | | 0.004 | 5.4 |
| | 1.76 | 0.12 | 0.06 | 0.007 | 0.47 | | | 0.003 | 5.0 |
| | 1.80 | 0.11 | 0.04 | 0.004 | 0.55 | | | 0.002 | 3.5 |
| | 1.84 | 0.10 | 0.04 | 0.004 | 0.61 | | | 0.002 | 3.6 |
| | 1.88 | 0.10 | 0.04 | 0.004 | 0.59 | | | 0.002 | 3.5 |
| | 1.92 | 0.11 | 0.06 | 0.007 | 0.48 | | | 0.003 | 4.6 |
| | 2.00 | 0.10 | 0.06 | 0.006 | 0.45 | | | 0.003 | 4.0 |
| | 2.04 | 0.11 | 0.04 | 0.004 | 0.62 | | | 0.003 | 4.0 |
| | 2.08 | 0.11 | 0.06 | 0.007 | 0.6 | | | 0.004 | 5.8 |
| | 2.16 | 0.10 | 0.08 | 0.008 | 0.64 | | | 0.005 | 7.5 |
| | 2.24 | 0.06 | 0.06 | 0.004 | 0.59 | | | 0.002 | 3.1 |
| | 2.28 | 0.06 | 0.04 | 0.002 | 0.56 | | | 0.001 | 2.0 |
| | 2.32 | 0.06 | 0.06 | 0.004 | 0.47 | | | 0.002 | 2.5 |
| 1 | 2.40 | 0.04 | 0.08 | 0.003 | 0.3 | | | 0.001 | 1.4 |
| CF = | 2.48 | 0.04 | 0.1 | 0.00 | 0 | | | 0.000 | 0.0 |
| Left Bank | 2.56 | 0.00 | 0.0 | 0.00 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0680** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 4-Jul-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:50:00 PM | **End Time:** | 2:00:00 PM |
| **Personnel** | Craig Hatt, Assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 95 | 0.688 | 101.018 | | 100.330 | |
| BM 94 | | | 1.018 | 100.000 | |
| BM 93 | | | 1.558 | 99.460 | |
| PT | | | 2.774 | 98.244 | |
| WL 1 | | | 2.622 | **98.396** | Upstream of weir |
| WL 2 | | | 2.878 | 98.147 | Downstream of weir |
| BM 93 | 1.565 | 101.025 | | 99.460 | |
| BM 94 | | | 1.024 | 100.001 | |
| WL 1 | | | 2.628 | **98.397** | |
| WL 2 | | | 2.887 | 98.138 | |
| PT | | | 2.782 | 98.243 | |
| **BM 95** | | | **0.7** | 100.330 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 94 | | 100.001 | | |
| BM 93 | | 99.460 | | |
| BM 95 | | 100.330 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.397 |
| **Mean Discharge ($m^3/s$)** | 0.0639 |
| **Pressure Transducer Reading (m)** | 0.182 |
| **Pressure Transducer Elevation (m)** | 98.215 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 12:30 | **End** | 13:05 | **Location** | | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.182 | | **Time** | 12:30 | | | |
| | **End** | **Reading** | | | **Time** | 13:05 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 0.84 | 0.00 | 0.08 | 0.002 | 0 | | | 0.000 | 0.1 |
| CF = | 1.00 | 0.05 | 0.13 | 0.007 | 0.06 | | | 0.000 | 0.6 |
| 0.5 | 1.10 | 0.06 | 0.08 | 0.005 | 0.14 | | | 0.001 | 1.0 |
| | 1.15 | 0.06 | 0.05 | 0.003 | 0.3 | | | 0.001 | 1.4 |
| | 1.20 | 0.10 | 0.05 | 0.005 | 0.55 | | | 0.003 | 4.3 |
| | 1.25 | 0.10 | 0.05 | 0.005 | 0.56 | | | 0.003 | 4.4 |
| | 1.30 | 0.10 | 0.05 | 0.005 | 0.39 | | | 0.002 | 3.1 |
| | 1.35 | 0.12 | 0.05 | 0.006 | 0.31 | | | 0.002 | 2.9 |
| | 1.40 | 0.12 | 0.05 | 0.006 | 0.17 | | | 0.001 | 1.6 |
| | 1.45 | 0.12 | 0.05 | 0.006 | 0.22 | | | 0.001 | 2.1 |
| | 1.50 | 0.12 | 0.05 | 0.006 | 0.4 | | | 0.002 | 3.8 |
| | 1.55 | 0.10 | 0.05 | 0.005 | 0.7 | | | 0.004 | 5.5 |
| | 1.60 | 0.10 | 0.05 | 0.005 | 0.82 | | | 0.004 | 6.4 |
| | 1.65 | 0.13 | 0.05 | 0.006 | 0.62 | | | 0.004 | 6.3 |
| | 1.70 | 0.12 | 0.05 | 0.006 | 0.55 | | | 0.003 | 5.2 |
| | 1.75 | 0.12 | 0.05 | 0.006 | 0.69 | | | 0.004 | 6.5 |
| | 1.80 | 0.12 | 0.05 | 0.006 | 0.81 | | | 0.005 | 7.6 |
| | 1.85 | 0.11 | 0.05 | 0.005 | 0.17 | | | 0.001 | 1.5 |
| | 1.90 | 0.11 | 0.08 | 0.008 | 0.68 | | | 0.006 | 8.8 |
| | 2.00 | 0.10 | 0.10 | 0.010 | 0.39 | | | 0.004 | 6.1 |
| | 2.10 | 0.10 | 0.10 | 0.010 | 0.58 | | | 0.006 | 9.1 |
| | 2.20 | 0.09 | 0.10 | 0.009 | 0.53 | | | 0.005 | 7.5 |
| 1 | 2.30 | 0.06 | 0.10 | 0.006 | 0.41 | | | 0.003 | 3.9 |
| CF = | 2.40 | 0.07 | 0.10 | 0.007 | 0.03 | | | 0.000 | 0.3 |
| Left Bank | 2.50 | 0.00 | 0.05 | 0.002 | 0 | | | 0.000 | 0.1 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0639** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 7-Aug-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:15:00 AM | **End Time:** | 12:30:00 PM |
| **Personnel** | Craig Hatt, Assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 94 | 1.079 | 101.079 | | 100.000 | |
| BM 93 | | | 1.624 | 99.455 | |
| BM 95 | | | 0.750 | 100.329 | |
| WL | | | 2.763 | **98.316** | |
| WL | | | 2.745 | **98.317** | |
| BM 95 | 0.733 | 101.062 | | 100.329 | |
| BM93 | | | 1.607 | 99.455 | |
| BM 94 | | | 1.060 | 100.002 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 94 | | 100.001 | | |
| BM 93 | | 99.455 | | |
| BM 95 | | 100.329 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.317 |
| **Mean Discharge ($m^3/s$)** | 0.00026 |
| **Pressure Transducer Reading (m)** | 0.258 |
| **Pressure Transducer Elevation (m)** | 98.059 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 10:25 | **End** | 11:00 | **Location** | | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.258 | | **Time** | 10:25 | | | |
| | **End** | **Reading** | | | **Time** | 11:00 | | | |

| | **Station** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| right bank | 0.70 | 0.00 | 0.05 | 0.000 | 0 | | | 0.0000 | 0.1 |
| CF= | 0.80 | 0.07 | 0.10 | 0.010 | 0 | | | 0.0000 | 0.6 |
| 1 | 0.90 | 0.09 | 0.10 | 0.010 | -0.02 | | | -0.0002 | 1.0 |
| | 1.00 | 0.12 | 0.10 | 0.010 | -0.01 | | | -0.0001 | 1.4 |
| | 1.10 | 0.15 | 0.10 | 0.020 | 0 | | | 0.0000 | 4.3 |
| | 1.20 | 0.18 | 0.10 | 0.020 | 0.01 | | | 0.0002 | 4.4 |
| | 1.30 | 0.18 | 0.08 | 0.010 | 0 | | | 0.0000 | 3.1 |
| | 1.35 | 0.17 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 2.9 |
| | 1.40 | 0.18 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 1.6 |
| | 1.45 | 0.18 | 0.05 | 0.010 | 0.02 | | | 0.0002 | 2.1 |
| | 1.50 | 0.18 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 3.8 |
| | 1.55 | 0.17 | 0.05 | 0.010 | 0.02 | | | 0.0002 | 5.5 |
| | 1.60 | 0.20 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 6.4 |
| | 1.65 | 0.22 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 6.3 |
| | 1.70 | 0.21 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 5.2 |
| | 1.75 | 0.20 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 6.5 |
| | 1.80 | 0.18 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 7.6 |
| | 1.85 | 0.19 | 0.05 | 0.010 | 0.01 | | | 0.0001 | 1.5 |
| | 1.90 | 0.18 | 0.08 | 0.010 | 0 | | | 0.0000 | 8.8 |
| | 2.00 | 0.14 | 0.10 | 0.010 | 0 | | | 0.0000 | 6.1 |
| | 2.10 | 0.10 | 0.10 | 0.010 | -0.01 | | | -0.0001 | 9.1 |
| | 2.20 | 0.09 | 0.10 | 0.010 | -0.02 | | | -0.0002 | 7.5 |
| 1 | 2.30 | 0.08 | 0.10 | 0.010 | -0.03 | | | -0.0002 | 3.9 |
| CF= | 2.40 | 0.07 | 0.15 | 0.010 | -0.03 | | | -0.0003 | 0.3 |
| left bank | 2.60 | 0.00 | 0.10 | 0.000 | 0 | | | 0.00000 | 0.1 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.00026** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-3 | | | |
| Stream Name | Twenty Creek | | | |
| Date Monitored | 8-Sep-11 | | | |
| Time at Site (24 hr) | Start Time: | 5:00:00 PM | End Time: | 6:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS 9800 | Serial # | 2721022 |
| Gain | 3.4573 | Offset | -0.0054 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 94 | 0.997 | 100.997 | | 100.000 | |
| BM 93 | | | 1.544 | 99.453 | |
| BM 95 | | | 0.669 | 100.328 | |
| WL | | | 2.697 | **98.300** | |
| WL | | | 2.722 | **98.303** | |
| BM 95 | 0.697 | 101.025 | 0.697 | 100.328 | |
| BM 93 | | | 1.571 | 99.454 | |
| BM 94 | | | 1.023 | 100.002 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 94 | | 100.001 | | |
| BM 93 | | 99.454 | | |
| BM 95 | | 100.328 | | |

| Summary | |
|---|---|
| Stage (m) | 98.302 |
| Mean Discharge ($m^3/s$) | 0.00001 |
| Pressure Transducer Reading (m) | 0.253 |
| Pressure Transducer Elevation (m) | 98.049 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 17:25 | End | 18:00 | Location | | | | | | | | |
| Method | Filling 250ml bottle | | | Instrument Model | | | | | | | | | |
| Flow Meter Type | | | | Instrument Serial # | | | | | | | | | |
| Stage (m) | Start | Reading | 0.253 | Time | 17:25 | | | | | | | | |
| | End | Reading | | Time | | | | | | | | | |
| | Volume | Time | | | | | | | | | | Q | |
| Notes | ($m^3$) | (s) | | | | | | | | | | (m3/s) | |
| Filling 250ml bottle | 0.00 | 43.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 42.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 47.00 | | | | | | | | | | 0.00001 | |
| Filling 250ml bottle | 0.00 | 45.00 | | | | | | | | | | 0.00001 | |
| | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | |
| Total Q | | | | | | | | | | | | 0.00001 | 100.0 |

| General Notes |
|---|
| |

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 17-Oct-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 1:00:00 PM | **End Time:** | 4:00:00 PM |
| **Personnel** | Craig Hatt, Assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 94 | 0.961 | 100.961 | | 100.000 | |
| BM 93 | | | 1.506 | 99.455 | |
| BM 95 | | | 0.631 | 100.330 | |
| WL | | | 2.662 | **98.299** | |
| WL | | | 2.664 | **98.300** | |
| BM 95 | 0.634 | 100.964 | | 100.330 | |
| BM 93 | | | 1.509 | 99.455 | |
| BM 94 | | | 0.963 | 100.001 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 94 | | 100.001 | | |
| BM 93 | | 99.455 | | |
| BM 95 | | 100.330 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.300 |
| **Mean Discharge ($m^3/s$)** | 0.00009 |
| **Pressure Transducer Reading (m)** | 0.254 |
| **Pressure Transducer Elevation (m)** | 98.046 |

| Discharge Measurement - Mid-Section Method | | | | | | |
|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 16:00 | **End** | 16:30 | **Location** | |
| **Method** | Filling 400ml bottle | | | **Instrument Model** | | |
| **Flow Meter Type** | | | | **Instrument Serial #** | | |
| **Stage (m)** | **Start** | **Reading** | 0.254 | **Time** | 16:00 | |
| | **End** | **Reading** | | **Time** | | |

| | Volume | Time | | | | | | Q | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **($m^3$)** | **(s)** | | | | | | **(m3/s)** | |
| Filling 400ml bottle | 0.00 | 4.26 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.50 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.26 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.32 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.39 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.82 | | | | | | 0.00008 | |
| Filling 400ml bottle | 0.00 | 4.57 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.64 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.57 | | | | | | 0.00009 | |
| Filling 400ml bottle | 0.00 | 4.88 | | | | | | 0.00008 | |
| **Total Q** | | | | | | | | **0.00009** | **100.0** |

**General Notes**

## Appendix 2-3a. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 16-Nov-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:40:00 PM | **End Time:** | 7:00:00 PM |
| **Personnel** | Craig Hatt, Assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 625519 | 6096897 | | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 94 | 0.942 | 100.942 | | 100.000 | |
| BM 93 | | | 1.490 | 99.452 | |
| BM 95 | | | 0.614 | 100.328 | |
| WL | | | 2.648 | **98.294** | |
| BM 95 | 0.645 | 100.973 | | 100.328 | |
| WL | | | 2.679 | **98.294** | |
| BM 93 | | | 1.520 | 99.453 | |
| BM 94 | | | 0.973 | 100.000 | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 94 | | 100.000 | | |
| BM 93 | | 99.453 | | |
| BM 95 | | 100.328 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.294 |
| **Mean Discharge ($m^3/s$)** | 0.00011 |
| **Pressure Transducer Reading (m)** | 0.249 |
| **Pressure Transducer Elevation (m)** | 98.045 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 12:50 | **End** | 13:25 | **Location** | | | | |
| **Method** | Filling 320ml bottle | | | | **Instrument Model** | | | | |
| **Flow Meter Type** | | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.249 | | **Time** | 16:00 | | | |
| | **End** | **Reading** | | | **Time** | | | | |

| | **Volume** | **Time** | | | | | | **Q** | |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **($m^3$)** | **(s)** | | | | | | **(m3/s)** | |
| Filling 320ml bottle | 0.00 | 3.07 | | | | | | 0.00010 | |
| Filling 320ml bottle | 0.00 | 3.14 | | | | | | 0.00010 | |
| Filling 320ml bottle | 0.00 | 3.01 | | | | | | 0.00011 | |
| Filling 320ml bottle | 0.00 | 2.70 | | | | | | 0.00012 | |
| Filling 320ml bottle | 0.00 | 2.76 | | | | | | 0.00012 | |
| Filling 320ml bottle | 0.00 | 2.95 | | | | | | 0.00011 | |
| Filling 320ml bottle | 0.00 | 2.78 | | | | | | 0.00012 | |
| Filling 320ml bottle | 0.00 | 2.70 | | | | | | 0.00012 | |
| Filling 320ml bottle | 0.00 | 2.83 | | | | | | 0.00011 | |
| Filling 320ml bottle | 0.00 | 2.89 | | | | | | 0.00011 | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | |

## Appendix 2-3b. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 27-Apr-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | | **End Time:** | |
| **Personnel** | Craig Hatt, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 766 | |
| **Weather Conditions** | Sunny and Windy | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | 27-Apr-12 | **Crest Gauges** | no |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 36 | 1.369 | 101.369 | | 100.000 | |
| BM 37 | | | 1.879 | 99.490 | |
| BM 38 | | | 2.387 | 98.982 | |
| PT | | | 3.907 | 97.462 | |
| WL | | | 3.727 | **97.642** | **Time: 17:43** |
| TBM | 2.931 | 101.317 | 2.983 | 98.386 | |
| WL | | | 3.673 | **97.644** | |
| PT | | | 3.855 | 97.462 | |
| BM 38 | | | 2.334 | 98.983 | |
| BM 37 | | | 1.827 | 99.490 | |
| BM 36 | | | 1.317 | 100.000 | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 37 | 99.490 | 99.490 | | Established on this date |
| BM 38 | 98.983 | 98.983 | | Established on this date |
| PT | 97.462 | 97.462 | | Installed on this date |

| Summary | |
|---|---|
| **Stage (m)** | 97.643 |
| **Discharge ($m^3$/s)** | 0.0949 |
| **Pressure Transducer Reading (m)** | 0.169 |
| **Pressure Transducer Elevation (m)** | 97.474 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 16:15 | **End** | 16:45 | **Location** | At PT | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | 2007612 | | |
| **Stage (m)** | **Start** | **Reading** | | **Time** | 16:15 | | | |
| | **End** | **Reading** | | **Time** | 16:45 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| Right Bank | 2.68 | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.000 | 0.0 |
| | 2.70 | 0.18 | 0.02 | 0.01 | 0.06 | | | 0.001 | 0.7 |
| | 2.80 | 0.19 | 0.10 | 0.01 | 0.28 | | | 0.004 | 4.2 |
| | 2.85 | 0.18 | 0.05 | 0.01 | 0.30 | | | 0.003 | 2.8 |
| | 2.90 | 0.18 | 0.05 | 0.01 | 0.47 | | | 0.004 | 4.5 |
| | 2.95 | 0.18 | 0.05 | 0.01 | 0.42 | | | 0.004 | 4.0 |
| | 3.00 | 0.18 | 0.05 | 0.01 | 0.70 | | | 0.006 | 6.6 |
| | 3.05 | 0.18 | 0.05 | 0.01 | 0.92 | | | 0.008 | 8.7 |
| | 3.10 | 0.17 | 0.05 | 0.01 | 1.10 | | | 0.009 | 9.9 |
| | 3.15 | 0.16 | 0.05 | 0.01 | 1.04 | | | 0.008 | 8.8 |
| | 3.20 | 0.16 | 0.05 | 0.01 | 0.85 | | | 0.007 | 7.2 |
| | 3.25 | 0.15 | 0.05 | 0.01 | 0.75 | | | 0.006 | 5.9 |
| | 3.30 | 0.14 | 0.05 | 0.01 | 0.57 | | | 0.006 | 6.3 |
| | 3.40 | 0.14 | 0.10 | 0.01 | 0.44 | | | 0.006 | 6.5 |
| | 3.50 | 0.13 | 0.10 | 0.01 | 0.43 | | | 0.006 | 5.9 |
| | 3.60 | 0.12 | 0.10 | 0.01 | 0.41 | | | 0.005 | 5.2 |
| | 3.70 | 0.12 | 0.10 | 0.01 | 0.35 | | | 0.004 | 4.4 |
| | 3.80 | 0.11 | 0.10 | 0.01 | 0.24 | | | 0.003 | 2.8 |
| | 3.90 | 0.12 | 0.10 | 0.01 | 0.14 | | | 0.002 | 1.8 |
| | 4.00 | 0.12 | 0.10 | 0.01 | 0.11 | | | 0.001 | 1.4 |
| | 4.10 | 0.13 | 0.10 | 0.01 | 0.09 | | | 0.001 | 1.2 |
| | 4.20 | 0.11 | 0.10 | 0.01 | 0.11 | | | 0.001 | 1.3 |
| Left Bank | 4.30 | 0 | 0.10 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| | | | | | | | | | |
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| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0949** | **100.0** |

**General Notes**

Located 20m downstream of culverts. Water surface is relatively flat with controls upstream and downstream. PT Accuracy test - Manual Measurement: 17.5cm, PT Reading 17.6cm

## Appendix 2-3b. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH3 | | | |
| **Stream Name** | Twenty Creek | | | |
| **Date Monitored** | 20-May-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 14:20 | **End Time:** | |
| **Personnel** | Craig Hatt, David Moellenbeck | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 766 | |
| **Weather Conditions** | Sunny 16C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS 9800 | **Serial #** | 2721022 |
| **Gain** | 3.4573 | **Offset** | -0.0054 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | 3312 | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | no |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 36 | 1.408 | 101.408 | | 100.000 | |
| BM 37 | | | 1.917 | 99.491 | |
| BM 38 | | | 2.425 | 98.983 | |
| PT | | | 3.888 | 97.520 | Top of Angle iron |
| WL | | | 3.737 | **97.671** | |
| TBM | 3.758 | 101.359 | 3.807 | 97.601 | Rock |
| WL | | | 3.685 | **97.674** | |
| PT | | | 3.839 | 97.520 | Top of Angle iron |
| BM 38 | | | 2.376 | 98.983 | |
| BM 37 | | | 1.868 | 99.491 | |
| BM 36 | | | 1.359 | 100.000 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 37 | 99.490 | 99.491 | 0.001 | |
| BM 38 | 98.983 | 98.983 | 0.001 | |
| PT | 97.462 | 97.520 | 0.058 | |

| Summary | |
|---|---|
| **Stage (m)** | 97.673 |
| **Discharge ($m^3/s$)** | 0.0940 |
| **Pressure Transducer Reading (m)** | 0.202 |
| **Pressure Transducer Elevation (m)** | 97.471 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:45 | **End** | 15:30 | **Location** | .5m downstream of pt | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | FH-950 | | | |
| **Flow Meter Type** | FH-950 | | | | **Instrument Serial #** | 121181001061 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.1847 | **Time** | 14:40 | | | | |
| | **End** | **Reading** | 0.1873 | **Time** | 15:31 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| *Right Bank, square bank* | 1.38 | 0.00 | 0.00 | 0.00 | 0.000 | | | 0.000 | 0.0 |
| | 1.42 | 0.18 | 0.04 | 0.01 | 0.089 | | | 0.001 | 1.0 |
| | 1.50 | 0.18 | 0.08 | 0.01 | 0.238 | | | 0.003 | 3.6 |
| | 1.58 | 0.18 | 0.08 | 0.01 | 0.480 | | | 0.007 | 7.4 |
| | 1.66 | 0.18 | 0.08 | 0.01 | 0.440 | | | 0.006 | 6.7 |
| | 1.74 | 0.17 | 0.08 | 0.01 | 0.313 | | | 0.004 | 4.5 |
| | 1.82 | 0.16 | 0.08 | 0.01 | 0.254 | | | 0.003 | 3.5 |
| | 1.90 | 0.15 | 0.08 | 0.01 | 0.290 | | | 0.003 | 3.7 |
| | 1.98 | 0.15 | 0.08 | 0.01 | 0.329 | | | 0.004 | 4.2 |
| | 2.06 | 0.14 | 0.08 | 0.01 | 0.368 | | | 0.004 | 4.4 |
| | 2.14 | 0.14 | 0.08 | 0.01 | 0.512 | | | 0.006 | 6.1 |
| | 2.22 | 0.13 | 0.08 | 0.01 | 0.481 | | | 0.005 | 5.3 |
| | 2.30 | 0.11 | 0.08 | 0.01 | 0.468 | | | 0.004 | 4.4 |
| | 2.38 | 0.12 | 0.08 | 0.01 | 0.436 | | | 0.004 | 4.5 |
| | 2.46 | 0.11 | 0.08 | 0.01 | 0.517 | | | 0.005 | 4.8 |
| | 2.54 | 0.11 | 0.08 | 0.01 | 0.495 | | | 0.004 | 4.6 |
| | 2.62 | 0.13 | 0.08 | 0.01 | 0.562 | | | 0.006 | 6.2 |
| | 2.70 | 0.14 | 0.08 | 0.01 | 0.613 | | | 0.007 | 7.3 |
| | 2.78 | 0.14 | 0.08 | 0.01 | 0.536 | | | 0.006 | 6.4 |
| | 2.86 | 0.15 | 0.08 | 0.01 | 0.443 | | | 0.005 | 5.7 |
| | 2.94 | 0.13 | 0.08 | 0.01 | 0.451 | | | 0.005 | 5.0 |
| | 3.02 | 0.06 | 0.08 | 0.01 | 0.084 | | | 0.001 | 0.7 |
| Left Bank | 3.20 | 0.00 | 0.18 | 0.01 | 0.000 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0940** | **100.0** |

**General Notes**

Sediment buildup in and around pipe and transducer. Checked data and it appears to be ok. Removed as much of the sediment as possible. Centre of transducer to water surface - 21cm. Centre of transduce to top of angle iron - 4cm.

## Appendix 2-3b. Manual Discharge Measurements and Levelling Surveys at MH-3 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-3 | | | |
| Stream Name | Camp Creek | | | |
| Date Monitored | 29-Jun-12 | | | |
| Time at Site (24 hr) | Start Time: | 16:25 | End Time: | |
| Personnel | Craig Hatt, Calvin Pin | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 766 | |
| Weather Conditions | Overcast | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS 9800 | Serial # | 2721022 |
| Gain | 3.4573 | Offset | -0.0054 |
| Status | Active | Battery | 100% |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | no |

**Hydrometric Leveling Survey (Before moving PT)**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM36 | 1.304 | 101.304 | | 100.000 | |
| BM37 | | | 1.812 | 99.492 | |
| PT (new location) | | | 3.943 | 97.361 | |
| WL | | | 3.671 | 97.633 | Time: 16:25 |
| BM38 | 2.282 | 101.266 | 2.320 | 98.984 | |
| PT (new location) | | | 3.907 | 97.359 | |
| WL | | | 3.634 | 97.632 | |
| BM37 | | | 1.775 | 99.491 | |
| BM36 | | | 1.265 | 100.001 | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 37 | 99.490 | 99.492 | 0.002 | |
| BM 38 | 98.983 | 98.984 | 0.002 | |
| PT | 97.462 | 97.360 | -0.102 | New PT location |

**Summary**

| | |
|---|---|
| Stage (m) | 97.633 |
| Discharge ($m^3/s$) | 0.0424 |
| Pressure Transducer Reading (m) | 0.288 |
| Pressure Transducer Elevation (m) (new location) | 97.345 |
| Pressure Transducer Elevation (m) (old location) | 97.097 Estimated |

**Hydrometric Leveling Survey - Old PT Location**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM36 | 1.302 | 101.302 | | 100.000 | |
| PT1 | | | 3.806 | 97.496 | |
| PT2 | | | 3.939 | 97.363 | |
| PT (manually calculated) | | | | 97.097 | See scanned field notes for calculation |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | | End | | Location | MH-3 | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | | |
| Flow Meter Type | FH950 | | | Instrument Serial # | | | |
| Stage (m) | Start | Reading | | Time | 15:13 | | |
| | End | Reading | | Time | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| RB | 0.90 | 0.00 | 0.00 | 0.00 | 0 | | | 0.000 | 0.0 |
| | 0.95 | 0.14 | 0.05 | 0.01 | 0.011 | | | 0.000 | 0.2 |
| | 1.00 | 0.16 | 0.05 | 0.01 | 0.012 | | | 0.000 | 0.3 |
| | 1.10 | 0.24 | 0.10 | 0.02 | 0.023 | | | 0.001 | 1.3 |
| | 1.20 | 0.28 | 0.10 | 0.03 | 0.053 | | | 0.001 | 3.5 |
| | 1.30 | 0.31 | 0.10 | 0.02 | 0.153 | | | 0.004 | 8.4 |
| | 1.35 | 0.30 | 0.05 | 0.02 | 0.157 | | | 0.002 | 5.5 |
| | 1.40 | 0.31 | 0.05 | 0.02 | 0.19 | | | 0.003 | 6.9 |
| | 1.45 | 0.30 | 0.05 | 0.02 | 0.29 | | | 0.004 | 10.2 |
| | 1.50 | 0.30 | 0.05 | 0.02 | 0.294 | | | 0.004 | 10.4 |
| | 1.55 | 0.30 | 0.05 | 0.02 | 0.326 | | | 0.005 | 11.5 |
| | 1.60 | 0.30 | 0.05 | 0.02 | 0.337 | | | 0.005 | 11.9 |
| | 1.65 | 0.29 | 0.05 | 0.01 | 0.267 | | | 0.004 | 9.1 |
| | 1.70 | 0.30 | 0.05 | 0.02 | 0.187 | | | 0.003 | 6.6 |
| | 1.75 | 0.29 | 0.05 | 0.01 | 0.145 | | | 0.002 | 5.0 |
| | 1.80 | 0.28 | 0.05 | 0.02 | 0.111 | | | 0.002 | 5.5 |
| | 1.90 | 0.25 | 0.10 | 0.03 | 0.043 | | | 0.001 | 2.5 |
| | 2.00 | 0.21 | 0.10 | 0.02 | 0.043 | | | 0.001 | 2.1 |
| | 2.10 | 0.16 | 0.10 | 0.02 | 0.011 | | | 0.000 | 0.4 |
| | 2.20 | 0.14 | 0.10 | 0.01 | -0.011 | | | 0.000 | -0.4 |
| | 2.30 | 0.12 | 0.10 | 0.01 | -0.018 | | | 0.000 | -0.5 |
| | 2.40 | 0.10 | 0.10 | 0.01 | -0.022 | | | 0.000 | -0.5 |
| | 2.50 | 0.08 | 0.10 | 0.01 | -0.024 | | | 0.000 | -0.5 |
| | 2.60 | 0.06 | 0.10 | 0.01 | -0.007 | | | 0.000 | -0.1 |
| | 2.70 | 0.04 | 0.10 | 0.00 | -0.001 | | | 0.000 | 0.0 |
| | 2.80 | 0.04 | 0.10 | 0.00 | 0.047 | | | 0.000 | 0.3 |
| | 2.85 | 0.02 | 0.05 | 0.00 | 0.047 | | | 0.000 | 0.1 |
| LB | 2.90 | 0.00 | 0.05 | 0.00 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| Total Q | | | | | | | | 0.0424 | 100.0 |

**General Notes**

Real time stage taken at 17:50. Moderate flow rate observed. PT buried in significant amount of sediment. Took elevation at 2 abritrary points along uncovered part of transducer and extrapolated angle to determine elevation of transducer tip.

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-4 | | | |
| **Stream Name** | Upper Camp Creek | | | |
| **Date Monitored** | 14-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 2:00:00 PM | **End Time:** | 4:30:00 PM |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 1.038 | 101.038 | | 100.000 | Nail in tree |
| BM 2 | | | 1.125 | 99.913 | Nail in tree |
| BM 3 | | | 1.051 | 99.987 | Nail in tree |
| WL | | | 2.396 | 98.642 | Taken at Station |
| BM 2 | 1.159 | 101.072 | | **99.913** | |
| BM 3 | | | 1.084 | 99.988 | |
| WL | | | 2.426 | 98.646 | |
| BM 1 | | | 1.070 | 100.002 | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 1 | | 100.000 | | |
| BM 2 | | 99.280 | | |
| BM 3 | | 99.995 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.644 |
| **Mean Discharge ($m^3/s$)** | 0.828 |
| **Pressure Transducer Reading (m)** | 0.675 |
| **Pressure Transducer Elevation (m)** | 97.969 |

| Discharge Measurement - Mid-Section Method (5/14/11 #1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:15 | **End** | 14:45 | **Location** | | | |
| **Method** | Velocity-area (Mid-section) | | | **Indicator Constant** | 425 | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | 006713 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.675 | **Time** | 17:15 | Measurement #1 | | |
| | **End** | **Reading** | | **Time** | 17:45 | | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | (m/s) | (m/s) | (m3/s) | % |
| Right Bank | 1.10 | 0.00 | 0.20 | 0.010 | 0.00 | 0.00 | 0.000 | 0.0 |
| | 1.50 | 0.12 | 0.33 | 0.04 | 0.00 | 0.02 | 0.001 | 0.1 |
| | 1.75 | 0.12 | 0.25 | 0.03 | 0.11 | 0.10 | 0.003 | 0.3 |
| | 2.00 | 0.40 | 0.25 | 0.10 | 0.10 | 0.09 | 0.009 | 1.1 |
| | 2.25 | 0.51 | 0.25 | 0.13 | 0.16 | 0.13 | 0.017 | 2.0 |
| | 2.50 | 0.49 | 0.25 | 0.12 | 0.39 | 0.29 | 0.035 | 4.2 |
| | 2.75 | 0.65 | 0.25 | 0.16 | 0.40 | 0.29 | 0.046 | 5.7 |
| | 3.00 | 0.66 | 0.25 | 0.17 | 0.44 | 0.32 | 0.054 | 6.3 |
| | 3.25 | 0.65 | 0.25 | 0.16 | 0.65 | 0.46 | 0.074 | 9.0 |
| | 3.50 | 0.64 | 0.25 | 0.16 | 0.66 | 0.47 | 0.075 | 9.0 |
| | 3.75 | 0.64 | 0.25 | 0.16 | 0.84 | 0.59 | 0.094 | 11.4 |
| | 4.00 | 0.65 | 0.25 | 0.16 | 0.61 | 0.43 | 0.069 | 8.5 |
| | 4.25 | 0.69 | 0.25 | 0.17 | 0.71 | 0.50 | 0.085 | 10.4 |
| | 4.50 | 0.38 | 0.25 | 0.10 | 0.89 | 0.62 | 0.062 | 7.1 |
| | 4.75 | 0.47 | 0.25 | 0.12 | 0.63 | 0.45 | 0.054 | 6.3 |
| | 5.00 | 0.45 | 0.25 | 0.11 | 0.58 | 0.41 | 0.045 | 5.6 |
| | 5.25 | 0.41 | 0.28 | 0.11 | 0.59 | 0.42 | 0.046 | 5.7 |
| | 5.55 | 0.40 | 0.25 | 0.10 | 0.44 | 0.32 | 0.032 | 3.8 |
| | 5.75 | 0.32 | 0.23 | 0.07 | 0.19 | 0.15 | 0.011 | 1.3 |
| | 6.00 | 0.27 | 0.25 | 0.07 | 0.24 | 0.18 | 0.013 | 1.5 |
| | 6.25 | 0.13 | 0.30 | 0.04 | 0.10 | 0.09 | 0.004 | 0.4 |
| Left Bank | 6.60 | 0.00 | 0.18 | 0.01 | 0.00 | 0.00 | 0.000 | 0.1 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **0.828** | **100.0** |

| General Notes |
|---|
| Use average of two discharge measurements |

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-4 | | | |
| **Stream Name** | Upper Camp Creek | | | |
| **Date Monitored** | 14-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 2:00:00 PM | **End Time:** | 4:30:00 PM |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 1.038 | 101.038 | | 100.000 | Nail in tree |
| BM 2 | | | 1.125 | 99.913 | Nail in tree |
| BM 3 | | | 1.051 | 99.987 | Nail in tree |
| WL | | | 2.396 | 98.642 | Taken at Station |
| BM 2 | 1.159 | 101.072 | | **99.913** | |
| BM 3 | | | 1.084 | 99.988 | |
| WL | | | 2.426 | 98.646 | |
| BM 1 | | | 1.070 | 100.002 | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 1 | | 100.000 | | |
| BM 2 | | 99.280 | | |
| BM 3 | | 99.995 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.644 |
| **Mean Discharge ($m^3/s$)** | 0.844 |
| **Pressure Transducer Reading (m)** | 0.675 |
| **Pressure Transducer Elevation (m)** | 97.969 |

| Discharge Measurement - Mid-Section Method (5/14/11 #2) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 14:45 | **End** | 15:15 | **Location** | | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.675 | **Time** | 17:15 | Measurement #2 | | | |
| | **End** | **Reading** | | **Time** | 17:45 | | | | |
| | **Station** | **Depth** | **Distance** | **Area** | **Velocity** | **Cal. Velocity** | **Q** | **% of Total Q** | |
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **(m/s)** | **(m/s)** | **(m3/s)** | **%** | |
| Left Bank | 6.60 | 0.00 | 0.13 | 0.010 | 0.00 | 0.00 | 0.000 | 0.0 | |
| | 6.35 | 0.08 | 0.25 | 0.02 | 0.05 | 0.06 | 0.001 | 0.1 | |
| | 6.10 | 0.16 | 0.25 | 0.04 | 0.07 | 0.07 | 0.003 | 0.3 | |
| | 5.85 | 0.29 | 0.25 | 0.07 | 0.22 | 0.17 | 0.012 | 1.5 | |
| | 5.60 | 0.36 | 0.25 | 0.09 | 0.44 | 0.32 | 0.029 | 3.4 | |
| | 5.35 | 0.42 | 0.25 | 0.11 | 0.53 | 0.38 | 0.042 | 4.7 | |
| | 5.10 | 0.45 | 0.25 | 0.11 | 0.68 | 0.48 | 0.053 | 6.4 | |
| | 4.85 | 0.46 | 0.25 | 0.12 | 0.60 | 0.43 | 0.052 | 5.8 | |
| | 4.60 | 0.36 | 0.25 | 0.09 | 0.77 | 0.54 | 0.049 | 5.8 | |
| | 4.35 | 0.37 | 0.25 | 0.09 | 0.88 | 0.62 | 0.056 | 6.8 | |
| | 4.10 | 0.67 | 0.20 | 0.13 | 0.86 | 0.60 | 0.078 | 9.6 | |
| | 3.95 | 0.65 | 0.13 | 0.08 | 0.87 | 0.61 | 0.049 | 5.9 | |
| | 3.85 | 0.65 | 0.18 | 0.11 | 0.70 | 0.50 | 0.055 | 6.7 | |
| | 3.60 | 0.62 | 0.25 | 0.16 | 0.72 | 0.51 | 0.082 | 9.4 | |
| | 3.35 | 0.65 | 0.25 | 0.16 | 0.58 | 0.41 | 0.066 | 8.0 | |
| | 3.10 | 0.66 | 0.25 | 0.17 | 0.47 | 0.34 | 0.058 | 6.7 | |
| | 2.85 | 0.67 | 0.25 | 0.17 | 0.49 | 0.35 | 0.060 | 7.0 | |
| | 2.60 | 0.58 | 0.25 | 0.15 | 0.47 | 0.34 | 0.051 | 5.8 | |
| | 2.35 | 0.45 | 0.25 | 0.11 | 0.35 | 0.26 | 0.029 | 3.5 | |
| | 2.10 | 0.40 | 0.25 | 0.10 | 0.17 | 0.14 | 0.014 | 1.6 | |
| | 1.85 | 0.20 | 0.25 | 0.05 | 0.11 | 0.10 | 0.005 | 0.6 | |
| | 1.60 | 0.15 | 0.38 | 0.06 | 0.05 | 0.06 | 0.004 | 0.4 | |
| Right Bank | 1.10 | 0.00 | 0.25 | 0.02 | 0.00 | 0.00 | 0.000 | 0.1 | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | **0.844** | **100.0** | |

| General Notes |
|---|
| Use average of two discharge measurements |

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-4 | | | |
| Stream Name | Upper Camp Creek | | | |
| Date Monitored | 1-Jul-11 | | | |
| Time at Site (24 hr) | Start Time: | 1:30:00 PM | End Time: | 4:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2721020 |
| Gain | 3.5293 | Offset | -0.0029 |
| Status | active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 1 | 0.884 | 100.884 | | 100.000 | |
| BM 2 | | | 0.982 | 99.902 | |
| BM 3 | | | 0.902 | 99.982 | |
| WL 1 | | | 2.313 | 98.571 | |
| WL 2 | | | 2.292 | **98.592** | |
| BM 3 | 0.899 | 100.881 | 1.084 | 99.982 | |
| BM 2 | | | 0.979 | 99.902 | |
| WL 1 | | | 2.307 | 98.574 | |
| WL 2 | | | 2.288 | **98.593** | |
| BM 1 | | | 0.879 | 100.002 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 1 | | 100.001 | | |
| BM 2 | | 99.902 | | |
| BM 3 | | 100.001 | | |

| Summary | |
|---|---|
| Stage (m) | 98.573 |
| Mean Discharge ($m^3/s$) | 0.461 |
| Pressure Transducer Reading (m) before moving | 0.257 |
| Pressure Transducer Elevation (m) before moving | 98.316 |
| Pressure Transducer Reading (m) after moving | 0.589 |
| Pressure Transducer Elevation (m) after moving | 98.004 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:30 | End | 14:00 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.257 | Time | 13:30 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.80 | 0.00 | 0.05 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 1.90 | 0.10 | 0.18 | 0.02 | -0.06 | | | -0.001 | -0.2 |
| 1 | 2.15 | 0.29 | 0.25 | 0.07 | -0.05 | | | -0.004 | -0.8 |
| | 2.40 | 0.38 | 0.23 | 0.09 | -0.02 | | | -0.002 | -0.4 |
| | 2.60 | 0.43 | 0.18 | 0.08 | 0.08 | | | 0.006 | 1.3 |
| | 2.75 | 0.52 | 0.15 | 0.08 | 0.11 | | | 0.009 | 1.9 |
| | 2.90 | 0.52 | 0.15 | 0.08 | 0.13 | | | 0.010 | 2.2 |
| | 3.05 | 0.50 | 0.15 | 0.08 | 0.14 | | | 0.011 | 2.3 |
| | 3.20 | 0.47 | 0.15 | 0.07 | 0.15 | | | 0.011 | 2.3 |
| | 3.35 | 0.58 | 0.15 | 0.09 | 0.16 | | | 0.014 | 3.0 |
| | 3.50 | 0.57 | 0.15 | 0.09 | 0.12 | | | 0.010 | 2.2 |
| | 3.65 | 0.58 | 0.15 | 0.09 | 0.15 | | | 0.013 | 2.8 |
| | 3.80 | 0.62 | 0.15 | 0.09 | 0.17 | | | 0.016 | 3.4 |
| | 3.95 | 0.60 | 0.15 | 0.09 | 0.19 | | | 0.017 | 3.7 |
| | 4.10 | 0.58 | 0.15 | 0.09 | 0.23 | | | 0.020 | 4.3 |
| | 4.25 | 0.54 | 0.15 | 0.08 | 0.27 | | | 0.022 | 4.7 |
| | 4.40 | 0.50 | 0.15 | 0.08 | 0.32 | | | 0.024 | 5.2 |
| | 4.55 | 0.44 | 0.15 | 0.07 | 0.35 | | | 0.023 | 5.0 |
| | 4.70 | 0.44 | 0.15 | 0.07 | 0.35 | | | 0.023 | 5.0 |
| | 4.85 | 0.45 | 0.15 | 0.07 | 0.37 | | | 0.025 | 5.4 |
| | 5.00 | 0.46 | 0.15 | 0.07 | 0.39 | | | 0.027 | 5.8 |
| | 5.15 | 0.49 | 0.15 | 0.07 | 0.38 | | | 0.028 | 6.1 |
| | 5.30 | 0.48 | 0.15 | 0.07 | 0.36 | | | 0.026 | 5.6 |
| | 5.45 | 0.54 | 0.15 | 0.08 | 0.3 | | | 0.024 | 5.3 |
| | 5.60 | 0.48 | 0.15 | 0.07 | 0.22 | | | 0.016 | 3.4 |
| | 5.75 | 0.49 | 0.2 | 0.07 | 0.2 | | | 0.015 | 3.2 |
| | 5.90 | 0.44 | 0.2 | 0.07 | 0.24 | | | 0.016 | 3.4 |
| | 6.05 | 0.43 | 0.2 | 0.06 | 0.26 | | | 0.017 | 3.6 |
| | 6.20 | 0.40 | 0.2 | 0.06 | 0.26 | | | 0.016 | 3.4 |
| | 6.35 | 0.32 | 0.2 | 0.05 | 0.26 | | | 0.012 | 2.7 |
| | 6.50 | 0.23 | 0.2 | 0.04 | 0.23 | | | 0.009 | 2.0 |
| 0.5 | 6.70 | 0.18 | 0.2 | 0.04 | 0.18 | | | 0.006 | 1.4 |
| CF = | 6.90 | 0.12 | 0.2 | 0.02 | 0.1 | | | 0.002 | 0.5 |
| Left Bank | 7.10 | 0.00 | 0.1 | 0.01 | 0 | | | 0.000 | 0.1 |
| **Total Q** | | | | | | | | **0.461** | **100.0** |

**General Notes - None**

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-4 | | | |
| Stream Name | Upper Camp Creek | | | |
| Date Monitored | 6-Aug-11 | | | |
| Time at Site (24 hr) | Start Time: | 7:00:00 PM | End Time: | 8:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2721020 |
| Gain | 3.5293 | Offset | -0.0029 |
| Status | active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 1 | 0.801 | 100.801 | | 100.000 | |
| BM 2 | | | 0.900 | 99.901 | |
| BM 3 | | | 0.821 | 99.980 | |
| WL | | | 2.356 | **98.445** | |
| BM 3 | 0.812 | 100.792 | | 99.980 | |
| BM 2 | | | 0.892 | 99.900 | |
| WL | | | 2.347 | **98.445** | |
| BM 1 | | | 0.792 | 100.000 | |
| | | | | | |
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| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 1 | | 100.000 | | |
| BM 2 | | 99.901 | | |
| BM 3 | | 99.980 | | |

| Summary | |
|---|---|
| Stage (m) | 98.445 |
| Mean Discharge ($m^3/s$) | 0.138 |
| Pressure Transducer Reading (m) before moving | 0.649 |
| Pressure Transducer Elevation (m) before moving | 97.796 |
| Pressure Transducer Reading (m) after moving | 0.633 |
| Pressure Transducer Elevation (m) after moving | 99.347 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 19:30 | End | 20:00 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.649 | Time | 19:30 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.90 | 0.00 | 0.10 | 0.01 | 0 | | | 0.000 | 0.2 |
| CF = | 2.10 | 0.14 | 0.25 | 0.04 | 0.04 | | | 0.001 | 1.0 |
| 1 | 2.40 | 0.06 | 0.20 | 0.01 | 0.08 | | | 0.001 | 0.7 |
| | 2.50 | 0.42 | 0.15 | 0.06 | 0.09 | | | 0.006 | 4.1 |
| | 2.70 | 0.44 | 0.20 | 0.09 | 0.08 | | | 0.007 | 5.1 |
| | 2.90 | 0.45 | 0.20 | 0.09 | 0.11 | | | 0.010 | 7.2 |
| | 3.10 | 0.44 | 0.20 | 0.09 | 0.09 | | | 0.008 | 5.7 |
| | 3.30 | 0.44 | 0.20 | 0.09 | 0.11 | | | 0.010 | 7.0 |
| | 3.50 | 0.41 | 0.20 | 0.08 | 0.1 | | | 0.008 | 5.9 |
| | 3.70 | 0.38 | 0.20 | 0.08 | 0.14 | | | 0.011 | 7.7 |
| | 3.90 | 0.34 | 0.20 | 0.07 | 0.15 | | | 0.010 | 7.4 |
| | 4.10 | 0.30 | 0.20 | 0.06 | 0.15 | | | 0.009 | 6.5 |
| | 4.30 | 0.26 | 0.20 | 0.05 | 0.16 | | | 0.008 | 6.0 |
| | 4.50 | 0.25 | 0.20 | 0.05 | 0.15 | | | 0.008 | 5.4 |
| | 4.70 | 0.28 | 0.20 | 0.06 | 0.13 | | | 0.007 | 5.3 |
| | 4.90 | 0.32 | 0.20 | 0.06 | 0.12 | | | 0.008 | 5.6 |
| | 5.10 | 0.32 | 0.20 | 0.06 | 0.13 | | | 0.008 | 6.0 |
| | 5.30 | 0.35 | 0.20 | 0.07 | 0.06 | | | 0.004 | 3.0 |
| | 5.50 | 0.32 | 0.20 | 0.06 | 0.11 | | | 0.007 | 5.1 |
| 1 | 5.70 | 0.20 | 0.20 | 0.04 | 0.08 | | | 0.003 | 2.3 |
| CF = | 5.90 | 0.18 | 0.23 | 0.04 | 0.07 | | | 0.003 | 2.1 |
| Left Bank | 6.15 | 0.00 | 0.13 | 0.01 | 0 | | | 0.001 | 0.6 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | 0.138 | 100.0 |

General Notes - None

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-4 | | | |
| Stream Name | Upper Camp Creek | | | |
| Date Monitored | 3-Sep-11 | | | |
| Time at Site (24 hr) | Start Time: | 10:00:00 AM | End Time: | 12:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2721020 |
| Gain | 3.5293 | Offset | -0.0029 |
| Status | active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 1 | 0.731 | 100.731 | | 100.000 | |
| BM 2 | | | 0.830 | 99.901 | |
| BM 3 | | | 0.750 | 99.981 | |
| WL | | | 2.344 | **98.387** | |
| BM 3 | 0.749 | 100.730 | | 99.981 | |
| BM 2 | | | 0.829 | 99.901 | |
| WL | | | 2.342 | **98.388** | |
| BM 1 | | | 0.730 | 100.000 | |
| | | | | | |
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| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 1 | | 100.000 | | |
| BM 2 | | 99.901 | | |
| BM 3 | | 99.981 | | |

| Summary | |
|---|---|
| Stage (m) | 98.388 |
| Mean Discharge ($m^3/s$) | 0.0520 |
| Pressure Transducer Reading (m) | 0.573 |
| Pressure Transducer Elevation (m) | 97.815 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 10:30 | End | 11:05 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.573 | Time | 10:30 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 2.00 | 0.00 | 0.10 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 2.20 | 0.04 | 0.20 | 0.01 | -0.02 | | | 0.000 | -0.3 |
| 1 | 2.40 | 0.12 | 0.20 | 0.02 | 0.03 | | | 0.001 | 1.4 |
| | 2.60 | 0.26 | 0.20 | 0.05 | 0.03 | | | 0.002 | 3.0 |
| | 2.80 | 0.30 | 0.20 | 0.06 | 0.07 | | | 0.004 | 8.1 |
| | 3.00 | 0.28 | 0.15 | 0.04 | 0.09 | | | 0.004 | 7.3 |
| | 3.10 | 0.22 | 0.10 | 0.02 | 0.07 | | | 0.002 | 3.0 |
| | 3.20 | 0.34 | 0.10 | 0.03 | 0.07 | | | 0.002 | 4.6 |
| | 3.30 | 0.30 | 0.10 | 0.03 | 0.08 | | | 0.002 | 4.6 |
| | 3.40 | 0.32 | 0.10 | 0.03 | 0.09 | | | 0.003 | 5.5 |
| | 3.50 | 0.28 | 0.10 | 0.03 | 0.09 | | | 0.003 | 4.8 |
| | 3.60 | 0.36 | 0.10 | 0.04 | 0.09 | | | 0.003 | 6.2 |
| | 3.70 | 0.24 | 0.10 | 0.02 | 0.1 | | | 0.002 | 4.6 |
| | 3.80 | 0.22 | 0.10 | 0.02 | 0.1 | | | 0.002 | 4.2 |
| | 3.90 | 0.22 | 0.10 | 0.02 | 0.09 | | | 0.002 | 3.8 |
| | 4.00 | 0.22 | 0.15 | 0.03 | 0.09 | | | 0.003 | 5.7 |
| | 4.20 | 0.20 | 0.20 | 0.04 | 0.08 | | | 0.003 | 6.1 |
| | 4.40 | 0.20 | 0.20 | 0.04 | 0.06 | | | 0.002 | 4.6 |
| | 4.60 | 0.19 | 0.20 | 0.04 | 0.05 | | | 0.002 | 3.6 |
| | 4.80 | 0.18 | 0.20 | 0.04 | 0.06 | | | 0.002 | 4.1 |
| | 5.00 | 0.16 | 0.20 | 0.03 | 0.06 | | | 0.002 | 3.7 |
| | 5.20 | 0.24 | 0.20 | 0.05 | 0.05 | | | 0.002 | 4.6 |
| | 5.40 | 0.19 | 0.20 | 0.04 | 0.06 | | | 0.002 | 4.4 |
| | 5.60 | 0.18 | 0.20 | 0.04 | 0.02 | | | 0.001 | 1.4 |
| | 5.80 | 0.16 | 0.20 | 0.03 | 0.03 | | | 0.001 | 1.8 |
| 1 | 6.00 | 0.12 | 0.2 | 0.02 | 0 | | | 0.000 | 0.0 |
| CF = | 6.20 | 0.06 | 0.2 | 0.01 | -0.04 | | | 0.000 | -0.8 |
| Left Bank | 6.35 | 0.00 | 0.1 | 0.00 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0520** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-4 | | | |
| Stream Name | Upper Camp Creek | | | |
| Date Monitored | 16-Oct-11 | | | |
| Time at Site (24 hr) | Start Time: | 1:00:00 PM | End Time: | 3:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | | | | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 2721020 |
| Gain | 3.5293 | Offset | -0.0029 |
| Status | active | Battery | |
| # of Records | 0620031 | 6101563 | 1108 |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 1 | 0.724 | 100.724 | | 100.000 | |
| BM 2 | | | 0.822 | 99.902 | |
| BM 3 | | | 0.742 | 99.982 | |
| WL | | | 2.352 | **98.372** | |
| BM 3 | 0.759 | 100.741 | | 99.982 | |
| BM 2 | | | 0.839 | 99.902 | |
| WL | | | 2.368 | **98.373** | |
| BM 1 | | | 0.740 | 100.001 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 1 | | 100.001 | | |
| BM 2 | | 99.902 | | |
| BM 3 | | 99.982 | | |

| Summary | |
|---|---|
| Stage (m) | 98.373 |
| Mean Discharge ($m^3/s$) | 0.0290 |
| Pressure Transducer Reading (m) | 0.554 |
| Pressure Transducer Elevation (m) | 97.819 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:00 | End | 11:05 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.554 | Time | 13:00 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 2.40 | 0.00 | 0.10 | 0.01 | 0 | | | 0.000 | 0.0 |
| CF = | 2.60 | 0.18 | 0.20 | 0.04 | 0.02 | | | 0.001 | 2.5 |
| 1 | 2.80 | 0.18 | 0.20 | 0.04 | 0.03 | | | 0.001 | 3.7 |
| | 3.00 | 0.27 | 0.20 | 0.05 | 0.04 | | | 0.002 | 7.4 |
| | 3.20 | 0.28 | 0.20 | 0.06 | 0.04 | | | 0.002 | 7.6 |
| | 3.40 | 0.33 | 0.15 | 0.05 | 0.05 | | | 0.002 | 8.5 |
| | 3.50 | 0.20 | 0.10 | 0.02 | 0.05 | | | 0.001 | 3.4 |
| | 3.60 | 0.26 | 0.10 | 0.03 | 0.03 | | | 0.001 | 2.7 |
| | 3.70 | 0.30 | 0.10 | 0.03 | 0.06 | | | 0.002 | 6.1 |
| | 3.80 | 0.32 | 0.10 | 0.03 | 0.05 | | | 0.002 | 5.5 |
| | 3.90 | 0.32 | 0.10 | 0.03 | 0.05 | | | 0.002 | 5.5 |
| | 4.00 | 0.30 | 0.15 | 0.05 | 0.05 | | | 0.002 | 7.7 |
| | 4.20 | 0.28 | 0.20 | 0.06 | 0.04 | | | 0.002 | 7.6 |
| | 4.40 | 0.24 | 0.20 | 0.05 | 0.04 | | | 0.002 | 6.6 |
| | 4.60 | 0.22 | 0.20 | 0.04 | 0.03 | | | 0.001 | 4.5 |
| | 4.80 | 0.26 | 0.20 | 0.05 | 0.04 | | | 0.002 | 7.1 |
| | 5.00 | 0.24 | 0.20 | 0.05 | 0.03 | | | 0.001 | 4.9 |
| | 5.20 | 0.20 | 0.20 | 0.04 | 0.03 | | | 0.001 | 4.1 |
| | 5.40 | 0.20 | 0.20 | 0.04 | 0.02 | | | 0.001 | 2.7 |
| | 5.60 | 0.20 | 0.20 | 0.04 | 0.01 | | | 0.000 | 1.4 |
| | 5.80 | 0.20 | 0.20 | 0.04 | 0.02 | | | 0.001 | 2.7 |
| 1 | 6.00 | 0.10 | 0.20 | 0.02 | -0.01 | | | 0.000 | -0.7 |
| CF = | 6.20 | 0.06 | 0.18 | 0.01 | -0.04 | | | 0.000 | -1.4 |
| Left Bank | 6.35 | 0.00 | 0.07 | 0.00 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.0290** | **100.0** |

| General Notes |
|---|
| |

## Appendix 2-4a. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-4 | | | |
| **Stream Name** | Upper Camp Creek | | | |
| **Date Monitored** | 16-Nov-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:30:00 AM | **End Time:** | 12:00:00 PM |
| **Personnel** | Craig Hatt, Max Taylor | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 0.693 | 100.693 | | 100.000 | |
| BM 2 | | | 0.792 | 99.901 | |
| BM 3 | | | 0.711 | 99.982 | |
| WL | | | 2.249 | **98.444** | |
| Top of Ice | | | 2.215 | 98.478 | |
| BM 3 | 0.665 | 100.647 | | 99.982 | |
| BM 2 | | | 0.746 | **99.901** | |
| WL | | | 2.202 | 98.445 | |
| Top of Ice | | | 2.167 | **98.480** | |
| BM 1 | | | 0.647 | 100.000 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 1 | | 100.000 | | |
| BM 2 | | 99.901 | | |
| BM 3 | | 99.982 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.445 |
| **Mean Discharge ($m^3/s$)** | 0.0470 |
| **Pressure Transducer Reading (m)** | 0.628 |
| **Pressure Transducer Elevation (m)** | 97.817 |

| General Notes |
|---|
| Stream covered in approx. 20cm of ice. Stage value effected by ice loading |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 10:30 | **End** | 11:05 | **Location** | | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | 2000 | | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.628 | **Time** | 10:30 | | | | |
| | **End** | **Reading** | | **Time** | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 2.45 | 0.00 | 0.08 | 0.00 | 0 | | | 0.000 | 0.0 |
| CF = | 2.60 | 0.12 | 0.18 | 0.02 | 0 | | | 0.000 | 0.0 |
| 1 | 2.80 | 0.10 | 0.13 | 0.01 | 0.01 | | | 0.000 | 0.3 |
| | 2.85 | 0.40 | 0.10 | 0.04 | 0.04 | | | 0.002 | 3.5 |
| | 3.00 | 0.40 | 0.11 | 0.05 | 0.07 | | | 0.003 | 6.9 |
| | 3.08 | 0.42 | 0.08 | 0.03 | 0.06 | | | 0.002 | 4.1 |
| | 3.15 | 0.39 | 0.08 | 0.03 | 0.07 | | | 0.002 | 4.5 |
| | 3.23 | 0.42 | 0.08 | 0.03 | 0.09 | | | 0.003 | 6.2 |
| | 3.30 | 0.43 | 0.08 | 0.03 | 0.08 | | | 0.003 | 5.6 |
| | 3.38 | 0.44 | 0.08 | 0.03 | 0.09 | | | 0.003 | 6.5 |
| | 3.45 | 0.42 | 0.08 | 0.03 | 0.07 | | | 0.002 | 4.8 |
| | 3.53 | 0.43 | 0.08 | 0.03 | 0.07 | | | 0.002 | 4.9 |
| | 3.60 | 0.44 | 0.08 | 0.03 | 0.08 | | | 0.003 | 5.7 |
| | 3.68 | 0.42 | 0.08 | 0.03 | 0.06 | | | 0.002 | 4.1 |
| | 3.75 | 0.42 | 0.08 | 0.03 | 0.08 | | | 0.003 | 5.5 |
| | 3.83 | 0.40 | 0.08 | 0.03 | 0.1 | | | 0.003 | 6.5 |
| | 3.90 | 0.38 | 0.08 | 0.03 | 0.09 | | | 0.003 | 5.6 |
| | 3.98 | 0.36 | 0.08 | 0.03 | 0.09 | | | 0.002 | 5.3 |
| | 4.05 | 0.34 | 0.08 | 0.03 | 0.09 | | | 0.002 | 5.0 |
| | 4.13 | 0.34 | 0.08 | 0.03 | 0.08 | | | 0.002 | 4.4 |
| | 4.20 | 0.32 | 0.11 | 0.04 | 0.06 | | | 0.002 | 4.7 |
| | 4.35 | 0.29 | 0.15 | 0.04 | -0.01 | | | 0.000 | -0.9 |
| | 4.50 | 0.29 | 0.15 | 0.04 | 0 | | | 0.000 | 0.0 |
| | 4.65 | 0.25 | 0.15 | 0.04 | 0.01 | | | 0.000 | 0.8 |
| | 4.80 | 0.26 | 0.15 | 0.04 | 0 | | | 0.000 | 0.0 |
| | 4.95 | 0.26 | 0.2 | 0.04 | -0.01 | | | 0.000 | -0.8 |
| | 5.10 | 0.26 | 0.2 | 0.05 | 0 | | | 0.000 | 0.0 |
| | 5.30 | 0.24 | 0.2 | 0.05 | 0.01 | | | 0.000 | 1.0 |
| | 5.50 | 0.19 | 0.2 | 0.04 | 0.02 | | | 0.001 | 1.7 |
| | 5.70 | 0.30 | 0.2 | 0.06 | 0 | | | 0.000 | 0.0 |
| | 5.90 | 0.28 | 0.2 | 0.06 | 0.04 | | | 0.002 | 4.9 |
| | 6.10 | 0.20 | 0.2 | 0.04 | 0.01 | | | 0.000 | 0.9 |
| 0.5 | 6.30 | 0.14 | 0.2 | 0.03 | -0.01 | | | 0.000 | -0.6 |
| CF = | 6.50 | 0.10 | 0.2 | 0.02 | -0.02 | | | 0.000 | -0.8 |
| Left Bank | 6.65 | 0.00 | 0.1 | 0.00 | 0 | | | 0.000 | -0.1 |
| **Total Q** | | | | | | | | **0.0470** | **100.0** |

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH4 | | | |
| **Stream Name** | Camp Creek | | | |
| **Date Monitored** | 28-Apr-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 13:30 | **End Time:** | |
| **Personnel** | Craig Hatt, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | Overcast, light rain, Temp: 8 degC | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | active | **Battery** | 100% |
| **# of Records** | | **Memory Free** | 65456 |
| **Date Serviced** | 28-Apr-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 0.830 | 100.830 | | 100.000 | |
| BM 2 | | | 0.925 | 99.905 | |
| BM 3 | | | 0.848 | 99.982 | |
| PT | | | 2.935 | 97.895 | |
| WL | | | 2.337 | 98.493 | |
| BM 3 | 0.811 | 100.793 | 1.080 | 99.982 | |
| WL | | | 2.304 | 98.489 | |
| PT | | | 2.900 | 97.893 | |
| BM 2 | | | 0.889 | 99.904 | |
| BM 1 | | | 0.794 | 99.999 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 2 | 99.902 | 99.905 | 0.003 | Established May 14 2011 |
| BM 3 | 99.982 | 99.982 | 0.000 | Established May 14 2011 |
| PT | 97.894 | 97.894 | | Established on this date |

| Summary | | |
|---|---|---|
| **Stage (m)** | 98.491 | |
| **Discharge ($m^3/s$)** | 0.273 | |
| **Pressure Transducer Reading (m)** | 0.613 | RTR at 21:00 |
| **Pressure Transducer Elevation (m)** | 97.878 | |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | | **End** | | **Location** | 3m downstream of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | Flo-Mate | | | |
| **Flow Meter Type** | Flo-Mate | | | | **Instrument Serial #** | 2007 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.651 | **Time** | 16:30 | | | | |
| | **End** | **Reading** | 0.654 | **Time** | 17:10 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| RB | 1.65 | 0.00 | 0.00 | 0.01 | 0 | | | 0.000 | 0.0 |
| | 1.80 | 0.14 | 0.15 | 0.02 | 0.04 | | | 0.001 | 0.4 |
| | 2.00 | 0.20 | 0.20 | 0.04 | 0.12 | | | 0.005 | 1.8 |
| | 2.20 | 0.23 | 0.20 | 0.03 | 0.04 | | | 0.001 | 0.5 |
| | 2.30 | 0.36 | 0.10 | 0.04 | 0.1 | | | 0.004 | 1.3 |
| | 2.40 | 0.34 | 0.10 | 0.03 | 0.14 | | | 0.005 | 1.7 |
| | 2.50 | 0.34 | 0.10 | 0.03 | 0.18 | | | 0.006 | 2.2 |
| | 2.60 | 0.40 | 0.10 | 0.04 | 0.13 | | | 0.005 | 1.9 |
| | 2.70 | 0.41 | 0.10 | 0.04 | 0.16 | | | 0.007 | 2.4 |
| | 2.80 | 0.40 | 0.10 | 0.04 | 0.21 | | | 0.008 | 3.1 |
| | 2.90 | 0.46 | 0.10 | 0.05 | 0.2 | | | 0.009 | 3.4 |
| | 3.00 | 0.43 | 0.10 | 0.04 | 0.2 | | | 0.009 | 3.1 |
| | 3.10 | 0.41 | 0.10 | 0.06 | 0.2 | | | 0.012 | 4.5 |
| | 3.30 | 0.33 | 0.20 | 0.07 | 0.26 | | | 0.017 | 6.3 |
| | 3.50 | 0.34 | 0.20 | 0.07 | 0.27 | | | 0.018 | 6.7 |
| | 3.70 | 0.35 | 0.20 | 0.07 | 0.29 | | | 0.020 | 7.4 |
| | 3.90 | 0.20 | 0.20 | 0.04 | 0.32 | | | 0.013 | 4.7 |
| | 4.10 | 0.30 | 0.20 | 0.05 | 0.33 | | | 0.017 | 6.3 |
| | 4.25 | 0.29 | 0.15 | 0.04 | 0.34 | | | 0.015 | 5.4 |
| | 4.40 | 0.29 | 0.15 | 0.04 | 0.31 | | | 0.013 | 4.9 |
| | 4.55 | 0.27 | 0.15 | 0.04 | 0.32 | | | 0.013 | 4.7 |
| | 4.70 | 0.30 | 0.15 | 0.05 | 0.3 | | | 0.014 | 4.9 |
| | 4.85 | 0.30 | 0.15 | 0.05 | 0.24 | | | 0.011 | 4.0 |
| | 5.00 | 0.29 | 0.15 | 0.05 | 0.24 | | | 0.012 | 4.5 |
| | 5.20 | 0.29 | 0.20 | 0.06 | 0.22 | | | 0.013 | 4.7 |
| | 5.40 | 0.27 | 0.20 | 0.05 | 0.23 | | | 0.012 | 4.5 |
| | 5.60 | 0.26 | 0.20 | 0.05 | 0.2 | | | 0.010 | 3.8 |
| | 5.80 | 0.10 | 0.20 | 0.02 | 0.05 | | | 0.001 | 0.4 |
| | 6.00 | 0.12 | 0.20 | 0.02 | 0.05 | | | 0.001 | 0.4 |
| LB | 6.20 | 0.00 | 0.20 | 0.01 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.273** | **100.0** |

| General Notes |
|---|
| Same location as in 2011 |

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH4 | | | |
| **Stream Name** | Camp Creek | | | |
| **Date Monitored** | 19-May-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:45 | **End Time:** | 15:00 |
| **Personnel** | Craig Hatt, David Moellenbeck | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | Partly Cloudy 11C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | active | **Battery** | 100% |
| **# of Records** | 3002 | **Memory Free** | 62146 |
| **Date Serviced** | 19-May-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 0.710 | 100.710 | | 100.000 | |
| BM 2 | | | 0.807 | 99.903 | |
| BM 3 | | | 0.728 | 99.982 | |
| PT | | | 2.817 | 97.893 | |
| WL | | | 2.104 | **98.606** | |
| TBM | 1.922 | 100.703 | 1.929 | 98.781 | |
| WL | | | 2.097 | **98.606** | |
| PT | | | 2.808 | 97.895 | |
| BM 3 | | | 0.722 | 99.981 | |
| BM 2 | | | 0.799 | 99.904 | |
| BM 1 | | | 0.703 | 100.000 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 2 | 99.902 | 99.904 | 0.001 | |
| BM 3 | 99.982 | 99.982 | -0.001 | |
| PT | 97.894 | 97.894 | 0.000 | |

| Summary | |
|---|---|
| **Stage (m)** | 98.606 |
| **Discharge ($m^3/s$)** | 0.645 |
| **Pressure Transducer Reading (m)** | 0.726 |
| **Pressure Transducer Elevation (m)** | 97.880 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:00 | **End** | 14:15 | **Location** | 4m downstream of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | FH950 | | | |
| **Flow Meter Type** | FH950 | | | | **Instrument Serial #** | 121181001061 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.7251 | **Time** | 12:58 | | | | |
| | **End** | **Reading** | 0.7253 | **Time** | 14:15 | | | | |

| | **Station** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| RB | 2.35 | 0.00 | 0.00 | 0.02 | 0.000 | | | 0.000 | 0.0 |
| | 2.60 | 0.16 | 0.25 | 0.04 | -0.003 | | | 0.000 | 0.0 |
| | 2.85 | 0.23 | 0.25 | 0.06 | 0.014 | | | 0.001 | 0.1 |
| | 3.10 | 0.31 | 0.25 | 0.08 | 0.061 | | | 0.005 | 0.7 |
| | 3.35 | 0.42 | 0.25 | 0.11 | 0.142 | | | 0.015 | 2.3 |
| | 3.60 | 0.44 | 0.25 | 0.10 | 0.285 | | | 0.028 | 4.4 |
| | 3.80 | 0.49 | 0.20 | 0.10 | 0.313 | | | 0.031 | 4.8 |
| | 4.00 | 0.50 | 0.20 | 0.10 | 0.307 | | | 0.031 | 4.8 |
| | 4.20 | 0.44 | 0.20 | 0.09 | 0.317 | | | 0.028 | 4.3 |
| | 4.40 | 0.43 | 0.20 | 0.09 | 0.339 | | | 0.029 | 4.5 |
| | 4.60 | 0.41 | 0.20 | 0.08 | 0.396 | | | 0.032 | 5.0 |
| | 4.80 | 0.41 | 0.20 | 0.08 | 0.430 | | | 0.035 | 5.5 |
| | 5.00 | 0.41 | 0.20 | 0.08 | 0.495 | | | 0.041 | 6.3 |
| | 5.20 | 0.40 | 0.20 | 0.08 | 0.474 | | | 0.038 | 5.9 |
| | 5.40 | 0.39 | 0.20 | 0.08 | 0.508 | | | 0.040 | 6.1 |
| | 5.60 | 0.38 | 0.20 | 0.08 | 0.528 | | | 0.040 | 6.2 |
| | 5.80 | 0.39 | 0.20 | 0.08 | 0.527 | | | 0.041 | 6.4 |
| | 6.00 | 0.37 | 0.20 | 0.07 | 0.516 | | | 0.038 | 5.9 |
| | 6.20 | 0.46 | 0.20 | 0.09 | 0.444 | | | 0.041 | 6.3 |
| | 6.40 | 0.41 | 0.20 | 0.08 | 0.465 | | | 0.038 | 5.9 |
| | 6.60 | 0.37 | 0.20 | 0.07 | 0.458 | | | 0.034 | 5.3 |
| | 6.80 | 0.29 | 0.20 | 0.06 | 0.460 | | | 0.027 | 4.1 |
| | 7.00 | 0.18 | 0.20 | 0.04 | 0.494 | | | 0.018 | 2.8 |
| | 7.20 | 0.19 | 0.20 | 0.04 | 0.406 | | | 0.015 | 2.4 |
| | 7.40 | 0.16 | 0.20 | 0.03 | 0.006 | | | 0.000 | 0.0 |
| LB | 7.60 | 0.00 | 0.20 | 0.02 | 0.000 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.645** | **100.0** |

**General Notes**

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-4 (Transducer moved to new location) | | | |
| **Stream Name** | Camp Creek | | | |
| **Date Monitored** | 30-Jun-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:28:00 AM | **End Time:** | |
| **Personnel** | Craig Hatt, Calvin Pin | | | |
| **Station Cordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | Overcast | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | active | **Battery** | 100% |
| **# of Records** | 3002 | **Memory Free** | 62146 |
| **Date Serviced** | 30-Jun-12 | **Crest Gauges** | no |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM1 | 0.671 | 100.671 | | 100.000 | |
| Bm2 | | | 0.772 | 99.899 | |
| BM3 | | | 0.689 | 99.982 | |
| WL | | | 2.131 | **98.540** | |
| PT | | | 2.832 | 97.839 | **New Location** |
| TBM1 | 1.289 | 100.624 | 1.336 | 99.335 | Ring Bolt |
| WL | | | 2.085 | **98.539** | |
| BM2 | | | 0.724 | 99.900 | |
| BM3 | | | 0.642 | 99.982 | |
| PT | | | 2.783 | 97.841 | New location |
| BM1 | | | 0.624 | 100.000 | |

| BM# | Established Elevation (m) | | Difference (m) | Notes |
|---|---|---|---|---|
| BM 2 | 99.902 | 99.900 | -0.003 | |
| BM 3 | 99.982 | 99.982 | 0.000 | |
| PT | 97.894 | 97.840 | -0.054 | PT Moved @ 10:18 |

| Summary | | |
|---|---|---|
| **Stage (m)** | 98.540 | |
| **Discharge ($m^3$/s)** | 0.350 | |
| **Pressure Transducer Reading (m)** | 0.722 | At new location |
| **Pressure Transducer New Elevation (m)** | 97.818 | |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | | **End** | | **Location** | 3m Downstream of PT | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | FH950 | | |
| **Flow Meter Type** | FH950 | | | | **Instrument Serial #** | 121181001061 | | |
| **Stage (m)** | **Start** | **Reading** | 0.709 | **Time** | 9:20 | Before Transducer was Moved | | |
| | **End** | **Reading** | 0.709 | **Time** | 9:50 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| LB | 2.75 | 0.00 | 0.00 | 0.01 | 0 | | | 0.000 | 0.0 |
| | 2.95 | 0.09 | 0.20 | 0.02 | 0.228 | | | 0.005 | 1.3 |
| | 3.20 | 0.15 | 0.25 | 0.04 | 0.226 | | | 0.008 | 2.4 |
| | 3.45 | 0.21 | 0.25 | 0.05 | 0.171 | | | 0.009 | 2.6 |
| | 3.70 | 0.29 | 0.25 | 0.07 | 0.266 | | | 0.019 | 5.5 |
| | 3.95 | 0.32 | 0.25 | 0.08 | 0.255 | | | 0.020 | 5.8 |
| | 4.20 | 0.35 | 0.25 | 0.09 | 0.233 | | | 0.020 | 5.8 |
| | 4.45 | 0.32 | 0.25 | 0.08 | 0.279 | | | 0.022 | 6.4 |
| | 4.70 | 0.31 | 0.25 | 0.07 | 0.349 | | | 0.024 | 7.0 |
| | 4.90 | 0.33 | 0.20 | 0.07 | 0.333 | | | 0.022 | 6.3 |
| | 5.10 | 0.33 | 0.20 | 0.07 | 0.319 | | | 0.021 | 6.0 |
| | 5.30 | 0.33 | 0.20 | 0.07 | 0.302 | | | 0.020 | 5.7 |
| | 5.50 | 0.35 | 0.20 | 0.07 | 0.294 | | | 0.021 | 5.9 |
| | 5.70 | 0.36 | 0.20 | 0.07 | 0.271 | | | 0.020 | 5.6 |
| | 5.90 | 0.39 | 0.20 | 0.09 | 0.242 | | | 0.021 | 6.1 |
| | 6.15 | 0.42 | 0.25 | 0.11 | 0.242 | | | 0.025 | 7.3 |
| | 6.40 | 0.43 | 0.25 | 0.11 | 0.245 | | | 0.026 | 7.5 |
| | 6.65 | 0.41 | 0.25 | 0.10 | 0.238 | | | 0.024 | 7.0 |
| | 6.90 | 0.30 | 0.25 | 0.05 | 0.125 | | | 0.007 | 1.9 |
| | 7.00 | 0.25 | 0.10 | 0.04 | 0.114 | | | 0.005 | 1.4 |
| | 7.25 | 0.28 | 0.25 | 0.07 | 0.106 | | | 0.007 | 2.1 |
| | 7.50 | 0.12 | 0.25 | 0.03 | 0.04 | | | 0.001 | 0.4 |
| RB | 7.80 | 0.00 | 0.30 | 0.02 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.350** | **100.0** |

**General Notes**

Transducer moved at 10:18. RTR measured at 10:36. Moderate flow rate observed.

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-4 | | | |
| Stream Name | Camp Creek | | | |
| Date Monitored | 15-Aug-12 | | | |
| Time at Site (24 hr) | Start Time: | 9:15 | End Time: | |
| Personnel | Craig Hatt | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| Weather Conditions | Clear | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | | Serial # | |
| Gain | | Offset | |
| Status | | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 1 | 0.650 | 100.650 | | 100.000 | |
| BM 2 | | | 0.751 | 99.899 | |
| BM 3 | | | 0.668 | 99.982 | |
| WL | | | 2.232 | **98.418** | Time: 10:37 |
| PT | | | 2.819 | 97.831 | |
| BM 3 | 0.693 | 100.675 | | 99.982 | |
| WL | | | 2.256 | **98.419** | |
| PT | | | 2.844 | 97.831 | |
| BM 2 | | | 0.776 | 99.899 | |
| BM 1 | | | 0.675 | 100.000 | |
| | | | | | |
| BM# | Established Elevation (m) | | | Difference (m) | Notes |
| BM 2 | 99.902 | | 99.899 | -0.003 | |
| BM 3 | 99.982 | | 99.982 | 0.000 | |
| PT | 97.84 | | 97.831 | -0.009 | |

| Summary | |
|---|---|
| Stage (m) | 98.419 |
| Discharge ($m^3/s$) | 0.0855 |
| Pressure Transducer Reading (m) | 0.585 |
| Pressure Transducer Elevation (m) | 97.834 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 9:30 | End | 10:07 | Location | 2-3 m downstream of PT | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | | | | |
| Flow Meter Type | FH950 | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | | Time | 9:30 | | | | |
| | End | Reading | | Time | 10:07 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | (m3/s) | % |
| RB | 2.50 | 0.00 | 0.00 | 0.01 | 0.000 | | | 0.000 | 0.0 |
| | 2.70 | 0.10 | 0.20 | 0.03 | 0.059 | | | 0.001 | 1.7 |
| | 3.00 | 0.28 | 0.30 | 0.07 | 0.023 | | | 0.002 | 1.9 |
| | 3.20 | 0.29 | 0.20 | 0.06 | 0.088 | | | 0.005 | 6.0 |
| | 3.40 | 0.32 | 0.20 | 0.06 | 0.111 | | | 0.007 | 8.3 |
| | 3.60 | 0.32 | 0.20 | 0.06 | 0.105 | | | 0.007 | 7.9 |
| | 3.80 | 0.32 | 0.20 | 0.06 | 0.114 | | | 0.007 | 8.5 |
| | 4.00 | 0.28 | 0.20 | 0.06 | 0.108 | | | 0.006 | 7.1 |
| | 4.20 | 0.26 | 0.20 | 0.05 | 0.110 | | | 0.006 | 6.7 |
| | 4.40 | 0.25 | 0.20 | 0.05 | 0.113 | | | 0.006 | 6.6 |
| | 4.60 | 0.23 | 0.20 | 0.05 | 0.111 | | | 0.005 | 6.0 |
| | 4.80 | 0.23 | 0.20 | 0.05 | 0.111 | | | 0.005 | 6.0 |
| | 5.00 | 0.24 | 0.20 | 0.05 | 0.107 | | | 0.005 | 6.0 |
| | 5.20 | 0.25 | 0.20 | 0.05 | 0.111 | | | 0.006 | 6.5 |
| | 5.40 | 0.22 | 0.20 | 0.04 | 0.075 | | | 0.003 | 3.9 |
| | 5.60 | 0.22 | 0.20 | 0.04 | 0.082 | | | 0.004 | 4.2 |
| | 5.80 | 0.27 | 0.20 | 0.05 | 0.075 | | | 0.004 | 4.7 |
| | 6.00 | 0.20 | 0.20 | 0.04 | 0.090 | | | 0.004 | 4.2 |
| | 6.20 | 0.17 | 0.20 | 0.03 | 0.064 | | | 0.002 | 2.5 |
| | 6.40 | 0.13 | 0.20 | 0.03 | 0.037 | | | 0.001 | 1.1 |
| | 6.60 | 0.04 | 0.20 | 0.01 | 0.003 | | | 0.000 | 0.0 |
| | 6.80 | 0.05 | 0.20 | 0.01 | 0.016 | | | 0.000 | 0.2 |
| LB | 7.00 | 0.00 | 0.20 | 0.01 | 0.000 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0855** | **100.0** |

**General Notes**

Batteries dead in datalogger. Replaced the batteries. Downloaded data. Had data until August 2.

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-4 | | | |
| **Stream Name** | Camp Creek | | | |
| **Date Monitored** | 28-Sep-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 1:20:00 PM | **End Time:** | 2:40:00 PM |
| **Personnel** | Eli Heyman, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | Mix of Sun and Cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | ok | **Battery** | 95% |
| **# of Records** | 6217 | **Memory Free** | 29429 |
| **Date Serviced** | 28-Sep-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 0.699 | 100.699 | | 100.000 | |
| BM 2 | | | 0.802 | 99.897 | |
| BM 3 | | | 0.716 | 99.983 | |
| PT | | | 2.866 | 97.833 | |
| WL | | | 2.355 | 98.344 | |
| TBM | 2.152 | 100.617 | 2.234 | 98.465 | |
| WL | | | 2.273 | **98.344** | |
| PT | | | 2.783 | **97.834** | |
| BM 3 | | | 0.634 | **99.983** | |
| BM 2 | | | 0.718 | **99.899** | |
| BM 1 | | | 0.617 | **100.000** | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 2 | 99.902 | 99.898 | -0.004 | |
| BM 3 | 99.982 | 99.983 | 0.001 | |
| PT | 97.84 | 97.834 | -0.007 | |

| Summary | |
|---|---|
| **Stage (m)** | 98.344 |
| **Discharge ($m^3/s$)** | 0.0198 |
| **Pressure Transducer Reading (m)** | 0.533 |
| **Pressure Transducer Elevation (m)** | 97.811 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:26 | **End** | 14:00 | **Location** | 3m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | Flo-Mate 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.532 | **Time** | 13:26 | | | | |
| | **End** | **Reading** | 0.533 | **Time** | 14:00 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| RB | 2.20 | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.000 | 0.0 |
| | 2.85 | 0.01 | 0.65 | 0.00 | 0.00 | | | 0.000 | 0.0 |
| | 3.00 | 0.02 | 0.15 | 0.00 | -0.03 | | | 0.000 | -0.5 |
| | 3.15 | 0.04 | 0.15 | 0.01 | -0.04 | | | 0.000 | -1.2 |
| | 3.30 | 0.05 | 0.15 | 0.01 | -0.02 | | | 0.000 | -0.8 |
| | 3.45 | 0.09 | 0.15 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| | 3.60 | 0.10 | 0.15 | 0.02 | 0.02 | | | 0.000 | 1.5 |
| | 3.75 | 0.13 | 0.15 | 0.02 | 0.02 | | | 0.000 | 2.0 |
| | 3.90 | 0.10 | 0.15 | 0.02 | 0.02 | | | 0.000 | 1.5 |
| | 4.05 | 0.10 | 0.15 | 0.02 | 0.02 | | | 0.000 | 1.5 |
| | 4.20 | 0.13 | 0.15 | 0.02 | 0.02 | | | 0.000 | 2.0 |
| | 4.35 | 0.12 | 0.15 | 0.02 | 0.03 | | | 0.001 | 2.7 |
| | 4.50 | 0.13 | 0.15 | 0.02 | 0.03 | | | 0.001 | 3.0 |
| | 4.65 | 0.14 | 0.15 | 0.02 | 0.04 | | | 0.001 | 4.2 |
| | 4.80 | 0.18 | 0.15 | 0.03 | 0.04 | | | 0.001 | 5.5 |
| | 4.95 | 0.18 | 0.15 | 0.03 | 0.04 | | | 0.001 | 5.5 |
| | 5.10 | 0.18 | 0.15 | 0.03 | 0.04 | | | 0.001 | 5.5 |
| | 5.25 | 0.19 | 0.15 | 0.03 | 0.05 | | | 0.001 | 7.2 |
| | 5.40 | 0.20 | 0.15 | 0.03 | 0.05 | | | 0.002 | 7.6 |
| | 5.55 | 0.23 | 0.15 | 0.03 | 0.05 | | | 0.002 | 8.7 |
| | 5.70 | 0.24 | 0.15 | 0.04 | 0.05 | | | 0.002 | 9.1 |
| | 5.85 | 0.26 | 0.15 | 0.04 | 0.05 | | | 0.002 | 9.9 |
| | 6.00 | 0.24 | 0.15 | 0.04 | 0.04 | | | 0.001 | 7.3 |
| | 6.15 | 0.19 | 0.15 | 0.03 | 0.05 | | | 0.001 | 7.2 |
| | 6.30 | 0.20 | 0.15 | 0.03 | 0.04 | | | 0.001 | 7.1 |
| | 6.50 | 0.16 | 0.20 | 0.04 | 0.02 | | | 0.001 | 3.6 |
| | 6.75 | 0.02 | 0.25 | 0.00 | 0 | | | 0.000 | 0.0 |
| LB | 6.80 | 0.00 | 0.05 | 0.00 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0198** | **100.0** |

| General Notes |
|---|
| Distance from top of pipe to centre of PT=25mm |

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-4 | | | |
| **Stream Name** | Upper Camp Creek | | | |
| **Date Monitored** | 8-Nov-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 2:20:00 PM | **End Time:** | 4:30:00 PM |
| **Personnel** | Eli Heyman, Arnold Payou | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620031 | 6101563 | 1108 | |
| **Weather Conditions** | Mix of Sun and Cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | ok | **Battery** | 66% |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | 8-Nov-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 0.830 | 100.830 | | 100.000 | |
| BM 2 | | | 0.932 | 99.898 | |
| BM 3 | | | | | Not measured |
| PT | | | | | Not measured |
| WL | | | 2.233 | 98.597 | |
| TBM | | | | | |
| WL | | | | | |
| PT | | | | | |
| BM 3 | | | | | |
| BM 2 | | | | | |
| BM 1 | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 2 | 99.902 | 99.898 | -0.004 | |
| BM 3 | 99.982 | | | Not Measured |
| PT | 97.84 | | | Not Measured |

| Summary | |
|---|---|
| **Stage (m)** | 98.597 |
| **Discharge ($m^3/s$)** | 0.0787 |
| **Pressure Transducer Reading (m)** | 0.757 |
| **Pressure Transducer Elevation (m)** | 97.840 |

| Discharge Measurement - Mid-Section Method | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 15:30 | **End** | 16:15 | **Location** | 10m DS of PT | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | 2006775 | |
| **Stage (m)** | **Start** | **Reading** | 0.67 | **Time** | 14:30 | Stage changing during measurment due to ice jam | |
| | **End** | **Reading** | 0.757 | **Time** | 16:15 | and water back-up | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **(m3/s)** | **%** |
| LB | 0.30 | 0.00 | 0.00 | 0.03 | 0.00 | | | 0.000 | 0.0 |
| Pool. No Flow | 0.70 | 0.15 | 0.40 | 0.05 | 0.00 | | | 0.000 | 0.0 |
| | 0.90 | 0.23 | 0.20 | 0.05 | -0.01 | | | 0.000 | -0.6 |
| | 1.10 | 0.26 | 0.20 | 0.05 | 0.00 | | | 0.000 | 0.0 |
| | 1.30 | 0.26 | 0.20 | 0.05 | -0.01 | | | -0.001 | -0.7 |
| | 1.50 | 0.24 | 0.20 | 0.05 | 0.01 | | | 0.000 | 0.6 |
| | 1.70 | 0.30 | 0.20 | 0.06 | 0.01 | | | 0.001 | 0.8 |
| | 1.90 | 0.30 | 0.20 | 0.06 | 0.02 | | | 0.001 | 1.5 |
| | 2.10 | 0.28 | 0.20 | 0.06 | 0.05 | | | 0.003 | 3.6 |
| | 2.30 | 0.18 | 0.20 | 0.04 | 0.11 | | | 0.004 | 5.0 |
| | 2.50 | 0.19 | 0.20 | 0.04 | 0.14 | | | 0.005 | 6.8 |
| | 2.70 | 0.20 | 0.20 | 0.04 | 0.17 | | | 0.007 | 8.6 |
| | 2.90 | 0.26 | 0.20 | 0.05 | 0.11 | | | 0.006 | 7.3 |
| | 3.10 | 0.28 | 0.20 | 0.06 | 0.16 | | | 0.009 | 11.4 |
| | 3.30 | 0.29 | 0.20 | 0.06 | 0.19 | | | 0.011 | 14.0 |
| | 3.50 | 0.32 | 0.20 | 0.06 | 0.10 | | | 0.006 | 8.1 |
| | 3.70 | 0.28 | 0.20 | 0.06 | 0.11 | | | 0.006 | 7.8 |
| | 3.90 | 0.38 | 0.20 | 0.08 | 0.09 | | | 0.007 | 8.7 |
| | 4.10 | 0.27 | 0.20 | 0.05 | 0.07 | | | 0.004 | 4.8 |
| | 4.30 | 0.25 | 0.20 | 0.05 | 0.04 | | | 0.002 | 2.5 |
| | 4.50 | 0.36 | 0.20 | 0.07 | 0.05 | | | 0.004 | 4.6 |
| | 4.70 | 0.34 | 0.20 | 0.07 | 0.01 | | | 0.001 | 0.9 |
| | 4.90 | 0.31 | 0.20 | 0.06 | 0.02 | | | 0.001 | 1.6 |
| | 5.10 | 0.30 | 0.20 | 0.06 | 0.03 | | | 0.002 | 2.3 |
| | 5.30 | 0.23 | 0.20 | 0.05 | 0.01 | | | 0.000 | 0.6 |
| | 5.50 | 0.08 | 0.20 | 0.02 | -0.01 | | | 0.000 | -0.2 |
| RB | 5.70 | 0.00 | 0.20 | 0.01 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0787** | **100.0** |

**General Notes**

PT reading increased from 0.670 to 0.757 after ice was broken up downstream of PT due to build up of ice that could not be moved. Water was observed backing up over top of ice in pool where the PT is located. Survey incomplete due to lack of time. Returned following morning to complete survey.

## Appendix 2-4b. Manual Discharge Measurements and Levelling Surveys at MH-4 in 2012

| Site Information | | | | | |
|---|---|---|---|---|---|
| **Project Name** | Murray River | | | | |
| **Station Identification** | MH-4 | | | | |
| **Stream Name** | Upper Camp Creek | | | | |
| **Date Monitored** | 9-Nov-12 (Survey Only) | | | | |
| **Time at Site (24 hr)** | **Start Time:** | 9:00:00 AM | **End Time:** | 10:00:00 AM | |
| **Personnel** | Eli Heyman, Arnold | | | | |
| **Station Cordinates** | Easting | Northing | Elevation | | |
| | 0620031 | 6101563 | 1108 | | |
| **Weather Conditions** | Cold (-14C) with light snow | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721020 |
| **Gain** | 3.5293 | **Offset** | -0.0029 |
| **Status** | ok | **Battery** | 0.66 |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | 9-Nov-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 1 | 0.814 | 100.814 | | 100.000 | |
| BM 2 | | | 0.917 | 99.897 | |
| BM 3 | | | 0.833 | 99.981 | |
| PT | | | | | |
| WL | | | 2.271 | 98.543 | **Before ice break-up** |
| TBM | 1.808 | 100.679 | 1.943 | 98.871 | |
| WL | | | 2.138 | **98.541** | **Before ice break-up** |
| PT | | | 2.861 | **97.818** | |
| BM 3 | | | 0.699 | **99.980** | |
| BM 2 | | | 0.783 | **99.896** | |
| BM 1 | | | 0.681 | **99.998** | |
| | | | | | |
| WL (after ice) | | | 2.142 | **98.537** | After ice break-up |
| | | | | | |
| | | | | | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 2 | 99.902 | 99.897 | -0.005 | |
| BM 3 | 99.982 | 99.981 | -0.001 | |
| PT | 97.84 | 97.818 | -0.022 | |

| Summary | |
|---|---|
| **Stage (m)** | 98.542 |
| **Discharge ($m^3/s$)** | Not Measured |
| **Pressure Transducer Reading (m)** | 0.725 |
| **Pressure Transducer Elevation (m)** | 97.817 |

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 12-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 3:00:00 PM | **End Time:** | 5:00:00 PM |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 27210 |
| **Gain** | 3.5311 | **Offset** | -0.0048 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 100 | 1.294 | 101.294 | | 100.000 | Nail in tree |
| BM 99 | | | 1.039 | 100.255 | Nail in tree |
| BM 98 | | | 1.186 | 100.108 | Nail in tree |
| WL | | | 2.353 | **98.941** | Taken at Station |
| BM 99 | 0.986 | 101.241 | | 100.255 | |
| BM 98 | | | 1.130 | 100.111 | |
| WL | | | 2.291 | **98.950** | |
| BM 100 | | | 1.240 | 100.001 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 100 | | 100.001 | | |
| BM 99 | | 100.255 | | |
| BM 98 | | 100.110 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.946 |
| **Mean Discharge ($m^3/s$)** | 0.328 |
| **Pressure Transducer Reading (m)** | 0.604 |
| **Pressure Transducer Elevation (m)** | 98.342 |

| Discharge Measurement - Mid-Section Method (5/12/11 #1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 15:05 | **End** | 15:30 | **Location** | | | |
| **Method** | Velocity-area (Mid-section) | | | **Indicator Constant** | | 421 | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | 006713 | | |
| **Stage (m)** | **Start** | **Reading** | 0.604 | **Time** | 15:05 | Measurement #1 | | |
| | **End** | **Reading** | | **Time** | | | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | (m/s) | (m/s) | ($m^3/s$) | % |
| right bank | 1.35 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.000 | 0.1 |
| CF= | 1.45 | 0.12 | 0.10 | 0.01 | 0.08 | 0.08 | 0.001 | 0.3 |
| 1 | 1.55 | 0.52 | 0.10 | 0.05 | 0.06 | 0.06 | 0.003 | 1.0 |
| | 1.65 | 0.52 | 0.10 | 0.05 | 0.14 | 0.12 | 0.006 | 1.8 |
| | 1.75 | 0.50 | 0.10 | 0.05 | 0.26 | 0.20 | 0.010 | 3.0 |
| | 1.85 | 0.48 | 0.10 | 0.05 | 0.21 | 0.16 | 0.008 | 2.4 |
| | 1.95 | 0.48 | 0.10 | 0.05 | 1.13 | 0.79 | 0.040 | 11.4 |
| | 2.05 | 0.44 | 0.08 | 0.03 | 0.98 | 0.69 | 0.021 | 6.8 |
| | 2.10 | 0.47 | 0.05 | 0.02 | 1.00 | 0.70 | 0.014 | 5.0 |
| | 2.15 | 0.46 | 0.08 | 0.03 | 1.05 | 0.73 | 0.022 | 7.6 |
| | 2.25 | 0.47 | 0.10 | 0.05 | 1.01 | 0.71 | 0.036 | 10.0 |
| | 2.35 | 0.45 | 0.10 | 0.05 | 1.00 | 0.70 | 0.035 | 9.5 |
| | 2.45 | 0.45 | 0.10 | 0.04 | 0.94 | 0.66 | 0.026 | 9.0 |
| | 2.55 | 0.45 | 0.10 | 0.04 | 0.87 | 0.61 | 0.024 | 8.3 |
| | 2.65 | 0.38 | 0.10 | 0.04 | 0.60 | 0.43 | 0.017 | 4.9 |
| | 2.75 | 0.38 | 0.10 | 0.04 | 0.51 | 0.37 | 0.015 | 4.2 |
| | 2.85 | 0.35 | 0.10 | 0.04 | 0.61 | 0.43 | 0.017 | 4.6 |
| | 2.95 | 0.33 | 0.10 | 0.03 | 0.41 | 0.30 | 0.009 | 3.0 |
| | 3.05 | 0.25 | 0.10 | 0.03 | 0.61 | 0.43 | 0.013 | 3.3 |
| 1 | 3.15 | 0.23 | 0.10 | 0.02 | 0.34 | 0.25 | 0.005 | 1.8 |
| CF= | 3.25 | 0.25 | 0.10 | 0.03 | 0.28 | 0.21 | 0.006 | 1.6 |
| left bank | 3.35 | 0.00 | 0.05 | 0.01 | 0.00 | 0.00 | 0.000 | 0.4 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **0.328** | **100.0** |

| General Notes |
|---|
| Use average of two discharge measurements |

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 12-May-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 3:00:00 PM | **End Time:** | 5:00:00 PM |
| **Personnel** | Craig Hatt, Adrian Ang | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 27210 |
| **Gain** | 3.5311 | **Offset** | -0.0048 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 100 | 1.294 | 101.294 | | 100.000 | Nail in tree |
| BM 99 | | | 1.039 | 100.255 | Nail in tree |
| BM 98 | | | 1.186 | 100.108 | Nail in tree |
| WL | | | 2.353 | **98.941** | Taken at Station |
| BM 99 | 0.986 | 101.241 | | 100.255 | |
| BM 98 | | | 1.130 | 100.111 | |
| WL | | | 2.291 | **98.950** | |
| BM 100 | | | 1.240 | 100.001 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 100 | | 100.001 | | |
| BM 99 | | 100.255 | | |
| BM 98 | | 100.110 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.946 |
| **Mean Discharge ($m^3/s$)** | 0.341 |
| **Pressure Transducer Reading (m)** | 0.604 |
| **Pressure Transducer Elevation (m)** | 98.342 |

| Discharge Measurement - Mid-Section Method (5/12/11 #2) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 15:30 | **End** | 16:00 | **Location** | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | | | |
| **Flow Meter Type** | Swoffer | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.604 | **Time** | 15:30 | Measurment #2 | | |
| | **End** | **Reading** | | **Time** | | | | |

| | Station | Depth | Distance | Area | Velocity | Cal. Velocity | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | (m/s) | (m/s) | ($m^3/s$) | % |
| left bank | 3.35 | 0.00 | 0.08 | 0.01 | 0.00 | 0.00 | 0.000 | 0.0 |
| CF= | 3.20 | 0.25 | 0.13 | 0.03 | 0.25 | 0.19 | 0.006 | 0.1 |
| 1 | 3.10 | 0.24 | 0.10 | 0.02 | 0.49 | 0.35 | 0.007 | 0.3 |
| | 3.00 | 0.25 | 0.10 | 0.03 | 0.72 | 0.51 | 0.015 | 1.5 |
| | 2.90 | 0.30 | 0.10 | 0.03 | 0.67 | 0.48 | 0.014 | 3.4 |
| | 2.80 | 0.35 | 0.10 | 0.03 | 0.21 | 0.16 | 0.005 | 4.7 |
| | 2.70 | 0.39 | 0.10 | 0.04 | 0.58 | 0.41 | 0.016 | 6.4 |
| | 2.60 | 0.44 | 0.10 | 0.04 | 0.75 | 0.53 | 0.021 | 5.8 |
| | 2.50 | 0.45 | 0.10 | 0.05 | 0.87 | 0.61 | 0.031 | 5.8 |
| | 2.40 | 0.45 | 0.10 | 0.05 | 0.94 | 0.66 | 0.033 | 6.8 |
| | 2.30 | 0.47 | 0.08 | 0.04 | 0.98 | 0.69 | 0.028 | 9.6 |
| | 2.25 | 0.47 | 0.05 | 0.02 | 1.00 | 0.70 | 0.014 | 5.9 |
| | 2.20 | 0.47 | 0.05 | 0.02 | 1.04 | 0.73 | 0.015 | 6.7 |
| | 2.15 | 0.47 | 0.05 | 0.02 | 1.06 | 0.74 | 0.015 | 9.4 |
| | 2.10 | 0.47 | 0.08 | 0.04 | 1.05 | 0.73 | 0.029 | 8.0 |
| | 2.00 | 0.44 | 0.10 | 0.04 | 0.88 | 0.62 | 0.025 | 6.7 |
| | 1.90 | 0.50 | 0.10 | 0.05 | 1.07 | 0.75 | 0.038 | 7.0 |
| | 1.80 | 0.48 | 0.10 | 0.05 | 0.32 | 0.24 | 0.012 | 5.8 |
| | 1.70 | 0.50 | 0.10 | 0.05 | 0.14 | 0.12 | 0.006 | 3.5 |
| 1 | 1.60 | 0.51 | 0.10 | 0.05 | 0.17 | 0.14 | 0.007 | 1.6 |
| CF= | 1.50 | 0.50 | 0.13 | 0.06 | 0.09 | 0.08 | 0.005 | 0.6 |
| right bank | 1.35 | 0.00 | 0.08 | 0.02 | 0.00 | 0.00 | 0.000 | 0.4 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total Q** | | | | | | | **0.341** | **100.0** |

| General Notes |
|---|
| Use average of two discharge measurements |

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 1-Jul-11 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:00:00 PM | **End Time:** | 2:00:00 PM |
| **Personnel** | Craig Hatt, Assistant | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| **Weather Conditions** | | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 27210 |
| **Gain** | 3.5311 | **Offset** | -0.0048 |
| **Status** | Active | **Battery** | |
| **# of Records** | | **Memory Free** | |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 100 | 0.982 | 100.982 | | 100.000 | |
| BM 99 | | | 0.738 | 100.244 | |
| BM 98 | | | 0.870 | 100.112 | |
| WL | | | 2.366 | **98.616** | |
| BM 98 | 0.898 | 101.010 | | 100.112 | |
| BM 99 | | | 0.766 | 100.244 | |
| WL | | | 2.397 | **98.613** | |
| BM 100 | | | 1.010 | 100.000 | |
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| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 100 | | 100.000 | | |
| BM 99 | | 100.244 | | |
| BM 98 | | 100.112 | | |

| Summary | |
|---|---|
| **Stage (m)** | 98.615 |
| **Mean Discharge ($m^3/s$)** | 0.0720 |
| **Pressure Transducer Reading (m)** | 0.281 |
| **Pressure Transducer Elevation (m)** | 98.334 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 12:20 | **End** | 12:40 | **Location** | | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | 2000 | | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.281 | **Time** | 12:20 | | | | |
| | **End** | **Reading** | | **Time** | | | | | |

| | **Station** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **($m^3/s$)** | **%** |
| Left Bank | 2.60 | 0.00 | 0.05 | 0.001 | 0 | | | 0.000 | 0.0 |
| CF= | 2.50 | 0.04 | 0.10 | 0.004 | -0.02 | | | 0.000 | -0.1 |
| 1 | 2.40 | 0.04 | 0.10 | 0.004 | -0.02 | | | 0.000 | -0.1 |
| | 2.30 | 0.06 | 0.10 | 0.006 | -0.03 | | | 0.000 | -0.3 |
| | 2.20 | 0.08 | 0.08 | 0.006 | -0.04 | | | 0.000 | -0.3 |
| | 2.15 | 0.09 | 0.05 | 0.005 | -0.02 | | | 0.000 | -0.1 |
| | 2.10 | 0.10 | 0.05 | 0.005 | -0.01 | | | 0.000 | -0.1 |
| | 2.05 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.000 | 0.3 |
| | 2.00 | 0.10 | 0.05 | 0.005 | 0.14 | | | 0.001 | 1.0 |
| | 1.95 | 0.12 | 0.05 | 0.006 | 0.25 | | | 0.002 | 2.1 |
| | 1.90 | 0.15 | 0.05 | 0.007 | 0.32 | | | 0.002 | 3.4 |
| | 1.85 | 0.14 | 0.05 | 0.007 | 0.42 | | | 0.003 | 4.2 |
| | 1.80 | 0.18 | 0.05 | 0.009 | 0.47 | | | 0.004 | 6.0 |
| | 1.75 | 0.15 | 0.05 | 0.008 | 0.54 | | | 0.004 | 5.7 |
| | 1.70 | 0.16 | 0.05 | 0.008 | 0.57 | | | 0.005 | 6.4 |
| | 1.65 | 0.16 | 0.05 | 0.008 | 0.6 | | | 0.005 | 6.8 |
| | 1.60 | 0.16 | 0.05 | 0.008 | 0.6 | | | 0.005 | 6.8 |
| | 1.55 | 0.16 | 0.05 | 0.008 | 0.63 | | | 0.005 | 7.1 |
| | 1.50 | 0.14 | 0.05 | 0.007 | 0.67 | | | 0.005 | 6.6 |
| | 1.45 | 0.13 | 0.05 | 0.007 | 0.65 | | | 0.004 | 6.0 |
| | 1.40 | 0.14 | 0.05 | 0.007 | 0.6 | | | 0.004 | 5.9 |
| | 1.35 | 0.20 | 0.05 | 0.010 | 0.51 | | | 0.005 | 7.2 |
| | 1.30 | 0.20 | 0.05 | 0.010 | 0.53 | | | 0.005 | 7.5 |
| | 1.25 | 0.25 | 0.05 | 0.013 | 0.51 | | | 0.006 | 9.0 |
| | 1.20 | 0.26 | 0.05 | 0.013 | 0.4 | | | 0.005 | 7.3 |
| | 1.15 | 0.27 | 0.1 | 0.01 | 0.17 | | | 0.002 | 3.2 |
| | 1.10 | 0.28 | 0.0 | 0.01 | 0.03 | | | 0.000 | 0.3 |
| | 1.05 | 0.28 | 0.0 | 0.01 | -0.02 | | | 0.000 | -0.2 |
| | 1.00 | 0.26 | 0.0 | 0.01 | -0.03 | | | 0.000 | -0.3 |
| | 0.95 | 0.24 | 0.0 | 0.01 | -0.05 | | | 0.000 | -0.4 |
| 1 | 0.90 | 0.20 | 0.0 | 0.01 | -0.05 | | | 0.000 | -0.4 |
| CF= | 0.80 | 0.14 | 0.1 | 0.01 | -0.04 | | | 0.000 | -0.4 |
| Right Bank | 0.75 | 0.00 | 0.0 | 0.00 | 0 | | | 0.000 | -0.1 |
| **Total Q** | | | | | | | | **0.0720** | **100.0** |

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 4-Aug-11 | | | |
| Time at Site (24 hr) | Start Time: | 11:40:00 AM | End Time: | 1:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 27210 |
| Gain | 3.5311 | Offset | -0.0048 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 100 | 1.092 | 101.092 | | 100.000 | |
| BM 99 | | | 0.846 | 100.246 | |
| BM 98 | | | 0.981 | 100.111 | |
| WL | | | 2.584 | **98.508** | |
| BM 98 | 0.999 | 101.110 | | 100.111 | |
| BM 99 | | | 0.863 | 100.247 | |
| WL | | | 2.600 | **98.510** | |
| BM 100 | | | 1.109 | 100.001 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 100 | | 100.001 | | |
| BM 99 | | 100.247 | | |
| BM 98 | | 100.111 | | |

| Summary | |
|---|---|
| Stage (m) | 98.509 |
| Mean Discharge ($m^3/s$) | 0.0300 |
| Pressure Transducer Reading (m) | 0.186 |
| Pressure Transducer Elevation (m) | 98.323 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 12:20 | End | 12:40 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.186 | Time | 12:20 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.10 | 0.00 | 0.05 | 0.001 | 0 | | | 0.000 | 0.0 |
| CF= | 1.20 | 0.04 | 0.08 | 0.003 | 0 | | | 0.000 | 0.0 |
| 1 | 1.25 | 0.07 | 0.05 | 0.004 | 0.08 | | | 0.000 | 1.1 |
| | 1.30 | 0.12 | 0.05 | 0.006 | 0.15 | | | 0.001 | 3.6 |
| | 1.35 | 0.14 | 0.05 | 0.007 | 0.16 | | | 0.001 | 4.5 |
| | 1.40 | 0.15 | 0.05 | 0.007 | 0.17 | | | 0.001 | 5.1 |
| | 1.45 | 0.16 | 0.05 | 0.008 | 0.19 | | | 0.002 | 6.0 |
| | 1.50 | 0.18 | 0.05 | 0.009 | 0.19 | | | 0.002 | 6.8 |
| | 1.55 | 0.18 | 0.05 | 0.009 | 0.18 | | | 0.002 | 6.4 |
| | 1.60 | 0.18 | 0.05 | 0.009 | 0.18 | | | 0.002 | 6.4 |
| | 1.65 | 0.18 | 0.05 | 0.009 | 0.17 | | | 0.002 | 6.1 |
| | 1.70 | 0.20 | 0.05 | 0.010 | 0.16 | | | 0.002 | 6.4 |
| | 1.75 | 0.20 | 0.05 | 0.010 | 0.15 | | | 0.002 | 6.0 |
| | 1.80 | 0.17 | 0.05 | 0.009 | 0.13 | | | 0.001 | 4.4 |
| | 1.85 | 0.16 | 0.05 | 0.008 | 0.14 | | | 0.001 | 4.5 |
| | 1.90 | 0.13 | 0.05 | 0.006 | 0.14 | | | 0.001 | 3.6 |
| | 1.95 | 0.12 | 0.05 | 0.006 | 0.13 | | | 0.001 | 3.1 |
| | 2.00 | 0.12 | 0.05 | 0.006 | 0.14 | | | 0.001 | 3.3 |
| | 2.05 | 0.12 | 0.05 | 0.006 | 0.13 | | | 0.001 | 3.1 |
| | 2.10 | 0.12 | 0.05 | 0.006 | 0.12 | | | 0.001 | 2.9 |
| | 2.15 | 0.12 | 0.05 | 0.006 | 0.1 | | | 0.001 | 2.4 |
| | 2.20 | 0.12 | 0.05 | 0.006 | 0.11 | | | 0.001 | 2.6 |
| | 2.25 | 0.12 | 0.05 | 0.006 | 0.11 | | | 0.001 | 2.6 |
| | 2.30 | 0.12 | 0.05 | 0.006 | 0.12 | | | 0.001 | 2.9 |
| | 2.35 | 0.12 | 0.05 | 0.006 | 0.11 | | | 0.001 | 2.6 |
| | 2.40 | 0.12 | 0.1 | 0.009 | 0.07 | | | 0.001 | 2.5 |
| 1 | 2.50 | 0.08 | 0.1 | 0.004 | 0.07 | | | 0.000 | 1.1 |
| CF= | 2.60 | 0.05 | 0.1 | 0.003 | 0 | | | 0.000 | 0.0 |
| Left Bank | 2.70 | 0.00 | 0.1 | 0.001 | 0 | | | 0.000 | 0.0 |
| Total Q | | | | | | | | **0.0300** | 100.0 |

| General Notes |
|---|

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 2-Sep-11 | | | |
| Time at Site (24 hr) | Start Time: | 2:00:00 PM | End Time: | 4:00:00 PM |
| Personnel | Craig Hatt, Assistant | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 27210 |
| Gain | 3.5311 | Offset | -0.0048 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 100 | 1.060 | 101.060 | | 100.000 | |
| BM 99 | | | 0.809 | 100.251 | |
| BM 98 | | | 0.947 | 100.113 | |
| WL | | | 2.590 | **98.470** | |
| BM 98 | 0.937 | 101.050 | | 100.113 | |
| BM 99 | | | 0.800 | 100.250 | |
| WL | | | 2.582 | **98.468** | |
| BM 100 | | | 1.049 | 100.001 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 100 | | 100.001 | | |
| BM 99 | | 100.251 | | |
| BM 98 | | 100.113 | | |

| Summary | |
|---|---|
| Stage (m) | 98.469 |
| Mean Discharge ($m^3/s$) | 0.00884 |
| Pressure Transducer Reading (m) | 0.144 |
| Pressure Transducer Elevation (m) | 98.325 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 14:10 | End | 14:40 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.144 | Time | 14:10 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.55 | 0.00 | 0.05 | 0.002 | 0 | | | 0.0001 | 0.7 |
| CF= | 1.65 | 0.06 | 0.08 | 0.005 | 0.04 | | | 0.0002 | 2.2 |
| 1 | 1.71 | 0.10 | 0.06 | 0.006 | 0.08 | | | 0.0005 | 5.4 |
| | 1.77 | 0.10 | 0.06 | 0.006 | 0.07 | | | 0.0004 | 4.8 |
| | 1.83 | 0.12 | 0.06 | 0.007 | 0.09 | | | 0.0007 | 7.3 |
| | 1.89 | 0.12 | 0.06 | 0.007 | 0.09 | | | 0.0007 | 7.3 |
| | 1.95 | 0.13 | 0.05 | 0.006 | 0.09 | | | 0.0005 | 6.0 |
| | 1.98 | 0.14 | 0.03 | 0.004 | 0.09 | | | 0.0004 | 4.3 |
| | 2.01 | 0.14 | 0.03 | 0.004 | 0.09 | | | 0.0004 | 4.3 |
| | 2.04 | 0.14 | 0.03 | 0.004 | 0.09 | | | 0.0004 | 4.3 |
| | 2.07 | 0.14 | 0.03 | 0.004 | 0.09 | | | 0.0004 | 4.3 |
| | 2.10 | 0.13 | 0.03 | 0.004 | 0.09 | | | 0.0004 | 4.0 |
| | 2.13 | 0.12 | 0.03 | 0.004 | 0.09 | | | 0.0003 | 3.7 |
| | 2.16 | 0.12 | 0.03 | 0.004 | 0.08 | | | 0.0003 | 3.3 |
| | 2.19 | 0.12 | 0.04 | 0.005 | 0.08 | | | 0.0004 | 4.9 |
| | 2.25 | 0.10 | 0.06 | 0.006 | 0.08 | | | 0.0005 | 5.4 |
| | 2.31 | 0.09 | 0.06 | 0.005 | 0.07 | | | 0.0004 | 4.3 |
| | 2.37 | 0.09 | 0.06 | 0.005 | 0.07 | | | 0.0004 | 4.3 |
| | 2.43 | 0.08 | 0.06 | 0.005 | 0.05 | | | 0.0002 | 2.7 |
| | 2.49 | 0.09 | 0.06 | 0.005 | 0.05 | | | 0.0003 | 3.1 |
| | 2.55 | 0.10 | 0.06 | 0.006 | 0.06 | | | 0.0004 | 4.1 |
| | 2.61 | 0.09 | 0.06 | 0.005 | 0.06 | | | 0.0003 | 3.7 |
| | 2.67 | 0.08 | 0.06 | 0.005 | 0.05 | | | 0.0002 | 2.7 |
| 1 | 2.73 | 0.08 | 0.06 | 0.005 | 0.04 | | | 0.0002 | 2.2 |
| CF= | 2.79 | 0.06 | 0.09 | 0.005 | 0.01 | | | 0.0001 | 0.6 |
| Left Bank | 2.91 | 0.00 | 0.1 | 0.00 | 0 | | | 0.0000 | 0.5 |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.00884** | 100.0 |

| General Notes |
|---|

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 15-Oct-11 | | | |
| Time at Site (24 hr) | Start Time: | 3:20:00 PM | End Time: | 5:20:00 PM |
| Personnel | Craig Hatt, Max Taylor | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 27210 |
| Gain | 3.5311 | Offset | -0.0048 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 100 | 0.945 | 100.945 | | 100.000 | |
| BM 99 | | | 0.699 | 100.246 | |
| BM 98 | | | 0.833 | 100.112 | |
| WL | | | 2.489 | **98.456** | |
| BM 98 | 0.838 | 100.950 | | 100.112 | |
| BM 99 | | | 0.704 | 100.246 | |
| WL | | | 2.495 | **98.455** | |
| BM 100 | | | 0.950 | 100.000 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 100 | | 100.000 | | |
| BM 99 | | 100.246 | | |
| BM 98 | | 100.112 | | |

| Summary | |
|---|---|
| Stage (m) | 98.456 |
| Mean Discharge ($m^3/s$) | 0.00420 |
| Pressure Transducer Reading (m) | 0.123 |
| Pressure Transducer Elevation (m) | 98.333 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 15:30 | End | 16:00 | Location | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.123 | Time | 15:30 | | | | |
| | End | Reading | | Time | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.60 | 0.00 | 0.08 | 0.003 | 0 | | | 0.0001 | 1.4 |
| CF= | 1.75 | 0.07 | 0.10 | 0.007 | 0.02 | | | 0.0001 | 3.6 |
| 1 | 1.80 | 0.08 | 0.05 | 0.004 | 0.02 | | | 0.0001 | 2.1 |
| | 1.85 | 0.08 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 3.1 |
| | 1.90 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 5.2 |
| | 1.95 | 0.10 | 0.05 | 0.005 | 0.05 | | | 0.0003 | 6.5 |
| | 2.00 | 0.11 | 0.05 | 0.005 | 0.05 | | | 0.0003 | 7.2 |
| | 2.05 | 0.12 | 0.05 | 0.006 | 0.05 | | | 0.0003 | 7.8 |
| | 2.10 | 0.11 | 0.05 | 0.006 | 0.05 | | | 0.0003 | 7.2 |
| | 2.15 | 0.11 | 0.05 | 0.006 | 0.06 | | | 0.0003 | 8.6 |
| | 2.20 | 0.10 | 0.05 | 0.005 | 0.05 | | | 0.0003 | 6.5 |
| | 2.25 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 5.2 |
| | 2.30 | 0.10 | 0.05 | 0.005 | 0.05 | | | 0.0003 | 6.5 |
| | 2.35 | 0.09 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 4.7 |
| | 2.40 | 0.08 | 0.05 | 0.004 | 0.04 | | | 0.0002 | 4.2 |
| | 2.45 | 0.08 | 0.05 | 0.004 | 0.04 | | | 0.0002 | 4.2 |
| | 2.50 | 0.08 | 0.05 | 0.004 | 0.04 | | | 0.0002 | 4.2 |
| | 2.55 | 0.08 | 0.05 | 0.004 | 0.04 | | | 0.0002 | 4.2 |
| | 2.60 | 0.07 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 2.7 |
| | 2.65 | 0.07 | 0.05 | 0.004 | 0.02 | | | 0.0001 | 1.8 |
| | 2.70 | 0.06 | 0.05 | 0.003 | 0.03 | | | 0.0001 | 2.3 |
| 1 | 2.75 | 0.06 | 0.05 | 0.003 | 0.01 | | | 0.0000 | 0.8 |
| CF= | 2.80 | 0.05 | 0.10 | 0.005 | 0 | | | 0.0000 | 0.0 |
| Left Bank | 2.95 | 0.00 | 0.08 | 0.002 | 0 | | | 0.0000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.00420** | 100.0 |

| General Notes |
|---|
| |

## Appendix 2-5a. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2011

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 16-Nov-11 | | | |
| Time at Site (24 hr) | Start Time: | 1:40:00 PM | End Time: | 3:30:00 PM |
| Personnel | Craig Hatt, Max Taylor | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| Weather Conditions | | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 27210 |
| Gain | 3.5311 | Offset | -0.0048 |
| Status | Active | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 100 | 1.048 | 101.048 | | 100.000 | |
| BM 99 | | | 0.803 | 100.245 | |
| BM 98 | | | 0.934 | 100.114 | |
| WL | | | 2.592 | **98.456** | |
| BM 98 | 0.955 | 101.069 | | 100.114 | |
| BM 99 | | | 0.824 | 100.245 | |
| WL | | | 2.614 | **98.455** | |
| BM 100 | | | 1.067 | 100.002 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 100 | | 100.001 | | |
| BM 99 | | 100.245 | | |
| BM 98 | | 100.114 | | |

| Summary | |
|---|---|
| Stage (m) | 98.456 |
| Mean Discharge ($m^3/s$) | 0.00260 |
| Pressure Transducer Reading (m) | 0.112 |
| Pressure Transducer Elevation (m) | 98.344 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:40 | End | 14:00 | Location | | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | 2000 | | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | | |
| Stage (m) | Start | Reading | 0.112 | Time | 13:40 | | | | | |
| | End | Reading | | Time | | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.60 | 0.00 | 0.05 | 0.002 | 0 | | | 0.0000 | 0.0 |
| CF= | 1.70 | 0.08 | 0.08 | 0.006 | 0 | | | 0.0000 | 0.0 |
| 1 | 1.75 | 0.08 | 0.05 | 0.004 | 0.02 | | | 0.0001 | 3.1 |
| | 1.80 | 0.08 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 4.6 |
| | 1.85 | 0.09 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 5.2 |
| | 1.90 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 7.7 |
| | 1.95 | 0.10 | 0.05 | 0.005 | 0.03 | | | 0.0002 | 5.8 |
| | 2.00 | 0.11 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 8.4 |
| | 2.05 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 7.7 |
| | 2.10 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 7.7 |
| | 2.15 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 7.7 |
| | 2.20 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 7.7 |
| | 2.25 | 0.10 | 0.05 | 0.005 | 0.04 | | | 0.0002 | 7.7 |
| | 2.30 | 0.08 | 0.05 | 0.004 | 0.02 | | | 0.0001 | 3.1 |
| | 2.35 | 0.08 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 4.6 |
| | 2.40 | 0.08 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 4.6 |
| | 2.45 | 0.07 | 0.05 | 0.004 | 0.03 | | | 0.0001 | 4.0 |
| | 2.50 | 0.07 | 0.05 | 0.003 | 0.02 | | | 0.0001 | 2.7 |
| | 2.55 | 0.06 | 0.05 | 0.003 | 0.01 | | | 0.0000 | 1.2 |
| | 2.60 | 0.06 | 0.05 | 0.003 | 0.03 | | | 0.0001 | 3.5 |
| | 2.65 | 0.06 | 0.05 | 0.003 | 0.02 | | | 0.0001 | 2.3 |
| 0.2 | 2.70 | 0.05 | 0.05 | 0.003 | 0.01 | | | 0.0000 | 1.0 |
| CF= | 2.75 | 0.05 | 0.08 | 0.004 | 0 | | | 0.0000 | 0.0 |
| Left Bank | 2.85 | 0.00 | 0.05 | 0.001 | 0 | | | 0.0000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.00260** | 100.0 |

| General Notes |
|---|
| |

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH 5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 25-Apr-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 14:30 | **End Time:** | |
| **Personnel** | Craig Hatt, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| **Weather Conditions** | Overcast, light rain | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 27210 |
| **Gain** | 3.5311 | **Offset** | -0.0048 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | \ | **Memory Free** | all |
| **Date Serviced** | 18-Apr-12 | **Crest Gauges** | no |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 100 | 1.232 | 101.232 | | 100.000 | |
| BM 99 | | | 0.973 | 100.259 | |
| BM 98 | | | 1.104 | 100.128 | |
| PT | | | 2.868 | 98.364 | |
| WL | | | 2.685 | **98.547** | |
| TBM | 0.887 | 101.237 | 0.882 | 100.350 | |
| WL | | | 2.689 | **98.548** | |
| PT | | | 2.873 | 98.364 | |
| BM 98 | | | 1.108 | 100.129 | |
| BM 99 | | | 0.977 | 100.260 | |
| BM 100 | | | 1.237 | 100.000 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 99 | 100.246 | 100.260 | 0.014 | Etablished May 12 2011 |
| BM 98 | 100.112 | 100.129 | 0.017 | Etablished May 12 2011 |
| PT | 98.364 | 98.364 | 0.000 | Installed on this date |

| Summary | |
|---|---|
| **Stage (m)** | 98.548 |
| **Discharge ($m^3/s$)** | 0.0520 |
| **Pressure Transducer Reading (m)** | 0.191 |
| **Pressure Transducer Elevation (m)** | 98.356 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | | **End** | | **Location** | At transducer | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | Flo-Mate | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | 2007612 | | |
| **Stage (m)** | **Start** | **Reading** | 0.191 | **Time** | 15:55 | | |
| | **End** | **Reading** | 0.191 | **Time** | 16:30 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| Right Bank | 1.70 | 0.00 | 0.00 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| | 1.80 | 0.21 | 0.10 | 0.02 | 0.07 | | | 0.001 | 2.8 |
| | 1.90 | 0.25 | 0.10 | 0.03 | 0.13 | | | 0.003 | 6.3 |
| | 2.00 | 0.23 | 0.10 | 0.02 | 0.18 | | | 0.003 | 6.0 |
| | 2.05 | 0.24 | 0.05 | 0.01 | 0.17 | | | 0.002 | 3.9 |
| | 2.10 | 0.25 | 0.05 | 0.01 | 0.18 | | | 0.002 | 4.3 |
| | 2.15 | 0.24 | 0.05 | 0.01 | 0.16 | | | 0.002 | 3.7 |
| | 2.20 | 0.23 | 0.05 | 0.01 | 0.18 | | | 0.002 | 4.0 |
| | 2.25 | 0.23 | 0.05 | 0.01 | 0.20 | | | 0.002 | 4.4 |
| | 2.30 | 0.24 | 0.05 | 0.01 | 0.19 | | | 0.002 | 4.4 |
| | 2.35 | 0.22 | 0.05 | 0.01 | 0.18 | | | 0.002 | 3.8 |
| | 2.40 | 0.23 | 0.05 | 0.01 | 0.18 | | | 0.002 | 4.0 |
| | 2.45 | 0.22 | 0.05 | 0.01 | 0.18 | | | 0.002 | 3.8 |
| | 2.50 | 0.21 | 0.05 | 0.01 | 0.18 | | | 0.002 | 3.6 |
| | 2.55 | 0.21 | 0.05 | 0.01 | 0.19 | | | 0.002 | 3.8 |
| | 2.60 | 0.22 | 0.05 | 0.01 | 0.19 | | | 0.002 | 4.0 |
| | 2.65 | 0.22 | 0.05 | 0.01 | 0.19 | | | 0.002 | 4.0 |
| | 2.70 | 0.21 | 0.05 | 0.01 | 0.21 | | | 0.002 | 4.2 |
| | 2.75 | 0.20 | 0.05 | 0.01 | 0.19 | | | 0.002 | 3.7 |
| | 2.80 | 0.2 | 0.05 | 0.01 | 0.20 | | | 0.002 | 3.8 |
| | 2.85 | 0.19 | 0.05 | 0.01 | 0.19 | | | 0.002 | 3.5 |
| | 2.90 | 0.19 | 0.05 | 0.01 | 0.19 | | | 0.003 | 5.2 |
| | 3.00 | 0.17 | 0.10 | 0.02 | 0.17 | | | 0.003 | 5.6 |
| | 3.10 | 0.14 | 0.10 | 0.01 | 0.17 | | | 0.002 | 4.6 |
| | 3.20 | 0.11 | 0.10 | 0.01 | 0.12 | | | 0.001 | 2.5 |
| Left Bank | 3.30 | 0.00 | 0.10 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0520** | **100.0** |

**General Notes**

Activated logger at 15:32 PDT. Stable water level during flow measurement. Moved PT around @ 15:45

Station at same location as 2011.

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH 5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 29-Apr-12 | (Survey Only) | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:30 | **End Time:** | 12:15:00 PM |
| **Personnel** | Craig Hatt, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0620292 | 6103209 | 1087+-9 | |
| **Weather Conditions** | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 2721021 |
| **Gain** | 3.523 | **Offset** | -0.0076 |
| **Status** | Active | **Battery** | 100% |
| **# of Records** | \ | **Memory Free** | all |
| **Date Serviced** | 18-Apr-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 100 | 1.275 | 101.275 | | 100.000 | |
| BM 99 | | | 1.018 | 100.257 | |
| BM 98 | | | 1.149 | 100.126 | |
| PT | | | 2.928 | 98.347 | |
| WL | | | 2.742 | 98.533 | |
| TBM | 0.925 | 101.277 | 0.923 | 100.352 | |
| WL | | | 2.746 | **98.531** | |
| PT | | | 2.931 | **98.346** | |
| BM 98 | | | 1.152 | **100.125** | |
| BM 99 | | | 1.019 | **100.258** | |
| BM 100 | | | 1.277 | **100.000** | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 99 | 100.246 | 100.258 | 0.011 | Etablished May 12 2011 |
| BM 98 | 100.112 | 100.126 | 0.014 | Etablished May 12 2011 |
| PT | 98.347 | 98.347 | | Moved on this Date |

| Summary | |
|---|---|
| **Stage (m)** | 98.532 |
| **Discharge ($m^3/s$)** | Not measured on this date |
| **Pressure Transducer Reading (m)** | 0.215 |
| **Pressure Transducer Elevation (m)** | 98.317 |

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH 5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 18-May-12 | | | |
| Time at Site (24 hr) | Start Time: | 12:00:00 PM | End Time: | |
| Personnel | Craig Hatt, David Moellenbeck | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 620303 | 6103216 | 1099+-8 | |
| Weather Conditions | Cloudy, light snow, 4C | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS9800 | Serial # | 27210 |
| Gain | 3.5311 | Offset | -0.0076 |
| Status | ok | Battery | 100% |
| # of Records | 2751 | Memory Free | all |
| Date Serviced | 18-May-12 | Crest Gauges | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 100 | 1.137 | 101.137 | | 100.000 | |
| BM 99 | | | 0.886 | 100.251 | |
| BM 98 | | | 1.017 | 100.120 | |
| PT | | | 2.797 | 98.340 | |
| WL | | | 2.561 | **98.576** | |
| TBM | 0.752 | 101.098 | 0.791 | 100.346 | |
| WL | | | 2.521 | **98.577** | |
| PT | | | 2.757 | 98.341 | |
| BM 98 | | | 0.978 | 100.120 | |
| BM 99 | | | 0.847 | 100.251 | |
| BM 100 | | | 1.099 | 99.999 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 99 | 100.246 | 100.251 | 0.005 | Etablished May 12 2011 |
| BM 98 | 100.112 | 100.120 | 0.008 | Etablished May 12 2011 |
| PT | 98.347 | 98.341 | -0.007 | New elevation on April 29 |

| Summary | |
|---|---|
| Stage (m) | 98.577 |
| Discharge ($m^3/s$) | 0.0626 |
| Pressure Transducer Reading (m) | 0.253 |
| Pressure Transducer Elevation (m) | 98.324 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | | End | | Location | 0.5m downstream of transducer | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | Flo-Mate | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | 121181001061 | | | |
| Stage (m) | Start | Reading | 0.249 | Time | 12:19 | | | | |
| | End | Reading | 0.251 | Time | 13:55 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 2.40 | 0.00 | 0.00 | 0.00 | 0.000 | | | 0.000 | 0.0 |
| | 2.45 | 0.08 | 0.05 | 0.01 | 0.079 | | | 0.001 | 1.0 |
| | 2.60 | 0.10 | 0.15 | 0.02 | 0.142 | | | 0.002 | 3.4 |
| | 2.75 | 0.22 | 0.15 | 0.03 | 0.169 | | | 0.005 | 7.4 |
| | 2.85 | 0.24 | 0.10 | 0.02 | 0.222 | | | 0.005 | 8.5 |
| | 2.95 | 0.23 | 0.10 | 0.02 | 0.224 | | | 0.004 | 6.2 |
| | 3.00 | 0.23 | 0.05 | 0.01 | 0.214 | | | 0.002 | 3.9 |
| | 3.05 | 0.23 | 0.05 | 0.01 | 0.223 | | | 0.003 | 4.1 |
| | 3.10 | 0.23 | 0.05 | 0.01 | 0.233 | | | 0.003 | 4.3 |
| | 3.15 | 0.23 | 0.05 | 0.01 | 0.240 | | | 0.003 | 4.4 |
| | 3.20 | 0.23 | 0.05 | 0.01 | 0.246 | | | 0.003 | 4.5 |
| | 3.25 | 0.22 | 0.05 | 0.01 | 0.239 | | | 0.003 | 4.2 |
| | 3.30 | 0.22 | 0.05 | 0.01 | 0.236 | | | 0.003 | 4.1 |
| | 3.35 | 0.22 | 0.05 | 0.01 | 0.235 | | | 0.003 | 4.1 |
| | 3.40 | 0.22 | 0.05 | 0.01 | 0.201 | | | 0.002 | 3.5 |
| | 3.45 | 0.23 | 0.05 | 0.02 | 0.226 | | | 0.004 | 6.2 |
| | 3.55 | 0.22 | 0.10 | 0.02 | 0.201 | | | 0.004 | 7.1 |
| | 3.65 | 0.23 | 0.10 | 0.02 | 0.207 | | | 0.005 | 7.6 |
| | 3.75 | 0.22 | 0.10 | 0.02 | 0.223 | | | 0.005 | 7.8 |
| | 3.85 | 0.21 | 0.10 | 0.02 | 0.111 | | | 0.002 | 3.7 |
| | 3.95 | 0.22 | 0.10 | 0.03 | 0.009 | | | 0.000 | 0.4 |
| | 4.10 | 0.21 | 0.15 | 0.03 | 0.047 | | | 0.001 | 2.0 |
| | 4.20 | 0.16 | 0.10 | 0.02 | 0.058 | | | 0.001 | 1.5 |
| LB | 4.30 | 0.00 | 0.10 | 0.01 | 0.000 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | **0.0626** | **100.0** |

| General Notes |
|---|
| Distance from top of pipe to centre of PT=25mm. Used BM 98 as reference benchmark in survey and have corrected values in spreadsheet |

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 26-Jun-12 | | | |
| Time at Site (24 hr) | Start Time: | 3:05:00 PM | End Time: | |
| Personnel | Craig Hatt, Calvin Pin | | | |
| Station Coordinates | Easting | Northing | Elevation | |
| | | | | |
| Weather Conditions | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | | Serial # | |
| Gain | | Offset | |
| Status | | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM100 | 0.963 | 100.963 | | 100.000 | |
| BM99 | | | 0.714 | 100.249 | |
| BM98 | | | 0.850 | 100.113 | |
| WL | | | 2.458 | **98.505** | Time: 15:05 |
| PT | | | 2.620 | 98.343 | **Top Pipe** |
| TBM1 | 0.653 | 100.994 | 0.622 | 100.341 | |
| WL | | | 2.488 | **98.506** | |
| PT | | | 2.651 | 98.343 | **Top Pipe** |
| BM98 | | | 0.883 | 100.111 | |
| BM99 | | | 0.746 | 100.248 | |
| BM100 | | | 0.994 | 100.000 | |

| BM# | Established Elevation (m) | | Difference (m) | Notes |
|---|---|---|---|---|
| BM99 | 100.246 | 100.249 | 0.003 | Etablished May 12 2011 |
| BM98 | 100.112 | 100.112 | 0.000 | Etablished May 12 2011 |
| PT | 98.347 | 98.343 | -0.004 | April 29 2012 elevation |

| Summary | |
|---|---|
| Stage (m) | 98.506 |
| Discharge ($m^3/s$) | 0.0279 |
| Pressure Transducer Reading (m) | 0.177 |
| Pressure Transducer Elevation (m) | 98.329 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | | End | | Location | MH-5 on Mast Creek | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | | | | | |
| Flow Meter Type | FH950 | | | Instrument Serial # | | | | | | |
| Stage (m) | Start | Reading | 0.177 | Time | 14:15 | | | | | |
| | End | Reading | 0.177 | Time | 14:44 | | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 0.15 | 0.00 | 0.00 | 0.04 | 0 | | | 0.000 | 0.0 |
| | 1.30 | 0.07 | 1.15 | 0.05 | 0.065 | | | 0.003 | 10.6 |
| | 1.45 | 0.06 | 0.15 | 0.01 | 0.139 | | | 0.001 | 3.7 |
| | 1.55 | 0.16 | 0.10 | 0.01 | 0.159 | | | 0.002 | 6.8 |
| | 1.60 | 0.17 | 0.05 | 0.01 | 0.172 | | | 0.001 | 5.2 |
| | 1.65 | 0.17 | 0.05 | 0.01 | 0.16 | | | 0.001 | 4.9 |
| | 1.70 | 0.16 | 0.05 | 0.01 | 0.147 | | | 0.001 | 4.2 |
| | 1.75 | 0.17 | 0.05 | 0.01 | 0.129 | | | 0.001 | 3.9 |
| | 1.80 | 0.17 | 0.05 | 0.01 | 0.142 | | | 0.001 | 4.3 |
| | 1.85 | 0.17 | 0.05 | 0.01 | 0.13 | | | 0.001 | 4.0 |
| | 1.90 | 0.17 | 0.05 | 0.01 | 0.145 | | | 0.001 | 4.4 |
| | 1.95 | 0.16 | 0.05 | 0.01 | 0.138 | | | 0.001 | 4.0 |
| | 2.00 | 0.16 | 0.05 | 0.01 | 0.137 | | | 0.001 | 3.9 |
| | 2.05 | 0.16 | 0.05 | 0.01 | 0.132 | | | 0.002 | 5.7 |
| | 2.15 | 0.15 | 0.10 | 0.02 | 0.141 | | | 0.002 | 7.6 |
| | 2.25 | 0.15 | 0.10 | 0.02 | 0.123 | | | 0.002 | 6.6 |
| | 2.35 | 0.15 | 0.10 | 0.02 | 0.116 | | | 0.002 | 6.2 |
| | 2.45 | 0.15 | 0.10 | 0.02 | 0.139 | | | 0.002 | 7.5 |
| | 2.55 | 0.14 | 0.10 | 0.01 | 0.119 | | | 0.002 | 6.0 |
| | 2.65 | 0.13 | 0.10 | 0.01 | 0.005 | | | 0.000 | 0.2 |
| | 2.75 | 0.10 | 0.10 | 0.01 | 0.001 | | | 0.000 | 0.0 |
| | 2.90 | 0.07 | 0.15 | 0.01 | 0 | | | 0.000 | 0.0 |
| LB | 3.00 | 0.00 | 0.10 | 0.00 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0279** | **100.0** |

**General Notes**

Manual measurement from top of pipe to water surface = 0.164m @ 14:44. Data recorded at 14:50 = 0.182m. Moderate flow rate observed.

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-5 | | | |
| Stream Name | Mast Creek | | | |
| Date Monitored | 14-Aug-12 | | | |
| Time at Site (24 hr) | Start Time: | 14:10 | End Time: | |
| Personnel | | | | |
| Station Coordinates | Easting | Northing | Elevation | |
| | 620303 | 6103215 | 1088 | |
| Weather Conditions | Slight overcast but clearing | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | | Serial # | |
| Gain | | Offset | |
| Status | | Battery | |
| # of Records | | Memory Free | |
| Date Serviced | | Crest Gauges | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 100 | 0.864 | 100.864 | | 100.000 | |
| BM 99 | | | 0.618 | 100.246 | |
| BM 98 | | | 0.752 | 100.112 | |
| PT | | | 2.522 | 98.342 | Top of Pipe |
| WL | | | 2.416 | **98.448** | Time: 15:22 |
| BM 98 | 0.805 | 100.917 | | 100.112 | |
| PT | | | 2.573 | 98.344 | **Top of Pipe** |
| WL | | | 2.469 | **98.448** | |
| BM 99 | | | 0.67 | 100.247 | |
| BM 100 | | | 0.916 | **100.001** | |
| | | | | | |

| BM# | Established Elevation (m) | | Difference (m) | Notes |
|---|---|---|---|---|
| BM 99 | 100.246 | 100.247 | 0.001 | Etablished May 12 2011 |
| BM 98 | 100.112 | 100.112 | 0.000 | Etablished May 12 2011 |
| PT | 98.347 | 98.343 | -0.004 | April 29 2012 elevation |

| Summary | |
|---|---|
| Stage (m) | 98.448 |
| Discharge ($m^3/s$) | 0.0094 |
| Pressure Transducer Reading (m) | 0.118 |
| Pressure Transducer Elevation (m) | 98.330 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | | End | | Location | MH-5 on Mast Creek | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | FH950 | | | |
| Flow Meter Type | | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.118 | Time | 14:20 | | | | |
| | End | Reading | 0.118 | Time | 15:03 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 1.45 | 0.00 | 0.0 | 0.00 | 0.000 | | | 0.0000 | 0.0 |
| | 1.55 | 0.08 | 0.10 | 0.006 | 0.051 | | | 0.0003 | 3.3 |
| | 1.60 | 0.10 | 0.05 | 0.005 | 0.076 | | | 0.0004 | 4.1 |
| | 1.65 | 0.10 | 0.05 | 0.005 | 0.093 | | | 0.0005 | 5.0 |
| | 1.70 | 0.10 | 0.05 | 0.005 | 0.105 | | | 0.0005 | 5.6 |
| | 1.75 | 0.10 | 0.05 | 0.005 | 0.112 | | | 0.0006 | 6.0 |
| | 1.80 | 0.10 | 0.05 | 0.005 | 0.120 | | | 0.0006 | 6.4 |
| | 1.85 | 0.10 | 0.05 | 0.005 | 0.126 | | | 0.0006 | 6.7 |
| | 1.90 | 0.10 | 0.05 | 0.005 | 0.132 | | | 0.0007 | 7.0 |
| | 1.95 | 0.10 | 0.05 | 0.005 | 0.138 | | | 0.0007 | 7.4 |
| | 2.00 | 0.09 | 0.05 | 0.004 | 0.147 | | | 0.0007 | 7.1 |
| | 2.05 | 0.09 | 0.05 | 0.005 | 0.137 | | | 0.0006 | 6.6 |
| | 2.10 | 0.09 | 0.05 | 0.005 | 0.138 | | | 0.0006 | 6.6 |
| | 2.15 | 0.09 | 0.05 | 0.005 | 0.129 | | | 0.0006 | 6.2 |
| | 2.20 | 0.09 | 0.05 | 0.005 | 0.107 | | | 0.0005 | 5.1 |
| | 2.25 | 0.09 | 0.05 | 0.004 | 0.089 | | | 0.0004 | 4.3 |
| | 2.30 | 0.08 | 0.05 | 0.004 | 0.044 | | | 0.0002 | 1.9 |
| | 2.35 | 0.08 | 0.05 | 0.004 | 0.060 | | | 0.0002 | 2.6 |
| | 2.40 | 0.08 | 0.05 | 0.004 | 0.071 | | | 0.0003 | 3.0 |
| | 2.45 | 0.08 | 0.05 | 0.004 | 0.040 | | | 0.0002 | 1.7 |
| | 2.50 | 0.09 | 0.05 | 0.004 | 0.015 | | | 0.0001 | 0.7 |
| | 2.55 | 0.09 | 0.05 | 0.007 | 0.018 | | | 0.0001 | 1.3 |
| | 2.65 | 0.08 | 0.10 | 0.010 | 0.014 | | | 0.0001 | 1.5 |
| LB | 2.80 | 0.00 | 0.15 | 0.006 | 0.000 | | | 0.0000 | 0.0 |
| **Total Q** | | | | | | | | **0.0094** | **100.0** |

| General Notes |
|---|
| Measure Q 1m downstream of PT. At same location as previous measurements. |

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH 5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 28-Sep-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:40:00 AM | **End Time:** | 12:55:00 PM |
| **Personnel** | Eli Heyman, Cenling Xia | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 620303 | 6103216 | 1087 | |
| **Weather Conditions** | Cloudy | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 27210 |
| **Gain** | 3.5311 | **Offset** | -0.0076 |
| **Status** | ok | **Battery** | 100% |
| **# of Records** | 21879 | **Memory Free** | 21570 |
| **Date Serviced** | 28-Sep-12 | **Crest Gauges** | no |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 100 | 0.985 | 100.985 | | 100.000 | |
| BM 99 | | | 0.738 | 100.247 | |
| BM 98 | | | 0.874 | 100.111 | |
| PT | | | 2.646 | 98.339 | |
| WL | | | 2.542 | 98.443 | |
| TBM | 2.612 | 101.053 | 2.544 | 98.441 | |
| WL | | | 2.613 | **98.440** | |
| PT | | | 2.716 | **98.337** | |
| BM 98 | | | 0.943 | **100.110** | |
| BM 99 | | | 0.807 | **100.246** | |
| BM 100 | | | 1.054 | **99.999** | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 99 | 100.246 | 100.247 | 0.001 | Etablished May 12 2011 |
| BM 98 | 100.112 | 100.111 | -0.001 | Etablished May 12 2011 |
| PT | 98.347 | 98.338 | -0.009 | April 29 2012 elevation |

| Summary | |
|---|---|
| **Stage (m)** | 98.442 |
| **Discharge ($m^3/s$)** | 0.00254 |
| **Pressure Transducer Reading (m)** | 0.116 |
| **Pressure Transducer Elevation (m)** | 98.326 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 10:44 | **End** | 11:20 | **Location** | In line with PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | Flo-Mate 2000 | | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.112 | **Time** | 10:44 | | | | |
| | **End** | **Reading** | 0.115 | **Time** | 11:20 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| LB | 0.40 | 0.00 | 0.00 | 0.001 | 0.00 | | | 0.0000 | 0.0 |
| | 0.45 | 0.03 | 0.05 | 0.002 | -0.02 | | | 0.0000 | -1.8 |
| | 0.55 | 0.05 | 0.10 | 0.004 | 0.00 | | | 0.0000 | 0.0 |
| | 0.60 | 0.06 | 0.05 | 0.003 | 0.01 | | | 0.0000 | 1.2 |
| | 0.65 | 0.06 | 0.05 | 0.003 | 0.01 | | | 0.0000 | 1.3 |
| | 0.71 | 0.06 | 0.06 | 0.004 | 0.02 | | | 0.0001 | 2.8 |
| | 0.77 | 0.06 | 0.06 | 0.004 | 0.03 | | | 0.0001 | 4.2 |
| | 0.83 | 0.06 | 0.06 | 0.004 | 0.03 | | | 0.0001 | 4.2 |
| | 0.89 | 0.06 | 0.06 | 0.004 | 0.03 | | | 0.0001 | 4.2 |
| | 0.95 | 0.06 | 0.06 | 0.004 | 0.04 | | | 0.0001 | 5.7 |
| | 1.01 | 0.07 | 0.06 | 0.004 | 0.05 | | | 0.0002 | 8.3 |
| | 1.07 | 0.08 | 0.06 | 0.005 | 0.06 | | | 0.0003 | 11.3 |
| | 1.13 | 0.08 | 0.06 | 0.005 | 0.05 | | | 0.0002 | 9.4 |
| | 1.19 | 0.09 | 0.06 | 0.005 | 0.05 | | | 0.0003 | 10.6 |
| | 1.25 | 0.09 | 0.06 | 0.005 | 0.04 | | | 0.0002 | 8.5 |
| | 1.31 | 0.10 | 0.06 | 0.006 | 0.04 | | | 0.0002 | 9.4 |
| | 1.37 | 0.10 | 0.06 | 0.006 | 0.04 | | | 0.0002 | 9.4 |
| | 1.43 | 0.10 | 0.06 | 0.006 | 0.03 | | | 0.0002 | 7.1 |
| | 1.49 | 0.10 | 0.06 | 0.005 | 0.02 | | | 0.0001 | 4.3 |
| | 1.54 | 0.10 | 0.05 | 0.005 | 0.01 | | | 0.0000 | 2.0 |
| | 1.59 | 0.12 | 0.05 | 0.006 | -0.01 | | | -0.0001 | -2.4 |
| RB | 1.64 | 0.00 | 0.05 | 0.003 | 0.00 | | | 0.0000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.00254** | **100.0** |

**General Notes**

## Appendix 2-5b. Manual Discharge Measurements and Levelling Surveys at MH-5 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-5 | | | |
| **Stream Name** | Mast Creek | | | |
| **Date Monitored** | 8-Nov-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 11:18:00 AM | **End Time:** | 1:00:00 PM |
| **Personnel** | Eli Heyman, Arnold | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 620303 | 6103216 | 1087 | |
| **Weather Conditions** | Cloudy | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 27210 |
| **Gain** | 3.5311 | **Offset** | -0.0076 |
| **Status** | ok | **Battery** | 100% |
| **# of Records** | 27787 | **Memory Free** | 18618 |
| **Date Serviced** | 8-Nov-12 | **Crest Gauges** | no |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 100 | 1.023 | 101.023 | | 100.000 | |
| BM 99 | | | 0.776 | 100.247 | |
| BM 98 | | | 0.910 | 100.113 | |
| PT | | | 2.678 | 98.345 | |
| WL | | | 2.549 | 98.474 | |
| TBM | 2.503 | 100.944 | 2.582 | 98.441 | |
| WL | | | 2.473 | **98.471** | |
| PT | | | 2.601 | **98.343** | |
| BM 98 | | | 0.833 | **100.111** | |
| BM 99 | | | 0.699 | **100.245** | |
| BM 100 | | | 0.945 | **99.999** | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 99 | 100.246 | 100.246 | 0.000 | Etablished May 12 2011 |
| BM 98 | 100.112 | 100.112 | 0.000 | Etablished May 12 2011 |
| PT | 98.347 | 98.344 | -0.003 | April 29 2012 elevation |

| Summary | |
|---|---|
| **Stage (m)** | 98.473 |
| **Discharge ($m^3/s$)** | 0.00729 |
| **Pressure Transducer Reading (m)** | 0.134 |
| **Pressure Transducer Elevation (m)** | 98.339 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 11:21 | **End** | 11:50 | **Location** | In line with PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | Flo-Mate 2000 | | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | 2006775 | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.128 | **Time** | 11:21 | | | | |
| | **End** | **Reading** | 0.131 | **Time** | 11:50 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| LB | 0.30 | 0.00 | 0.00 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| | 0.35 | 0.08 | 0.05 | 0.004 | 0.00 | | | 0.000 | 0.0 |
| | 0.40 | 0.08 | 0.05 | 0.005 | 0.02 | | | 0.000 | 1.3 |
| | 0.47 | 0.08 | 0.07 | 0.006 | 0.05 | | | 0.000 | 3.8 |
| | 0.54 | 0.10 | 0.07 | 0.007 | 0.04 | | | 0.000 | 3.8 |
| | 0.61 | 0.11 | 0.07 | 0.008 | 0.05 | | | 0.000 | 5.3 |
| | 0.68 | 0.12 | 0.07 | 0.008 | 0.06 | | | 0.001 | 6.9 |
| | 0.75 | 0.11 | 0.07 | 0.008 | 0.08 | | | 0.001 | 8.4 |
| | 0.82 | 0.11 | 0.07 | 0.008 | 0.09 | | | 0.001 | 9.5 |
| | 0.89 | 0.12 | 0.07 | 0.008 | 0.07 | | | 0.001 | 8.1 |
| | 0.96 | 0.12 | 0.07 | 0.008 | 0.07 | | | 0.001 | 8.1 |
| | 1.03 | 0.12 | 0.07 | 0.008 | 0.06 | | | 0.001 | 6.9 |
| | 1.10 | 0.12 | 0.07 | 0.008 | 0.06 | | | 0.001 | 6.9 |
| | 1.17 | 0.12 | 0.07 | 0.008 | 0.05 | | | 0.000 | 5.8 |
| | 1.24 | 0.13 | 0.07 | 0.009 | 0.05 | | | 0.000 | 6.2 |
| | 1.31 | 0.14 | 0.07 | 0.010 | 0.05 | | | 0.000 | 6.7 |
| | 1.38 | 0.14 | 0.07 | 0.010 | 0.05 | | | 0.000 | 6.7 |
| | 1.45 | 0.14 | 0.07 | 0.008 | 0.06 | | | 0.001 | 6.9 |
| | 1.50 | 0.06 | 0.05 | 0.004 | 0.04 | | | 0.000 | 2.0 |
| | 1.57 | 0.04 | 0.07 | 0.003 | -0.02 | | | 0.000 | -0.8 |
| | 1.64 | 0.06 | 0.07 | 0.005 | -0.01 | | | 0.000 | -0.7 |
| | 1.73 | 0.06 | 0.09 | 0.005 | -0.03 | | | 0.000 | -2.0 |
| RB | 1.80 | 0.00 | 0.07 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.00729** | **100.0** |

| General Notes |
|---|

## Appendix 2-6a. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-6 | | | |
| **Stream Name** | Mile 17 Creek | | | |
| **Date Monitored** | 27-Sep-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 11:56 | **End Time:** | 4:00:00 PM |
| **Personnel** | Eli Heyman, Cenling Xia | | | |
| **Station Cordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0627134 | 6098319 | 764 | |
| **Weather Conditions** | Mix of Sun and cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 21235029 |
| **Gain** | | **Offset** | |
| **Status** | Active | **Battery** | |
| **# of Records** | 1 | **Memory Free** | 523,882 |
| **Date Serviced** | | **Crest Gauges** | N/A |

| Hydrometric Leveling Survey (Before moving PT) | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM1 | 0.769 | 100.769 | | 100.000 | |
| BM2 | | | 1.686 | 99.083 | |
| BM3 | | | | | Established during 2nd half |
| PT | | | 4.467 | 96.302 | |
| WL | | | 4.389 | **96.380** | |
| TBM1 | 4.093 | 100.674 | 4.188 | 96.581 | |
| WL | | | 4.292 | **96.382** | |
| PT | | | 4.372 | 96.302 | |
| BM3 | | | 2.982 | 97.692 | |
| BM2 | | | 1.588 | 99.086 | |
| BM1 | | | 0.674 | 100.000 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM2 | 99.085 | 99.085 | | Established on this date |
| BM3 | 97.692 | 97.692 | | Established on this date |
| PT | 96.302 | 96.302 | | Established on this date |

| Summary | |
|---|---|
| **Stage (m)** | 96.381 |
| **Discharge ($m^3/s$)** | 0.00161 |
| **Pressure Transducer Reading (m)** | 0.082 |
| **Pressure Transducer Elevation (m)** | 96.299 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 12:00 | **End** | 12:30 | **Location** | 2m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | Flo-Mate 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.119 | | **Time** | 12:00 | 0.01 m/s was subtracted from noted measurements | | |
| | **End** | **Reading** | 0.122 | | **Time** | 12:30 | due to zeroing problem | | |

| | **Station** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **($m^3/s$)** | **%** |
| RB | 0.40 | 0.00 | 0.00 | 0.000 | 0.00 | | | 0.000 | 0.0 |
| | 0.44 | 0.02 | 0.04 | 0.001 | 0.07 | | | 0.000 | 4.4 |
| | 0.50 | 0.02 | 0.06 | 0.001 | 0.00 | | | 0.000 | 0.0 |
| | 0.55 | 0.02 | 0.05 | 0.001 | 0.01 | | | 0.000 | 0.6 |
| | 0.60 | 0.04 | 0.05 | 0.002 | 0.11 | | | 0.000 | 13.7 |
| | 0.65 | 0.05 | 0.05 | 0.003 | 0.10 | | | 0.000 | 15.6 |
| | 0.70 | 0.05 | 0.05 | 0.003 | 0.11 | | | 0.000 | 17.1 |
| | 0.75 | 0.04 | 0.05 | 0.002 | 0.14 | | | 0.000 | 17.4 |
| | 0.80 | 0.04 | 0.05 | 0.002 | 0.14 | | | 0.000 | 17.4 |
| | 0.85 | 0.04 | 0.05 | 0.002 | -0.01 | | | 0.000 | -1.2 |
| | 0.90 | 0.04 | 0.05 | 0.002 | 0.09 | | | 0.000 | 11.2 |
| | 0.95 | 0.03 | 0.05 | 0.002 | 0.04 | | | 0.000 | 3.7 |
| LB | 1.00 | 0.00 | 0.05 | 0.001 | 0.00 | | | 0.000 | 0.0 |
| | | | | | | | | | |
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| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.00161** | **100.0** |

**General Notes**

Narrow channel section made it dificult to achieve 20+ verticals. Very low flow on this date. PT rerading dropped by 0.04m by 15:30. Likely due to air bubble in PT escaping after install.

## Appendix 2-6a. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-6 | | | |
| **Stream Name** | Mile 17 Creek | | | |
| **Date Monitored** | 6-Nov-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 11:00:00 AM | **End Time:** | 4:00:00 PM |
| **Personnel** | Eli Heyman, Arnold | | | |
| **Station Cordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0627134 | 6098319 | 764 | |
| **Weather Conditions** | Cloudy, -2C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 21235029 |
| **Gain** | | **Offset** | |
| **Status** | Active | **Battery** | 12.1V |
| **# of Records** | 5755 | **Memory Free** | 518,128 |
| **Date Serviced** | 6-Nov-12 | **Crest Gauges** | N/A |

**Hydrometric Leveling Survey (Before moving PT)**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM1 | 0.517 | 100.517 | | 100.000 | |
| BM2 | | | 1.431 | 99.086 | |
| BM3 | | | 2.823 | 97.694 | |
| PT | | | | | ice-covered |
| WL | | | 4.064 | **96.453** | use avg. |
| TBM1 | 1.253 | 100.498 | 1.272 | 99.245 | |
| WL | | | 4.049 | **96.449** | use avg. |
| PT | | | 4.197 | 96.301 | |
| BM3 | | | 2.805 | 97.693 | |
| BM2 | | | 1.412 | 99.086 | |
| BM1 | | | 0.499 | 99.999 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM2 | 99.085 | 99.086 | 0.001 | |
| BM3 | 97.692 | 97.694 | 0.001 | |
| PT | 96.302 | 96.301 | -0.001 | |

| Summary | |
|---|---|
| **Stage (m)** | 96.451 |
| **Discharge ($m^3/s$)** | 0.0275 |
| **Pressure Transducer Reading (m)** | 0.173 |
| **Pressure Transducer Elevation (m)** | 96.278 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 11:07 | **End** | 11:48 | **Location** | 20m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | Flo-Mate 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.173 | | **Time** | 11:07 | | | |
| | **End** | **Reading** | 0.173 | | **Time** | 11:48 | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 0.30 | 0.00 | 0.00 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| behind rock | 0.35 | 0.08 | 0.05 | 0.004 | -0.06 | | | 0.000 | -0.9 |
| behind rock | 0.40 | 0.09 | 0.05 | 0.005 | -0.07 | | | 0.000 | -1.1 |
| | 0.45 | 0.12 | 0.05 | 0.006 | 0.00 | | | 0.000 | 0.0 |
| | 0.50 | 0.08 | 0.05 | 0.004 | 0.05 | | | 0.000 | 0.7 |
| | 0.55 | 0.08 | 0.05 | 0.004 | 0.17 | | | 0.001 | 2.5 |
| | 0.60 | 0.08 | 0.05 | 0.004 | 0.22 | | | 0.001 | 3.2 |
| | 0.65 | 0.15 | 0.05 | 0.008 | 0.14 | | | 0.001 | 3.8 |
| | 0.70 | 0.14 | 0.05 | 0.007 | 0.20 | | | 0.001 | 5.1 |
| | 0.75 | 0.11 | 0.05 | 0.006 | 0.28 | | | 0.002 | 5.6 |
| | 0.80 | 0.12 | 0.05 | 0.006 | 0.38 | | | 0.002 | 8.3 |
| | 0.85 | 0.14 | 0.05 | 0.007 | 0.33 | | | 0.002 | 8.4 |
| | 0.90 | 0.14 | 0.05 | 0.007 | 0.34 | | | 0.002 | 8.7 |
| | 0.95 | 0.13 | 0.05 | 0.005 | 0.53 | | | 0.002 | 8.8 |
| | 0.97 | 0.15 | 0.02 | 0.004 | 0.55 | | | 0.002 | 7.5 |
| | 1.00 | 0.12 | 0.03 | 0.004 | 0.56 | | | 0.002 | 7.3 |
| | 1.03 | 0.11 | 0.03 | 0.003 | 0.50 | | | 0.001 | 5.0 |
| | 1.05 | 0.12 | 0.02 | 0.002 | 0.53 | | | 0.001 | 4.6 |
| | 1.07 | 0.14 | 0.02 | 0.004 | 0.52 | | | 0.002 | 6.6 |
| | 1.10 | 0.11 | 0.03 | 0.004 | 0.43 | | | 0.002 | 6.9 |
| | 1.15 | 0.12 | 0.05 | 0.006 | 0.34 | | | 0.002 | 7.4 |
| | 1.20 | 0.12 | 0.05 | 0.006 | 0.16 | | | 0.001 | 3.5 |
| | 1.25 | 0.15 | 0.05 | 0.008 | 0.08 | | | 0.001 | 2.2 |
| | 1.30 | 0.14 | 0.05 | 0.007 | 0.03 | | | 0.000 | 0.8 |
| eddy | 1.35 | 0.10 | 0.05 | 0.008 | -0.05 | | | 0.000 | -1.4 |
| eddy | 1.45 | 0.08 | 0.10 | 0.008 | -0.05 | | | 0.000 | -1.5 |
| eddy | 1.55 | 0.08 | 0.10 | 0.006 | -0.09 | | | -0.001 | -2.0 |
| LB | 1.60 | 0.00 | 0.05 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0275** | **100.0** |

**General Notes: None**

## Appendix 2-6b. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-6 | | | |
| Stream Name | Mile 17 Creek | | | |
| Date Monitored | 30-Apr-13 | | | |
| Time at Site (24 hr) | Start Time: | 9:30 | End Time: | 4:00:00 PM |
| Personnel | Eli Heyman, Natasha C. | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0627134 | 6098319 | 764 | |
| Weather Conditions | Mix of Sun and cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS98i | Serial # | 21235029 |
| Gain | 0.00022 | Offset | -0.854 |
| Status | Active | Battery | 11.74V |
| # of Records | 1 | Memory Free | 523,882 |
| Date Serviced | | Crest Gauges | N/A |

| Hydrometric Leveling Survey (Before moving PT) | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM1 | 0.702 | 100.702 | | 100.000 | |
| BM2 | | | 1.616 | 99.086 | |
| BM3 | | | 3.007 | 97.695 | |
| SG | | | 3.354 | 97.348 | |
| PT | | | 4.340 | 96.362 | |
| WL | | | 4.225 | **96.477** | (+.045) +/- 0.005 |
| TBM1 | 2.261 | 100.820 | 2.143 | 98.559 | |
| WL | | | 4.339 | **96.481** | (+.045) +/- 0.005 |
| PT | | | 4.456 | 96.364 | |
| SG | | | 3.469 | 97.351 | |
| BM3 | | | 3.125 | 97.695 | |
| BM2 | | | 1.734 | 99.086 | |
| BM1 | | | 0.819 | 100.001 | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM2 | 99.086 | 99.086 | 0.000 | |
| BM3 | 97.692 | 97.695 | -0.003 | |
| PT | 96.363 | 96.363 | 0.000 | |

| Summary | |
|---|---|
| Stage (m) | 96.524 |
| Discharge ($m^3/s$) | 0.288 |
| Pressure Transducer Reading (m) | 0.219 |
| Pressure Transducer Elevation (m) | 96.305 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 15:10 | End | 15:40 | Location | 6m DS of PT | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | Flo-Mate 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.223 | SG | 0.268 | Time | 15:10 | Gauge correction: | |
| | End | Reading | 0.223 | SG | 0.268 | Time | 15:40 | 96.256 | 97.350 |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 4.30 | 0.11 | 0.00 | 0.009 | 0.03 | | | 0.000 | 0.1 |
| | 4.15 | 0.12 | 0.15 | 0.018 | 0.23 | | | 0.004 | 1.4 |
| | 4 | 0.18 | 0.15 | 0.023 | 0.74 | | | 0.017 | 5.8 |
| | 3.9 | 0.18 | 0.10 | 0.018 | 0.96 | | | 0.017 | 6.0 |
| | 3.80 | 0.20 | 0.10 | 0.020 | 1.00 | | | 0.020 | 6.9 |
| | 3.70 | 0.22 | 0.10 | 0.022 | 0.97 | | | 0.021 | 7.4 |
| | 3.60 | 0.18 | 0.10 | 0.018 | 1.04 | | | 0.019 | 6.5 |
| | 3.50 | 0.16 | 0.10 | 0.016 | 1.03 | | | 0.016 | 5.7 |
| | 3.40 | 0.15 | 0.10 | 0.015 | 0.97 | | | 0.015 | 5.0 |
| | 3.30 | 0.15 | 0.10 | 0.015 | 0.98 | | | 0.015 | 5.1 |
| | 3.20 | 0.14 | 0.10 | 0.018 | 0.91 | | | 0.016 | 5.5 |
| | 3.05 | 0.13 | 0.15 | 0.020 | 0.65 | | | 0.013 | 4.4 |
| LB | 2.90 | 0.12 | 0.15 | 0.018 | 0.75 | | | 0.014 | 4.7 |
| | 2.75 | 0.10 | 0.15 | 0.015 | 0.55 | | | 0.008 | 2.9 |
| | 2.60 | 0.12 | 0.15 | 0.018 | 0.33 | | | 0.006 | 2.1 |
| | 2.45 | 0.12 | 0.15 | 0.018 | 0.49 | | | 0.009 | 3.1 |
| | 2.30 | 0.10 | 0.15 | 0.015 | 0.98 | | | 0.015 | 5.1 |
| | 2.15 | 0.10 | 0.15 | 0.015 | 0.89 | | | 0.013 | 4.6 |
| | 2.00 | 0.11 | 0.15 | 0.017 | 0.72 | | | 0.012 | 4.1 |
| | 1.85 | 0.09 | 0.15 | 0.014 | 0.69 | | | 0.009 | 3.2 |
| | 1.70 | 0.06 | 0.15 | 0.009 | 0.82 | | | 0.007 | 2.6 |
| | 1.55 | 0.09 | 0.15 | 0.014 | 0.69 | | | 0.009 | 3.2 |
| | 1.40 | 0.06 | 0.15 | 0.009 | 0.63 | | | 0.006 | 2.0 |
| | 1.25 | 0.06 | 0.15 | 0.009 | 0.57 | | | 0.005 | 1.8 |
| | 1.10 | 0.06 | 0.15 | 0.006 | 0.40 | | | 0.002 | 0.8 |
| | 1.06 | 0.00 | 0.04 | 0.001 | 0.00 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.288** | **100.0** |

| General Notes |
|---|
| Installed station at 15:00 (logger launched). Control downstream of of RB log. Variation in WL @ PT due to ripples in PT pool (+/- 0.004) |

## Appendix 2-6b. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-6 | | | |
| Stream Name | Mile 17 Creek | | | |
| Date Monitored | 27-Jun-13 | | | |
| Time at Site (24 hr) | Start Time: | 8:45 | End Time: | 11:00:00 AM |
| Personnel | Eli Heyman, Tyson Logan | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0627134 | 6098319 | 764 | |
| Weather Conditions | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS98i | Serial # | 21235029 |
| Gain | 0.00022 | Offset | -0.854 |
| Status | Active | Battery | 11.66V% |
| # of Records | 8316 | Memory Free | 515,567 |
| Manual Gauge | Yes | Crest Gauges | N/A |

| Hydrometric Leveling Survey (Before moving PT) | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM90 | 0.707 | 100.707 | | 100.000 | formerly BM1 |
| BM91 | | | 1.620 | 99.087 | formerly BM2 |
| BM92 | | | 3.013 | 97.694 | formerly BM3 |
| PT | | | 4.338 | 96.369 | New location |
| WL | | | 4.268 | **96.439** | |
| TBM1 | 1.474 | 100.638 | 1.543 | 99.164 | |
| WL | | | 4.202 | **96.436** | |
| PT | | | 4.267 | 96.371 | New Location |
| BM92 | | | 2.947 | 97.691 | |
| BM91 | | | 1.552 | 99.086 | |
| BM90 | | | 0.640 | 99.998 | |
| SG | | | 3.286 | 97.352 | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM91 | 99.087 | 99.087 | 0.000 | |
| BM92 | 97.692 | 97.693 | -0.001 | |
| PT | 96.370 | 96.370 | 0.000 | |

| Summary | |
|---|---|
| Stage (m) | 96.438 |
| Discharge ($m^3/s$) | 0.074 |
| Pressure Transducer Reading (m) | 0.122 |
| Pressure Transducer Elevation (m) | 96.315 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 10:00 | End | 10:40 | Location | 1m DS of PT | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | Flo-Mate 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | 0.124 | SG | 0.175 | Time | 10:06 | Gauge correction: | |
| | End | Reading | 0.124 | SG | 0.175 | Time | 10:35 | 96.263 | 97.352 |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| LB | 0.55 | 0.00 | 0.00 | 0.008 | 0.00 | | | 0.000 | 0.0 |
| | 0.7 | 0.1 | 0.15 | 0.013 | 0.14 | | | 0.002 | 2.4 |
| | 0.8 | 0.08 | 0.10 | 0.008 | 0.31 | | | 0.002 | 3.4 |
| | 0.9 | 0.12 | 0.10 | 0.012 | 0.26 | | | 0.003 | 4.2 |
| | 1.00 | 0.12 | 0.10 | 0.012 | 0.22 | | | 0.003 | 3.6 |
| | 1.10 | 0.11 | 0.10 | 0.011 | 0.27 | | | 0.003 | 4.0 |
| | 1.20 | 0.11 | 0.10 | 0.011 | 0.30 | | | 0.003 | 4.5 |
| | 1.30 | 0.10 | 0.10 | 0.010 | 0.31 | | | 0.003 | 4.2 |
| | 1.40 | 0.09 | 0.10 | 0.009 | 0.24 | | | 0.002 | 2.9 |
| | 1.50 | 0.09 | 0.10 | 0.009 | 0.26 | | | 0.002 | 3.2 |
| | 1.60 | 0.09 | 0.10 | 0.009 | 0.31 | | | 0.003 | 3.8 |
| | 1.70 | 0.10 | 0.10 | 0.010 | 0.30 | | | 0.003 | 4.1 |
| | 1.80 | 0.10 | 0.10 | 0.010 | 0.33 | | | 0.003 | 4.5 |
| | 1.90 | 0.09 | 0.10 | 0.009 | 0.38 | | | 0.003 | 4.6 |
| | 2.00 | 0.11 | 0.10 | 0.011 | 0.35 | | | 0.004 | 5.2 |
| | 2.10 | 0.11 | 0.10 | 0.011 | 0.33 | | | 0.004 | 4.9 |
| | 2.20 | 0.12 | 0.10 | 0.012 | 0.34 | | | 0.004 | 5.5 |
| | 2.30 | 0.12 | 0.10 | 0.012 | 0.32 | | | 0.004 | 5.2 |
| | 2.40 | 0.12 | 0.10 | 0.012 | 0.28 | | | 0.003 | 4.6 |
| | 2.50 | 0.14 | 0.10 | 0.014 | 0.28 | | | 0.004 | 5.3 |
| | 2.60 | 0.14 | 0.10 | 0.014 | 0.26 | | | 0.004 | 4.9 |
| | 2.70 | 0.14 | 0.10 | 0.014 | 0.23 | | | 0.003 | 4.4 |
| | 2.80 | 0.18 | 0.10 | 0.018 | 0.24 | | | 0.004 | 5.9 |
| | 2.90 | 0.14 | 0.10 | 0.010 | 0.33 | | | 0.003 | 4.7 |
| RB | 2.95 | 0.00 | 0.05 | 0.003 | 0.00 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| Total Q | | | | | | | | 0.074 | 100.0 |

**General Notes**

Moved rock near pT at 9:30. May have been affecting WL.

## Appendix 2-6b. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-6 | | | |
| **Stream Name** | Mile 17 Creek | | | |
| **Date Monitored** | 27-Jun-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 8:45 | **End Time:** | 11:00:00 AM |
| **Personnel** | Eli Heyman, Tyson Logan | | | |
| **Station Cordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0627134 | 6098319 | 764 | |
| **Weather Conditions** | Sunny | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 21235029 |
| **Gain** | 0.00022 | **Offset** | -0.854 |
| **Status** | Active | **Battery** | 11.66V% |
| **# of Records** | | **Memory Free** | |
| **Manual Gauge** | Yes | **Crest Gauges** | N/A |

**Hydrometric Leveling Survey (Before moving PT)**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM90 | | | | | |
| BM91 | | | | | |
| BM92 | | | | | |
| PT | | | | | |
| WL | | | | | |
| TBM1 | See 27-June-2013 (1) for survey | | | | |
| WL | | | | | |
| PT | | | | | |
| BM92 | | | | | |
| BM91 | | | | | |
| BM90 | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| SG | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM91 | | | | |
| BM92 | | | | |
| PT | | | | |

| Summary | |
|---|---|
| **Stage (m)** | 0.119 |
| **Discharge ($m^3/s$)** | 0.065 |
| **Pressure Transducer Reading (m)** | 0.119 |
| **Pressure Transducer Elevation (m)** | 0.000 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 15:45 | **End** | 16:17 | **Location** | 1m DS of PT | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.119 | **SG** | 0.167 | **Time** | 15:45 | **Gauge correction:** |
| | **End** | **Reading** | 0.119 | **SG** | 0.167 | **Time** | 16:17 | 0.048 |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **($m^3/s$)** | **%** |
| LB | 0.50 | 0.00 | 0.00 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| | 0.55 | 0.06 | 0.05 | 0.003 | 0.09 | | | 0.000 | 0.1 |
| | 0.6 | 0.08 | 0.05 | 0.006 | 0.07 | | | 0.000 | 0.1 |
| | 0.7 | 0.08 | 0.10 | 0.008 | 0.31 | | | 0.002 | 0.9 |
| | 0.8 | 0.10 | 0.10 | 0.010 | 0.28 | | | 0.003 | 1.0 |
| | 0.9 | 0.08 | 0.10 | 0.008 | 0.20 | | | 0.002 | 0.6 |
| | 1 | 0.10 | 0.10 | 0.010 | 0.20 | | | 0.002 | 0.7 |
| | 1.1 | 0.10 | 0.10 | 0.010 | 0.23 | | | 0.002 | 0.8 |
| | 1.2 | 0.10 | 0.10 | 0.010 | 0.23 | | | 0.002 | 0.8 |
| | 1.3 | 0.10 | 0.10 | 0.010 | 0.21 | | | 0.002 | 0.7 |
| | 1.4 | 0.08 | 0.10 | 0.008 | 0.27 | | | 0.002 | 0.7 |
| | 1.5 | 0.08 | 0.10 | 0.008 | 0.26 | | | 0.002 | 0.7 |
| | 1.6 | 0.09 | 0.10 | 0.009 | 0.29 | | | 0.003 | 0.9 |
| | 1.7 | 0.08 | 0.10 | 0.008 | 0.33 | | | 0.003 | 0.9 |
| | 1.8 | 0.09 | 0.10 | 0.009 | 0.26 | | | 0.002 | 0.8 |
| | 1.9 | 0.11 | 0.10 | 0.011 | 0.30 | | | 0.003 | 1.1 |
| | 2 | 0.11 | 0.10 | 0.011 | 0.27 | | | 0.003 | 1.0 |
| | 2.1 | 0.11 | 0.10 | 0.011 | 0.36 | | | 0.004 | 1.4 |
| | 2.2 | 0.11 | 0.10 | 0.011 | 0.39 | | | 0.004 | 1.5 |
| | 2.3 | 0.11 | 0.10 | 0.011 | 0.35 | | | 0.004 | 1.3 |
| | 2.4 | 0.13 | 0.10 | 0.013 | 0.30 | | | 0.004 | 1.4 |
| | 2.5 | 0.14 | 0.10 | 0.014 | 0.28 | | | 0.004 | 1.4 |
| | 2.6 | 0.14 | 0.10 | 0.014 | 0.29 | | | 0.004 | 1.4 |
| | 2.7 | 0.12 | 0.10 | 0.012 | 0.31 | | | 0.004 | 1.3 |
| | 2.8 | 0.14 | 0.10 | 0.010 | 0.31 | | | 0.003 | 1.1 |
| RB | 2.85 | 0.00 | 0.05 | 0.003 | 0.00 | | | 0.00 | 0.00 |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.065** | **22.7** |

**General Notes**

Moved rock near PT at 9:30 as it may have been causing some drawdown at the PT. Marked out options for x-sections up and DS (WL either on rock or with nails)

## Appendix 2-6b. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-6 | | | |
| **Stream Name** | Mile 17 Creek | | | |
| **Date Monitored** | 8-Aug-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 8:10:00 AM | **End Time:** | |
| **Personnel** | Mike Soloducha, Daniel Helm | | | |
| **Station Coordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0627134 | 6098319 | 764 | |
| **Weather Conditions** | overcast, calm. 15*C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | | **Serial #** | |
| **Gain** | | **Offset** | |
| **Status** | | **Battery** | 11.6226 |
| **# of Records** | 14385 | **Memory Free** | 509498 |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 90 | | | | | not surveyed |
| BM 91 | | | | | not surveyed |
| BM 92 | 1.063 | 98.756 | | 97.693 | |
| PT | | | 2.384 | 96.372 | old location |
| PT new | | | 2.397 | 96.359 | |
| RBWL | | | 2.365 | 96.391 | |
| LBWL | | | 2.434 | **96.322** | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | | **Difference (m)** | **Notes** |
| BM 90 | 99.086 | 97.693 | | | |
| BM 91 | 97.692 | 97.693 | | | |
| BM 92 | | 97.693 | | | |

| Summary | | |
|---|---|---|
| **Stage (m)** | 0.097 SG corrected: | 96.400 |
| **Discharge ($m^3/s$)** | 0.019 | |
| **Pressure Transducer Reading (m)** | 0.097 | |
| **Pressure Transducer Elevation (m)** | 0.000 from June 27 survey | |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 9:30 | **End** | 10:00 | **Location** | 1 m u/s of station | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flomate | | | |
| **Flow Meter Type** | Electromagnetic | | | **Instrument Serial #** | | 12921 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.097 | **SG** | 0.14 | **Time** | 9:30 | **Gauge Correction:** | |
| | **End** | **Reading** | 0.097 | **SG** | 0.14 | **Time** | 10:00 | 96.26 from June 27 | |

| | **Station** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **($m^3/s$)** | **%** |
| | 1.05 | 0.00 | 0.0 | 0.00 | 0 | | | 0.000 | 0.0 |
| | 1.10 | 0.10 | 0.1 | 0.01 | 0.09 | | | 0.001 | 3.5 |
| | 1.20 | 0.12 | 0.1 | 0.01 | 0.2 | | | 0.002 | 12.5 |
| | 1.30 | 0.12 | 0.1 | 0.01 | 0.17 | | | 0.002 | 10.6 |
| | 1.40 | 0.10 | 0.1 | 0.01 | 0.17 | | | 0.002 | 8.9 |
| | 1.50 | 0.08 | 0.1 | 0.01 | 0.18 | | | 0.001 | 7.5 |
| | 1.60 | 0.08 | 0.1 | 0.01 | 0.17 | | | 0.001 | 7.1 |
| behind rock | 1.70 | 0.10 | 0.1 | 0.01 | 0.05 | | | 0.001 | 2.6 |
| | 1.80 | 0.08 | 0.1 | 0.01 | 0.15 | | | 0.001 | 6.3 |
| | 1.90 | 0.07 | 0.1 | 0.01 | 0.16 | | | 0.001 | 5.8 |
| | 2.00 | 0.08 | 0.1 | 0.01 | 0.11 | | | 0.001 | 4.6 |
| | 2.10 | 0.08 | 0.1 | 0.01 | 0.08 | | | 0.001 | 3.3 |
| | 2.20 | 0.08 | 0.1 | 0.01 | 0.09 | | | 0.001 | 3.8 |
| | 2.30 | 0.07 | 0.1 | 0.01 | 0.08 | | | 0.001 | 2.9 |
| | 2.40 | 0.07 | 0.1 | 0.01 | 0.03 | | | 0.000 | 1.1 |
| | 2.50 | 0.07 | 0.1 | 0.01 | 0.05 | | | 0.000 | 1.8 |
| | 2.60 | 0.07 | 0.1 | 0.01 | 0.05 | | | 0.000 | 1.8 |
| | 2.70 | 0.08 | 0.1 | 0.01 | 0.01 | | | 0.000 | 0.4 |
| | 2.80 | 0.08 | 0.1 | 0.01 | 0.03 | | | 0.000 | 1.3 |
| | 2.90 | 0.08 | 0.1 | 0.01 | 0.04 | | | 0.000 | 1.7 |
| | 3.00 | 0.08 | 0.1 | 0.01 | 0.05 | | | 0.000 | 2.1 |
| | 3.10 | 0.08 | 0.1 | 0.01 | 0.09 | | | 0.001 | 3.8 |
| | 3.20 | 0.07 | 0.1 | 0.01 | 0.08 | | | 0.001 | 2.9 |
| | 3.30 | 0.08 | 0.1 | 0.01 | 0.07 | | | 0.001 | 2.9 |
| | 3.40 | 0.05 | 0.1 | 0.01 | 0.03 | | | 0.000 | 0.8 |
| | 3.50 | 0.00 | 0.1 | 0.003 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.019** | **100.0** |

**General Notes**

PT was moved into a deeper section of the pool at ~12:30

## Appendix 2-6b. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-6 | | | |
| **Stream Name** | Mile 17 Creek | | | |
| **Date Monitored** | 8-Oct-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 9:30:00 AM | **End Time:** | |
| **Personnel** | Eli Heyman, Jem Morrisson | | | |
| **Station Coordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0627134 | 6098319 | 764 | |
| **Weather Conditions** | overcast, calm. 4*C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 21236007 |
| **Gain** | 0.00022 | **Offset** | -0.854 |
| **Status** | Active | **Battery** | 11.4 |
| **# of Records** | 23151 | **Memory Free** | 500732 |
| **Date Serviced** | 10/8/2013 | **Crest Gauges** | n?A |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 90 | 0.653 | 100.653 | | 100.000 | |
| BM 91 | | | 1.568 | 99.085 | |
| BM 92 | | | 2.961 | 97.692 | |
| PT | | | | | not surveyed |
| WL | | | 4.250 | **96.403** | |
| SG | | | 3.301 | 97.352 | |
| TBM | 1.168 | 100.674 | 1.147 | 99.506 | |
| SG | | | 3.321 | 97.353 | |
| WL | | | 4.269 | **96.405** | |
| PT | | | 4.312 | 96.362 | |
| BM 92 | | | 2.981 | 97.693 | |
| BM 91 | | | 1.589 | 99.085 | |
| BM 90 | | | 0.675 | 99.999 | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 91 | 99.086 | 99.085 | -0.001 | |
| BM 92 | 97.692 | 97.693 | 0.001 | |
| PT | | 96.362 | | |

| Summary | |
|---|---|
| **Stage (m)** | 96.404 |
| **Discharge ($m^3/s$)** | 0.020 |
| **Pressure Transducer Reading (m)** | 0.110 |
| **Pressure Transducer Elevation (m)** | 96.294 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 10:30 | **End** | 11:00 | **Location** | 1m d/s of PT | | | | |
| **Method** | Velocity-area (Mid-section) | | | | **Instrument Model** | Flomate | | | | |
| **Flow Meter Type** | Electromagnetic | | | | **Instrument Serial #** | 14614 | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.11 | **SG** | 0.146 | **Time** | 10:30 | **Gauge correction:** | | |
| | **End** | **Reading** | 0.11 | **SG** | 0.146 | **Time** | 11:00 | 96.258 | 97.353 | |

| | Station | Depth | Depth | Distance | Area | Velocity (m/s) | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(ft)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **80%** | **($m^3/s$)** | **%** |
| LB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.0 |
| | 0.05 | 0.10 | 0.03 | 0.1 | 0.00 | -0.05 | | 0.000 | -1.0 |
| | 0.25 | 0.12 | 0.04 | 0.2 | 0.01 | 0.05 | | 0.000 | 1.6 |
| | 0.40 | 0.12 | 0.04 | 0.2 | 0.01 | 0.03 | | 0.000 | 1.0 |
| | 0.60 | 0.10 | 0.03 | 0.2 | 0.01 | 0.05 | | 0.000 | 1.3 |
| | 0.75 | 0.19 | 0.06 | 0.2 | 0.01 | 0.06 | | 0.001 | 2.6 |
| | 0.90 | 0.15 | 0.05 | 0.2 | 0.01 | 0.06 | | 0.000 | 2.1 |
| | 1.05 | 0.12 | 0.04 | 0.2 | 0.01 | 0.07 | | 0.000 | 1.9 |
| | 1.20 | 0.19 | 0.06 | 0.2 | 0.01 | 0.12 | | 0.001 | 5.2 |
| | 1.35 | 0.15 | 0.05 | 0.2 | 0.01 | 0.11 | | 0.001 | 3.8 |
| | 1.50 | 0.20 | 0.06 | 0.2 | 0.01 | 0.11 | | 0.001 | 5.0 |
| | 1.65 | 0.28 | 0.09 | 0.2 | 0.01 | 0.03 | | 0.000 | 1.9 |
| | 1.80 | 0.30 | 0.09 | 0.2 | 0.01 | 0.11 | | 0.001 | 6.3 |
| | 1.90 | 0.30 | 0.09 | 0.1 | 0.01 | 0.15 | | 0.001 | 6.9 |
| | 2.00 | 0.30 | 0.09 | 0.1 | 0.01 | 0.15 | | 0.001 | 6.9 |
| | 2.10 | 0.31 | 0.09 | 0.1 | 0.01 | 0.17 | | 0.002 | 8.0 |
| | 2.20 | 0.31 | 0.09 | 0.1 | 0.01 | 0.19 | | 0.002 | 9.0 |
| | 2.30 | 0.33 | 0.10 | 0.1 | 0.01 | 0.2 | | 0.002 | 8.5 |
| | 2.37 | 0.40 | 0.12 | 0.1 | 0.01 | 0.16 | | 0.001 | 6.8 |
| | 2.44 | 0.50 | 0.15 | 0.1 | 0.01 | 0.14 | | 0.001 | 7.5 |
| | 2.51 | 0.50 | 0.15 | 0.1 | 0.01 | 0.11 | | 0.001 | 5.9 |
| | 2.58 | 0.53 | 0.16 | 0.1 | 0.01 | 0.09 | | 0.001 | 5.4 |
| | 2.66 | 0.53 | 0.16 | 0.1 | 0.01 | 0.06 | | 0.001 | 4.1 |
| | 2.75 | 0.11 | 0.03 | 0.1 | 0.00 | -0.04 | | 0.000 | -0.6 |
| RB | 2.85 | 0.00 | 0.00 | 0.1 | 0.00 | 0 | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.0200** | **100.0** |

**General Notes**

RB minimal flow 10cm wide, 5cm deep

## Appendix 2-6b. Manual Discharge Measurements and Levelling Surveys at MH-6 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-6 | | | |
| Stream Name | Mile 17 Creek | | | |
| Date Monitored | 6-Nov-13 | | | |
| Time at Site (24 hr) | Start Time: | 1:00:00 PM | End Time: | 3:00:00 PM |
| Personnel | Eli Heyman, Tyler Gale | | | |
| Station Coordinates | Easting | Northing | Elevation | |
| | 0627134 | 6098319 | 764 | |
| Weather Conditions | Snow, -1C | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS98i | Serial # | 21236007 |
| Gain | 0.00022 | Offset | -0.854 |
| Status | Active | Battery | 13.5 |
| # of Records | 4340 | Memory Free | 496376 |
| Date Serviced | 10/8/2013 | Crest Gauges | N/A |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM 90 | 0.697 | 100.697 | | 100.000 | |
| BM 91 | | | 1.610 | 99.087 | |
| BM 92 | | | 3.003 | 97.694 | |
| PT | | | 4.340 | 96.357 | |
| WL | | | 4.330 | 96.367 | error (DS of PT) |
| SG | | | 3.345 | 97.352 | |
| TBM | 1.785 | 100.650 | 1.832 | 98.865 | |
| SG | | | 3.298 | 97.352 | |
| WL | | | 4.268 | **96.382** | good |
| PT | | | 4.289 | 96.361 | |
| BM 92 | | | 2.956 | 97.694 | |
| BM 91 | | | 1.563 | 99.087 | |
| BM 90 | | | 0.649 | 100.001 | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 91 | 99.086 | 99.087 | 0.001 | |
| BM 92 | 97.692 | 97.694 | 0.002 | |
| PT | 96.362 | 96.359 | -0.003 | |

| Summary | |
|---|---|
| Stage (m) | 96.382 |
| Discharge ($m^3/s$) | 0.00392 |
| Pressure Transducer Reading (m) | 0.087 |
| Pressure Transducer Elevation (m) | 96.295 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 13:50 | End | 14:20 | Location | 2m d/s of PT | | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | Flomate | | | | |
| Flow Meter Type | Electromagnetic | | | Instrument Serial # | | 14614 | | | | |
| Stage (m) | Start | Reading | 0.087 | SG | 0.122 | Time | 13:50 | Gauge correction: | | |
| | End | Reading | 0.087 | SG | 0.122 | Time | 14:20 | 96.258 | 97.352 | |

| | Station | Depth | Depth | Distance | Area | Velocity (m/s) | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (ft) | (m) | (m) | ($m^2$) | 60% | 80% | ($m^3/s$) | % |
| RB | 0.55 | 0.00 | 0.00 | 0.0 | 0.00 | 0 | | 0.000 | 0.0 |
| | 0.60 | 0.25 | 0.08 | 0.0 | 0.00 | 0.09 | | 0.000 | 10.5 |
| | 0.67 | 0.30 | 0.09 | 0.1 | 0.01 | 0.09 | | 0.001 | 14.7 |
| | 0.74 | 0.31 | 0.09 | 0.1 | 0.01 | 0.08 | | 0.001 | 13.5 |
| | 0.81 | 0.31 | 0.09 | 0.1 | 0.01 | 0.09 | | 0.001 | 15.2 |
| | 0.88 | 0.30 | 0.09 | 0.1 | 0.01 | 0.1 | | 0.001 | 16.3 |
| | 0.95 | 0.26 | 0.08 | 0.1 | 0.00 | 0.1 | | 0.000 | 12.1 |
| | 1.00 | 0.21 | 0.06 | 0.1 | 0.00 | 0.09 | | 0.000 | 7.3 |
| | 1.05 | 0.20 | 0.06 | 0.1 | 0.00 | 0.08 | | 0.000 | 6.2 |
| | 1.10 | 0.20 | 0.06 | 0.1 | 0.00 | 0.06 | | 0.000 | 4.7 |
| | 1.15 | 0.19 | 0.06 | 0.0 | 0.00 | 0.06 | | 0.000 | 4.4 |
| | 1.20 | 0.19 | 0.06 | 0.1 | 0.00 | 0.06 | | 0.000 | 4.4 |
| | 1.25 | 0.15 | 0.05 | 0.1 | 0.00 | 0.04 | | 0.000 | 2.3 |
| | 1.30 | 0.15 | 0.05 | 0.1 | 0.00 | 0.02 | | 0.000 | 1.2 |
| | 1.35 | 0.15 | 0.05 | 0.1 | 0.00 | 0.03 | | 0.000 | 2.6 |
| | 1.45 | 0.19 | 0.06 | 0.1 | 0.01 | 0.03 | | 0.000 | 4.4 |
| | 1.55 | 0.19 | 0.06 | 0.1 | 0.01 | 0.03 | | 0.000 | 5.5 |
| | 1.70 | 0.16 | 0.05 | 0.2 | 0.01 | 0.01 | | 0.000 | 1.9 |
| | 1.85 | 0.12 | 0.04 | 0.2 | 0.01 | -0.03 | | 0.000 | -4.2 |
| | 2.00 | 0.12 | 0.04 | 0.2 | 0.01 | -0.04 | | 0.000 | -6.5 |
| | 2.20 | 0.12 | 0.04 | 0.2 | 0.01 | -0.03 | | 0.000 | -5.6 |
| | 2.40 | 0.15 | 0.05 | 0.2 | 0.01 | -0.03 | | 0.000 | -7.0 |
| | 2.60 | 0.13 | 0.04 | 0.2 | 0.01 | -0.02 | | 0.000 | -4.0 |
| | 2.80 | 0.10 | 0.03 | 0.2 | 0.00 | 0 | | 0.000 | 0.0 |
| LB | 2.90 | 0.00 | 0.0 | 0.1 | 0.00 | 0 | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | 0.00392 | 100.0 |

| General Notes |
|---|
| |

## Appendix 2-7a. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| Project Name | Murray River | | | |
| Station Identification | MH-7 | | | |
| Stream Name | Mile 19 Creek | | | |
| Date Monitored | 30-Sep-12 | | | |
| Time at Site (24 hr) | Start Time: | 14:46 | End Time: | 5:00:00 PM |
| Personnel | Eli Heyman, Cenling Xia | | | |
| Station Cordinates | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 776 | |
| Weather Conditions | Mix of Sun and cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| PT Model | PS98i | Serial # | 21235028 |
| Gain | | Offset | |
| Status | Active | Battery | 12.45V |
| # of Records | | Memory Free | 130,661 |
| Date Serviced | | Crest Gauges | N/A |

| Hydrometric Leveling Survey (Before moving PT) | | | | | |
|---|---|---|---|---|---|
| Stn | BS | HI | FS | Elevation | Notes |
| BM90 | 0.966 | 100.966 | | 100.000 | |
| BM92 | | | 0.086 | 100.880 | |
| BM93 | | | 0.432 | 100.534 | |
| PT | | | 3.515 | 97.451 | |
| WL | | | 3.388 | **97.578** | |
| TBM1 | 3.371 | 101.018 | 3.319 | 97.647 | |
| WL | | | 3.440 | **97.578** | |
| PT | | | 3.569 | 97.449 | |
| BM93 | | | 0.484 | 100.534 | |
| BM92 | | | 0.138 | 100.880 | |
| BM90 | | | 1.017 | 100.001 | |

| BM# | Established Elevation (m) | Elevation (this date) | Difference (m) | Notes |
|---|---|---|---|---|
| BM92 | 100.880 | 100.880 | | Established on this date |
| BM93 | 100.534 | 100.534 | | Established on this date |
| PT | 97.450 | 97.450 | | Established on this date |

| Summary | |
|---|---|
| Stage (m) | 97.578 |
| Discharge ($m^3/s$) | 0.00314 |
| Pressure Transducer Reading (m) | 0.193 |
| Pressure Transducer Elevation (m) | 97.450 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time (24 hr) | Start | 14:50 | End | 15:30 | Location | 15m DS of PT | | | |
| Method | Velocity-area (Mid-section) | | | Instrument Model | | Flo-Mate 2000 | | | |
| Flow Meter Type | Flo-Mate | | | Instrument Serial # | | | | | |
| Stage (m) | Start | Reading | | Time | | | | | |
| | End | Reading | 0.193 | Time | 15:30 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| Notes | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 0.40 | 0.00 | 0.00 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| | 0.44 | 0.11 | 0.04 | 0.004 | 0.06 | | | 0.000 | 8.4 |
| | 0.48 | 0.11 | 0.04 | 0.003 | 0.06 | | | 0.000 | 6.3 |
| | 0.50 | 0.10 | 0.02 | 0.002 | 0.06 | | | 0.000 | 3.8 |
| | 0.52 | 0.12 | 0.02 | 0.002 | 0.07 | | | 0.000 | 5.4 |
| | 0.54 | 0.10 | 0.02 | 0.002 | 0.06 | | | 0.000 | 3.8 |
| | 0.56 | 0.11 | 0.02 | 0.003 | 0.07 | | | 0.000 | 7.4 |
| | 0.60 | 0.12 | 0.04 | 0.004 | 0.07 | | | 0.000 | 8.0 |
| | 0.62 | 0.12 | 0.02 | 0.002 | 0.07 | | | 0.000 | 5.4 |
| | 0.64 | 0.12 | 0.02 | 0.002 | 0.07 | | | 0.000 | 5.4 |
| | 0.66 | 0.11 | 0.02 | 0.002 | 0.07 | | | 0.000 | 4.9 |
| | 0.68 | 0.11 | 0.02 | 0.003 | 0.07 | | | 0.000 | 7.4 |
| | 0.72 | 0.10 | 0.04 | 0.004 | 0.06 | | | 0.000 | 7.7 |
| | 0.76 | 0.10 | 0.04 | 0.004 | 0.05 | | | 0.000 | 6.4 |
| | 0.80 | 0.09 | 0.04 | 0.004 | 0.06 | | | 0.000 | 6.9 |
| | 0.84 | 0.08 | 0.04 | 0.003 | 0.06 | | | 0.000 | 6.1 |
| | 0.88 | 0.06 | 0.04 | 0.002 | 0.05 | | | 0.000 | 3.8 |
| | 0.92 | 0.05 | 0.04 | 0.002 | 0.03 | | | 0.000 | 1.9 |
| | 0.96 | 0.05 | 0.04 | 0.002 | 0.02 | | | 0.000 | 1.3 |
| | 1.00 | 0.04 | 0.04 | 0.002 | 0.01 | | | 0.000 | 0.5 |
| | 1.04 | 0.04 | 0.04 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| | 1.08 | 0.04 | 0.04 | 0.002 | 0.00 | | | 0.000 | 0.0 |
| | 1.12 | 0.02 | 0.04 | 0.001 | -0.03 | | | 0.000 | -0.7 |
| LB | 1.15 | 0.00 | 0.03 | 0.000 | 0.00 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| Total Q | | | | | | | | 0.00314 | 100.0 |

| General Notes |
|---|
| |

## Appendix 2-7a. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2012

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH-7 | | | |
| **Stream Name** | Mile 19 Creek | | | |
| **Date Monitored** | 4-Nov-12 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 1:00:00 PM | **End Time:** | 4:00:00 PM |
| **Personnel** | Eli Heyman, Arnold | | | |
| **Station Cordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | Rain. 3C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS98i | **Serial #** | 21235028 |
| **Gain** | | **Offset** | |
| **Status** | Active | **Battery** | 12.1V |
| **# of Records** | 5025 | **Memory Free** | 125,642 |
| **Date Serviced** | 11/4/2012 | **Crest Gauges** | N/A |

| Hydrometric Leveling Survey (Before moving PT) | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM90 | 1.109 | 101.109 | | 100.000 | |
| BM92 | | | 0.230 | 100.879 | |
| BM93 | | | 0.576 | 100.533 | |
| PT | | | 3.662 | 97.447 | |
| WL | | | 3.423 | **97.686** | |
| TBM1 | 3.245 | 101.041 | 3.313 | 97.796 | |
| WL | | | 3.357 | **97.684** | |
| PT | | | 3.595 | 97.446 | |
| BM93 | | | 0.509 | 100.532 | |
| BM92 | | | 0.162 | 100.879 | |
| BM90 | | | 1.042 | 99.999 | |

| BM# | Established Elevation (m) | Elevation (this date) | Difference (m) | Notes |
|---|---|---|---|---|
| BM92 | 100.880 | 100.879 | -0.001 | |
| BM93 | 100.534 | 100.533 | -0.001 | |
| PT | 97.450 | 97.447 | -0.004 | |

| Summary | |
|---|---|
| **Stage (m)** | 97.685 |
| **Discharge ($m^3/s$)** | 0.0391 |
| **Pressure Transducer Reading (m)** | 0.306 |
| **Pressure Transducer Elevation (m)** | 97.447 |

| General Notes |
|---|
| Rising stage during visit (heavy rain event) |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:10 | **End** | 14:00 | **Location** | 15m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | | | |
| **Flow Meter Type** | Flo-Mate | | | **Instrument Serial #** | | | | | |
| **Stage (m)** | **Start** | **Reading** | 0.297 | **Time** | 13:10 | Heavy Rain during measurement | | | |
| | **End** | **Reading** | 0.303 | **Time** | 14:00 | | | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **($m^3/s$)** | **%** |
| LB | 1.10 | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.000 | 0.0 |
| Pool, low flow | 1.15 | 0.08 | 0.05 | 0.01 | -0.03 | | | 0.000 | -0.6 |
| Pool, low flow | 1.30 | 0.10 | 0.15 | 0.02 | -0.02 | | | 0.000 | -0.9 |
| Pool, low flow | 1.50 | 0.10 | 0.20 | 0.02 | -0.02 | | | 0.000 | -1.0 |
| Pool, low flow | 1.70 | 0.12 | 0.20 | 0.02 | -0.01 | | | 0.000 | -0.5 |
| Pool, low flow | 1.80 | 0.14 | 0.10 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| Pool, low flow | 1.90 | 0.14 | 0.10 | 0.01 | 0.01 | | | 0.000 | 0.4 |
| | 2.00 | 0.14 | 0.10 | 0.01 | 0.02 | | | 0.000 | 0.7 |
| | 2.10 | 0.16 | 0.10 | 0.02 | 0.03 | | | 0.000 | 1.2 |
| | 2.20 | 0.17 | 0.10 | 0.02 | 0.04 | | | 0.001 | 1.7 |
| | 2.30 | 0.19 | 0.10 | 0.02 | 0.04 | | | 0.001 | 1.9 |
| | 2.40 | 0.20 | 0.10 | 0.02 | 0.06 | | | 0.001 | 3.1 |
| | 2.50 | 0.19 | 0.10 | 0.02 | 0.07 | | | 0.001 | 3.4 |
| | 2.60 | 0.19 | 0.10 | 0.02 | 0.08 | | | 0.002 | 3.9 |
| | 2.70 | 0.20 | 0.10 | 0.02 | 0.11 | | | 0.002 | 5.6 |
| | 2.80 | 0.20 | 0.10 | 0.02 | 0.12 | | | 0.002 | 6.1 |
| | 2.90 | 0.21 | 0.10 | 0.02 | 0.13 | | | 0.003 | 7.0 |
| | 3.00 | 0.20 | 0.10 | 0.02 | 0.14 | | | 0.003 | 7.2 |
| | 3.10 | 0.21 | 0.10 | 0.02 | 0.16 | | | 0.003 | 6.5 |
| | 3.15 | 0.20 | 0.05 | 0.01 | 0.18 | | | 0.002 | 4.6 |
| | 3.20 | 0.21 | 0.05 | 0.01 | 0.18 | | | 0.002 | 4.8 |
| | 3.25 | 0.21 | 0.05 | 0.01 | 0.19 | | | 0.002 | 5.1 |
| | 3.30 | 0.21 | 0.05 | 0.01 | 0.19 | | | 0.002 | 5.1 |
| | 3.35 | 0.22 | 0.05 | 0.01 | 0.18 | | | 0.002 | 5.1 |
| | 3.40 | 0.22 | 0.05 | 0.01 | 0.14 | | | 0.002 | 3.9 |
| | 3.45 | 0.22 | 0.05 | 0.01 | 0.12 | | | 0.001 | 3.4 |
| | 3.50 | 0.26 | 0.05 | 0.03 | 0.12 | | | 0.003 | 8.0 |
| | 3.65 | 0.12 | 0.15 | 0.02 | 0.20 | | | 0.003 | 7.7 |
| | 3.75 | 0.11 | 0.10 | 0.01 | 0.17 | | | 0.001 | 3.6 |
| | 3.80 | 0.11 | 0.05 | 0.01 | 0.14 | | | 0.001 | 3.0 |
| RB | 3.90 | 0.00 | 0.10 | 0.01 | 0.00 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **0.0391** | **100.0** |

## Appendix 2-7b. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH7 | | | |
| **Stream Name** | Mile 19 Creek | | | |
| **Date Monitored** | 1-May-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 10:00 | **End Time:** | 15:50 |
| **Personnel** | Eli Heyman, Natasha Cowie | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | Mix Sun | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 21235028 |
| **Gain** | 0.000222 | **Offset** | -0.867 |
| **Status** | Active | **Battery** | 11.7V |
| **# of Records** | 98 | **Memory Free** | 130569 |
| **Date Serviced** | 1-May-12 | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 21 | 1.220 | 101.220 | | 100.000 | |
| BM 22 | | | 0.771 | 100.449 | |
| | | | | | |
| PT | | | 4.548 | 96.672 | Clamp closest to duct tape |
| WL | | | 4.037 | **97.183** | |
| TBM | 3.947 | 101.183 | 3.984 | 97.236 | |
| WL | | | 4.001 | **97.182** | |
| PT | | | | | Use first mmt. |
| | | | | | |
| BM 22 | | | 0.733 | 100.450 | |
| BM 21 | | | 1.183 | 100.000 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 22 | 100.45 | 100.450 | | |
| | | | | |
| PT | 96.672 | 96.672 | | |

| Summary | |
|---|---|
| **Stage (m)** | 97.183 |
| **Discharge ($m^3/s$)** | 2.402 |
| **Pressure Transducer Reading (m)** | 0.694 +/- 0.005 |
| **Pressure Transducer Elevation (m)** | 96.489 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 8:25 | **End** | 10:05 | **Location** | 50m US of PT | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 6592 | |
| **Stage (m)** | **Start** | **Reading** | 0.695 | **Time** | 8:25 | | |
| | **End** | **Reading** | 0.695 | **Time** | 10:05 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| LB | 11.90 | 0.00 | 0.00 | 0.005 | 0 | | | 0.000 | 0.0 |
| | 11.8 | 0.1 | 0.10 | 0.020 | 0.05 | | | 0.001 | 0.0 |
| | 11.5 | 0.08 | 0.30 | 0.032 | 0.03 | | | 0.001 | 0.0 |
| | 11 | 0.18 | 0.50 | 0.090 | 0.07 | | | 0.006 | 0.3 |
| | 10.50 | 0.32 | 0.50 | 0.160 | 0.11 | | | 0.018 | 0.7 |
| | 10.00 | 0.37 | 0.50 | 0.148 | 0.29 | | | 0.043 | 1.8 |
| | 9.70 | 0.36 | 0.30 | 0.090 | 0.36 | | | 0.032 | 1.3 |
| On rock | 9.50 | 0.39 | 0.20 | 0.078 | 0.23 | | | 0.018 | 0.7 |
| | 9.30 | 0.57 | 0.20 | 0.114 | 0.93 | | | 0.106 | 4.4 |
| | 9.10 | 0.56 | 0.20 | 0.112 | 0.86 | | | 0.096 | 4.0 |
| | 8.90 | 0.47 | 0.20 | 0.118 | 0.82 | | | 0.096 | 4.0 |
| | 8.60 | 0.44 | 0.30 | 0.110 | 1.75 | | | 0.193 | 8.0 |
| | 8.40 | 0.54 | 0.20 | 0.135 | 1.29 | | | 0.174 | 7.2 |
| | 8.10 | 0.85 | 0.30 | 0.213 | | 1.45 | 0.83 | 0.2423 | 10.1 |
| | 7.90 | 0.72 | 0.20 | 0.144 | 1.31 | | | 0.189 | 7.9 |
| | 7.70 | 0.75 | 0.20 | 0.150 | | 1.15 | 1.09 | 0.168 | 7.0 |
| | 7.50 | 0.72 | 0.20 | 0.144 | 1.31 | | | 0.189 | 7.9 |
| | 7.30 | 0.67 | 0.20 | 0.168 | 0.96 | | | 0.161 | 6.7 |
| | 7.00 | 0.58 | 0.30 | 0.174 | 0.38 | | | 0.066 | 2.8 |
| | 6.70 | 0.47 | 0.30 | 0.141 | 0.21 | | | 0.030 | 1.2 |
| | 6.40 | 0.52 | 0.30 | 0.156 | 0.36 | | | 0.056 | 2.3 |
| | 6.10 | 0.50 | 0.30 | 0.150 | 0.97 | | | 0.146 | 6.1 |
| | 5.80 | 0.43 | 0.30 | 0.129 | 0.88 | | | 0.114 | 4.7 |
| | 5.50 | 0.43 | 0.30 | 0.129 | 1.04 | | | 0.134 | 5.6 |
| RB | 5.20 | 0.32 | 0.30 | 0.096 | 0.92 | | | 0.088 | 3.7 |
| | 4.90 | 0.22 | 0.30 | 0.066 | 0.38 | | | 0.025 | 1.0 |
| | 4.60 | 0.16 | 0.30 | 0.048 | 0.2 | | | 0.010 | 0.4 |
| | 4.30 | 0.11 | 0.30 | 0.028 | 0.04 | | | 0.001 | 0.0 |
| | 4.10 | 0.06 | 0.20 | 0.015 | 0.03 | | | 0.000 | 0.0 |
| | 3.80 | 0.00 | 0.30 | 0.009 | 0 | | | 0.000 | 0.0 |
| **Total Q** | | | | | | | | **2.402** | **100.0** |

**General Notes**

Measurement taken US of PT due to high flows and safety concerns at station. Stream makes sharp turn 10m US of section. Measurements 1-14 taken starting from LB, then EH crossed stream and took measurements 15-31 beginning mid-stream at 7.9m.

## Appendix 2-7b. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH7 | | | |
| **Stream Name** | Mile 19 Creek | | | |
| **Date Monitored** | 26-Jun-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 15:00 | **End Time:** | 18:00 |
| **Personnel** | Eli Heyman, Tyson Logan | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | Mix Sun | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 21235028 |
| **Gain** | 0.000222 | **Offset** | -0.867 |
| **Status** | Active | **Battery** | 11.7V |
| **# of Records** | 7915 | **Memory Free** | 122752 |
| **Manual Gauge** | No | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 21 | 1.112 | 101.112 | | 100.000 | |
| BM 22 | | | 0.664 | 100.556 | |
| | | | | | |
| PT | | | 4.577 | 96.643 | |
| WL | | | 4.217 | **97.003** | |
| TBM | 1.608 | 101.124 | 1.704 | 99.516 | |
| WL | | | 4.124 | **97.059** | |
| PT | | | 4.454 | 96.729 | |
| | | | | | |
| BM 22 | | | 0.567 | 100.616 | |
| BM 21 | | | 1.017 | 100.166 | |
| | | | | | |
| BM92 | | | 1.081 | 100.102 | |
| BM93 | | | 1.428 | 99.755 | |
| BM 90 | | | 1.961 | 99.222 | Old reference BM |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 22 | 100.45 | 100.586 | 0.136 | |
| | | | | |
| PT | 96.561 | 96.686 | | |

| Summary | |
|---|---|
| **Stage (m)** | 97.031 |
| **Discharge ($m^3/s$)** | 0.448 |
| **Pressure Transducer Reading (m)** | 0.391 |
| **Pressure Transducer Elevation (m)** | 96.640 |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 16:10 | **End** | 16:40 | **Location** | 8m DS of PT | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 6592 | |
| **Stage (m)** | **Start** | **Reading** | 0.391 | **Time** | 16:10 | | |
| | **End** | **Reading** | 0.388 | **Time** | 16:40 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 1.20 | 0.00 | 0.00 | 0.006 | 0 | | | 0.000 | 0.0 |
| | 1.3 | 0.11 | 0.10 | 0.014 | 0.47 | | | 0.006 | 0.3 |
| | 1.45 | 0.11 | 0.15 | 0.017 | 0.6 | | | 0.010 | 0.4 |
| | 1.6 | 0.16 | 0.15 | 0.028 | 0.61 | | | 0.017 | 0.7 |
| | 1.80 | 0.14 | 0.20 | 0.028 | 0.58 | | | 0.016 | 0.7 |
| | 2.00 | 0.29 | 0.20 | 0.058 | 0.62 | | | 0.036 | 1.5 |
| | 2.20 | 0.32 | 0.20 | 0.048 | 0.64 | | | 0.031 | 1.3 |
| | 2.30 | 0.34 | 0.10 | 0.034 | 0.54 | | | 0.018 | 0.8 |
| | 2.40 | 0.36 | 0.10 | 0.036 | 0.69 | | | 0.025 | 1.0 |
| | 2.50 | 0.33 | 0.10 | 0.033 | 0.68 | | | 0.022 | 0.9 |
| | 2.60 | 0.33 | 0.10 | 0.033 | 0.63 | | | 0.021 | 0.9 |
| | 2.70 | 0.32 | 0.10 | 0.032 | 0.61 | | | 0.020 | 0.8 |
| | 2.80 | 0.33 | 0.10 | 0.050 | 0.6 | | | 0.030 | 1.2 |
| | 3.00 | 0.32 | 0.20 | 0.064 | 0.52 | | | 0.033 | 1.4 |
| | 3.20 | 0.30 | 0.20 | 0.060 | 0.47 | | | 0.028 | 1.2 |
| | 3.40 | 0.28 | 0.20 | 0.056 | 0.42 | | | 0.024 | 1.0 |
| | 3.60 | 0.25 | 0.20 | 0.050 | 0.41 | | | 0.021 | 0.9 |
| | 3.80 | 0.24 | 0.20 | 0.048 | 0.42 | | | 0.020 | 0.8 |
| | 4.00 | 0.24 | 0.20 | 0.048 | 0.44 | | | 0.021 | 0.9 |
| | 4.20 | 0.22 | 0.20 | 0.044 | 0.42 | | | 0.018 | 0.8 |
| | 4.40 | 0.21 | 0.20 | 0.042 | 0.34 | | | 0.014 | 0.6 |
| | 4.60 | 0.16 | 0.20 | 0.032 | 0.26 | | | 0.008 | 0.3 |
| | 4.80 | 0.12 | 0.20 | 0.024 | 0.18 | | | 0.004 | 0.2 |
| | 5.00 | 0.08 | 0.20 | 0.016 | 0.16 | | | 0.003 | 0.1 |
| | 5.20 | 0.06 | 0.20 | 0.012 | 0.07 | | | 0.001 | 0.0 |
| | 5.40 | 0.04 | 0.20 | 0.006 | 0.01 | | | 0.000 | 0.0 |
| LB | 5.50 | 0.00 | 0.10 | 0.002 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.448** | **18.6** |

**General Notes**

## Appendix 2-7b. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH7 | | | |
| **Stream Name** | Mile 19 Creek | | | |
| **Date Monitored** | 28-Jun-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 7:54 | **End Time:** | 8:36 |
| **Personnel** | Eli Heyman, Tyson Logan | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | Mix Sun + Cloud | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 21235028 |
| **Gain** | 0.000222 | **Offset** | -0.867 |
| **Status** | Active | **Battery** | 11.7V |
| **# of Records** | 8160 | **Memory Free** | 122507 |
| **Manual Gauge** | No | **Crest Gauges** | No |

**Hydrometric Leveling Survey**

| Stn | BS | HI | FS | Elevation | Notes |
|---|---|---|---|---|---|
| BM 21 | | | | | |
| BM 22 | | | | | |
| | | | | | |
| PT | | | | | |
| WL | | | | | |
| TBM | See June 26 for survey details | | | | |
| WL | | | | | |
| PT | | | | | |
| | | | | | |
| BM 22 | | | | | |
| BM 21 | | | | | |
| | | | | | |
| BM92 | | | | | |
| BM93 | | | | | |
| BM 90 | | | | | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 22 | | | | |
| | | | | |
| PT | | | | |

| Summary | | |
|---|---|---|
| **Stage (m)** | 0.357 | from PT Record |
| **Discharge ($m^3/s$)** | 0.329 | |
| **Pressure Transducer Reading (m)** | 0.357 | |
| **Pressure Transducer Elevation (m)** | 0.000 | June 26 PT elevation |

**Discharge Measurement - Mid-Section Method**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 16:10 | **End** | 16:40 | **Location** | 8m DS of PT | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 6592 | |
| **Stage (m)** | **Start** | **Reading** | 0.357 | **Time** | 7:54 | | |
| | **End** | **Reading** | 0.356 | **Time** | 8:36 | | |

| | Station | Depth | Distance | Area | Velocity (m/s) | | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (m) | (m) | ($m^2$) | 60% | 20% | 80% | ($m^3/s$) | % |
| RB | 1.20 | 0.00 | 0.00 | 0.004 | 0 | | | 0.000 | 0.0 |
| | 1.3 | 0.08 | 0.10 | 0.012 | 0.45 | | | 0.005 | 0.2 |
| | 1.5 | 0.1 | 0.20 | 0.020 | 0.57 | | | 0.011 | 0.5 |
| | 1.7 | 0.09 | 0.20 | 0.018 | 0.55 | | | 0.010 | 0.4 |
| | 1.90 | 0.12 | 0.20 | 0.018 | 0.52 | | | 0.009 | 0.4 |
| | 2.00 | 0.26 | 0.10 | 0.026 | 0.55 | | | 0.014 | 0.6 |
| | 2.10 | 0.31 | 0.10 | 0.031 | 0.59 | | | 0.018 | 0.8 |
| | 2.20 | 0.32 | 0.10 | 0.032 | 0.57 | | | 0.018 | 0.8 |
| | 2.30 | 0.31 | 0.10 | 0.031 | 0.43 | | | 0.013 | 0.6 |
| | 2.40 | 0.29 | 0.10 | 0.029 | 0.56 | | | 0.016 | 0.7 |
| | 2.50 | 0.30 | 0.10 | 0.030 | 0.57 | | | 0.017 | 0.7 |
| | 2.60 | 0.30 | 0.10 | 0.030 | 0.56 | | | 0.017 | 0.7 |
| | 2.70 | 0.29 | 0.10 | 0.044 | 0.54 | | | 0.023 | 1.0 |
| | 2.90 | 0.29 | 0.20 | 0.058 | 0.5 | | | 0.029 | 1.2 |
| | 3.10 | 0.27 | 0.20 | 0.054 | 0.45 | | | 0.024 | 1.0 |
| | 3.30 | 0.24 | 0.20 | 0.048 | 0.4 | | | 0.019 | 0.8 |
| | 3.50 | 0.20 | 0.20 | 0.040 | 0.39 | | | 0.016 | 0.6 |
| | 3.70 | 0.20 | 0.20 | 0.040 | 0.32 | | | 0.013 | 0.5 |
| | 3.90 | 0.21 | 0.20 | 0.042 | 0.33 | | | 0.014 | 0.6 |
| | 4.10 | 0.20 | 0.20 | 0.040 | 0.37 | | | 0.015 | 0.6 |
| | 4.30 | 0.18 | 0.20 | 0.036 | 0.31 | | | 0.011 | 0.5 |
| | 4.50 | 0.14 | 0.20 | 0.035 | 0.27 | | | 0.009 | 0.4 |
| | 4.80 | 0.10 | 0.30 | 0.030 | 0.14 | | | 0.004 | 0.2 |
| | 5.10 | 0.04 | 0.30 | 0.008 | 0.07 | | | 0.001 | 0.0 |
| LB | 5.20 | 0.00 | 0.10 | 0.002 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.329** | **13.7** |

**General Notes**

## Appendix 2-7b. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH7 | | | |
| **Stream Name** | M-19 Creek | | | |
| **Date Monitored** | 9-Aug-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 7:30:00 AM | **End Time:** | 9:30:00 AM |
| **Personnel** | Mike S., Dan H. | | | |
| **Station Coordinates** | **Easting** | **Northing** | **Elevation** | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | 15*C, cloudy, light overcast | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | | **Serial #** | 21235028 |
| **Gain** | 0.000222 | **Offset** | -0.867 |
| **Status** | active | **Battery** | 11.6122 |
| **# of Records** | 14230 | **Memory Free** | 116437 |
| **Date Serviced** | | **Crest Gauges** | |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 21 | 1.237 | 101.237 | | 100.000 | |
| TBM1 | | | 2.742 | 98.478 | |
| BM22 | | | 0.788 | 100.432 | |
| BM23 | | | 0.538 | 100.682 | |
| TBMX | 0.936 | 101.187 | 0.969 | 100.251 | |
| BM23 | | | 0.503 | -0.503 | |
| BM22 | | | 0.753 | -0.753 | |
| TBM1 | | | 2.708 | -2.708 | |
| BM21 | | | 1.203 | -1.203 | |
| | | | | | |
| | | | | | |
| **TBM1** | 0.641 | 48.526 | | 47.885 | **from BM survey** |
| **RBWL** | | | 2.301 | -2.301 | |
| **LBWL** | | | 2.3 | -2.300 | |
| **PT** | | | 2.582 | -2.582 | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM22 | 100.45 | 49.840 | -50.611 | |
| BM23 | 100.7 | 50.090 | -50.611 | |
| PT | | -2.582 | -2.582 | |

| Summary | |
|---|---|
| **Stage (m)** | -2.301 |
| **Discharge ($m^3/s$)** | 0.282 |
| **Pressure Transducer Reading (m)** | 0.335 |
| **Pressure Transducer Elevation (m)** | -2.636 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 8:10 | **End** | 8:35 | **Location** | 5 m u/s of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flomate | | | |
| **Flow Meter Type** | Electromagnetic | | | **Instrument Serial #** | | 12921 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.336 | **Time** | 8:10 | | | | |
| | **End** | **Reading** | 0.335 | **Time** | 8:35 | | | | |

| | **Station** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **20%** | **80%** | **($m^3/s$)** | **%** |
| RB | 4.00 | 0.00 | 0.0 | 0.02 | 0 | | | 0.000 | 0.0 |
| | 4.20 | 0.18 | 0.2 | 0.03 | 0.16 | | | 0.004 | 960.0 |
| | 4.30 | 0.62 | 0.1 | 0.08 | 0.11 | | | 0.009 | 1894.4 |
| | 4.45 | 0.68 | 0.2 | 0.10 | 0.38 | | | 0.039 | 8613.3 |
| | 4.60 | 0.60 | 0.1 | 0.09 | 0.44 | | | 0.040 | 8800.0 |
| | 4.75 | 0.50 | 0.2 | 0.08 | 0.39 | | | 0.029 | 6500.0 |
| | 4.90 | 0.50 | 0.2 | 0.08 | 0.25 | | | 0.019 | 4166.7 |
| | 5.05 | 0.46 | 0.1 | 0.07 | 0.24 | | | 0.017 | 3680.0 |
| | 5.20 | 0.52 | 0.2 | 0.08 | 0.25 | | | 0.020 | 4333.3 |
| | 5.35 | 0.52 | 0.1 | 0.08 | 0.27 | | | 0.021 | 4680.0 |
| | 5.50 | 0.44 | 0.2 | 0.07 | 0.24 | | | 0.016 | 3520.0 |
| | 5.65 | 0.42 | 0.2 | 0.06 | 0.25 | | | 0.016 | 3500.0 |
| | 5.80 | 0.40 | 0.1 | 0.06 | 0.17 | | | 0.010 | 2266.7 |
| | 5.95 | 0.31 | 0.2 | 0.05 | 0.24 | | | 0.011 | 2480.0 |
| | 6.10 | 0.27 | 0.1 | 0.04 | 0.24 | | | 0.010 | 2160.0 |
| | 6.25 | 0.25 | 0.2 | 0.04 | 0.23 | | | 0.009 | 1916.7 |
| | 6.40 | 0.20 | 0.2 | 0.03 | 0.19 | | | 0.006 | 1266.7 |
| | 6.55 | 0.14 | 0.1 | 0.02 | 0.23 | | | 0.005 | 1073.3 |
| | 6.70 | 0.10 | 0.2 | 0.02 | 0.16 | | | 0.002 | 533.3 |
| | 6.85 | 0.08 | 0.1 | 0.01 | 0.09 | | | 0.001 | 240.0 |
| | 7.00 | 0.06 | 0.2 | 0.02 | 0.02 | | | 0.000 | 86.7 |
| LB | 7.50 | 0.00 | 0.5 | 0.00 | 0 | | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.282** | **62671.1** |

| General Notes |
|---|
| WL and PT surveyed during cross-section survey. TBM used during WL survey reference in BM survey. |

## Appendix 2-7b. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH7 | | | |
| **Stream Name** | Mile 19 Creek | | | |
| **Date Monitored** | 8-Oct-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 13:00 | **End Time:** | 14:30 |
| **Personnel** | Eli Heyman, Jem Morrison | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | Cloudy, recent rain | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 21235028 |
| **Gain** | 0.000222 | **Offset** | -0.867 |
| **Status** | Active | **Battery** | 11.7V |
| **# of Records** | 22874 | **Memory Free** | 107793 |
| **Manual Gauge** | No | **Crest Gauges** | No |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 21 | 1.162 | 101.162 | | 100.000 | |
| BM 22 | | | 0.713 | 100.507 | |
| BM 23 | | | 0.463 | 100.757 | |
| PT | | | 4.610 | 96.610 | pt depth = 0.185 |
| WL | | | 4.423 | **96.797** | |
| TBM | 2.028 | 101.175 | 2.073 | 99.147 | |
| WL | | | 4.378 | **96.805** | |
| PT | | | 4.561 | 96.622 | |
| BM 23 | | | 0.418 | 100.765 | |
| BM 22 | | | 0.667 | 100.516 | |
| BM 21 | | | 1.115 | 100.068 | |

| BM# | Established Elevation (m) | Mean Elevation (this date) (m) | Difference (m) | Notes |
|---|---|---|---|---|
| BM 22 | 100.45 | 100.512 | 0.062 | |
| BM 23 | 100.7 | 100.761 | 0.061 | |
| PT | 96.561 | 96.616 | 0.055 | |

| Summary | |
|---|---|
| **Stage (m)** | 96.801 |
| **Discharge ($m^3/s$)** | 0.052 |
| **Pressure Transducer Reading (m)** | 0.241 |
| **Pressure Transducer Elevation (m)** | 96.560 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 13:10 | **End** | 13:30 | **Location** | 8m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | | | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 6592 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.241 | **Time** | 13:10 | | | | |
| | **End** | **Reading** | 0.241 | **Time** | 13:30 | | | | |

| | Station | Depth | Depth | Distance | Area | Velocity (m/s) | | Q | % of Total Q |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | (m) | (ft) | (m) | (m) | ($m^2$) | 60% | 80% | ($m^3/s$) | % |
| LB | 0.40 | 0.00 | 0.00 | 0.0 | 0.00 | 0 | | 0.000 | 0.0 |
| | 0.45 | 0.20 | 0.06 | 0.1 | 0.01 | -0.02 | | 0.000 | -27.1 |
| | 0.60 | 0.25 | 0.08 | 0.2 | 0.01 | -0.01 | | 0.000 | -29.6 |
| | 0.80 | 0.38 | 0.12 | 0.2 | 0.03 | 0 | | 0.000 | 0.0 |
| | 1.05 | 0.38 | 0.12 | 0.3 | 0.03 | 0 | | 0.000 | 0.0 |
| | 1.30 | 0.50 | 0.15 | 0.3 | 0.04 | 0.01 | | 0.000 | 84.7 |
| | 1.55 | 0.53 | 0.16 | 0.3 | 0.03 | 0.03 | | 0.001 | 215.4 |
| | 1.70 | 0.60 | 0.18 | 0.2 | 0.03 | 0.06 | | 0.002 | 365.8 |
| | 1.85 | 0.70 | 0.21 | 0.2 | 0.03 | 0.07 | | 0.002 | 497.8 |
| | 2.00 | 0.81 | 0.25 | 0.2 | 0.04 | 0.09 | | 0.003 | 740.7 |
| | 2.15 | 0.70 | 0.21 | 0.2 | 0.03 | 0.12 | | 0.004 | 853.4 |
| | 2.30 | 0.80 | 0.24 | 0.2 | 0.04 | 0.13 | | 0.005 | 1056.6 |
| | 2.45 | 0.81 | 0.25 | 0.2 | 0.04 | 0.14 | | 0.005 | 1152.1 |
| | 2.60 | 0.90 | 0.27 | 0.2 | 0.04 | 0.17 | | 0.007 | 1554.5 |
| | 2.75 | 0.60 | 0.18 | 0.2 | 0.03 | 0.21 | | 0.006 | 1280.2 |
| | 2.90 | 0.41 | 0.12 | 0.2 | 0.02 | 0.21 | | 0.003 | 729.0 |
| | 3.00 | 0.70 | 0.21 | 0.1 | 0.02 | 0.17 | | 0.004 | 806.0 |
| | 3.10 | 0.70 | 0.21 | 0.1 | 0.02 | 0.21 | | 0.004 | 995.7 |
| | 3.20 | 0.40 | 0.12 | 0.1 | 0.01 | 0.13 | | 0.002 | 352.2 |
| | 3.30 | 0.35 | 0.11 | 0.1 | 0.01 | 0.1 | | 0.001 | 296.3 |
| | 3.45 | 0.40 | 0.12 | 0.2 | 0.02 | 0.12 | | 0.002 | 487.7 |
| | 3.60 | 0.30 | 0.09 | 0.2 | 0.01 | 0.05 | | 0.001 | 127.0 |
| | 3.70 | 0.15 | 0.05 | 0.1 | 0.00 | 0.01 | | 0.000 | 10.2 |
| RB | 3.80 | 0.00 | 0.00 | 0.1 | 0.00 | 0 | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.052** | **11548.5** |

| General Notes |
|---|
| |

## Appendix 2-7b. Manual Discharge Measurements and Levelling Surveys at MH-7 in 2013

| Site Information | | | | |
|---|---|---|---|---|
| **Project Name** | Murray River | | | |
| **Station Identification** | MH7 | | | |
| **Stream Name** | Mile 19 Creek | | | |
| **Date Monitored** | 7-Nov-13 | | | |
| **Time at Site (24 hr)** | **Start Time:** | 12:00 | **End Time:** | 14:00 |
| **Personnel** | Eli Heyman, Tyler Gale | | | |
| **Station Cordinates** | Easting | Northing | Elevation | |
| | 0625141 | 6097069 | 776 | |
| **Weather Conditions** | Cloudy -2C | | | |

| Transducer Information | | | |
|---|---|---|---|
| **PT Model** | PS9800 | **Serial #** | 21235028 |
| **Gain** | 0.000222 | **Offset** | -0.867 |
| **Status** | Active | **Battery** | 10.06V |
| **# of Records** | 4307 | **Memory Free** | 103470 |
| **Manual Gauge** | No | **Crest Gauges** | No |

| Hydrometric Leveling Survey | | | | | |
|---|---|---|---|---|---|
| **Stn** | **BS** | **HI** | **FS** | **Elevation** | **Notes** |
| BM 21 | 1.132 | 101.132 | | 100.000 | |
| BM 22 | | | 0.684 | 100.536 | |
| BM 23 | | | 0.435 | 100.785 | |
| BM 24 | | | 2.640 | 98.580 | |
| PT | | | 4.583 | 96.637 | pt depth = 0.142 |
| WL | | | 4.443 | **96.777** | ice |
| TBM | 1.214 | 101.183 | 1.251 | 99.969 | |
| WL | | | 4.405 | **-4.405** | |
| PT | | | 4.546 | -4.546 | |
| BM 24 | | | 2.604 | -2.604 | |
| BM 23 | | | 0.399 | -0.399 | |
| BM 22 | | | 0.648 | -0.648 | |
| BM 21 | | | 1.096 | -1.096 | |
| WL @ 12:00 | | | 4.407 | -4.407 | no ice |
| | | | | | |

| **BM#** | **Established Elevation (m)** | **Mean Elevation (this date) (m)** | **Difference (m)** | **Notes** |
|---|---|---|---|---|
| BM 22 | 100.45 | 49.944 | -50.506 | |
| BM 23 | 100.7 | 50.193 | -50.507 | |
| PT | 96.561 | 46.046 | -50.516 | |

| Summary | |
|---|---|
| **Stage (m)** | 46.186 |
| **Discharge ($m^3/s$)** | 0.018 |
| **Pressure Transducer Reading (m)** | 0.202 |
| **Pressure Transducer Elevation (m)** | 45.984 |

| Discharge Measurement - Mid-Section Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time (24 hr)** | **Start** | 12:29 | **End** | 12:58 | **Location** | 8m DS of PT | | | |
| **Method** | Velocity-area (Mid-section) | | | **Instrument Model** | | Flo-Mate 2000 | | | |
| **Flow Meter Type** | Flo-mate | | | **Instrument Serial #** | | 14614 | | | |
| **Stage (m)** | **Start** | **Reading** | 0.202 | **Time** | 12:29 | | | | |
| | **End** | **Reading** | 0.202 | **Time** | 12:58 | | | | |

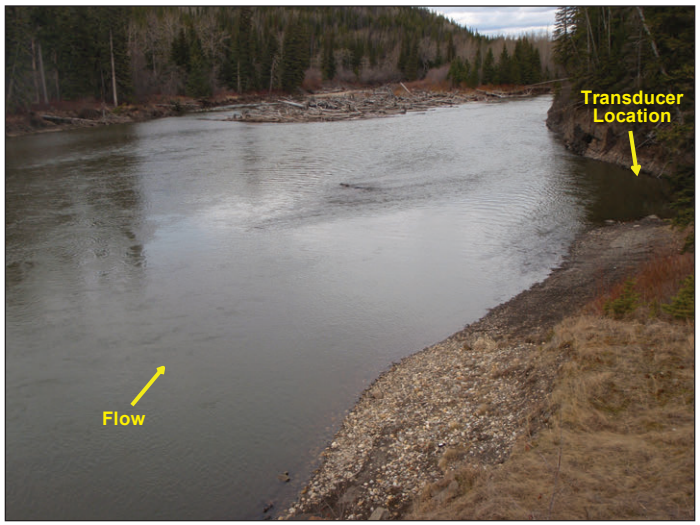
| | **Station** | **Depth** | **Depth** | **Distance** | **Area** | **Velocity (m/s)** | | **Q** | **% of Total Q** |
|---|---|---|---|---|---|---|---|---|---|
| **Notes** | **(m)** | **(ft)** | **(m)** | **(m)** | **($m^2$)** | **60%** | **80%** | **($m^3/s$)** | **%** |
| RB | 0.50 | 0.00 | 0.00 | 0.0 | 0.01 | 0 | | 0.000 | 0.0 |
| | 0.70 | 0.25 | 0.08 | 0.2 | 0.01 | 0.01 | | 0.000 | 29.6 |
| | 0.85 | 0.30 | 0.09 | 0.2 | 0.01 | 0.03 | | 0.000 | 91.4 |
| | 1.00 | 0.28 | 0.09 | 0.2 | 0.01 | 0.07 | | 0.001 | 199.1 |
| | 1.15 | 0.55 | 0.17 | 0.2 | 0.03 | 0.08 | | 0.002 | 447.0 |
| | 1.30 | 0.38 | 0.12 | 0.2 | 0.02 | 0.07 | | 0.001 | 270.3 |
| | 1.45 | 0.38 | 0.12 | 0.2 | 0.01 | 0.06 | | 0.001 | 154.4 |
| | 1.50 | 0.90 | 0.27 | 0.1 | 0.02 | 0.06 | | 0.001 | 274.3 |
| | 1.60 | 0.86 | 0.26 | 0.1 | 0.03 | 0.06 | | 0.002 | 349.5 |
| | 1.70 | 0.88 | 0.27 | 0.1 | 0.03 | 0.07 | | 0.002 | 417.2 |
| | 1.80 | 0.90 | 0.27 | 0.1 | 0.03 | 0.07 | | 0.002 | 426.7 |
| | 1.90 | 0.85 | 0.26 | 0.1 | 0.03 | 0.06 | | 0.002 | 345.4 |
| | 2.00 | 0.85 | 0.26 | 0.1 | 0.03 | 0.05 | | 0.001 | 287.9 |
| | 2.10 | 0.88 | 0.27 | 0.1 | 0.03 | 0.04 | | 0.001 | 238.4 |
| | 2.20 | 0.85 | 0.26 | 0.1 | 0.03 | 0.04 | | 0.001 | 230.3 |
| | 2.30 | 0.79 | 0.24 | 0.1 | 0.02 | 0.04 | | 0.001 | 214.0 |
| | 2.40 | 0.80 | 0.24 | 0.1 | 0.02 | 0.02 | | 0.000 | 108.4 |
| | 2.50 | 0.80 | 0.24 | 0.1 | 0.03 | 0.01 | | 0.000 | 67.7 |
| | 2.65 | 0.71 | 0.22 | 0.2 | 0.03 | 0 | | 0.000 | 0.0 |
| | 2.80 | 0.60 | 0.18 | 0.2 | 0.03 | 0 | | 0.000 | 0.0 |
| | 3.00 | 0.54 | 0.16 | 0.2 | 0.03 | 0 | | 0.000 | 0.0 |
| | 3.20 | 0.50 | 0.15 | 0.2 | 0.03 | -0.01 | | 0.000 | -67.7 |
| | 3.40 | 0.48 | 0.15 | 0.2 | 0.03 | -0.01 | | 0.000 | -56.9 |
| | 3.55 | 0.50 | 0.15 | 0.2 | 0.02 | -0.02 | | 0.000 | -67.7 |
| LB | 3.60 | 0.00 | 0.0 | 0.1 | 0.00 | 0 | | 0.000 | 0.0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total Q** | | | | | | | | **0.018** | **3959.5** |

| General Notes |
|---|
| |

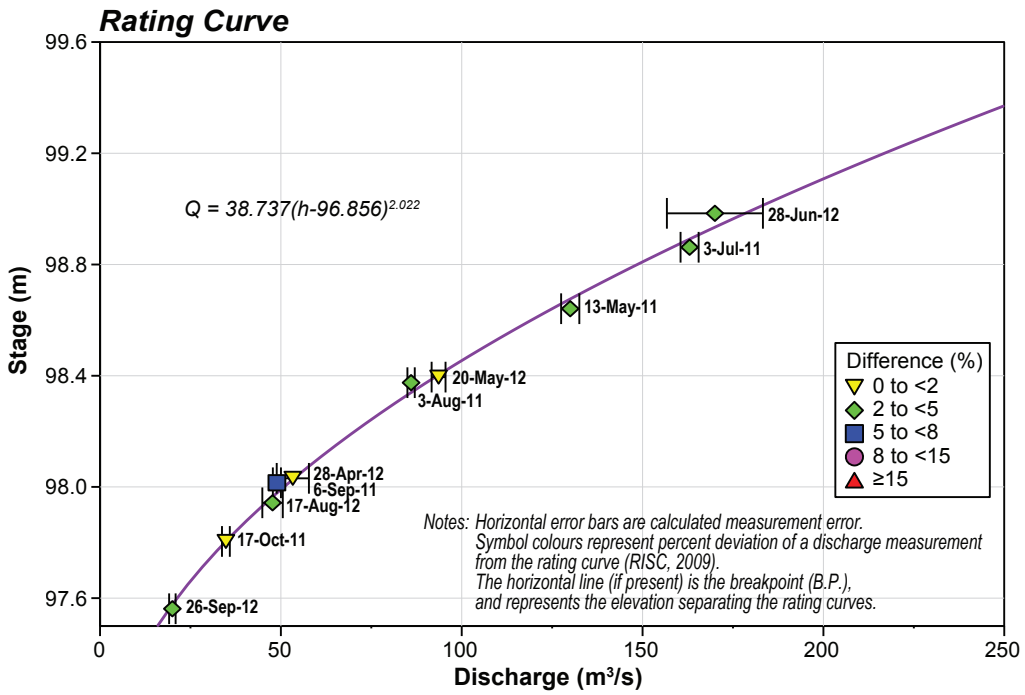
# Appendix 3

## Rating Curves and Cross-sections

ERM




Downstream view of the flow gauging section at MH-1 on the Murray River during moderate flow conditions. The pressure transducer is located in a pool on the right bank downstream of the Murray River FSR bridge crossing. The ADCP flow gauging section is located upstream of the bridge. Photograph taken April 29, 2012 from the Murray River FSR bridge.



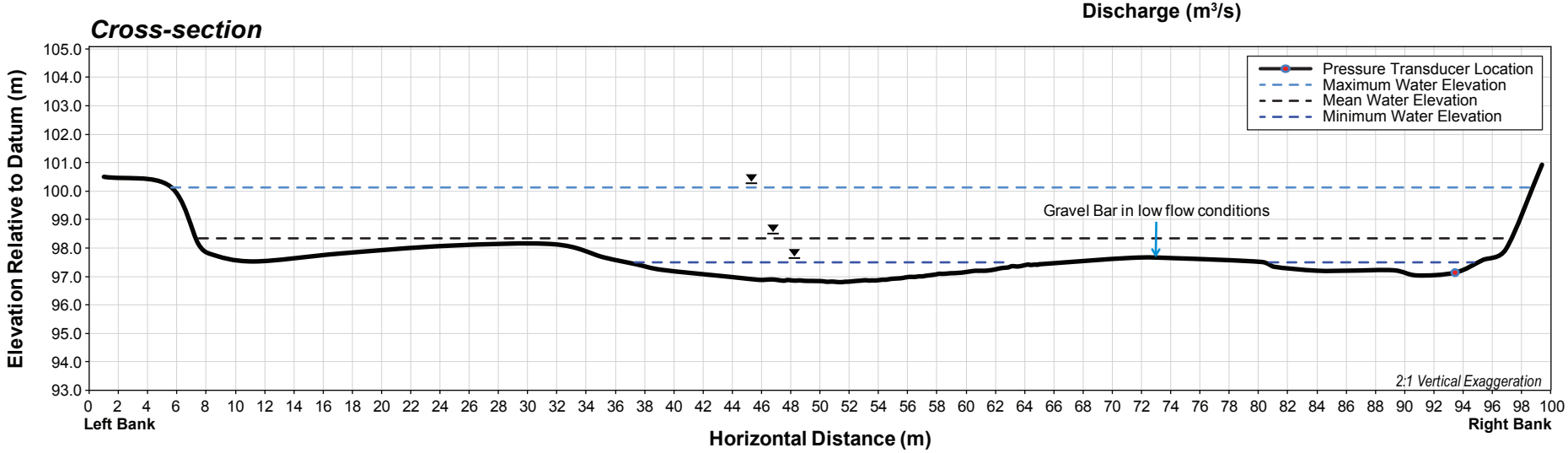




Figure A3-1

MURRAY RIVER COAL PROJECT

# MH-1 Stage-Discharge Rating Curve and Cross-Section (Rating Period May 13, 2011 to September 26, 2012 )

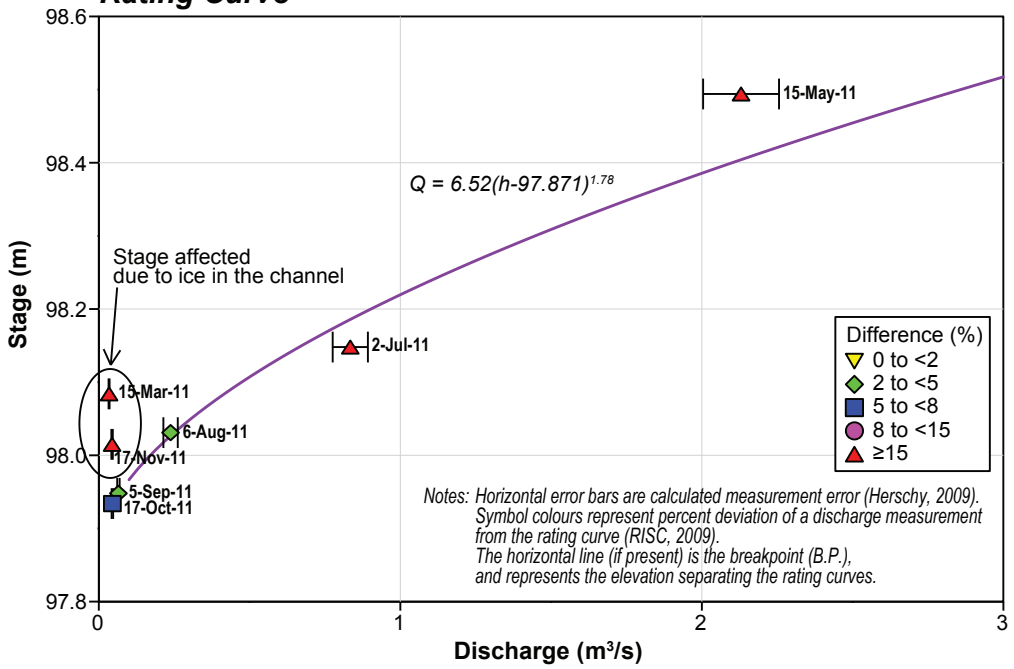
Figure A3-1

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A low angle view facing downstream and east towards the hydrometric station. Note the right bank failure that occurred during peak flows in May 2011 and the fallen trees on the left side of the channel that were the result ofthe bank failure. Photo taken August 6, 2011.

## Rating Curve




## Cross-section

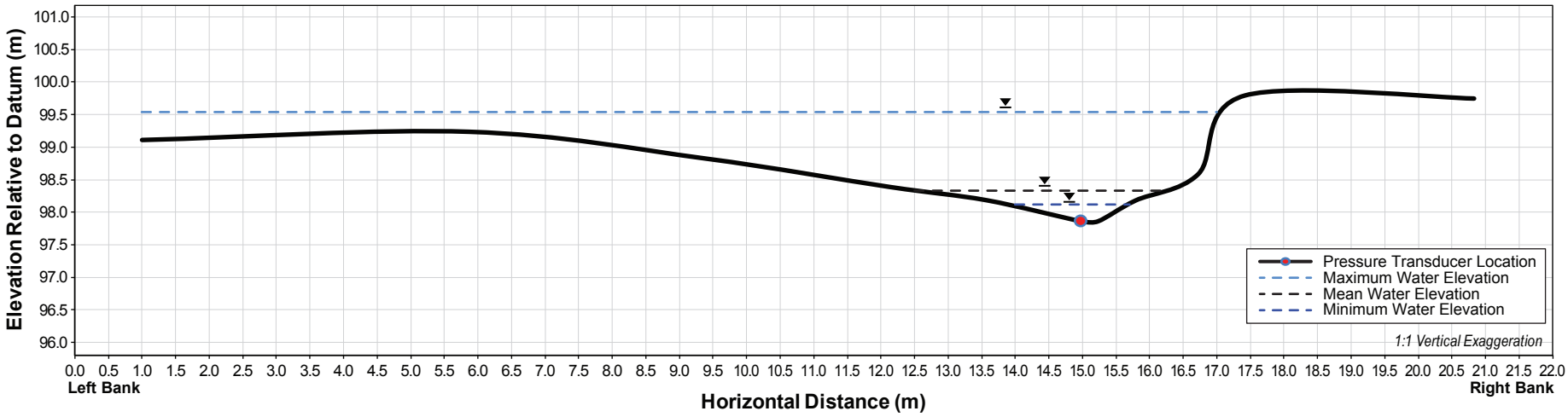



Figure A3-2

hd Mining | MURRAY RIVER COAL PROJECT

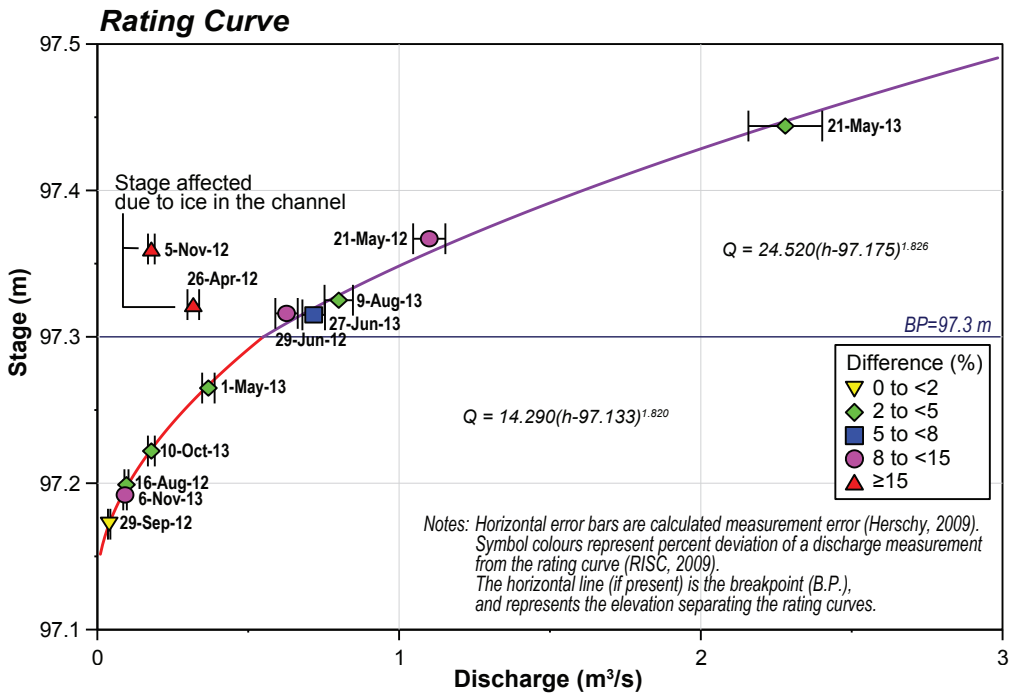
# MH-2 Stage-Discharge Rating Curve and Cross-Section (Rating Period March 15, 2011 to November 17, 2011)

Figure A3-2

Rescan Engineers & Scientists




*Low angle upstream view of the hydrometric station during moderate flow conditions. The transducer is located in a Photograph taken June 27, 2013.*



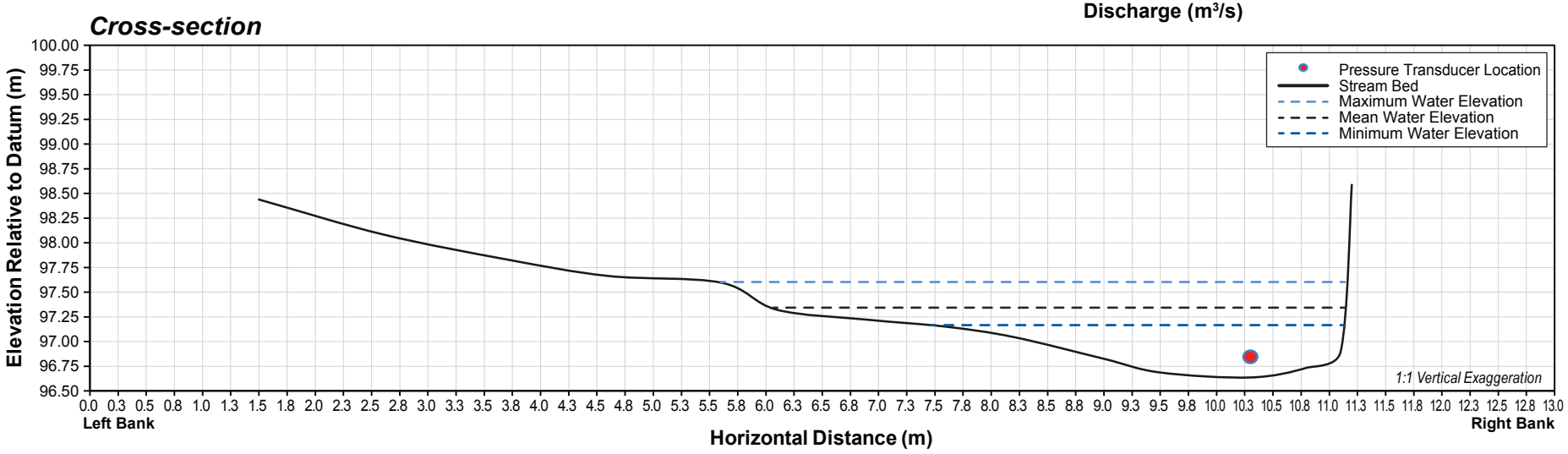
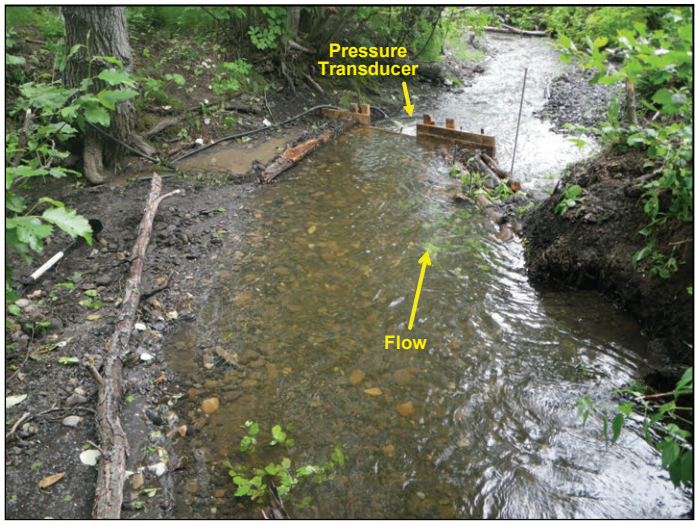




Figure A3-3

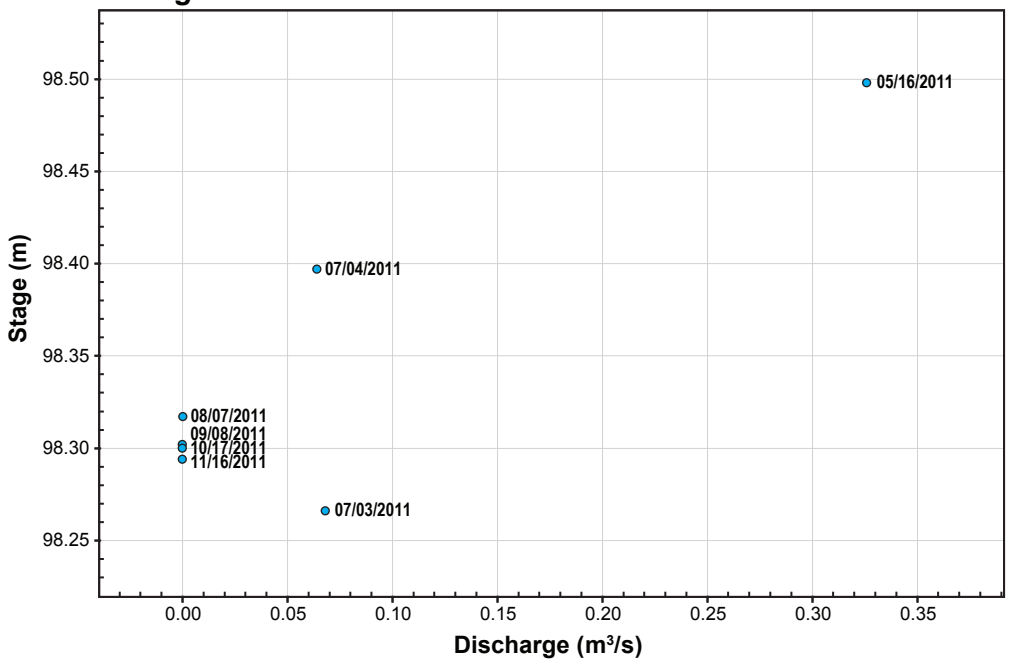
# MH-2 Stage-Discharge Rating Curve and Cross-Section (Rating Period April 26, 2012 to October 27, 2013)

Figure A3-3




Upstream view of MH-3 (2011) near the outflow of Twenty Creek into the Murray River. The pressure transducer was Downstream of a weir installed at the beginning of the 2011 field season. The station was moved for 2012 due to unreliable data collected at the 2011 location. Photograph taken July 3 2011.

## Rating Curve




## Cross-section

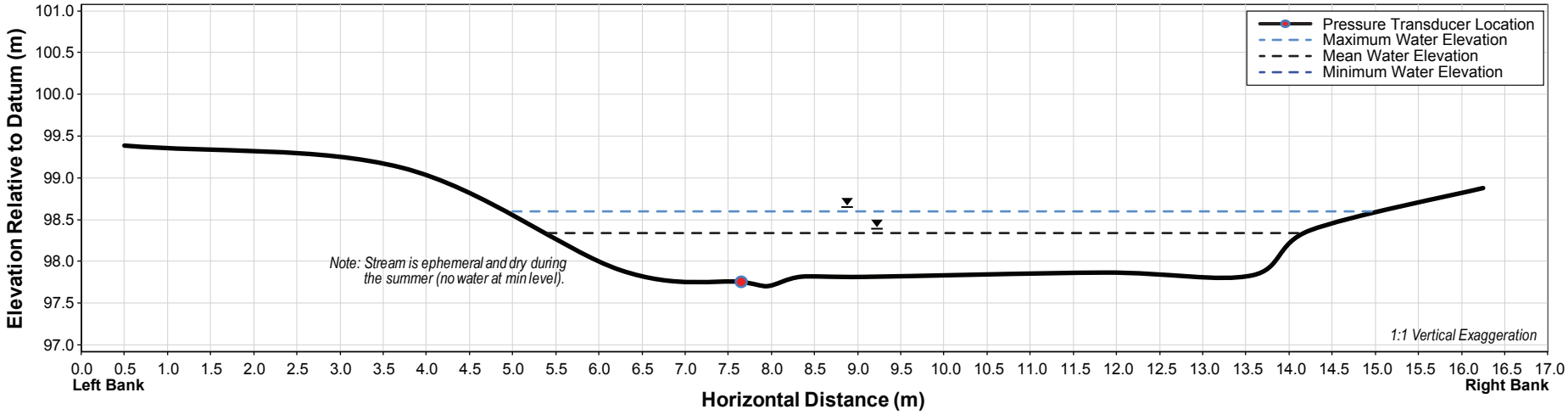



Figure A3-4

hd Mining | MURRAY RIVER COAL PROJECT

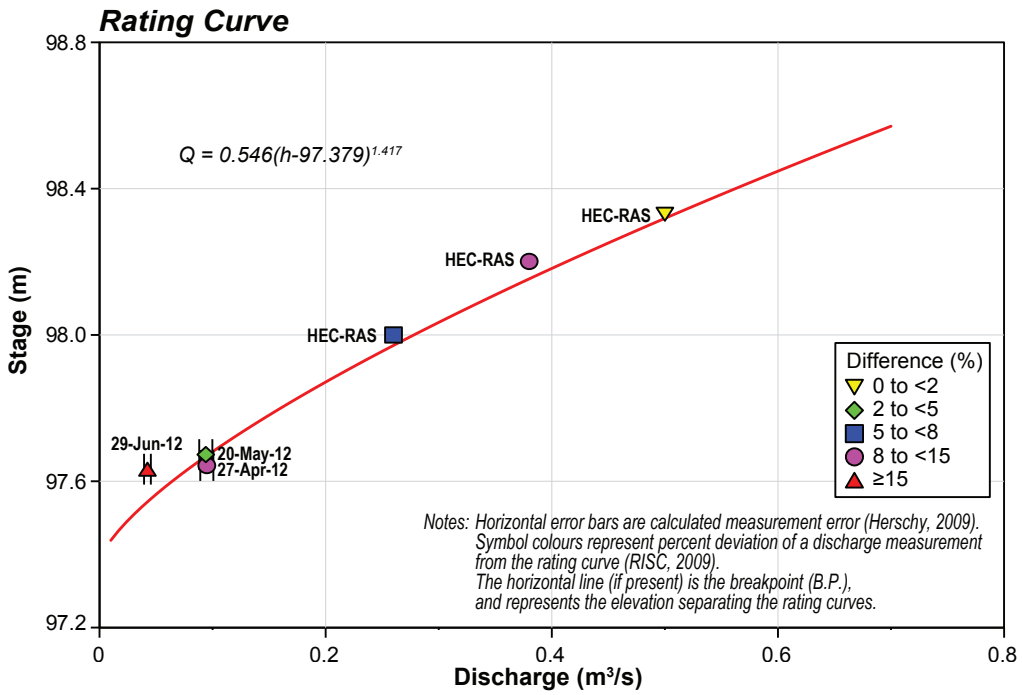
# MH-3 Stage-Discharge Rating Curve and Cross-Section (Rating Period May 16, 2011 to November 16, 2011)

Figure A3-4

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Low angle oblique view of the hydrometric station on Twenty Creek. The flow gauging section is indicated by the measuring tape and the transducer is in a pool created by a tree root upstream. This creek is ephemeral and dries up during the summer. Photograph taken May 20, 2012.



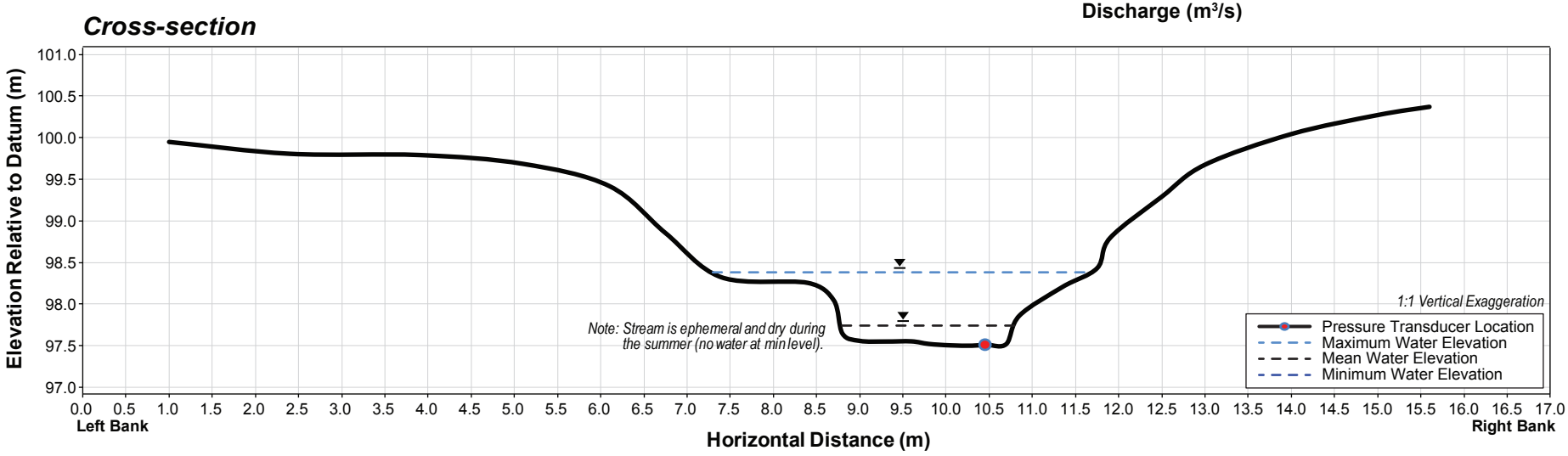



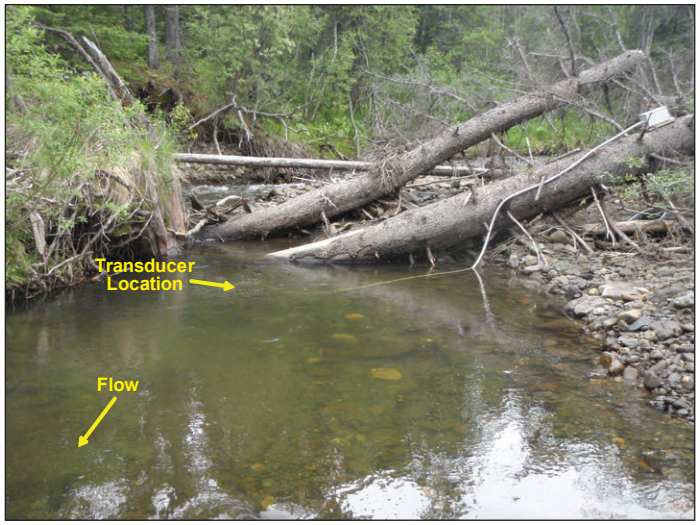

Figure A3-5

MURRAY RIVER COAL PROJECT

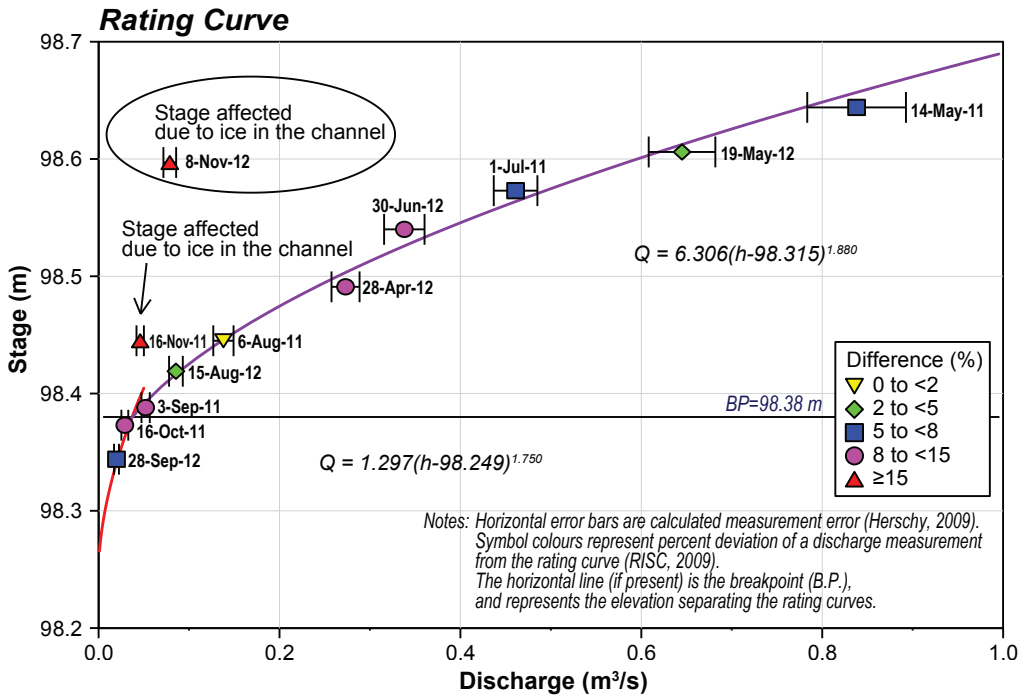
# MH-3 Stage-Discharge Rating Curve and Cross-Section (Rating Period April 27, 2012 to November 5, 2012)

Figure A3-5

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Upstream view of the flow gauging section at MH-4 on Upper Camp Creek. The station can be seen on the fallen tree on the left bank with the flow gauging located a few metres downstream of the transducer location (out of frame). The fallen trees upstream have resulted in a scoured pool where the transducer is located. Photograph taken June 30, 2012.



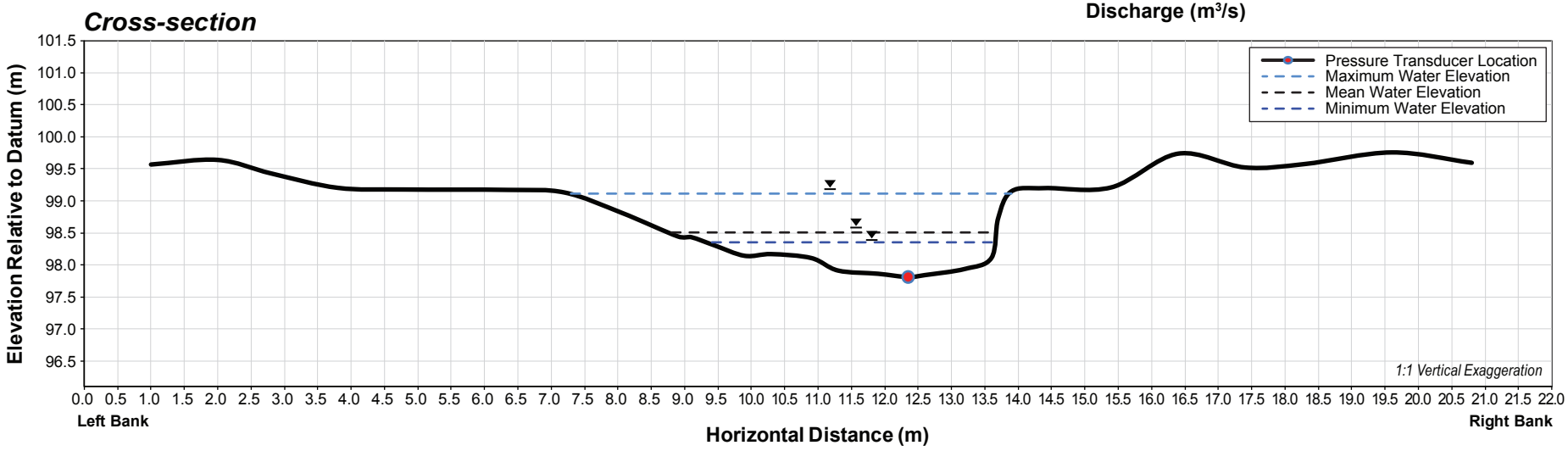
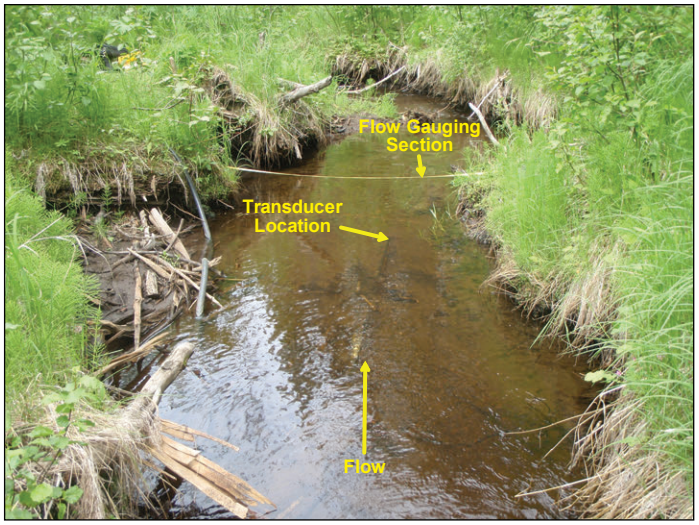



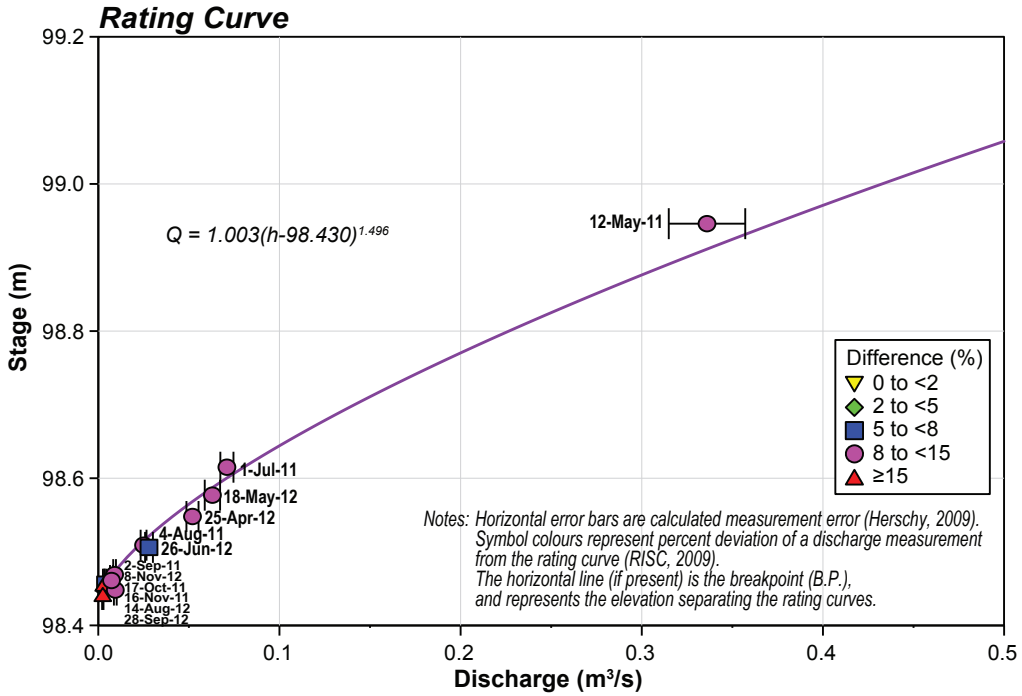

Figure A3-6

# MH-4 Stage-Discharge Rating Curve and Cross-Section (Rating Period May 14, 2011 to November 8, 2012)

Figure A3-6




Downstream view of the monitored reach at MH-5 on Mast Creek under moderate flow conditions. The flow gauging sectionis indicated by the measuring tape downstream of the the transducer location. Note the large amount of vegetation on the banks and the small grain sizes on the stream bed which result from the relative low energy of the stream. Photograph taken June 26, 2012.



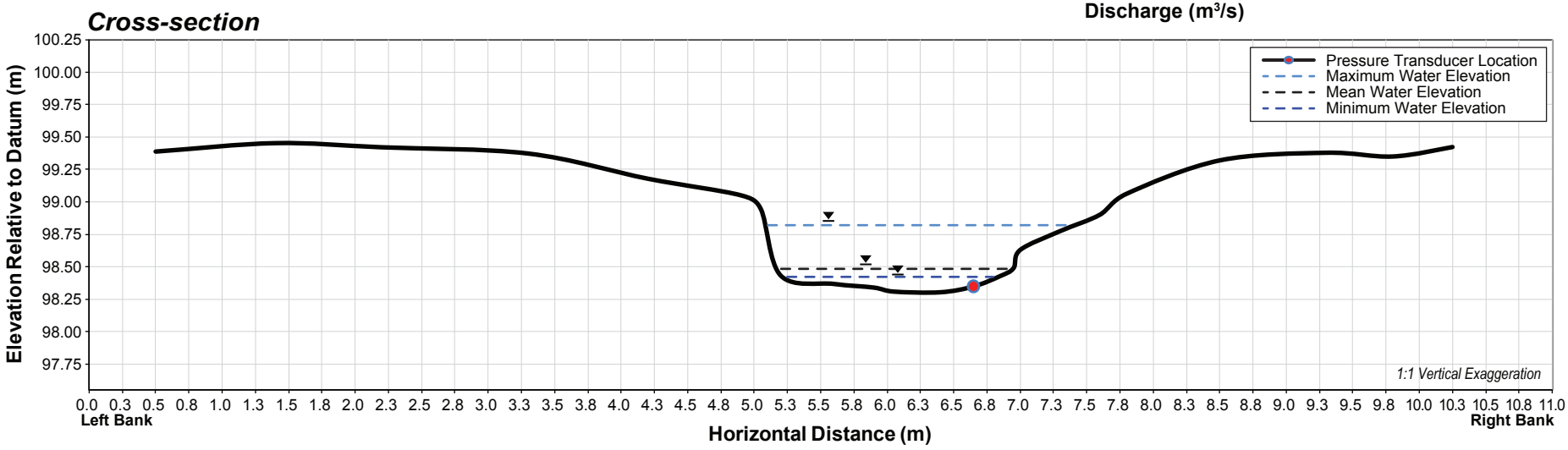



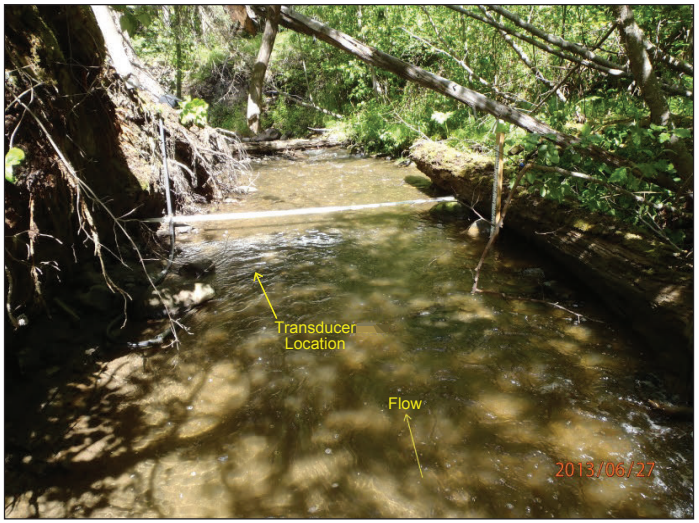

Figure A3-7

hd Mining | MURRAY RIVER COAL PROJECT

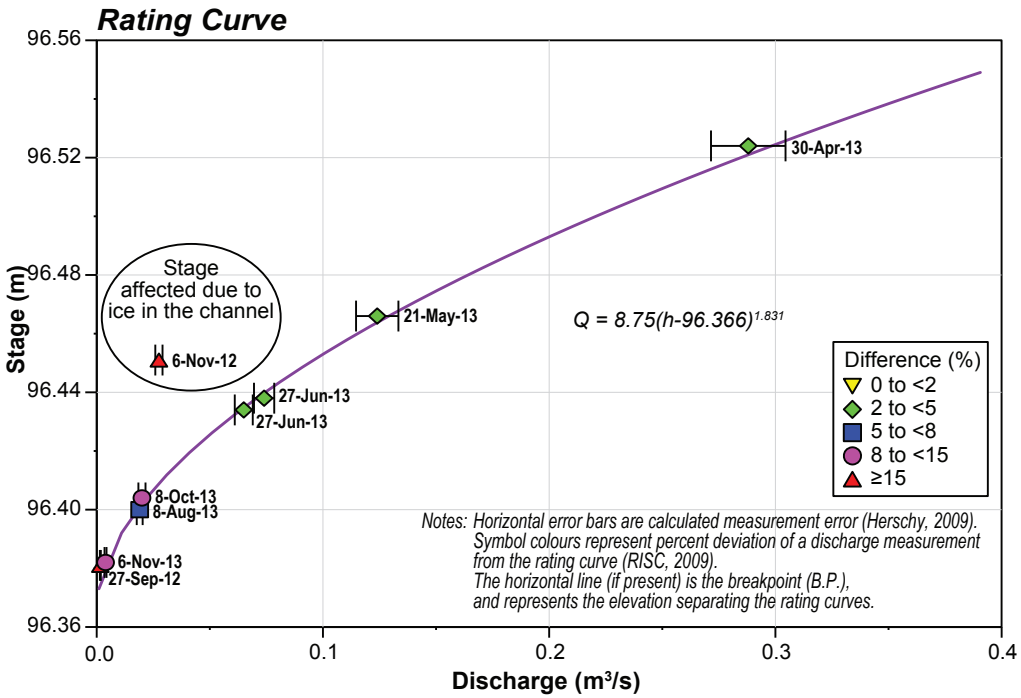
# MH-5 Stage-Discharge Rating Curve and Cross-Section (Rating Period April 28, 2011 to November 8, 2012)

Figure A3-7

Rescan Engineers & Scientists




Downstream view of the monitored reach at MH-6. Photograph taken June 27, 2013.



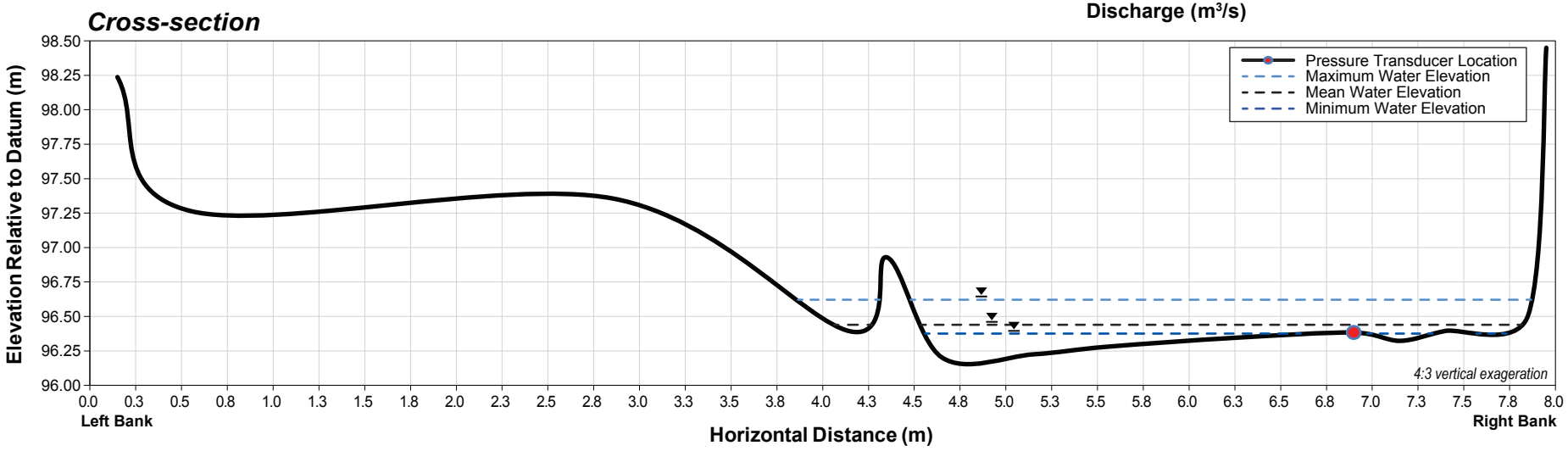



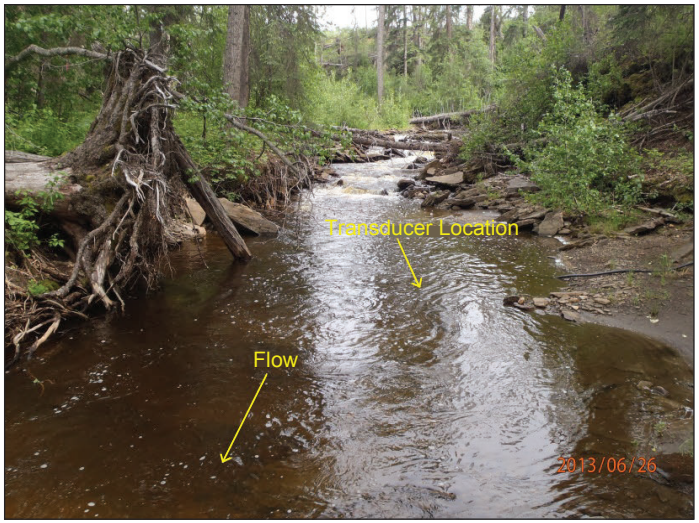

Figure A3-8

hd Mining | MURRAY RIVER COAL PROJECT

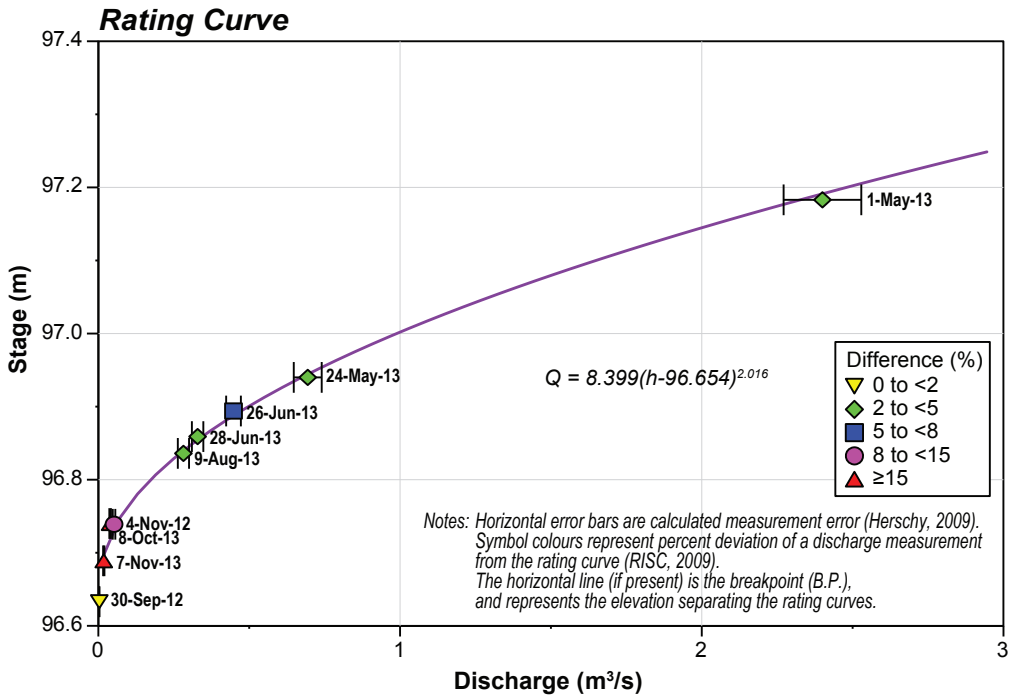
# MH-6 Stage-Discharge Rating Curve and Cross-Section (Rating Period September 27, 2013 to November 6, 2013)

Figure A3-8

Rescan Engineers & Scientists




Upstream view of the monitored reach at MH-7. Photograph taken June 26, 2013.



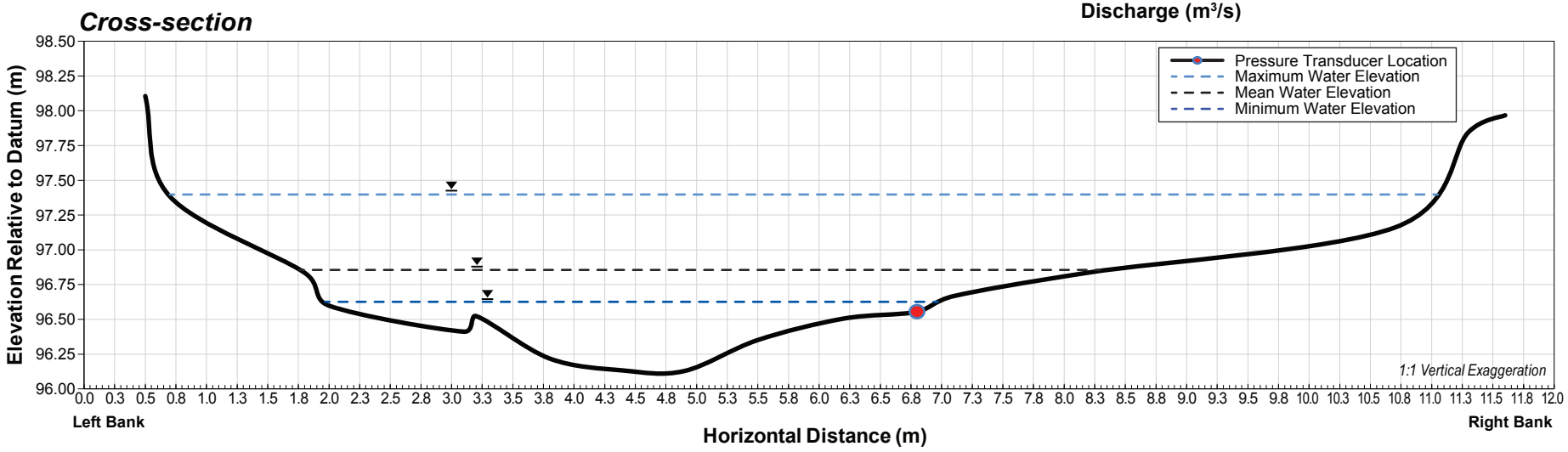




Figure A3-9

# MH-7 Stage-Discharge Rating Curve and Cross-Section (Rating Period September 27, 2013 to November 7, 2013 )

Figure A3-9

# Appendix 4
## Daily Discharge Tables

ERM

**Appendix 4-1a. 2011 Summary of Daily Discharge [Q] at Hydrometric Station MH-1 ($m^3/s$)**

| 2011 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *11.019* | *9.352* | *8.130* | *6.963* | 20.787 | 267.480 | 180.477 | 106.015 | 49.227 | 64.195 | 28.541 | *21.574* |
| 2 | *10.926* | *9.352* | *8.083* | *6.981* | 22.439 | 268.074 | 146.755 | 93.139 | 54.876 | 57.608 | 27.091 | *21.481* |
| 3 | *10.926* | *9.259* | *8.046* | *6.991* | 24.563 | 298.042 | 146.536 | 81.386 | 56.225 | 53.306 | 25.988 | *21.481* |
| 4 | *10.833* | *9.241* | *8.000* | *7.000* | 27.718 | 258.543 | 150.042 | 73.760 | 51.357 | 52.617 | *25.926* | *21.389* |
| 5 | *10.741* | *9.194* | *7.963* | *7.009* | 29.303 | 222.428 | 132.035 | 68.466 | 48.444 | 50.484 | *25.741* | *21.296* |
| 6 | *10.741* | *9.148* | *7.917* | *7.028* | 33.522 | 222.512 | 121.344 | 65.503 | 46.867 | 46.900 | *25.556* | *21.296* |
| 7 | *10.648* | *9.102* | *7.880* | *7.037* | 39.696 | 231.840 | 115.283 | 62.368 | 45.434 | 43.609 | *25.370* | *21.204* |
| 8 | *10.648* | *9.056* | *7.843* | *7.065* | 44.198 | 231.850 | 155.206 | 58.433 | 44.585 | 40.657 | *25.185* | *21.111* |
| 9 | *10.556* | *9.009* | *7.796* | *7.120* | 51.705 | 223.197 | 369.472 | 55.396 | 43.308 | 39.446 | *25.000* | *21.019* |
| 10 | *10.463* | *8.963* | *7.759* | *7.167* | 63.032 | 232.997 | 411.994 | 53.023 | 41.748 | 38.695 | *24.815* | *20.926* |
| 11 | *10.463* | *8.917* | *7.722* | *7.213* | 83.748 | 227.587 | 296.482 | 50.635 | 39.581 | 36.296 | *24.630* | *20.833* |
| 12 | *10.370* | *8.870* | *7.676* | *7.259* | 109.934 | 204.134 | 219.486 | 48.170 | 36.185 | 37.663 | *24.444* | *20.741* |
| 13 | *10.370* | *8.824* | *7.639* | *7.315* | 118.180 | 194.809 | 209.997 | 45.630 | 32.829 | 40.272 | *24.259* | *20.648* |
| 14 | *10.278* | *8.778* | *7.602* | *7.444* | 112.824 | 195.823 | 219.728 | 44.293 | 30.481 | 37.432 | *24.074* | *20.556* |
| 15 | *10.278* | *8.731* | *7.565* | *7.630* | 128.427 | 200.052 | 195.192 | 43.224 | 29.049 | 35.093 | *23.889* | *20.463* |
| 16 | *10.185* | *8.685* | *7.519* | *7.806* | 165.773 | 207.475 | 185.834 | 40.674 | 28.934 | 33.092 | *23.704* | *20.370* |
| 17 | *10.093* | *8.639* | *7.481* | *7.981* | 233.010 | 226.777 | 166.449 | 38.277 | 31.813 | 31.519 | *23.519* | *20.278* |
| 18 | *10.093* | *8.602* | *7.444* | *8.167* | 270.579 | 233.707 | 149.192 | 40.747 | 30.761 | 31.904 | *23.333* | *20.185* |
| 19 | *10.000* | *8.556* | *7.407* | *8.472* | 226.438 | 231.044 | 135.932 | 39.743 | 28.968 | 33.530 | *23.148* | *20.093* |
| 20 | *10.000* | *8.509* | *7.370* | *8.796* | 198.767 | 255.335 | 126.887 | 36.781 | 27.563 | 36.183 | *23.056* | *20.000* |
| 21 | *9.907* | *8.463* | *7.333* | *9.120* | 241.579 | 238.237 | 122.636 | 37.013 | 25.862 | 35.689 | *22.870* | *19.907* |
| 22 | *9.907* | *8.426* | *7.296* | *9.444* | 292.509 | 208.793 | 127.799 | 59.480 | 40.844 | 35.200 | *22.685* | *19.815* |
| 23 | *9.815* | *8.380* | *7.259* | *10.093* | 365.649 | 197.006 | 114.333 | 145.922 | 81.295 | 34.561 | *22.500* | *19.722* |
| 24 | *9.815* | *8.333* | *7.222* | *11.019* | 351.503 | 197.684 | 103.013 | 125.211 | 201.131 | 33.238 | *22.315* | *19.630* |
| 25 | *9.722* | *8.296* | *7.185* | *12.407* | 258.095 | 209.106 | 100.254 | 95.492 | 168.001 | 31.616 | *22.130* | *19.537* |
| 26 | *9.722* | *8.250* | *7.148* | *13.796* | 213.391 | 180.359 | 98.114 | 74.279 | 136.637 | 30.298 | *22.037* | *19.444* |
| 27 | *9.630* | *8.213* | *7.111* | 15.989 | 216.142 | 170.476 | 93.600 | 60.831 | 111.722 | 29.358 | *21.852* | *19.444* |
| 28 | *9.537* | *8.167* | *7.074* | 16.919 | 248.962 | 169.200 | 86.737 | 53.453 | 95.883 | 28.266 | *21.759* | *19.352* |
| 29 | *9.537* | | *7.037* | 18.177 | 255.577 | 193.214 | 87.352 | 53.467 | 81.397 | 28.121 | *21.759* | *19.259* |
| 30 | *9.444* | | *7.000* | 19.943 | 270.369 | 213.863 | 92.613 | 61.279 | 70.154 | 28.820 | *21.667* | *19.167* |
| 31 | *9.444* | | *6.963* | | 285.610 | | 110.408 | 55.198 | | 29.880 | | *19.167* |
| **Mean** | **10.197** | **8.761** | **7.531** | **9.512** | **161.420** | **220.388** | **160.361** | **63.461** | **60.372** | **38.244** | **23.961** | **20.367** |
| **Max** | **11.019** | **9.352** | **8.130** | **19.943** | **365.649** | **298.042** | **411.994** | **145.922** | **201.131** | **64.195** | **28.541** | **21.574** |
| **Min** | **9.444** | **8.167** | **6.963** | **6.963** | **20.787** | **169.200** | **86.737** | **36.781** | **25.862** | **28.121** | **21.667** | **19.167** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-1b. 2012 Summary of Daily Discharge [Q] at Hydrometric Station MH-1 ($m^3/s$)**

| 2012 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *20.600* | *17.500* | *12.800* | *54.400* | 67.309 | 208.062 | 191.060 | 74.198 | 31.564 | 22.102 | 27.090 | *18.642* |
| 2 | *20.500* | *17.300* | *12.600* | *52.900* | 70.779 | 234.055 | 184.739 | 71.056 | 28.949 | 85.429 | 27.659 | *18.424* |
| 3 | *20.500* | *17.100* | *12.500* | *54.100* | 72.312 | 231.392 | 173.602 | 66.955 | 27.393 | 77.426 | 24.423 | *18.207* |
| 4 | *20.400* | *16.900* | *12.300* | *53.600* | 74.763 | 200.797 | 175.793 | 65.153 | 27.086 | 54.933 | 25.552 | *17.989* |
| 5 | *20.300* | *16.700* | *12.200* | *51.000* | 80.494 | 200.252 | 178.431 | 71.492 | 26.908 | 43.413 | 53.575 | *17.772* |
| 6 | *20.300* | *16.600* | *12.100* | *49.800* | 75.350 | *282.565* | 162.838 | 73.211 | 26.856 | 36.782 | 110.694 | *17.554* |
| 7 | *20.200* | *16.400* | *11.900* | *48.900* | 77.115 | *404.651* | 154.519 | 70.000 | 26.654 | 33.457 | 86.840 | *17.337* |
| 8 | *20.200* | *16.200* | *11.800* | *47.100* | 98.583 | *374.876* | 156.155 | 65.354 | 27.233 | 32.029 | *55.633* | *17.119* |
| 9 | *20.100* | *16.100* | *11.600* | *45.200* | 116.041 | *294.435* | 160.972 | 64.623 | 27.634 | 30.193 | *44.529* | *16.902* |
| 10 | *20.000* | *15.900* | *11.500* | *43.800* | 107.865 | *269.115* | 167.659 | 61.105 | 30.875 | 28.160 | *35.641* | *16.684* |
| 11 | *19.800* | *15.700* | *11.400* | *43.000* | 93.554 | *277.475* | 171.626 | 55.160 | 34.199 | 25.817 | *28.527* | *16.467* |
| 12 | *19.700* | *15.500* | *11.200* | *44.900* | 83.494 | *293.571* | 161.677 | 49.508 | 30.947 | 24.514 | *22.833* | *16.249* |
| 13 | *19.600* | *15.400* | *11.100* | *48.800* | 87.350 | *300.658* | 144.852 | 45.556 | 27.239 | 29.939 | *22.478* | *16.032* |
| 14 | *19.500* | *15.200* | *11.000* | *48.800* | 105.715 | *278.134* | 134.269 | 47.408 | 24.844 | 55.830 | *22.795* | *15.814* |
| 15 | *19.400* | *15.000* | *10.800* | *42.000* | 127.337 | 228.213 | 133.344 | 57.190 | 24.425 | 83.636 | *23.558* | *15.597* |
| 16 | *19.200* | *14.900* | *10.700* | *18.200* | 149.507 | 197.827 | 136.638 | 52.121 | 23.421 | 80.006 | *23.458* | *15.379* |
| 17 | *19.100* | *14.700* | *10.600* | *17.000* | 139.959 | *274.308* | 138.353 | 46.187 | 21.674 | 64.776 | *21.608* | *15.162* |
| 18 | *19.000* | *14.500* | *10.400* | *16.800* | 121.153 | *326.582* | 137.707 | 43.428 | 20.377 | 52.894 | *21.469* | *14.944* |
| 19 | *18.900* | *14.400* | *10.300* | *17.100* | 104.156 | *300.827* | 128.600 | 43.177 | 19.417 | 48.249 | *21.252* | *14.727* |
| 20 | *18.800* | *14.200* | *10.200* | *19.100* | 92.561 | *261.341* | 115.657 | 43.349 | 19.179 | 45.048 | *21.034* | *14.509* |
| 21 | *18.700* | *14.100* | *10.000* | *23.753* | 93.006 | 248.377 | 118.869 | 43.650 | 19.425 | 38.891 | *20.817* | *14.292* |
| 22 | *18.600* | *13.900* | *35.000* | *25.645* | 112.337 | 251.265 | 120.045 | 46.273 | 20.121 | 33.939 | *20.599* | *14.074* |
| 23 | *18.400* | *13.800* | *54.300* | *27.326* | 141.504 | *287.213* | 111.246 | 44.494 | 20.260 | 31.059 | *20.382* | *13.857* |
| 24 | *18.300* | *13.600* | *53.200* | *32.639* | 155.665 | *332.446* | 109.905 | 40.639 | 19.924 | 28.635 | *20.164* | *13.639* |
| 25 | *18.200* | *13.500* | *52.700* | *41.700* | 166.333 | *313.596* | 109.581 | 37.228 | 19.770 | 26.556 | *19.947* | *13.422* |
| 26 | *18.100* | *13.400* | *53.200* | *51.415* | 171.772 | *275.990* | 107.505 | 34.442 | 19.409 | 26.683 | *19.729* | *13.204* |
| 27 | *18.000* | *13.200* | *54.300* | 52.700 | 187.647 | 227.416 | 105.304 | 31.866 | 18.250 | 26.427 | *19.512* | *12.987* |
| 28 | *17.900* | *13.100* | *55.400* | 53.636 | 219.185 | 186.249 | 100.203 | 30.466 | 17.239 | 24.272 | *19.294* | *12.769* |
| 29 | *17.800* | *12.900* | *55.900* | 55.334 | 254.735 | 171.985 | 93.423 | 30.302 | 17.451 | 21.908 | *19.077* | *12.552* |
| 30 | *17.700* | | *56.000* | 63.183 | 245.362 | 181.646 | 86.811 | 32.550 | 18.361 | 19.241 | *18.859* | *12.334* |
| 31 | *17.600* | | *55.700* | | 208.660 | | 79.866 | 33.608 | | 22.177 | | *11.900* |
| **Mean** | **19.206** | **15.093** | **24.668** | **41.461** | **125.858** | **263.844** | **137.137** | **50.701** | **23.903** | **40.465** | **30.634** | **15.372** |
| **Max** | **20.600** | **17.500** | **56.000** | **63.183** | **254.735** | **404.651** | **191.060** | **74.198** | **34.199** | **85.429** | **110.694** | **18.642** |
| **Min** | **17.600** | **12.900** | **10.000** | **16.800** | **67.309** | **171.985** | **79.866** | **30.302** | **17.239** | **19.241** | **18.859** | **11.900** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-2a. 2011 Summary of Daily Discharge [Q] at Hydrometric Station MH-2 ($m^3/s$)**

| 2011 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.030* | *0.030* | *0.030* | *0.106* | *0.993* | 1.119 | 0.699 | 0.375 | 0.077 | 0.061 | 0.053 | *0.030* |
| 2 | *0.030* | *0.030* | *0.030* | *0.115* | *1.069* | 1.202 | 0.621 | 0.355 | 0.092 | 0.070 | 0.048 | *0.030* |
| 3 | *0.030* | *0.030* | *0.030* | *0.123* | *1.152* | 1.445 | 0.548 | 0.318 | 0.085 | 0.089 | 0.031 | *0.030* |
| 4 | *0.030* | *0.030* | *0.030* | *0.133* | *1.241* | 1.109 | 0.471 | 0.298 | 0.074 | 0.101 | 0.010 | *0.030* |
| 5 | *0.030* | *0.030* | *0.030* | *0.143* | *1.337* | 1.059 | 0.405 | 0.276 | 0.066 | 0.096 | 0.059 | *0.030* |
| 6 | *0.030* | *0.030* | *0.030* | *0.154* | *1.440* | 0.978 | 0.365 | 0.244 | 0.061 | 0.088 | 0.073 | *0.030* |
| 7 | *0.030* | *0.030* | *0.030* | *0.166* | *1.552* | 0.938 | 0.324 | 0.225 | 0.057 | 0.078 | 0.058 | *0.030* |
| 8 | *0.030* | *0.030* | *0.030* | *0.179* | *1.671* | 0.840 | 1.902 | 0.211 | 0.055 | 0.070 | 0.036 | *0.030* |
| 9 | *0.030* | *0.030* | *0.030* | *0.193* | *1.801* | 0.816 | 3.150 | 0.197 | 0.052 | 0.068 | 0.039 | *0.030* |
| 10 | *0.030* | *0.030* | *0.030* | *0.208* | *1.940* | 0.803 | 3.019 | 0.184 | 0.049 | 0.065 | 0.166 | *0.030* |
| 11 | *0.030* | *0.030* | *0.030* | *0.224* | *2.090* | 0.712 | 2.546 | 0.177 | 0.048 | 0.066 | 0.144 | *0.030* |
| 12 | *0.030* | *0.030* | *0.030* | *0.241* | *2.251* | 0.655 | 2.029 | 0.163 | 0.047 | 0.072 | 0.095 | *0.030* |
| 13 | *0.030* | *0.030* | *0.030* | *0.260* | *2.425* | 0.667 | 2.111 | 0.156 | 0.046 | 0.066 | 0.083 | *0.030* |
| 14 | *0.030* | *0.030* | *0.030* | *0.280* | *2.613* | 0.647 | 2.005 | 0.160 | 0.045 | 0.061 | 0.057 | *0.030* |
| 15 | *0.030* | *0.030* | *0.030* | *0.302* | 3.032 | 0.686 | 1.588 | 0.146 | 0.047 | 0.056 | 0.059 | *0.030* |
| 16 | *0.030* | *0.030* | *0.032* | *0.325* | 3.104 | 0.855 | 1.340 | 0.134 | 0.049 | 0.055 | 0.137 | *0.030* |
| 17 | *0.030* | *0.030* | *0.035* | *0.350* | *3.717* | 0.876 | 1.182 | 0.129 | 0.044 | 0.055 | *0.030* | *0.030* |
| 18 | *0.030* | *0.030* | *0.038* | *0.377* | *4.016* | 0.870 | 1.028 | 0.123 | 0.045 | 0.055 | *0.030* | *0.030* |
| 19 | *0.030* | *0.030* | *0.040* | *0.406* | *3.869* | 0.846 | 0.906 | 0.116 | 0.044 | 0.055 | *0.030* | *0.030* |
| 20 | *0.030* | *0.030* | *0.044* | *0.438* | *3.886* | 0.841 | 0.810 | 0.113 | 0.041 | 0.049 | *0.030* | *0.030* |
| 21 | *0.030* | *0.030* | *0.047* | *0.471* | *4.165* | 0.727 | 0.777 | 0.108 | 0.041 | 0.048 | *0.030* | *0.030* |
| 22 | *0.030* | *0.030* | *0.051* | *0.508* | *5.599* | 0.660 | 0.807 | 0.110 | 0.081 | 0.055 | *0.030* | *0.030* |
| 23 | *0.030* | *0.030* | *0.054* | *0.547* | *7.102* | 0.681 | 0.714 | 0.114 | 0.132 | 0.052 | *0.030* | *0.030* |
| 24 | *0.030* | *0.030* | *0.059* | *0.589* | 1.826 | 1.133 | 0.630 | 0.099 | 0.167 | 0.048 | *0.030* | *0.030* |
| 25 | *0.030* | *0.030* | *0.063* | *0.635* | 1.085 | 1.363 | 0.619 | 0.088 | 0.113 | 0.046 | *0.030* | *0.030* |
| 26 | *0.030* | *0.030* | *0.068* | *0.684* | 0.988 | 1.123 | 0.557 | 0.086 | 0.091 | 0.048 | *0.030* | *0.030* |
| 27 | *0.030* | *0.030* | *0.073* | *0.737* | 1.258 | 0.987 | 0.513 | 0.081 | 0.077 | 0.044 | *0.030* | *0.030* |
| 28 | *0.030* | *0.030* | *0.079* | *0.794* | 1.297 | 0.882 | 0.476 | 0.080 | 0.068 | 0.046 | *0.030* | *0.030* |
| 29 | *0.030* | | *0.085* | *0.855* | 1.244 | 0.864 | 0.442 | 0.083 | 0.063 | 0.047 | *0.030* | *0.030* |
| 30 | *0.030* | | *0.092* | *0.921* | 1.439 | 0.759 | 0.416 | 0.079 | 0.065 | 0.058 | *0.030* | *0.030* |
| 31 | *0.030* | | *0.099* | | 1.224 | | 0.394 | 0.079 | | 0.047 | | *0.030* |
| **Mean** | **0.030** | **0.030** | **0.045** | **0.382** | **2.336** | **0.905** | **1.077** | **0.165** | **0.067** | **0.062** | **0.052** | **0.030** |
| **Max** | **0.030** | **0.030** | **0.099** | **0.921** | **7.102** | **1.445** | **3.150** | **0.375** | **0.167** | **0.101** | **0.166** | **0.030** |
| **Min** | **0.030** | **0.030** | **0.030** | **0.106** | **0.988** | **0.647** | **0.324** | **0.079** | **0.041** | **0.044** | **0.010** | **0.030** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-2b. 2012 Summary of Daily Discharge [Q] at Hydrometric Station MH-2($m^3/s$)**

| 2012 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.030* | *0.030* | *0.030* | *0.081* | *0.463* | 3.274 | 0.571 | 0.132 | 0.052 | 0.101 | *0.144* | *0.082* |
| 2 | *0.030* | *0.030* | *0.030* | *0.086* | *0.490* | 3.394 | 0.521 | 0.154 | 0.048 | 0.282 | *0.132* | *0.079* |
| 3 | *0.030* | *0.030* | *0.030* | *0.091* | *0.520* | 2.921 | 0.508 | 0.132 | 0.047 | 0.140 | *0.136* | *0.076* |
| 4 | *0.030* | *0.030* | *0.030* | *0.096* | *0.551* | 2.681 | 1.108 | 0.112 | 0.045 | 0.108 | *0.190* | *0.073* |
| 5 | *0.030* | *0.030* | *0.030* | *0.102* | *0.584* | 3.069 | 0.869 | 0.103 | 0.044 | 0.093 | *0.300* | *0.070* |
| 6 | *0.030* | *0.030* | *0.030* | *0.108* | *0.619* | 5.667 | 0.701 | 0.094 | 0.043 | 0.097 | *0.251* | *0.067* |
| 7 | *0.030* | *0.030* | *0.030* | *0.114* | *0.656* | 6.074 | 0.613 | 0.087 | 0.038 | 0.126 | *0.233* | *0.064* |
| 8 | *0.030* | *0.030* | *0.030* | *0.121* | *0.695* | 3.907 | 0.540 | 0.094 | 0.036 | 0.145 | *0.216* | *0.061* |
| 9 | *0.030* | *0.030* | *0.030* | *0.129* | *0.737* | 3.207 | 0.482 | 0.097 | 0.034 | 0.128 | *0.200* | *0.058* |
| 10 | *0.030* | *0.030* | *0.030* | *0.136* | *0.781* | 2.921 | 0.433 | 0.086 | 0.039 | 0.125 | *0.186* | *0.055* |
| 11 | *0.030* | *0.030* | *0.030* | *0.144* | *0.828* | 2.676 | 0.395 | 0.080 | 0.044 | 0.109 | *0.172* | *0.052* |
| 12 | *0.030* | *0.030* | *0.030* | *0.153* | *0.878* | 2.512 | 0.359 | 0.077 | 0.041 | 0.102 | *0.159* | *0.049* |
| 13 | *0.030* | *0.030* | *0.030* | *0.162* | *0.930* | 2.224 | 0.329 | 0.073 | 0.038 | 0.125 | *0.148* | *0.046* |
| 14 | *0.030* | *0.030* | *0.030* | *0.172* | *0.986* | 1.937 | 0.297 | 0.182 | 0.033 | 0.248 | *0.140* | *0.043* |
| 15 | *0.030* | *0.030* | *0.030* | *0.182* | *1.045* | 1.658 | 0.277 | 0.152 | 0.035 | 0.301 | *0.130* | *0.040* |
| 16 | *0.030* | *0.030* | *0.032* | *0.193* | *1.108* | 1.543 | 0.260 | 0.106 | 0.038 | 0.227 | *0.127* | *0.037* |
| 17 | *0.030* | *0.030* | *0.034* | *0.205* | *1.174* | 1.534 | 0.231 | 0.086 | 0.035 | 0.187 | *0.124* | *0.034* |
| 18 | *0.030* | *0.030* | *0.036* | *0.217* | *1.244* | 1.621 | 0.251 | 0.075 | 0.014 | 0.159 | *0.121* | *0.031* |
| 19 | *0.030* | *0.030* | *0.038* | *0.230* | *1.319* | 1.802 | 0.237 | 0.067 | 0.012 | 0.208 | *0.118* | *0.030* |
| 20 | *0.030* | *0.030* | *0.040* | *0.244* | *1.398* | 1.958 | 0.207 | 0.061 | 0.004 | 0.173 | *0.115* | *0.030* |
| 21 | *0.030* | *0.030* | *0.043* | *0.258* | 1.665 | 1.872 | 0.373 | 0.063 | 0.003 | 0.222 | *0.112* | *0.030* |
| 22 | *0.030* | *0.030* | *0.045* | *0.274* | 1.938 | 1.574 | 0.248 | 0.068 | 0.009 | 0.134 | *0.109* | *0.030* |
| 23 | *0.030* | *0.030* | *0.048* | *0.290* | 2.078 | 1.438 | 0.228 | 0.060 | 0.018 | 0.140 | *0.106* | *0.030* |
| 24 | *0.030* | *0.030* | *0.051* | *0.308* | 2.163 | 1.420 | 0.219 | 0.062 | 0.015 | 0.136 | *0.103* | *0.030* |
| 25 | *0.030* | *0.030* | *0.054* | *0.326* | 2.432 | 1.184 | 0.190 | 0.066 | 0.020 | 0.139 | *0.100* | *0.030* |
| 26 | *0.030* | *0.030* | *0.057* | *0.346* | 2.826 | 1.021 | 0.185 | 0.060 | 0.036 | 0.151 | *0.097* | *0.030* |
| 27 | *0.030* | *0.030* | *0.060* | *0.367* | 3.529 | 0.891 | 0.234 | 0.054 | 0.036 | 0.162 | *0.094* | *0.030* |
| 28 | *0.030* | *0.030* | *0.064* | *0.388* | 4.066 | 0.782 | 0.190 | 0.049 | 0.035 | *0.159* | *0.091* | *0.030* |
| 29 | *0.030* | *0.030* | *0.068* | *0.412* | 4.181 | 0.689 | 0.165 | 0.047 | 0.040 | *0.156* | *0.088* | *0.030* |
| 30 | *0.030* | | *0.072* | *0.436* | 3.638 | 0.630 | 0.149 | 0.051 | 0.039 | *0.153* | *0.085* | *0.030* |
| 31 | *0.030* | | *0.076* | | 3.368 | | 0.136 | 0.054 | | *0.150* | | *0.030* |
| **Mean** | **0.030** | **0.030** | **0.041** | **0.212** | **1.577** | **2.269** | **0.371** | **0.087** | **0.032** | **0.158** | **0.144** | **0.045** |
| **Max** | **0.030** | **0.030** | **0.076** | **0.436** | **4.181** | **6.074** | **1.108** | **0.182** | **0.052** | **0.301** | **0.300** | **0.082** |
| **Min** | **0.030** | **0.030** | **0.030** | **0.081** | **0.463** | **0.630** | **0.136** | **0.047** | **0.003** | **0.093** | **0.085** | **0.030** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-2c. 2013 Summary of Daily Discharge [Q] at Hydrometric Station MH-2 ($m^3/s$)**

| 2013 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.050* | *0.050* | *0.050* | *0.072* | 0.432 | *3.979* | 0.468 | 0.560 | 0.161 | 0.077 | *0.070* | *0.059* |
| 2 | *0.050* | *0.050* | *0.050* | *0.076* | 0.459 | 2.947 | 0.436 | 0.505 | 0.136 | 0.106 | *0.070* | *0.059* |
| 3 | *0.050* | *0.050* | *0.050* | *0.081* | 0.472 | 2.355 | 0.410 | 0.458 | 0.122 | 0.161 | *0.069* | *0.059* |
| 4 | *0.050* | *0.050* | *0.050* | *0.086* | 0.801 | 2.282 | 0.355 | 1.535 | 0.111 | 0.129 | *0.069* | *0.058* |
| 5 | *0.050* | *0.050* | *0.050* | *0.091* | 1.592 | 1.993 | 0.317 | 2.134 | 0.111 | 0.112 | *0.069* | *0.058* |
| 6 | *0.050* | *0.050* | *0.050* | *0.097* | 2.849 | 1.764 | 0.374 | 1.415 | 0.098 | 0.195 | *0.068* | *0.058* |
| 7 | *0.050* | *0.050* | *0.050* | *0.103* | *3.851* | 1.466 | 0.465 | 1.069 | 0.092 | 0.217 | *0.068* | *0.057* |
| 8 | *0.050* | *0.050* | *0.050* | *0.109* | *3.713* | 1.299 | 0.392 | 0.896 | 0.088 | 0.230 | *0.067* | *0.057* |
| 9 | *0.050* | *0.050* | *0.050* | *0.116* | 3.249 | 1.133 | 0.329 | 0.855 | 0.081 | 0.209 | *0.067* | *0.057* |
| 10 | *0.050* | *0.050* | *0.050* | *0.123* | *3.565* | 1.092 | 0.286 | 0.723 | 0.074 | 0.183 | *0.067* | *0.056* |
| 11 | *0.050* | *0.050* | *0.050* | *0.130* | *3.825* | 0.958 | 0.260 | 0.573 | 0.068 | 0.170 | *0.066* | *0.056* |
| 12 | *0.050* | *0.050* | *0.050* | *0.138* | *3.994* | 0.870 | 0.239 | 0.504 | 0.064 | 0.146 | *0.066* | *0.056* |
| 13 | *0.050* | *0.050* | *0.050* | *0.147* | *5.560* | 1.079 | 0.244 | 0.501 | 0.060 | 0.132 | *0.066* | *0.055* |
| 14 | *0.050* | *0.050* | *0.050* | *0.156* | *5.231* | 1.262 | 0.379 | 0.481 | 0.056 | 0.123 | *0.065* | *0.055* |
| 15 | *0.050* | *0.050* | *0.050* | *0.166* | *3.894* | 1.380 | 0.375 | 0.423 | 0.054 | 0.115 | *0.065* | *0.055* |
| 16 | *0.050* | *0.050* | *0.050* | *0.176* | 3.178 | 1.805 | 0.334 | 0.380 | 0.052 | 0.113 | *0.064* | *0.054* |
| 17 | *0.050* | *0.050* | *0.050* | *0.187* | 2.812 | 1.752 | 0.276 | 0.350 | 0.081 | 0.113 | *0.064* | *0.054* |
| 18 | *0.050* | *0.050* | *0.050* | *0.198* | 2.627 | 1.372 | 0.239 | 0.325 | 0.108 | 0.106 | *0.064* | *0.054* |
| 19 | *0.050* | *0.050* | *0.050* | *0.211* | 2.644 | 1.199 | 0.207 | 0.317 | 0.073 | 0.100 | *0.063* | *0.053* |
| 20 | *0.050* | *0.050* | *0.050* | *0.224* | 2.563 | 1.906 | 0.190 | 0.318 | 0.066 | 0.094 | *0.063* | *0.053* |
| 21 | *0.050* | *0.050* | *0.050* | *0.237* | 2.207 | 1.966 | 0.220 | 0.330 | 0.060 | 0.091 | *0.063* | *0.053* |
| 22 | *0.050* | *0.050* | *0.050* | *0.252* | 2.198 | 1.526 | 0.260 | 0.265 | 0.057 | 0.085 | *0.062* | *0.053* |
| 23 | *0.050* | *0.050* | *0.050* | *0.268* | 1.774 | 1.261 | 0.195 | 0.232 | 0.057 | 0.082 | *0.062* | *0.052* |
| 24 | *0.050* | *0.050* | *0.050* | *0.284* | 1.589 | 1.063 | 0.170 | 0.211 | 0.059 | 0.080 | *0.062* | *0.052* |
| 25 | *0.050* | *0.050* | *0.050* | *0.302* | 1.743 | 0.926 | 0.160 | 0.202 | 0.056 | 0.079 | *0.061* | *0.052* |
| 26 | *0.050* | *0.050* | *0.050* | *0.320* | 1.951 | 0.913 | 0.572 | 0.191 | 0.055 | 0.075 | *0.061* | *0.051* |
| 27 | *0.050* | *0.050* | *0.053* | *0.340* | 2.166 | 0.858 | 0.964 | 0.177 | 0.054 | 0.072 | *0.061* | *0.051* |
| 28 | *0.050* | *0.050* | *0.056* | *0.361* | 2.264 | 0.673 | 0.608 | 0.181 | 0.057 | *0.072* | *0.060* | *0.051* |
| 29 | *0.050* | | *0.060* | 0.383 | 2.459 | 0.561 | 0.958 | 0.163 | 0.053 | *0.071* | *0.060* | *0.051* |
| 30 | *0.050* | | *0.064* | 0.407 | 2.758 | 0.504 | 0.824 | 0.151 | 0.057 | *0.071* | *0.060* | *0.050* |
| 31 | *0.050* | | *0.067* | | *3.804* | | 0.684 | 0.181 | | *0.071* | | *0.050* |
| **Mean** | **0.050** | **0.050** | **0.052** | **0.195** | **2.652** | **1.471** | **0.393** | **0.536** | **0.077** | **0.119** | **0.065** | **0.054** |
| **Max** | **0.050** | **0.050** | **0.067** | **0.407** | **5.560** | **3.979** | **0.964** | **2.134** | **0.161** | **0.230** | **0.070** | **0.059** |
| **Min** | **0.050** | **0.050** | **0.050** | **0.072** | **0.432** | **0.504** | **0.160** | **0.151** | **0.052** | **0.071** | **0.060** | **0.050** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-3. 2012 Summary of Daily Discharge [Q] at Hydrometric Station MH-3 ($m^3/s$)**

| 2012 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.000* | *0.000* | *0.001* | *0.010* | 0.101 | *0.157* | 0.076 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 2 | *0.000* | *0.000* | *0.001* | *0.011* | 0.094 | *0.183* | 0.074 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 3 | *0.000* | *0.000* | *0.001* | *0.011* | 0.092 | *0.166* | 0.074 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 4 | *0.000* | *0.000* | *0.001* | *0.012* | 0.098 | *0.161* | 0.093 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 5 | *0.000* | *0.000* | *0.001* | *0.013* | 0.090 | *0.167* | 0.085 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 6 | *0.000* | *0.000* | *0.001* | *0.014* | 0.084 | *0.325* | 0.079 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 7 | *0.000* | *0.000* | *0.001* | *0.015* | 0.094 | *0.394* | 0.074 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* |
| 8 | *0.000* | *0.000* | *0.002* | *0.017* | 0.115 | *0.346* | 0.068 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 9 | *0.000* | *0.000* | *0.002* | *0.018* | 0.107 | *0.326* | 0.063 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 10 | *0.000* | *0.000* | *0.002* | *0.019* | 0.093 | *0.314* | 0.060 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 11 | *0.000* | *0.000* | *0.002* | *0.021* | 0.085 | *0.302* | 0.057 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 12 | *0.000* | *0.000* | *0.002* | *0.022* | 0.088 | *0.291* | 0.053 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 13 | *0.000* | *0.000* | *0.002* | *0.024* | 0.100 | *0.273* | 0.049 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 14 | *0.000* | *0.000* | *0.003* | *0.026* | 0.112 | *0.254* | 0.046 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 15 | *0.000* | *0.000* | *0.003* | *0.028* | 0.124 | *0.232* | 0.045 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 16 | *0.000* | *0.000* | *0.003* | *0.030* | 0.128 | *0.213* | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 17 | *0.000* | *0.000* | *0.003* | *0.033* | 0.114 | *0.188* | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 18 | *0.000* | *0.000* | *0.003* | *0.035* | 0.108 | *0.160* | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 19 | *0.000* | *0.000* | *0.004* | *0.038* | 0.102 | 0.073 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 20 | *0.000* | *0.000* | *0.004* | *0.041* | 0.100 | 0.046 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 21 | *0.000* | *0.000* | *0.004* | *0.044* | 0.102 | 0.031 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 22 | *0.000* | *0.001* | *0.005* | *0.047* | 0.102 | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 23 | *0.000* | *0.001* | *0.005* | *0.051* | 0.051 | 0.032 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 24 | *0.000* | *0.001* | *0.005* | *0.055* | 0.079 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 25 | *0.000* | *0.001* | *0.006* | *0.059* | 0.098 | 0.051 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 26 | *0.000* | *0.001* | *0.006* | *0.064* | 0.087 | 0.067 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 27 | *0.000* | *0.001* | *0.007* | 0.080 | 0.094 | 0.071 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 28 | *0.000* | *0.001* | *0.007* | 0.075 | 0.141 | 0.074 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 29 | *0.000* | *0.001* | *0.008* | 0.075 | *0.184* | 0.076 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 30 | *0.000* | | *0.008* | 0.079 | *0.171* | 0.078 | 0.000 | 0.000 | 0.000 | 0.000 | *0.000* | *0.000* |
| 31 | *0.000* | | *0.009* | | *0.162* | | 0.000 | 0.000 | | 0.000 | | *0.000* |
| **Mean** | **0.000** | **0.000** | **0.004** | **0.036** | **0.106** | **0.171** | **0.032** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** |
| **Max** | **0.000** | **0.001** | **0.009** | **0.080** | **0.184** | **0.394** | **0.093** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** |
| **Min** | **0.000** | **0.000** | **0.001** | **0.010** | **0.051** | **0.030** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-4a. 2011 Summary of Daily Discharge [Q] at Hydrometric Station MH-4 ($m^3/s$)**

| 2011 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.046* | *0.046* | *0.046* | *0.107* | *0.525* | 0.369 | 0.490 | 0.293 | 0.041 | 0.034 | 0.034 | *0.046* |
| 2 | *0.046* | *0.046* | *0.046* | *0.113* | *0.554* | 0.428 | 0.445 | 0.255 | 0.054 | 0.036 | 0.029 | *0.046* |
| 3 | *0.046* | *0.046* | *0.046* | *0.119* | *0.584* | 0.578 | 0.392 | 0.221 | 0.045 | 0.047 | 0.027 | *0.046* |
| 4 | *0.046* | *0.046* | *0.046* | *0.126* | *0.616* | 0.400 | 0.335 | 0.192 | 0.038 | 0.054 | 0.041 | *0.046* |
| 5 | *0.046* | *0.046* | *0.046* | *0.133* | *0.649* | 0.385 | 0.285 | 0.168 | 0.035 | 0.051 | 0.076 | *0.046* |
| 6 | *0.046* | *0.046* | *0.046* | *0.140* | *0.684* | 0.352 | 0.255 | 0.148 | 0.034 | 0.046 | 0.101 | *0.046* |
| 7 | *0.046* | *0.046* | *0.046* | *0.147* | *0.722* | 0.342 | 0.225 | 0.138 | 0.033 | 0.040 | 0.052 | *0.046* |
| 8 | *0.046* | *0.046* | *0.046* | *0.155* | *0.761* | 0.299 | *1.357* | 0.127 | 0.032 | 0.036 | 0.058 | *0.046* |
| 9 | *0.046* | *0.046* | *0.046* | *0.164* | *0.802* | 0.297 | *2.508* | 0.115 | 0.031 | 0.036 | 0.111 | *0.046* |
| 10 | *0.046* | *0.046* | *0.046* | *0.173* | *0.846* | 0.301 | *2.558* | 0.106 | 0.030 | 0.035 | 0.296 | *0.046* |
| 11 | *0.046* | *0.046* | *0.046* | *0.182* | *0.892* | 0.261 | *2.232* | 0.099 | 0.030 | 0.035 | 0.227 | *0.046* |
| 12 | *0.046* | *0.046* | *0.046* | *0.192* | *0.940* | 0.240 | *1.814* | 0.090 | 0.029 | 0.037 | 0.205 | *0.046* |
| 13 | *0.046* | *0.046* | *0.046* | *0.203* | *0.991* | 0.257 | *2.231* | 0.085 | 0.029 | 0.035 | 0.121 | *0.046* |
| 14 | *0.046* | *0.046* | *0.046* | *0.214* | *1.045* | 0.255 | *2.319* | 0.087 | 0.029 | 0.034 | 0.089 | *0.046* |
| 15 | *0.046* | *0.046* | *0.046* | *0.225* | 1.225 | 0.290 | *1.778* | 0.080 | 0.029 | 0.032 | 0.133 | *0.046* |
| 16 | *0.046* | *0.046* | *0.046* | *0.237* | *1.611* | 0.401 | *1.490* | 0.073 | 0.030 | 0.032 | *0.046* | *0.046* |
| 17 | *0.046* | *0.046* | *0.049* | *0.250* | *2.173* | 0.427 | *1.339* | 0.071 | 0.029 | 0.032 | *0.046* | *0.046* |
| 18 | *0.046* | *0.046* | *0.051* | *0.264* | *2.138* | 0.435 | 1.155 | 0.069 | 0.029 | 0.033 | *0.046* | *0.046* |
| 19 | *0.046* | *0.046* | *0.054* | *0.278* | *1.747* | 0.433 | 1.022 | 0.064 | 0.029 | 0.032 | *0.046* | *0.046* |
| 20 | *0.046* | *0.046* | *0.057* | *0.293* | *1.921* | 0.442 | 0.908 | 0.060 | 0.028 | 0.031 | *0.046* | *0.046* |
| 21 | *0.046* | *0.046* | *0.060* | *0.309* | *2.500* | 0.381 | 0.899 | 0.057 | 0.028 | 0.031 | *0.046* | *0.046* |
| 22 | *0.046* | *0.046* | *0.063* | *0.326* | *2.627* | 0.349 | 0.885 | 0.061 | 0.042 | 0.032 | *0.046* | *0.046* |
| 23 | *0.046* | *0.046* | *0.067* | *0.344* | *1.929* | 0.376 | 0.768 | 0.064 | 0.073 | 0.031 | *0.046* | *0.046* |
| 24 | *0.046* | *0.046* | *0.070* | *0.363* | 0.647 | 0.707 | 0.685 | 0.054 | 0.096 | 0.031 | *0.046* | *0.046* |
| 25 | *0.046* | *0.046* | *0.074* | *0.382* | 0.275 | 0.882 | 0.622 | 0.047 | 0.062 | 0.029 | *0.046* | *0.046* |
| 26 | *0.046* | *0.046* | *0.078* | *0.403* | 0.241 | 0.725 | 0.547 | 0.044 | 0.048 | 0.029 | *0.046* | *0.046* |
| 27 | *0.046* | *0.046* | *0.082* | *0.425* | 0.381 | 0.642 | 0.489 | 0.041 | 0.039 | 0.030 | *0.046* | *0.046* |
| 28 | *0.046* | *0.046* | *0.087* | *0.448* | 0.414 | 0.582 | 0.438 | 0.039 | 0.036 | 0.030 | *0.046* | *0.046* |
| 29 | *0.046* | | *0.092* | *0.472* | 0.399 | 0.583 | 0.395 | 0.042 | 0.034 | 0.030 | *0.046* | *0.046* |
| 30 | *0.046* | | *0.097* | *0.498* | 0.517 | 0.520 | 0.364 | 0.042 | 0.035 | 0.031 | *0.046* | *0.046* |
| 31 | *0.046* | | *0.102* | | 0.413 | | 0.332 | 0.041 | | 0.030 | | *0.046* |
| **Mean** | **0.046** | **0.046** | **0.059** | **0.256** | **1.025** | **0.431** | **1.018** | **0.099** | **0.039** | **0.035** | **0.076** | **0.046** |
| **Max** | **0.046** | **0.046** | **0.102** | **0.498** | **2.627** | **0.882** | **2.558** | **0.293** | **0.096** | **0.054** | **0.296** | **0.046** |
| **Min** | **0.046** | **0.046** | **0.046** | **0.107** | **0.241** | **0.240** | **0.225** | **0.039** | **0.028** | **0.029** | **0.027** | **0.046** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-4b. 2012 Summary of Daily Discharge [Q] at Hydrometric Station MH-4 ($m^3/s$)**

| 2012 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.046* | *0.046* | *0.046* | *0.087* | 0.450 | 0.966 | 0.346 | 0.090 | 0.034 | 0.066 | 0.082 | *0.046* |
| 2 | *0.046* | *0.046* | *0.046* | *0.090* | 0.459 | 0.980 | 0.318 | 0.089 | 0.033 | 0.126 | 0.053 | *0.046* |
| 3 | *0.046* | *0.046* | *0.046* | *0.094* | 0.485 | 0.808 | 0.310 | 0.088 | 0.033 | 0.063 | 0.053 | *0.046* |
| 4 | *0.046* | *0.046* | *0.046* | *0.097* | 0.542 | 0.730 | 0.711 | 0.087 | 0.032 | 0.049 | 0.095 | *0.046* |
| 5 | *0.046* | *0.046* | *0.046* | *0.101* | 0.513 | 0.899 | 0.537 | 0.085 | 0.032 | 0.045 | 0.405 | *0.046* |
| 6 | *0.046* | *0.046* | *0.046* | *0.105* | 0.495 | *2.457* | 0.443 | 0.084 | 0.031 | 0.055 | 0.152 | *0.046* |
| 7 | *0.046* | *0.046* | *0.046* | *0.109* | 0.648 | *2.686* | 0.393 | 0.083 | 0.029 | 0.079 | 0.108 | *0.046* |
| 8 | *0.046* | *0.046* | *0.046* | *0.113* | 0.883 | *1.834* | 0.356 | 0.082 | 0.029 | 0.088 | 0.160 | *0.046* |
| 9 | *0.046* | *0.046* | *0.046* | *0.118* | 0.783 | *1.561* | 0.323 | 0.080 | 0.029 | 0.073 | *0.046* | *0.046* |
| 10 | *0.046* | *0.046* | *0.046* | *0.122* | 0.600 | *1.421* | 0.293 | 0.079 | 0.030 | 0.065 | *0.046* | *0.046* |
| 11 | *0.046* | *0.046* | *0.046* | *0.127* | 0.523 | *1.301* | 0.267 | 0.078 | 0.030 | 0.052 | *0.046* | *0.046* |
| 12 | *0.046* | *0.046* | *0.046* | *0.132* | 0.567 | 1.224 | 0.243 | 0.077 | 0.029 | 0.049 | *0.046* | *0.046* |
| 13 | *0.046* | *0.046* | *0.046* | *0.137* | 0.771 | 1.101 | 0.224 | 0.075 | 0.028 | 0.078 | *0.046* | *0.046* |
| 14 | *0.046* | *0.046* | *0.046* | *0.142* | 0.996 | 0.963 | 0.206 | 0.074 | 0.026 | 0.143 | *0.046* | *0.046* |
| 15 | *0.046* | *0.046* | *0.046* | *0.147* | 1.218 | 0.831 | 0.196 | 0.073 | 0.026 | 0.146 | *0.046* | *0.046* |
| 16 | *0.046* | *0.046* | *0.048* | *0.153* | 1.221 | 0.791 | 0.183 | 0.069 | 0.026 | 0.120 | *0.046* | *0.046* |
| 17 | *0.046* | *0.046* | *0.050* | *0.159* | 0.901 | 0.787 | 0.166 | 0.059 | 0.026 | 0.095 | *0.046* | *0.046* |
| 18 | *0.046* | *0.046* | *0.051* | *0.165* | 0.734 | 0.866 | 0.161 | 0.052 | 0.025 | 0.085 | *0.046* | *0.046* |
| 19 | *0.046* | *0.046* | *0.053* | *0.171* | 0.625 | 0.926 | 0.155 | 0.048 | 0.024 | 0.092 | *0.046* | *0.046* |
| 20 | *0.046* | *0.046* | *0.055* | *0.178* | 0.635 | 1.024 | 0.161 | 0.045 | 0.024 | 0.079 | *0.046* | *0.046* |
| 21 | *0.046* | *0.046* | *0.058* | *0.184* | 0.780 | 0.963 | 0.287 | 0.047 | 0.024 | 0.094 | *0.046* | *0.046* |
| 22 | *0.046* | *0.046* | *0.060* | *0.192* | 1.021 | 0.827 | 0.180 | 0.047 | 0.024 | 0.066 | *0.046* | *0.046* |
| 23 | *0.046* | *0.046* | *0.062* | *0.199* | 1.154 | 0.776 | 0.170 | 0.041 | 0.024 | 0.081 | *0.046* | *0.046* |
| 24 | *0.046* | *0.046* | *0.064* | *0.206* | 1.219 | 0.774 | 0.157 | 0.041 | 0.024 | 0.083 | *0.046* | *0.046* |
| 25 | *0.046* | *0.046* | *0.067* | *0.214* | *1.273* | 0.662 | 0.140 | 0.044 | 0.025 | 0.071 | *0.046* | *0.046* |
| 26 | *0.046* | *0.046* | *0.070* | *0.223* | 1.166 | 0.577 | 0.133 | 0.039 | 0.024 | 0.065 | *0.046* | *0.046* |
| 27 | *0.046* | *0.046* | *0.072* | *0.231* | *1.335* | 0.512 | 0.170 | 0.037 | 0.024 | 0.060 | *0.046* | *0.046* |
| 28 | *0.046* | *0.046* | *0.075* | *0.240* | *1.392* | 0.459 | 0.134 | 0.035 | 0.024 | 0.063 | *0.046* | *0.046* |
| 29 | *0.046* | *0.046* | *0.078* | 0.259 | *1.319* | 0.419 | 0.118 | 0.034 | 0.025 | 0.066 | *0.046* | *0.046* |
| 30 | *0.046* | | *0.081* | 0.318 | 1.110 | 0.381 | 0.107 | 0.036 | 0.024 | 0.065 | *0.046* | *0.046* |
| 31 | *0.046* | | *0.084* | | 1.011 | | 0.096 | 0.035 | | 0.061 | | *0.046* |
| **Mean** | **0.046** | **0.046** | **0.055** | **0.160** | **0.865** | **1.017** | **0.248** | **0.062** | **0.027** | **0.078** | **0.071** | **0.046** |
| **Max** | **0.046** | **0.046** | **0.084** | **0.318** | **1.392** | **2.686** | **0.711** | **0.090** | **0.034** | **0.146** | **0.405** | **0.046** |
| **Min** | **0.046** | **0.046** | **0.046** | **0.087** | **0.450** | **0.381** | **0.096** | **0.034** | **0.024** | **0.045** | **0.046** | **0.046** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-5ba. 2011 Summary of Daily Discharge [Q] at Hydrometric Station MH-5 ($m^3/s$)**

| 2011 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.003* | *0.003* | *0.003* | *0.011* | *0.114* | 0.156 | 0.087 | 0.052 | 0.010 | 0.005 | 0.003 | *0.003* |
| 2 | *0.003* | *0.003* | *0.003* | *0.012* | *0.124* | 0.142 | 0.080 | 0.043 | 0.010 | 0.006 | 0.003 | *0.003* |
| 3 | *0.003* | *0.003* | *0.003* | *0.013* | *0.134* | 0.171 | 0.069 | 0.035 | 0.009 | 0.007 | 0.002 | *0.003* |
| 4 | *0.003* | *0.003* | *0.003* | *0.014* | *0.144* | 0.160 | 0.056 | 0.028 | 0.009 | 0.007 | 0.002 | *0.003* |
| 5 | *0.003* | *0.003* | *0.003* | *0.015* | *0.156* | 0.160 | 0.045 | 0.025 | 0.008 | 0.007 | 0.002 | *0.003* |
| 6 | *0.003* | *0.003* | *0.003* | *0.016* | *0.169* | 0.143 | 0.038 | 0.024 | 0.008 | 0.007 | 0.002 | *0.003* |
| 7 | *0.003* | *0.003* | *0.003* | *0.018* | *0.182* | 0.143 | 0.031 | 0.023 | 0.008 | 0.006 | 0.002 | *0.003* |
| 8 | *0.003* | *0.003* | *0.003* | *0.019* | *0.197* | 0.126 | 0.214 | 0.022 | 0.008 | 0.005 | 0.002 | *0.003* |
| 9 | *0.003* | *0.003* | *0.003* | *0.021* | *0.213* | 0.116 | 0.385 | 0.018 | 0.008 | 0.005 | 0.002 | *0.003* |
| 10 | *0.003* | *0.003* | *0.003* | *0.022* | *0.230* | 0.109 | 0.391 | 0.019 | 0.007 | 0.005 | 0.005 | *0.003* |
| 11 | *0.003* | *0.003* | *0.003* | *0.024* | *0.248* | 0.101 | 0.355 | 0.019 | 0.007 | 0.005 | 0.005 | *0.003* |
| 12 | *0.003* | *0.003* | *0.003* | *0.026* | *0.268* | 0.094 | 0.305 | 0.018 | 0.007 | 0.005 | 0.004 | *0.003* |
| 13 | *0.003* | *0.003* | *0.003* | *0.028* | 0.313 | 0.090 | 0.352 | 0.017 | 0.007 | 0.005 | 0.003 | *0.003* |
| 14 | *0.003* | *0.003* | *0.003* | *0.031* | 0.253 | 0.085 | 0.365 | 0.017 | 0.007 | 0.005 | 0.003 | *0.003* |
| 15 | *0.003* | *0.003* | *0.003* | *0.033* | 0.312 | 0.083 | 0.301 | 0.016 | 0.006 | 0.004 | *0.003* | *0.003* |
| 16 | *0.003* | *0.003* | *0.003* | *0.036* | 0.352 | 0.098 | 0.263 | 0.015 | 0.006 | 0.004 | *0.003* | *0.003* |
| 17 | *0.003* | *0.003* | *0.004* | *0.039* | 0.434 | 0.105 | 0.242 | 0.015 | 0.005 | 0.004 | *0.003* | *0.003* |
| 18 | *0.003* | *0.003* | *0.004* | *0.042* | 0.380 | 0.122 | 0.214 | 0.014 | 0.005 | 0.004 | *0.003* | *0.003* |
| 19 | *0.003* | *0.003* | *0.004* | *0.045* | 0.283 | 0.115 | 0.193 | 0.014 | 0.005 | 0.004 | *0.003* | *0.003* |
| 20 | *0.003* | *0.003* | *0.004* | *0.049* | 0.269 | 0.116 | 0.174 | 0.013 | 0.005 | 0.003 | *0.003* | *0.003* |
| 21 | *0.003* | *0.003* | *0.005* | *0.053* | 0.321 | 0.098 | 0.173 | 0.013 | 0.005 | 0.003 | *0.003* | *0.003* |
| 22 | *0.003* | *0.003* | *0.005* | *0.057* | 0.375 | 0.087 | 0.171 | 0.012 | 0.007 | 0.004 | *0.003* | *0.003* |
| 23 | *0.003* | *0.003* | *0.006* | *0.062* | *0.825* | 0.091 | 0.150 | 0.013 | 0.009 | 0.004 | *0.003* | *0.003* |
| 24 | *0.003* | *0.003* | *0.006* | *0.067* | *0.551* | 0.133 | 0.135 | 0.012 | 0.011 | 0.003 | *0.003* | *0.003* |
| 25 | *0.003* | *0.003* | *0.007* | *0.072* | 0.404 | 0.156 | 0.123 | 0.010 | 0.010 | 0.003 | *0.003* | *0.003* |
| 26 | *0.003* | *0.003* | *0.007* | *0.078* | 0.329 | 0.138 | 0.108 | 0.008 | 0.008 | 0.003 | *0.003* | *0.003* |
| 27 | *0.003* | *0.003* | *0.008* | *0.084* | 0.283 | 0.120 | 0.096 | 0.009 | 0.007 | 0.003 | *0.003* | *0.003* |
| 28 | *0.003* | *0.003* | *0.008* | *0.091* | 0.245 | 0.109 | 0.085 | 0.009 | 0.006 | 0.003 | *0.003* | *0.003* |
| 29 | *0.003* | | *0.009* | *0.098* | 0.214 | 0.106 | 0.076 | 0.009 | 0.006 | 0.003 | *0.003* | *0.003* |
| 30 | *0.003* | | *0.010* | *0.106* | 0.207 | 0.094 | 0.069 | 0.010 | 0.006 | 0.003 | *0.003* | *0.003* |
| 31 | *0.003* | | *0.010* | | 0.184 | | 0.062 | 0.010 | | 0.003 | | *0.003* |
| **Mean** | **0.003** | **0.003** | **0.005** | **0.043** | **0.281** | **0.119** | **0.174** | **0.018** | **0.007** | **0.005** | **0.003** | **0.003** |
| **Max** | **0.003** | **0.003** | **0.010** | **0.106** | **0.825** | **0.171** | **0.391** | **0.052** | **0.011** | **0.007** | **0.005** | **0.003** |
| **Min** | **0.003** | **0.003** | **0.003** | **0.011** | **0.114** | **0.083** | **0.031** | **0.008** | **0.005** | **0.003** | **0.002** | **0.003** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-5b. 2012 Summary of Daily Discharge [Q] at Hydrometric Station MH-5 ($m^3/s$)**

| 2012 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | *0.003* | *0.003* | *0.003* | *0.009* | 0.106 | 0.034 | 0.019 | 0.006 | 0.000 | 0.012 | 0.003 | *0.003* |
| **2** | *0.003* | *0.003* | *0.003* | *0.009* | 0.104 | 0.034 | 0.018 | 0.006 | 0.000 | 0.016 | 0.003 | *0.003* |
| **3** | *0.003* | *0.003* | *0.003* | *0.010* | 0.116 | 0.030 | 0.019 | 0.006 | 0.000 | 0.010 | 0.003 | *0.003* |
| **4** | *0.003* | *0.003* | *0.003* | *0.010* | 0.120 | 0.026 | 0.057 | 0.006 | 0.000 | 0.008 | 0.011 | *0.003* |
| **5** | *0.003* | *0.003* | *0.003* | *0.011* | 0.110 | 0.037 | 0.041 | 0.006 | 0.000 | 0.006 | 0.010 | *0.003* |
| **6** | *0.003* | *0.003* | *0.003* | *0.012* | 0.092 | 0.248 | 0.031 | 0.005 | 0.000 | 0.006 | 0.008 | *0.003* |
| **7** | *0.003* | *0.003* | *0.003* | *0.013* | 0.112 | 0.207 | 0.021 | 0.005 | 0.000 | 0.006 | 0.010 | *0.003* |
| **8** | *0.003* | *0.003* | *0.003* | *0.013* | 0.124 | 0.137 | 0.019 | 0.005 | 0.000 | 0.006 | 0.009 | *0.003* |
| **9** | *0.003* | *0.003* | *0.003* | *0.014* | 0.124 | 0.096 | 0.017 | 0.005 | 0.000 | 0.005 | *0.003* | *0.003* |
| **10** | *0.003* | *0.003* | *0.003* | *0.015* | 0.099 | 0.082 | 0.015 | 0.004 | 0.000 | 0.006 | *0.003* | *0.003* |
| **11** | *0.003* | *0.003* | *0.003* | *0.016* | 0.080 | 0.073 | 0.014 | 0.004 | 0.000 | 0.006 | *0.003* | *0.003* |
| **12** | *0.003* | *0.003* | *0.003* | *0.017* | 0.070 | 0.061 | 0.013 | 0.004 | 0.000 | 0.006 | *0.003* | *0.003* |
| **13** | *0.003* | *0.003* | *0.003* | *0.018* | 0.073 | 0.054 | 0.012 | 0.004 | 0.000 | 0.006 | *0.003* | *0.003* |
| **14** | *0.003* | *0.003* | *0.003* | *0.020* | 0.074 | 0.046 | 0.011 | 0.012 | 0.000 | 0.009 | *0.003* | *0.003* |
| **15** | *0.003* | *0.003* | *0.003* | *0.021* | 0.077 | 0.042 | 0.011 | 0.009 | 0.000 | 0.007 | *0.003* | *0.003* |
| **16** | *0.003* | *0.003* | *0.003* | *0.022* | 0.074 | 0.042 | 0.010 | 0.008 | 0.000 | 0.007 | *0.003* | *0.003* |
| **17** | *0.003* | *0.003* | *0.003* | *0.024* | 0.066 | 0.038 | 0.010 | 0.007 | 0.000 | 0.005 | *0.003* | *0.003* |
| **18** | *0.003* | *0.003* | *0.004* | *0.025* | 0.061 | 0.057 | 0.010 | 0.006 | 0.000 | 0.007 | *0.003* | *0.003* |
| **19** | *0.003* | *0.003* | *0.004* | *0.027* | 0.059 | 0.084 | 0.010 | 0.006 | 0.000 | 0.012 | *0.003* | *0.003* |
| **20** | *0.003* | *0.003* | *0.004* | *0.028* | 0.055 | 0.060 | 0.026 | 0.006 | 0.000 | 0.008 | *0.003* | *0.003* |
| **21** | *0.003* | *0.003* | *0.004* | *0.030* | 0.054 | 0.048 | 0.018 | 0.006 | 0.001 | 0.006 | *0.003* | *0.003* |
| **22** | *0.003* | *0.003* | *0.005* | *0.032* | 0.054 | 0.037 | 0.012 | 0.006 | 0.002 | 0.005 | *0.003* | *0.003* |
| **23** | *0.003* | *0.003* | *0.005* | *0.034* | 0.051 | 0.035 | 0.011 | 0.006 | 0.002 | 0.004 | *0.003* | *0.003* |
| **24** | *0.003* | *0.003* | *0.005* | *0.037* | 0.052 | 0.036 | 0.010 | 0.005 | 0.002 | 0.005 | *0.003* | *0.003* |
| **25** | *0.003* | *0.003* | *0.006* | *0.039* | 0.052 | 0.030 | 0.009 | 0.005 | 0.002 | 0.004 | *0.003* | *0.003* |
| **26** | *0.003* | *0.003* | *0.006* | *0.041* | 0.048 | 0.028 | 0.009 | 0.005 | 0.002 | 0.004 | *0.003* | *0.003* |
| **27** | *0.003* | *0.003* | *0.006* | *0.044* | 0.044 | 0.025 | 0.009 | 0.005 | 0.003 | 0.004 | *0.003* | *0.003* |
| **28** | *0.003* | *0.003* | *0.007* | *0.047* | 0.041 | 0.023 | 0.009 | 0.004 | 0.004 | 0.005 | *0.003* | *0.003* |
| **29** | *0.003* | *0.003* | *0.007* | 0.057 | 0.038 | 0.022 | 0.008 | 0.004 | 0.004 | 0.006 | *0.003* | *0.003* |
| **30** | *0.003* | | *0.008* | 0.101 | 0.038 | 0.022 | 0.008 | 0.004 | 0.004 | 0.006 | *0.003* | *0.003* |
| **31** | *0.003* | | *0.008* | | 0.035 | | 0.007 | 0.004 | | 0.004 | | *0.003* |
| **Mean** | **0.003** | **0.003** | **0.004** | **0.027** | **0.074** | **0.060** | **0.016** | **0.006** | **0.001** | **0.007** | **0.004** | **0.003** |
| **Max** | **0.003** | **0.003** | **0.008** | **0.101** | **0.124** | **0.248** | **0.057** | **0.012** | **0.004** | **0.016** | **0.011** | **0.003** |
| **Min** | **0.003** | **0.003** | **0.003** | **0.009** | **0.035** | **0.022** | **0.007** | **0.004** | **0.000** | **0.004** | **0.003** | **0.003** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-6. 2013 Summary of Daily Discharge [Q] at Hydrometric Station MH-6 ($m^3/s$)**

| 2013 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.002* | *0.002* | *0.002* | *0.005* | 0.271 | 0.213 | 0.034 | 0.018 | 0.005 | 0.017 | 0.007 | *0.005* |
| 2 | *0.002* | *0.002* | *0.002* | *0.006* | 0.337 | 0.157 | 0.029 | 0.013 | 0.004 | 0.031 | 0.007 | *0.005* |
| 3 | *0.002* | *0.002* | *0.002* | *0.007* | 0.511 | 0.154 | 0.023 | 0.017 | 0.004 | 0.017 | 0.008 | *0.004* |
| 4 | *0.002* | *0.002* | *0.002* | *0.008* | 0.647 | 0.132 | 0.021 | 0.021 | 0.004 | 0.015 | 0.011 | *0.004* |
| 5 | *0.002* | *0.002* | *0.002* | *0.009* | 0.687 | 0.105 | 0.036 | 0.013 | 0.003 | 0.021 | 0.006 | *0.004* |
| 6 | *0.002* | *0.002* | *0.002* | *0.010* | 0.620 | 0.088 | 0.055 | 0.009 | 0.003 | 0.026 | 0.010 | *0.004* |
| 7 | *0.002* | *0.002* | *0.002* | *0.011* | 0.484 | 0.075 | 0.041 | 0.013 | 0.003 | 0.025 | *0.009* | *0.004* |
| 8 | *0.002* | *0.002* | *0.002* | *0.013* | 0.363 | 0.066 | 0.030 | 0.017 | 0.002 | 0.025 | *0.009* | *0.004* |
| 9 | *0.002* | *0.002* | *0.002* | *0.015* | 0.302 | 0.083 | 0.023 | 0.015 | 0.001 | 0.019 | *0.009* | *0.004* |
| 10 | *0.002* | *0.002* | *0.002* | *0.017* | 0.265 | 0.084 | 0.020 | 0.010 | 0.002 | 0.016 | *0.009* | *0.004* |
| 11 | *0.002* | *0.002* | *0.002* | *0.019* | 0.236 | 0.079 | 0.018 | 0.007 | 0.002 | 0.014 | *0.008* | *0.004* |
| 12 | *0.002* | *0.002* | *0.002* | *0.022* | 0.237 | 0.158 | 0.020 | 0.019 | 0.002 | 0.012 | *0.008* | *0.003* |
| 13 | *0.002* | *0.002* | *0.002* | *0.025* | 0.208 | 0.328 | 0.049 | 0.037 | 0.002 | 0.011 | *0.008* | *0.003* |
| 14 | *0.002* | *0.002* | *0.002* | *0.028* | 0.171 | 0.434 | 0.039 | 0.014 | 0.003 | 0.011 | *0.008* | *0.003* |
| 15 | *0.002* | *0.002* | *0.002* | *0.032* | 0.148 | 0.420 | 0.029 | 0.010 | 0.003 | 0.010 | *0.007* | *0.003* |
| 16 | *0.002* | *0.002* | *0.002* | *0.037* | 0.131 | 0.261 | 0.021 | 0.008 | 0.009 | 0.010 | *0.007* | *0.003* |
| 17 | *0.002* | *0.002* | *0.002* | *0.042* | 0.117 | 0.178 | 0.016 | 0.007 | 0.009 | 0.010 | *0.007* | *0.003* |
| 18 | *0.002* | *0.002* | *0.002* | *0.048* | 0.105 | 0.151 | 0.012 | 0.007 | 0.005 | 0.009 | *0.007* | *0.003* |
| 19 | *0.002* | *0.002* | *0.002* | *0.055* | 0.092 | 0.274 | 0.010 | 0.008 | 0.005 | 0.008 | *0.007* | *0.003* |
| 20 | *0.002* | *0.002* | *0.002* | *0.063* | 0.096 | 0.240 | 0.013 | 0.010 | 0.005 | 0.007 | *0.006* | *0.003* |
| 21 | *0.002* | *0.002* | *0.002* | *0.072* | 0.150 | 0.161 | 0.019 | 0.007 | 0.006 | 0.007 | *0.006* | *0.003* |
| 22 | *0.002* | *0.002* | *0.002* | *0.082* | 0.137 | 0.118 | 0.011 | 0.005 | 0.006 | 0.007 | *0.006* | *0.003* |
| 23 | *0.002* | *0.002* | *0.002* | *0.094* | 0.121 | 0.090 | 0.008 | 0.005 | 0.006 | 0.006 | *0.006* | *0.003* |
| 24 | *0.002* | *0.002* | *0.002* | *0.107* | 0.107 | 0.073 | 0.007 | 0.004 | 0.006 | 0.006 | *0.006* | *0.002* |
| 25 | *0.002* | *0.002* | *0.002* | *0.122* | 0.098 | 0.082 | 0.018 | 0.004 | 0.006 | 0.006 | *0.006* | *0.002* |
| 26 | *0.002* | *0.002* | *0.002* | *0.140* | 0.099 | 0.085 | 0.034 | 0.005 | 0.007 | 0.006 | *0.005* | *0.002* |
| 27 | *0.002* | *0.002* | *0.003* | *0.160* | 0.096 | 0.065 | 0.035 | 0.005 | 0.007 | 0.009 | *0.005* | *0.002* |
| 28 | *0.002* | *0.002* | *0.003* | *0.182* | 0.118 | 0.052 | 0.082 | 0.004 | 0.007 | 0.010 | *0.005* | *0.002* |
| 29 | *0.002* | | *0.003* | *0.208* | 0.165 | 0.043 | 0.055 | 0.004 | 0.007 | 0.009 | *0.005* | *0.002* |
| 30 | *0.002* | | *0.004* | *0.238* | 0.358 | 0.039 | 0.041 | 0.010 | 0.013 | 0.008 | *0.005* | *0.002* |
| 31 | *0.002* | | *0.004* | | 0.344 | | 0.026 | 0.007 | | 0.008 | | *0.002* |
| **Mean** | **0.002** | **0.002** | **0.002** | **0.063** | **0.252** | **0.150** | **0.028** | **0.011** | **0.005** | **0.013** | **0.007** | **0.003** |
| **Max** | **0.002** | **0.002** | **0.004** | **0.238** | **0.687** | **0.434** | **0.082** | **0.037** | **0.013** | **0.031** | **0.011** | **0.005** |
| **Min** | **0.002** | **0.002** | **0.002** | **0.005** | **0.092** | **0.039** | **0.007** | **0.004** | **0.001** | **0.006** | **0.005** | **0.002** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

**Appendix 4-7. 2013 Summary of Daily Discharge [Q] at Hydrometric Station MH-7 ($m^3/s$)**

| 2013 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *0.004* | *0.004* | *0.004* | *0.012* | *1.686* | 2.937 | 0.207 | 0.463 | 0.034 | 0.011 | 0.017 | *0.009* |
| 2 | *0.004* | *0.004* | *0.004* | *0.014* | *1.988* | 2.230 | 0.176 | 0.354 | 0.025 | 0.015 | 0.017 | *0.009* |
| 3 | *0.004* | *0.004* | *0.004* | *0.017* | *2.343* | 1.634 | 0.147 | 0.280 | 0.020 | 0.031 | 0.016 | *0.009* |
| 4 | *0.004* | *0.004* | *0.004* | *0.020* | 2.761 | 1.435 | 0.122 | 0.253 | 0.017 | 0.039 | 0.016 | *0.008* |
| 5 | *0.004* | *0.004* | *0.004* | *0.024* | 4.024 | 1.187 | 0.103 | 0.352 | 0.014 | 0.033 | 0.008 | *0.008* |
| 6 | *0.004* | *0.004* | *0.004* | *0.028* | 5.229 | 0.925 | 0.116 | 0.309 | 0.011 | 0.033 | 0.014 | *0.008* |
| 7 | *0.004* | *0.004* | *0.004* | *0.033* | 5.399 | 0.746 | 0.230 | 0.254 | 0.009 | 0.036 | 0.018 | *0.008* |
| 8 | *0.004* | *0.004* | *0.004* | *0.039* | 4.824 | 0.628 | 0.303 | 0.251 | 0.009 | 0.044 | *0.017* | *0.008* |
| 9 | *0.004* | *0.004* | *0.004* | *0.045* | 3.905 | 0.565 | 0.268 | 0.276 | 0.008 | 0.055 | *0.017* | *0.007* |
| 10 | *0.004* | *0.004* | *0.004* | *0.053* | 3.381 | 0.551 | 0.216 | 0.247 | 0.006 | 0.059 | *0.016* | *0.007* |
| 11 | *0.004* | *0.004* | *0.004* | *0.063* | 2.960 | 0.564 | 0.174 | 0.199 | 0.004 | 0.060 | *0.016* | *0.007* |
| 12 | *0.004* | *0.004* | *0.004* | *0.074* | 2.604 | 0.509 | 0.137 | 0.160 | 0.003 | 0.055 | *0.016* | *0.007* |
| 13 | *0.004* | *0.004* | *0.004* | *0.088* | 2.634 | 0.708 | 0.129 | 0.140 | 0.003 | 0.046 | *0.015* | *0.007* |
| 14 | *0.004* | *0.004* | *0.004* | *0.103* | 2.333 | 0.980 | 0.245 | 0.148 | 0.002 | 0.039 | *0.015* | *0.006* |
| 15 | *0.004* | *0.004* | *0.004* | *0.122* | 1.852 | 1.308 | 0.273 | 0.125 | 0.002 | 0.033 | *0.014* | *0.006* |
| 16 | *0.004* | *0.004* | *0.004* | *0.143* | 1.488 | 1.622 | 0.261 | 0.100 | 0.002 | 0.029 | *0.014* | *0.006* |
| 17 | *0.004* | *0.004* | *0.004* | *0.169* | 1.212 | 1.234 | 0.194 | 0.085 | 0.009 | 0.027 | *0.013* | *0.006* |
| 18 | *0.004* | *0.004* | *0.004* | *0.199* | 1.046 | 0.927 | 0.148 | 0.074 | 0.014 | 0.025 | *0.013* | *0.006* |
| 19 | *0.004* | *0.004* | *0.004* | *0.235* | 0.862 | 0.770 | 0.115 | 0.067 | 0.007 | 0.023 | *0.013* | *0.006* |
| 20 | *0.004* | *0.004* | *0.004* | *0.277* | 0.738 | 1.078 | 0.092 | 0.066 | 0.006 | 0.021 | *0.012* | *0.005* |
| 21 | *0.004* | *0.004* | *0.004* | *0.326* | 0.669 | 1.122 | 0.092 | 0.074 | 0.006 | 0.019 | *0.012* | *0.005* |
| 22 | *0.004* | *0.004* | *0.004* | *0.384* | 0.822 | 0.853 | 0.133 | 0.057 | 0.005 | 0.017 | *0.012* | *0.005* |
| 23 | *0.004* | *0.004* | *0.004* | *0.453* | 0.810 | 0.655 | 0.106 | 0.045 | 0.005 | 0.016 | *0.011* | *0.005* |
| 24 | *0.004* | *0.004* | *0.004* | *0.534* | 0.746 | 0.534 | 0.082 | 0.038 | 0.004 | 0.016 | *0.011* | *0.005* |
| 25 | *0.004* | *0.004* | *0.004* | *0.629* | 0.663 | 0.435 | 0.073 | 0.030 | 0.004 | 0.016 | *0.011* | *0.005* |
| 26 | *0.004* | *0.004* | *0.005* | *0.742* | 0.611 | 0.416 | 0.091 | 0.027 | 0.004 | 0.016 | *0.011* | *0.005* |
| 27 | *0.004* | *0.004* | *0.005* | *0.874* | 0.620 | 0.462 | 0.288 | 0.025 | 0.005 | 0.014 | *0.010* | *0.004* |
| 28 | *0.004* | *0.004* | *0.006* | *1.030* | 0.622 | 0.383 | 0.274 | 0.024 | 0.005 | 0.019 | *0.010* | *0.004* |
| 29 | *0.004* | | *0.007* | *1.214* | 0.673 | 0.308 | 0.566 | 0.023 | 0.005 | 0.018 | *0.010* | *0.004* |
| 30 | *0.004* | | *0.009* | *1.431* | 0.943 | 0.248 | 0.632 | 0.021 | 0.005 | 0.017 | *0.009* | *0.004* |
| 31 | *0.004* | | *0.010* | | 2.397 | | 0.594 | 0.035 | | 0.017 | | *0.004* |
| **Mean** | **0.004** | **0.004** | **0.004** | **0.312** | **2.027** | **0.932** | **0.212** | **0.148** | **0.008** | **0.029** | **0.013** | **0.006** |
| **Max** | **0.004** | **0.004** | **0.010** | **1.431** | **5.399** | **2.937** | **0.632** | **0.463** | **0.034** | **0.060** | **0.018** | **0.009** |
| **Min** | **0.004** | **0.004** | **0.004** | **0.012** | **0.611** | **0.248** | **0.073** | **0.021** | **0.002** | **0.011** | **0.008** | **0.004** |

[1] *Estimated values are italicized.*

[2] *Values in red denote high uncertainty based on extrapolation of the rating curve beyond 1.5 times the greatest measured discharge.*

# Appendix 5
Hydrographs

ERM

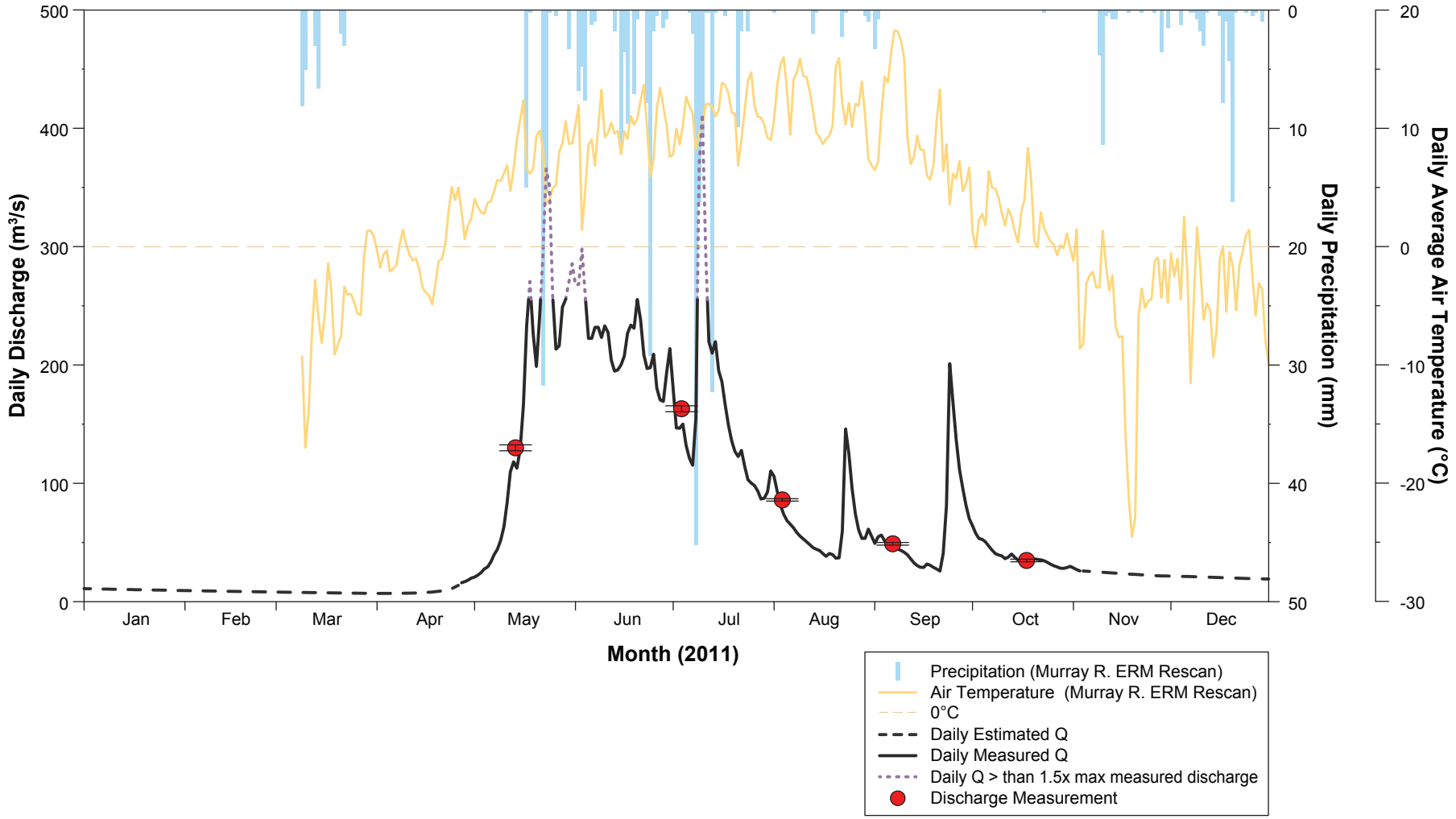



Figure A5-1

hd Mining

MURRAY RIVER COAL PROJECT

# Annual Hydrograph at Hydrometric Monitoring Station MH-1, 2011

Figure A5-1

Rescan Engineers & Scientists

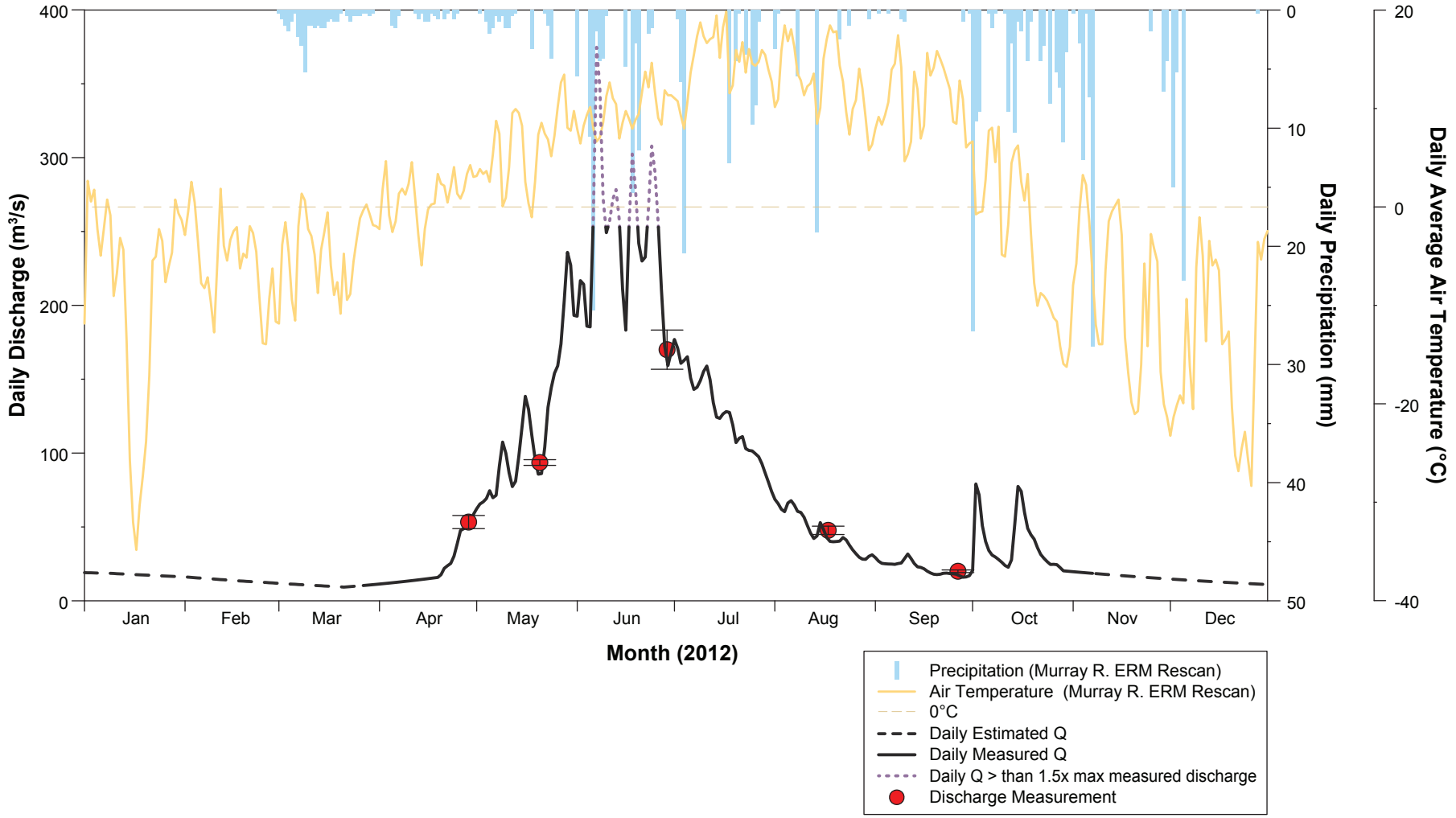



Figure A5-2

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-1, 2012

Figure A5-2

Rescan Engineers & Scientists

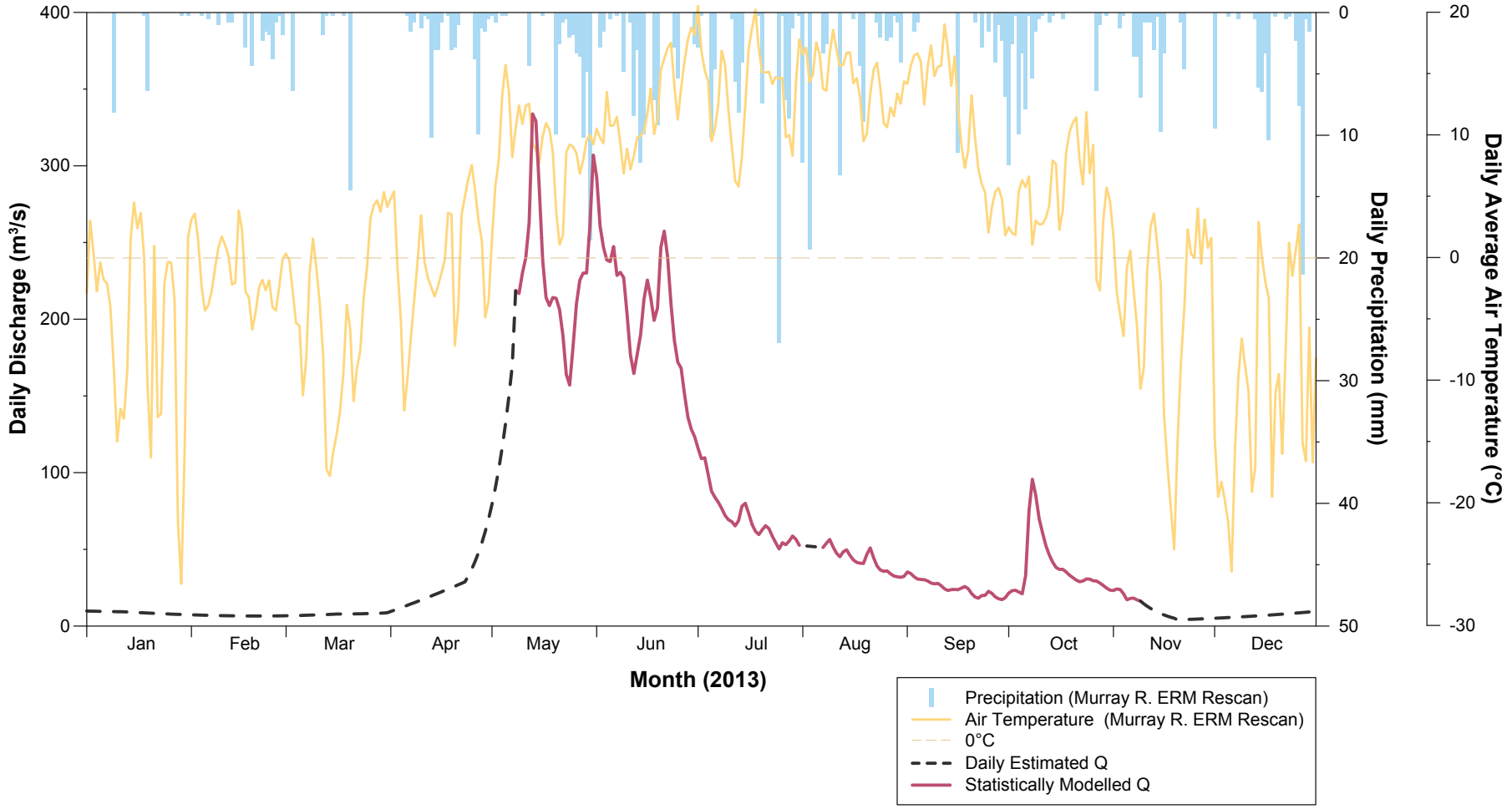



Figure A5-3

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-1, 2013

Figure A5-3

Rescan Engineers & Scientists

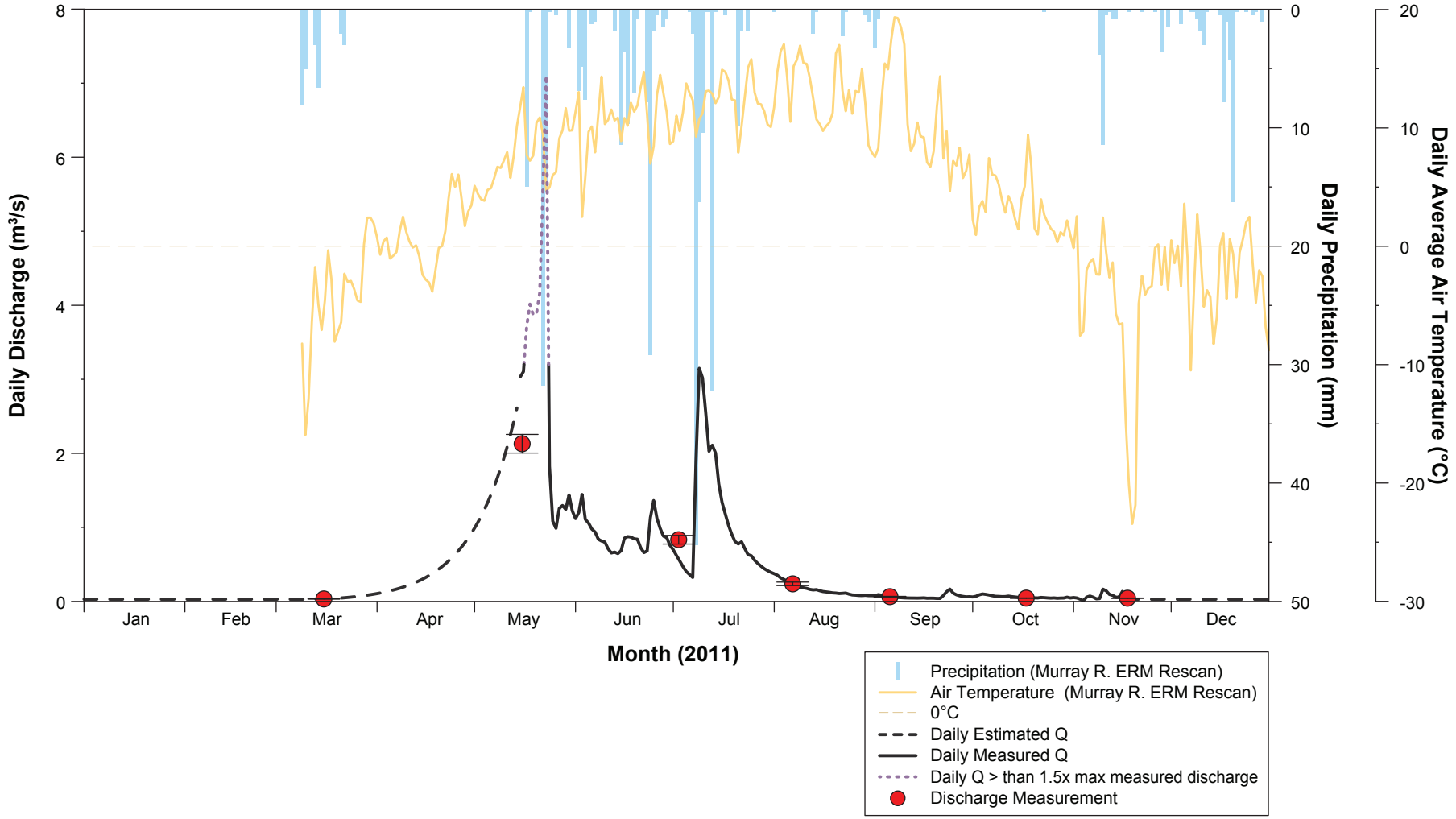



Figure A5-4

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-2, 2011

Figure A5-4

Rescan Engineers & Scientists

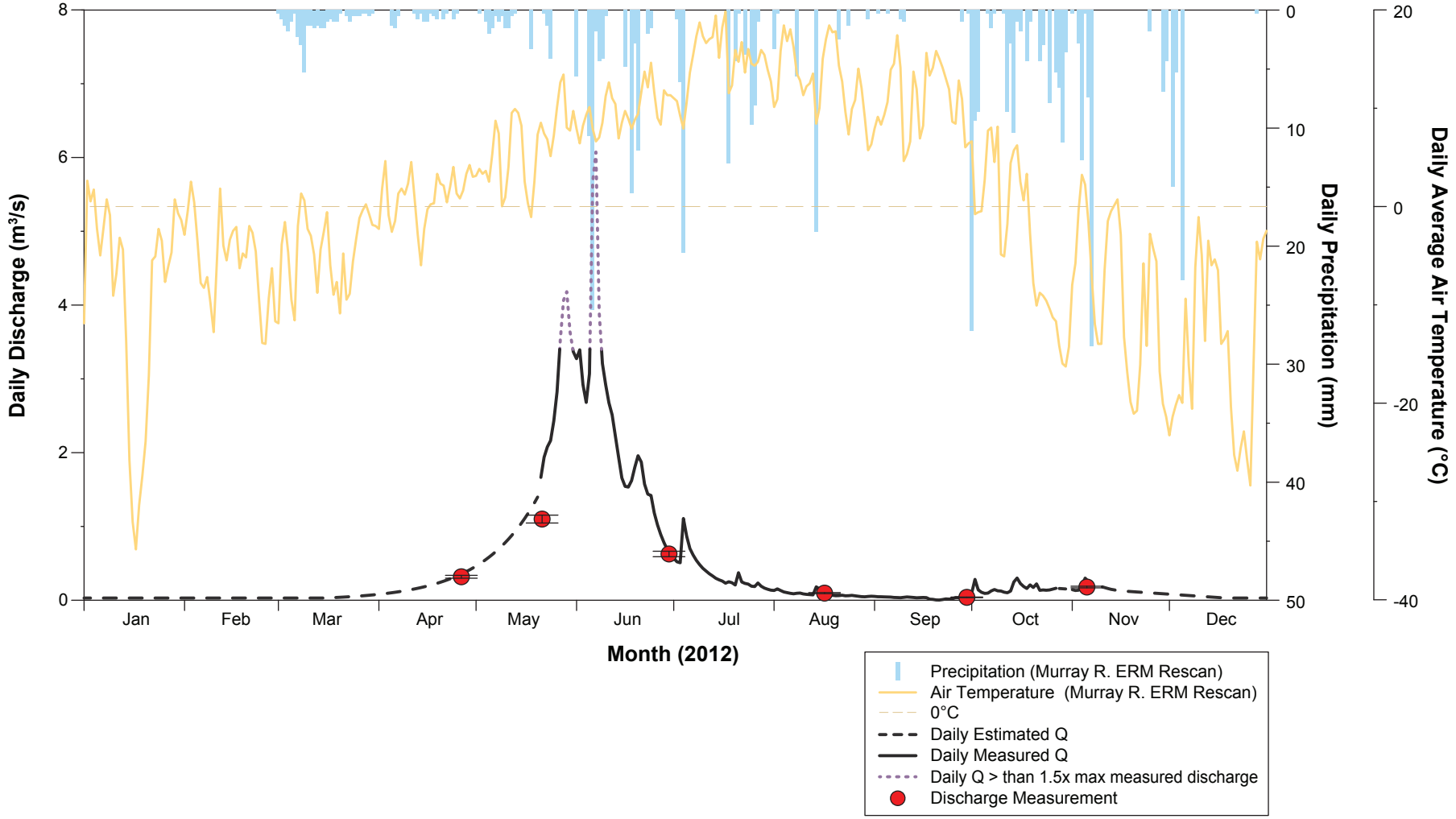



Figure A5-5

MURRAY RIVER COAL PROJECT

# Annual Hydrograph at Hydrometric Monitoring Station MH-2, 2012

Figure A5-5

Rescan Engineers & Scientists

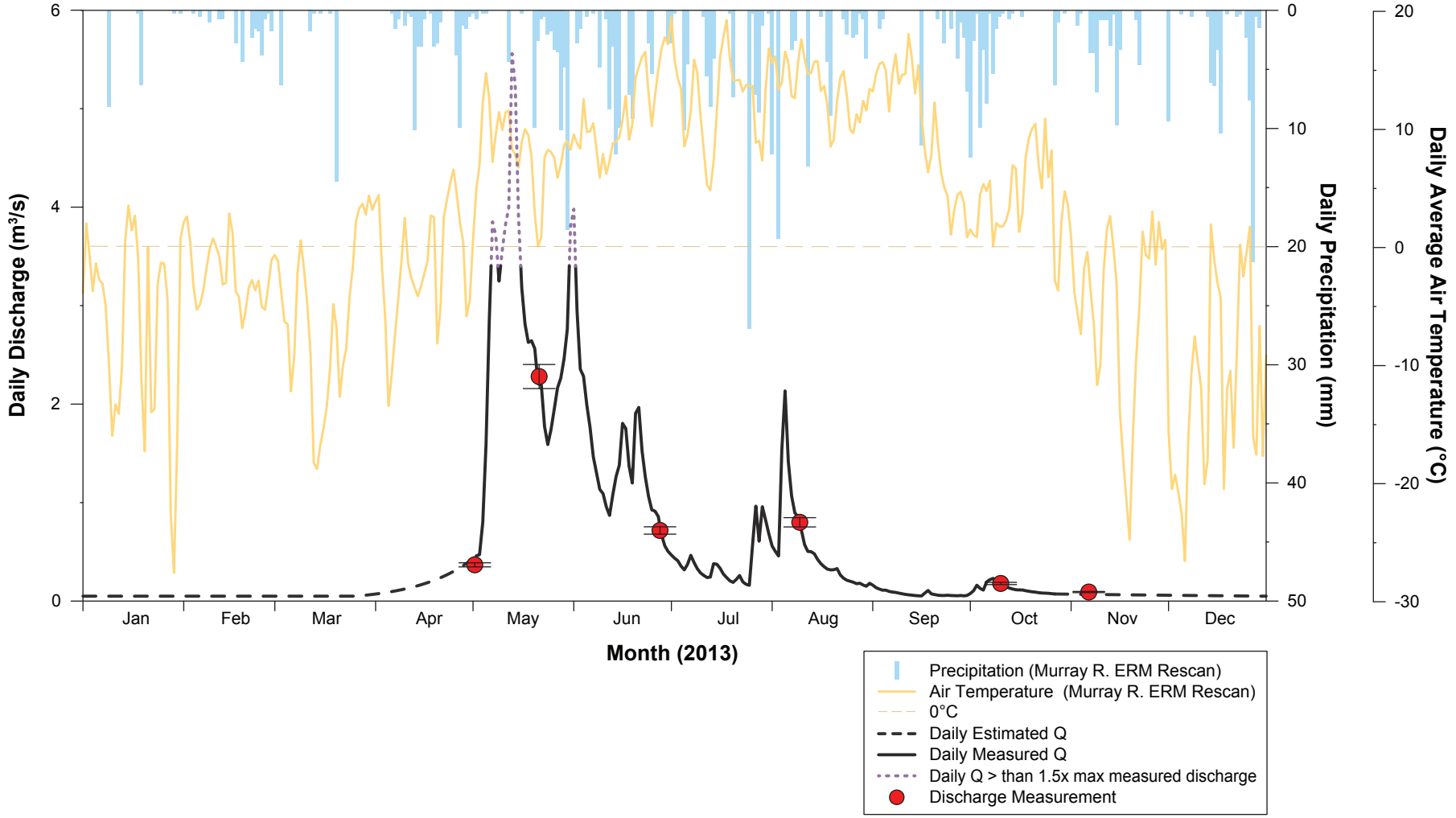



Figure A5-6

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-2, 2013

Figure A5-6

Rescan Engineers & Scientists

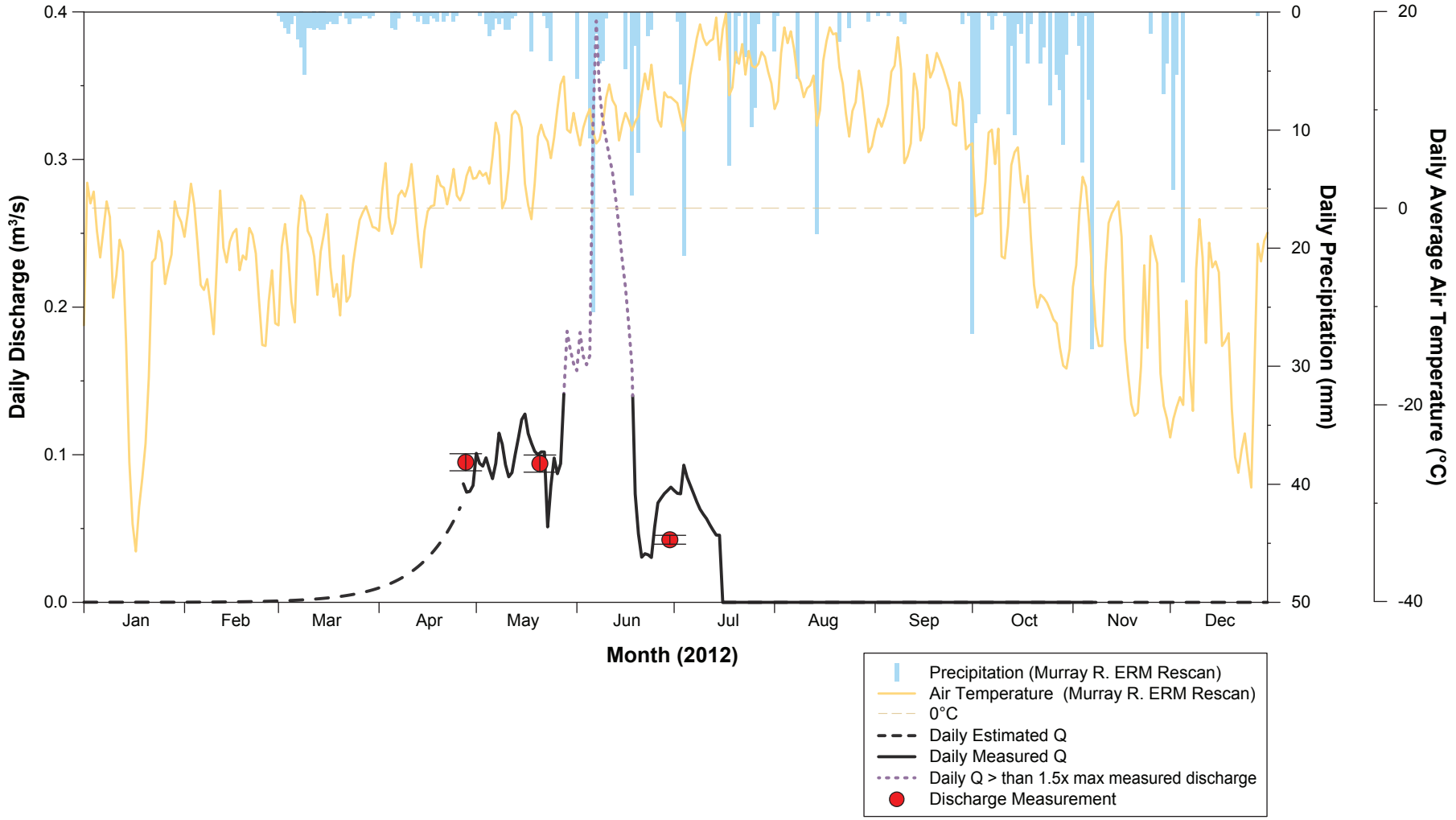



Figure A5-7

hd Mining

MURRAY RIVER COAL PROJECT

# Annual Hydrograph at Hydrometric Monitoring Station MH-3, 2012

Figure A5-7

Rescan Engineers & Scientists

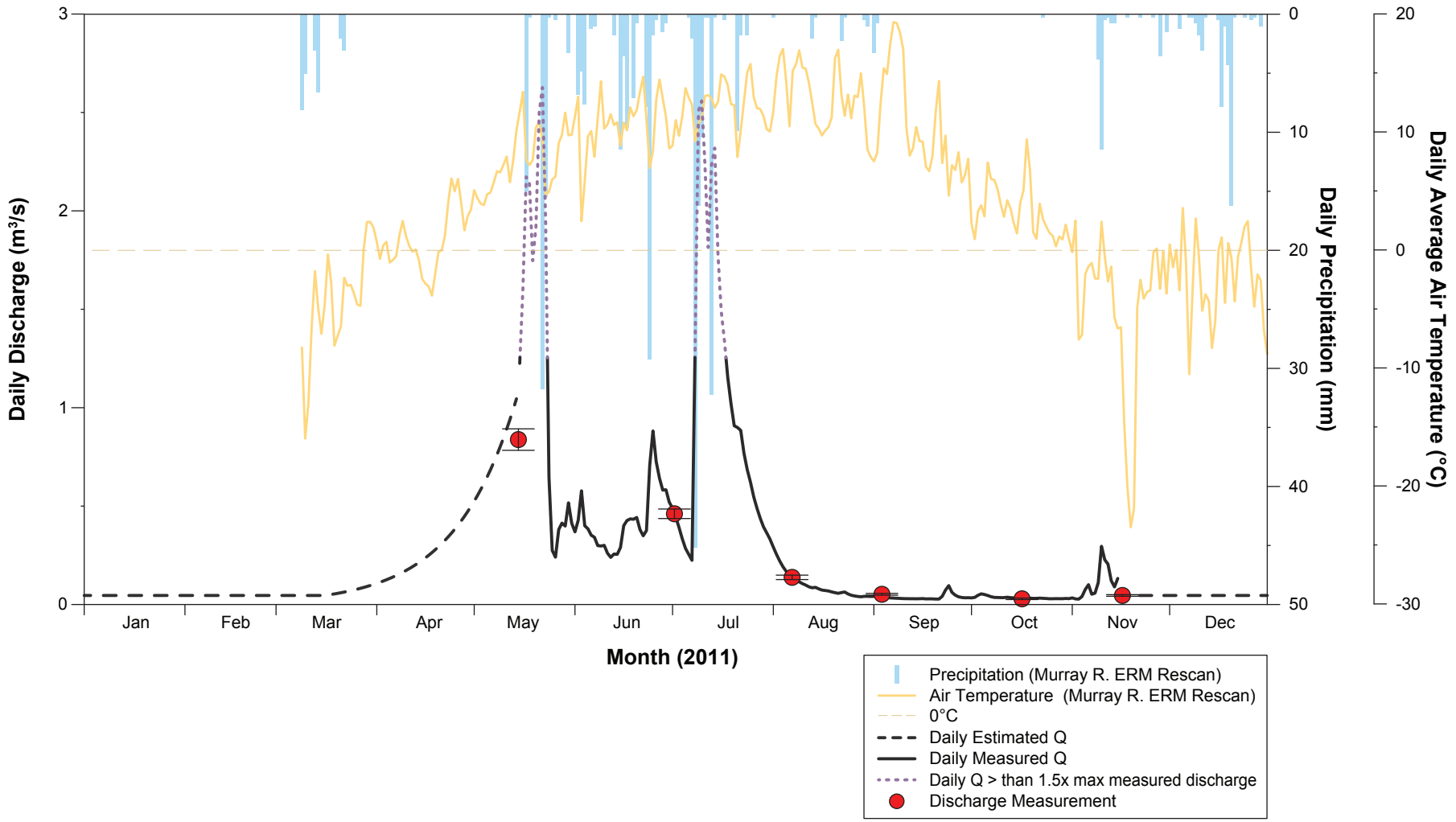



Figure A5-8

MURRAY RIVER COAL PROJECT

# Annual Hydrograph at Hydrometric Monitoring Station MH-4, 2011

Figure A5-8

Rescan Engineers & Scientists

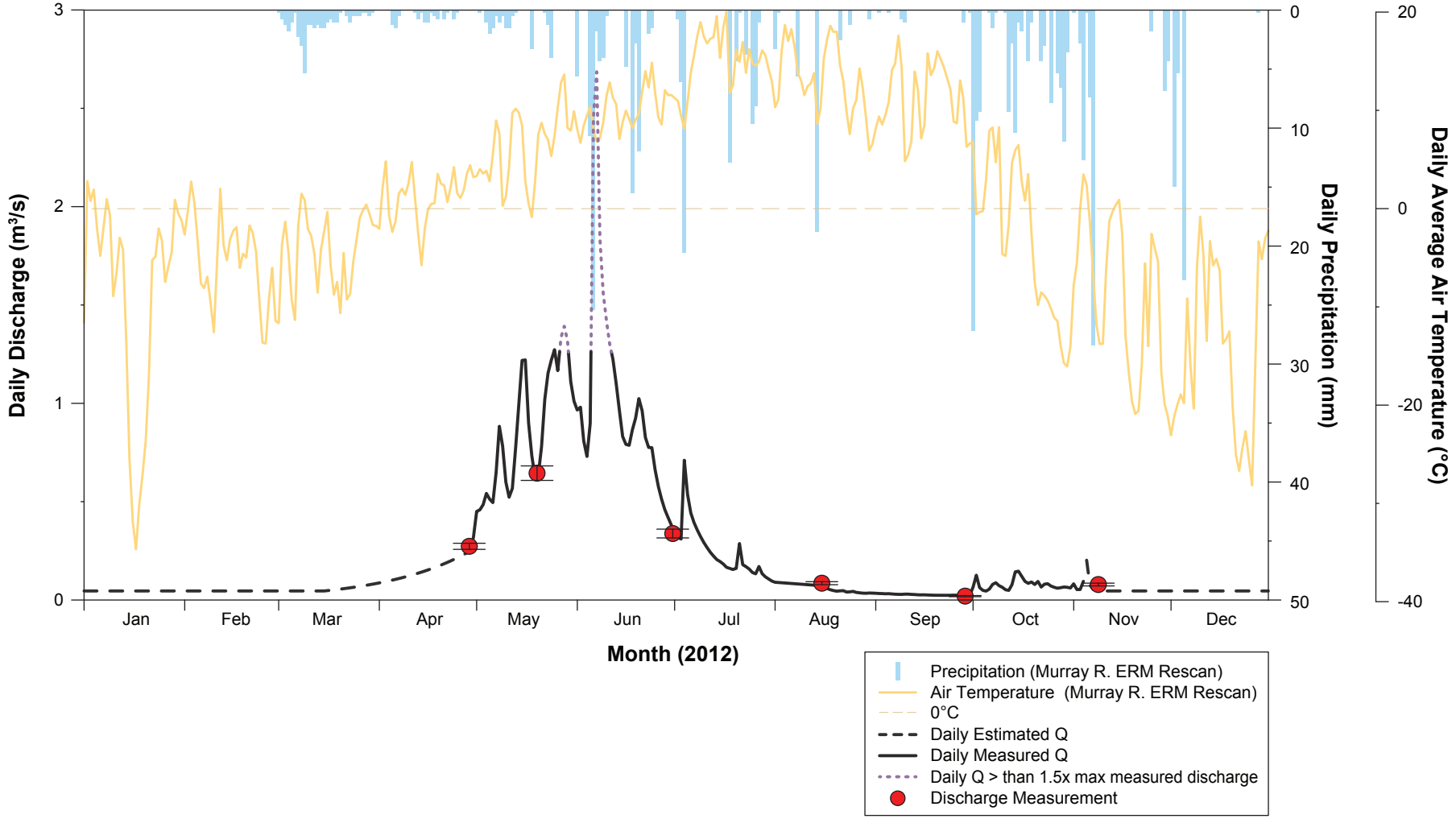



Figure A5-9

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-4, 2012

Figure A5-9

Rescan Engineers & Scientists

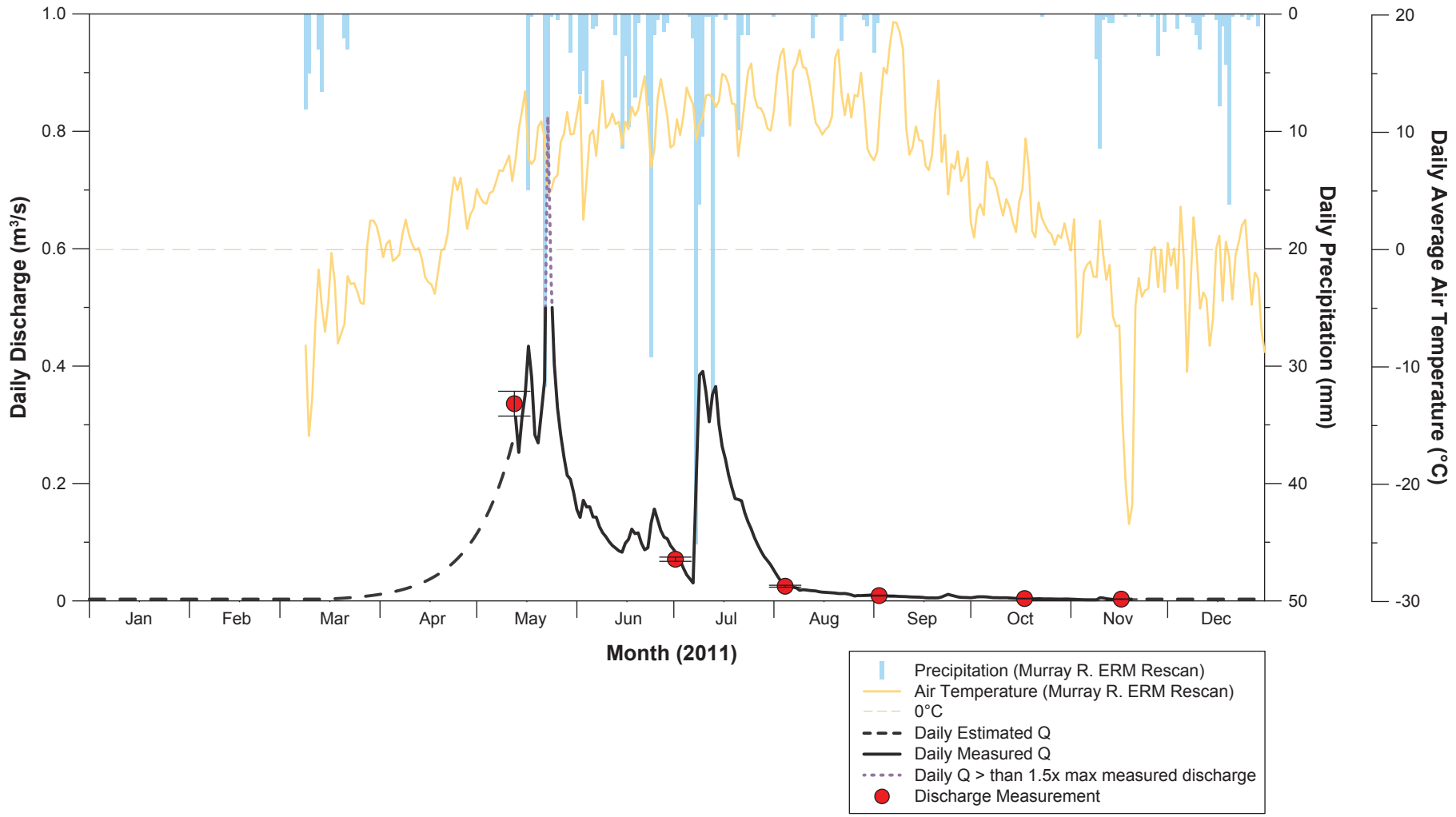



Figure A5-10

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-5, 2011

Figure A5-10

Rescan Engineers & Scientists

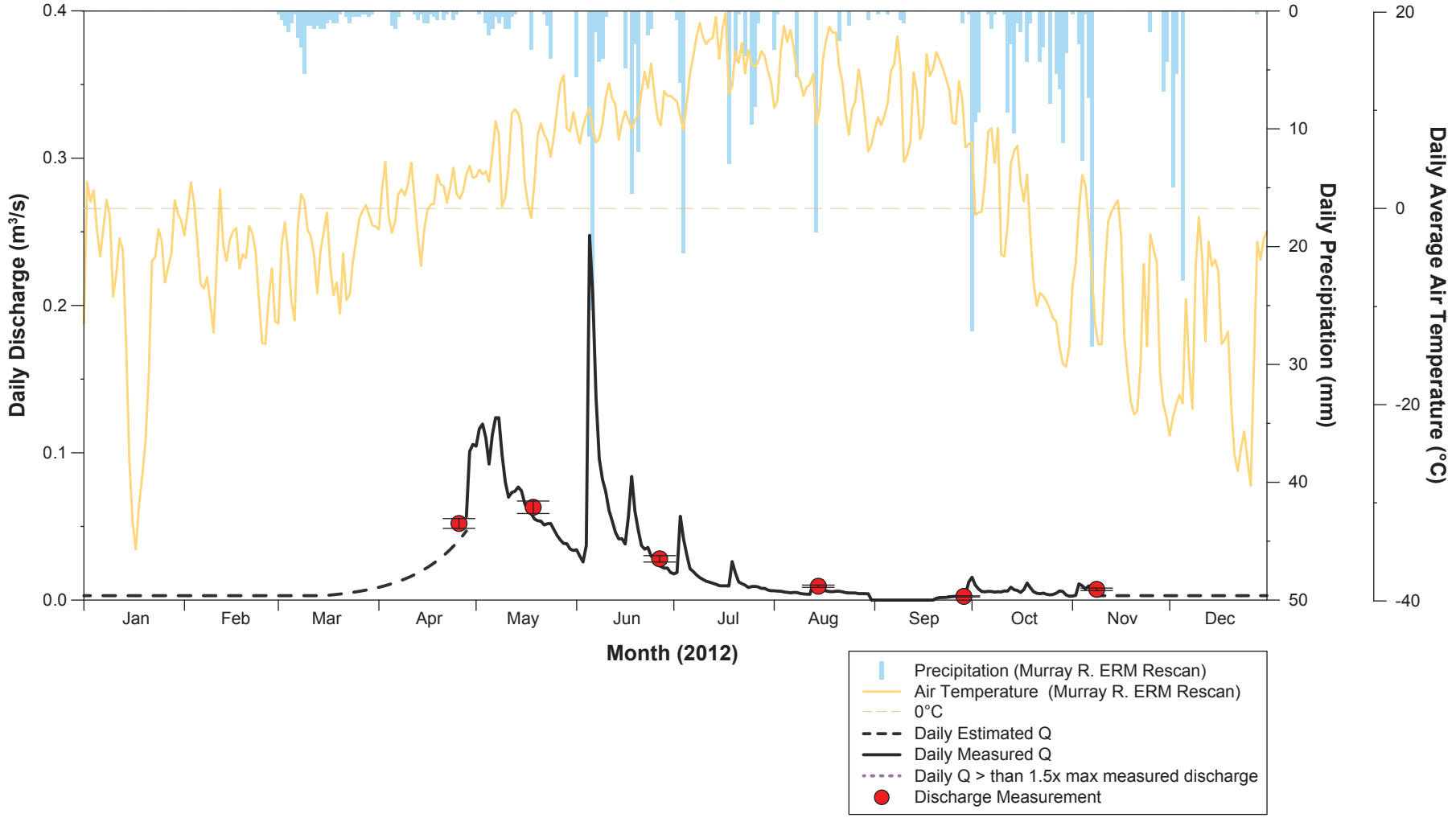



Figure A5-11

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-5, 2012

Figure A5-11

Rescan Engineers & Scientists

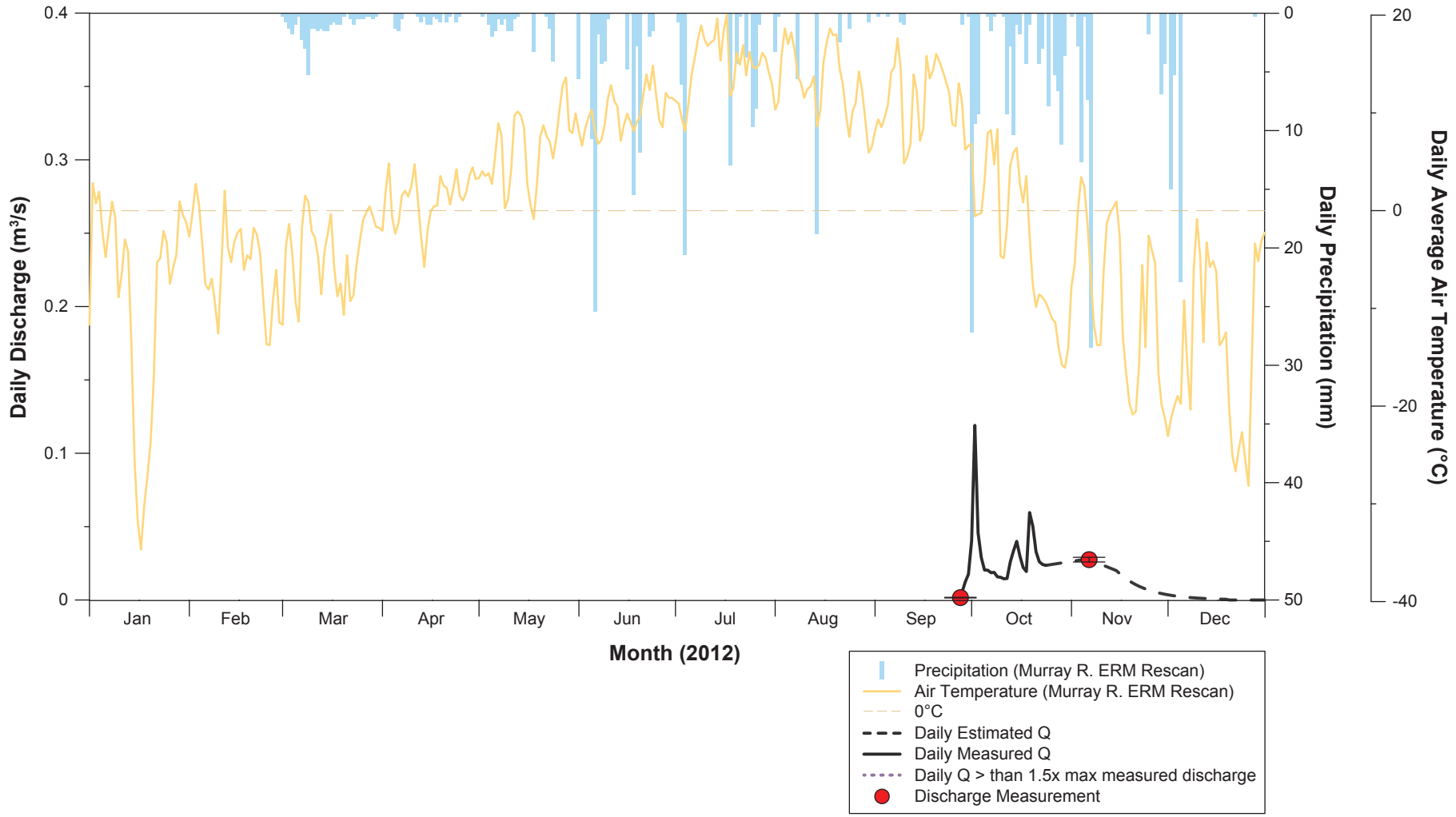



Figure A5-12

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-6, 2012

Figure A5-12

Rescan Engineers & Scientists

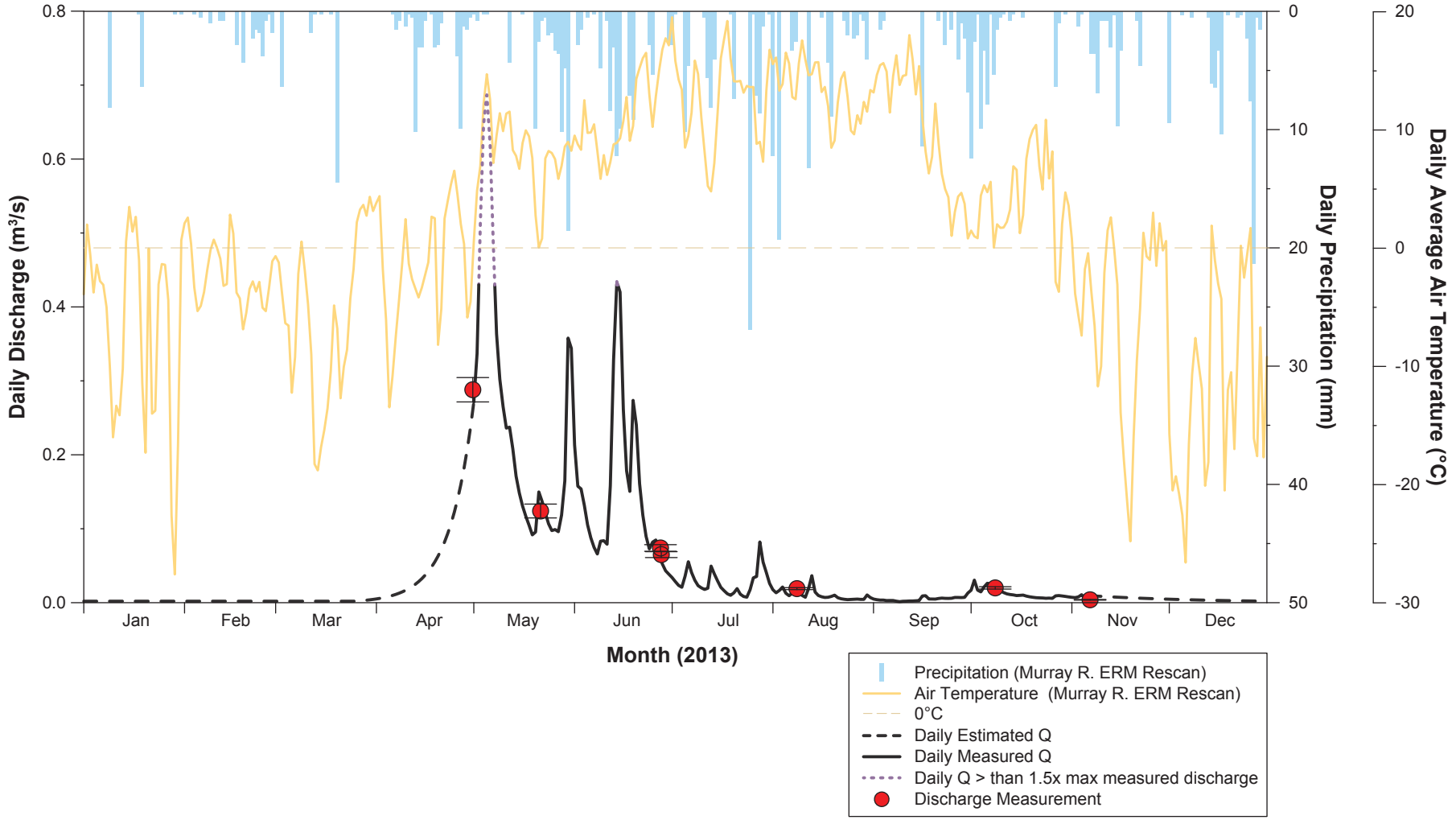



Figure A5-13

hd Mining

MURRAY RIVER COAL PROJECT

## Annual Hydrograph at Hydrometric Monitoring Station MH-6, 2013

Figure A5-13

Rescan Engineers & Scientists

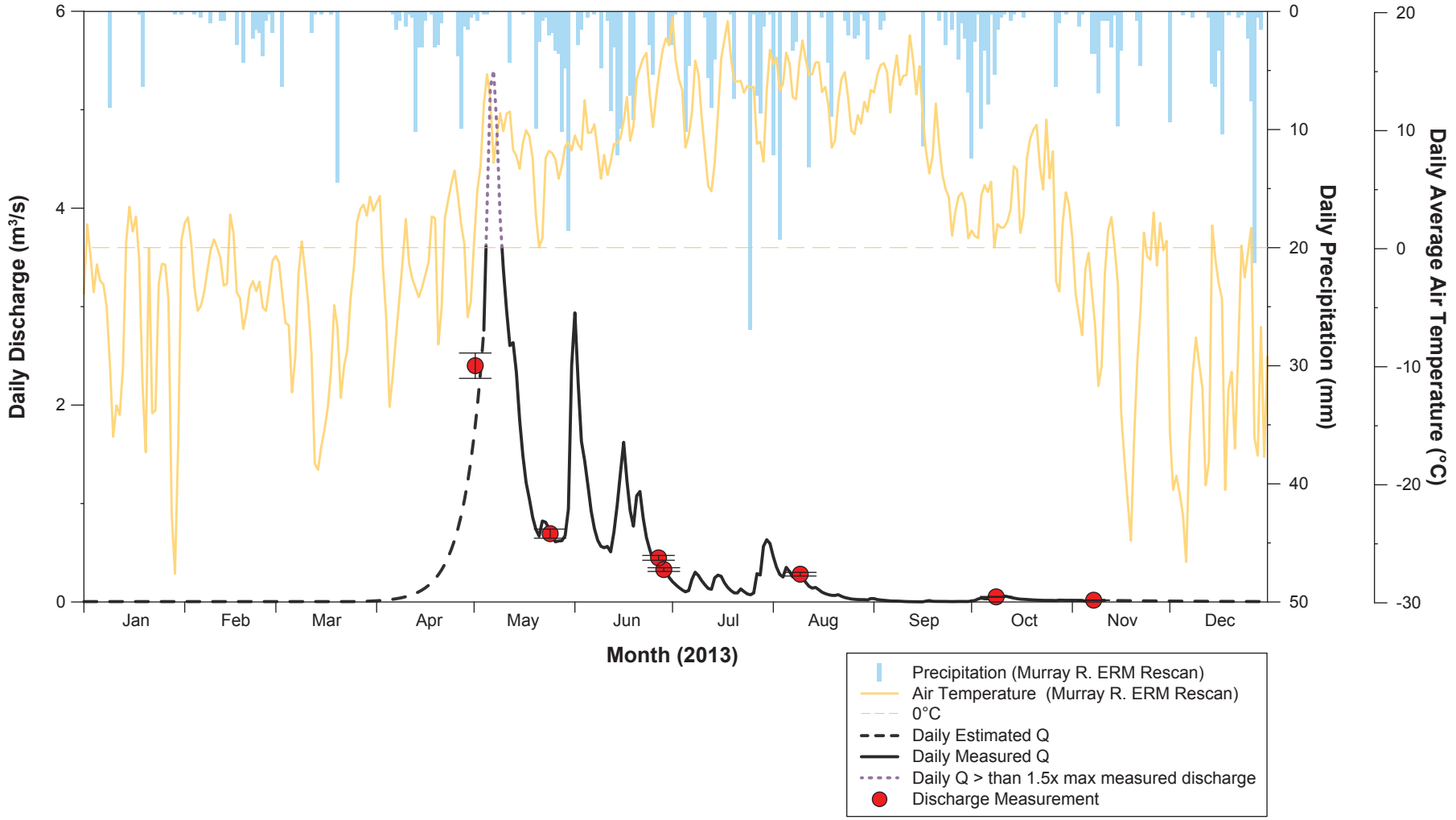



Figure A5-14

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## Annual Hydrograph at Hydrometric Monitoring Station MH-7, 2013

Figure A5-14

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# Appendix 6
## Frequency Analysis

ERM

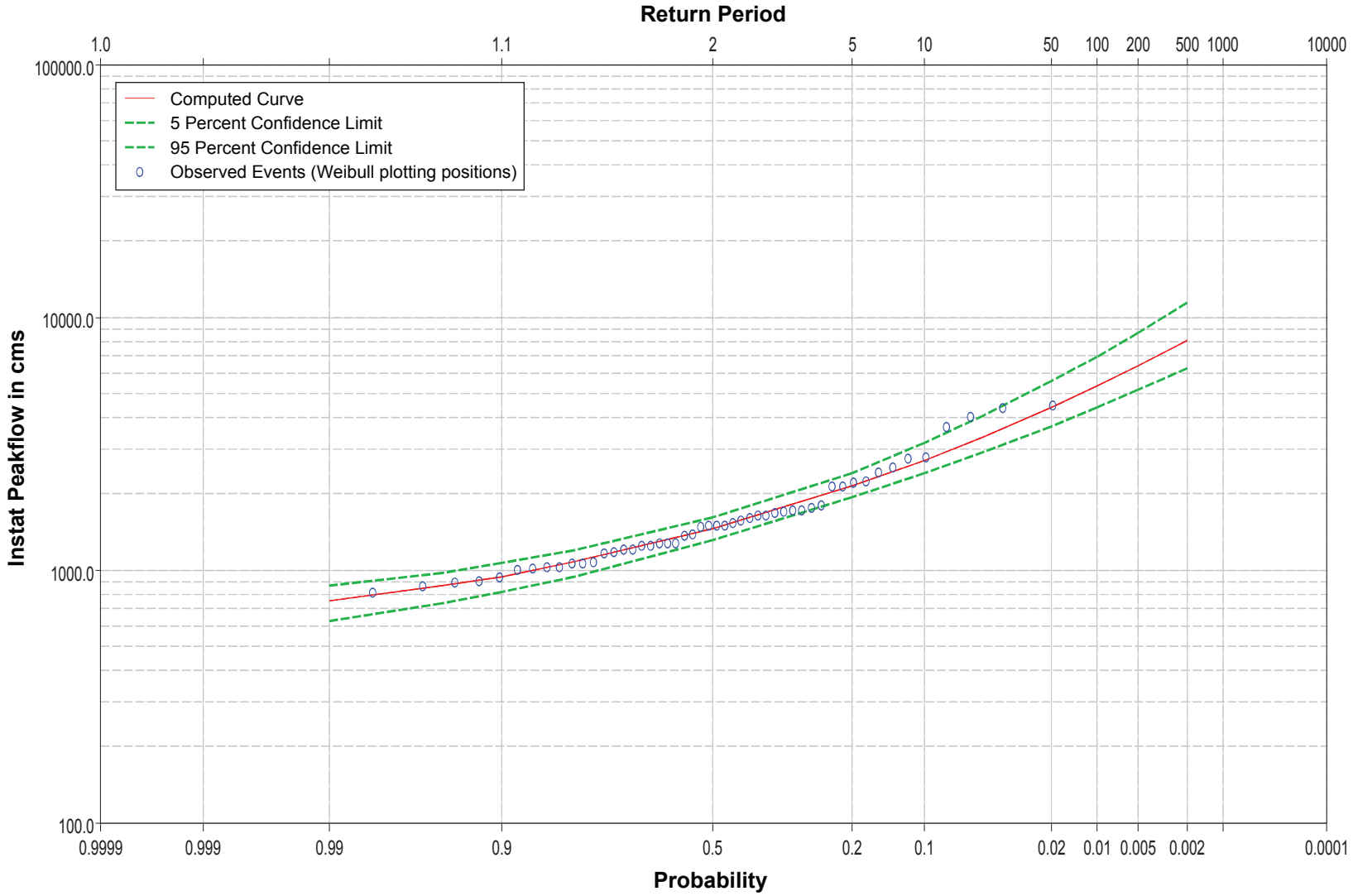



Figure A6-1

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## General Frequency Analytical Plot
## WSC07FB001 Pine River Peak Flow

Figure A6-1

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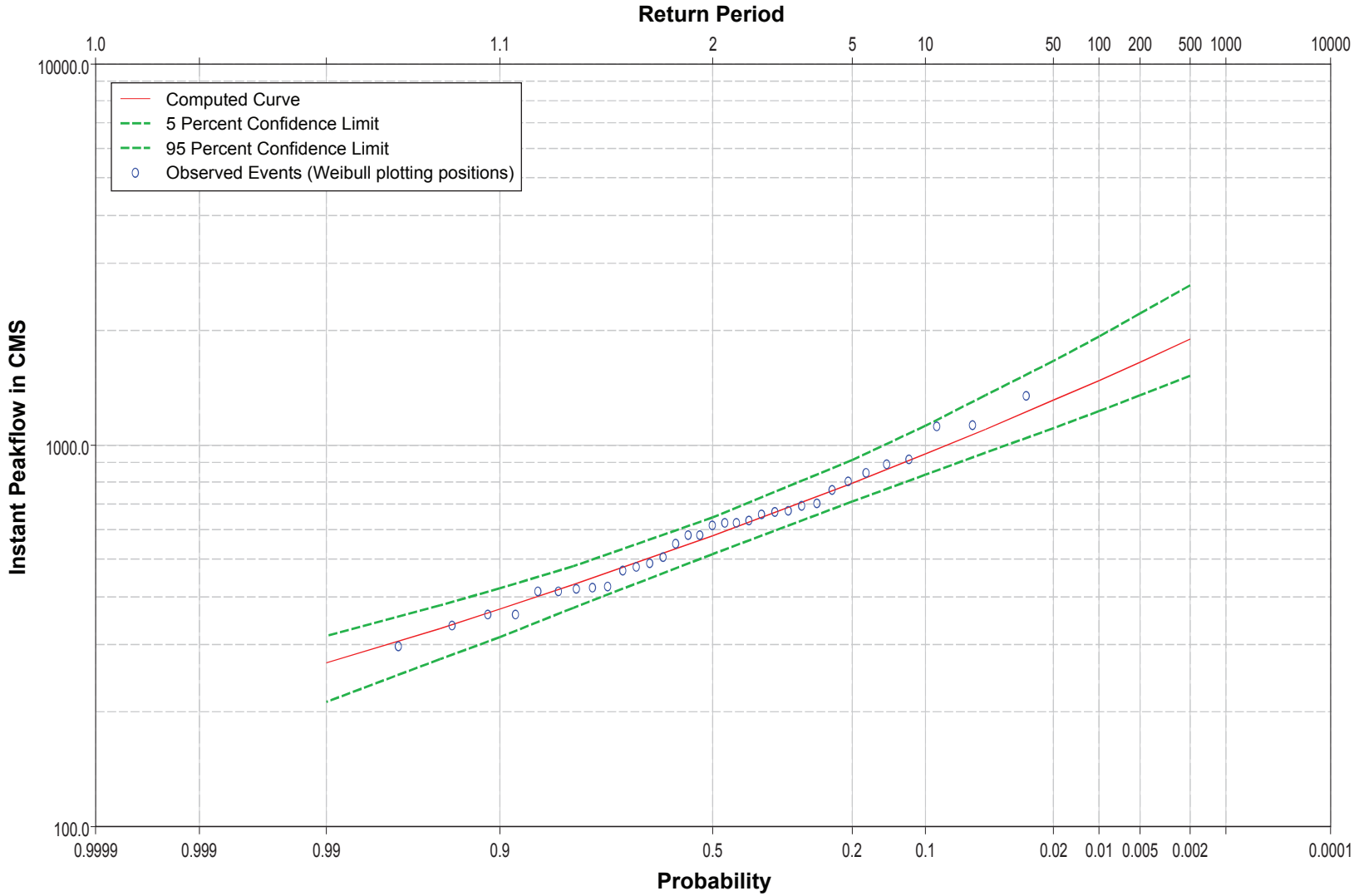



Figure A6-2

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# General Frequency Analytical Plot
# WSC07FB002 Murray River near the Mouth Peak Flow

Figure A6-2

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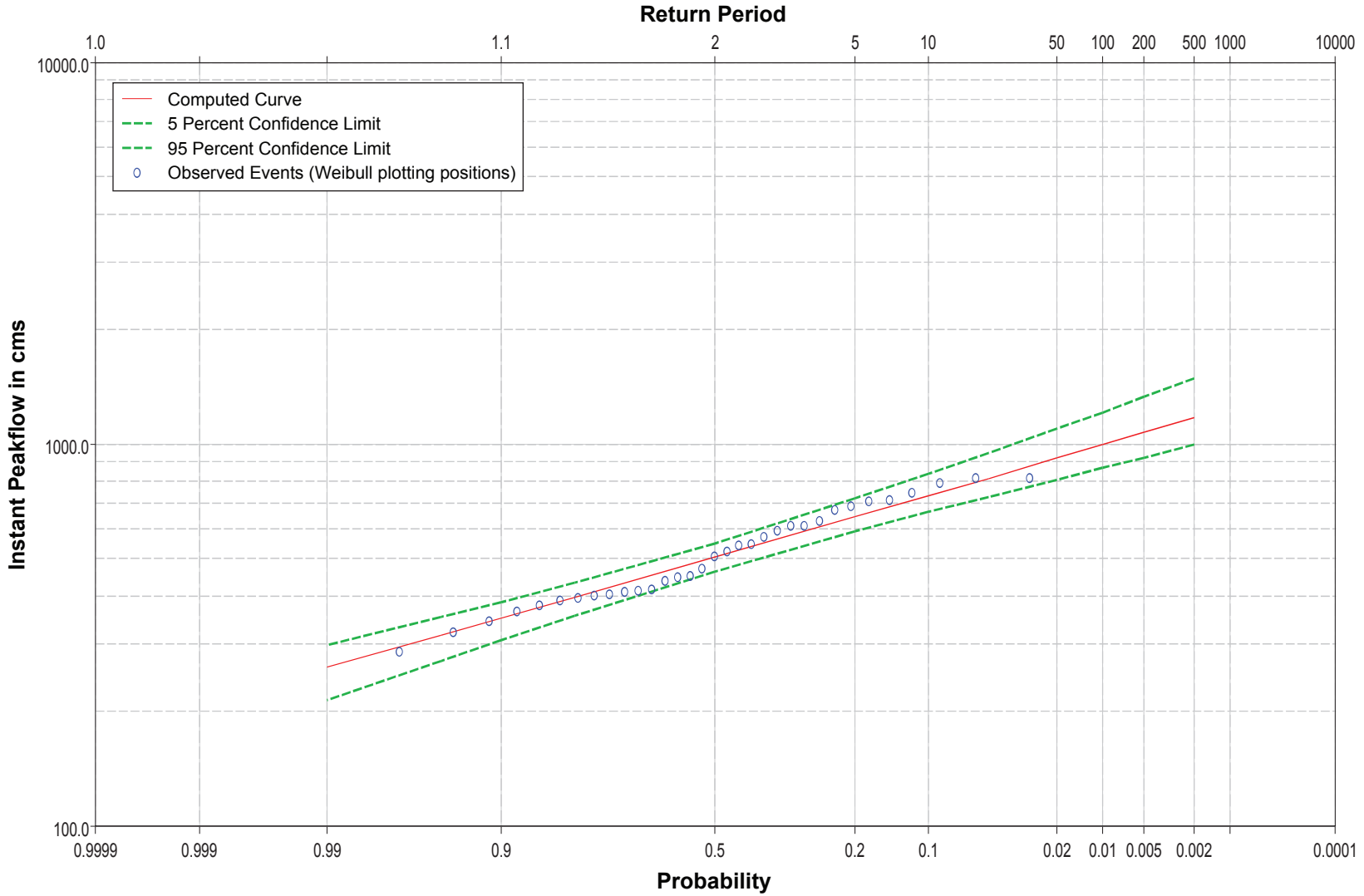



Figure A6-3

MURRAY RIVER COAL PROJECT

## General Frequency Analytical Plot
## WSC07FB003 Sukunka River Peak Flow

Figure A6-3

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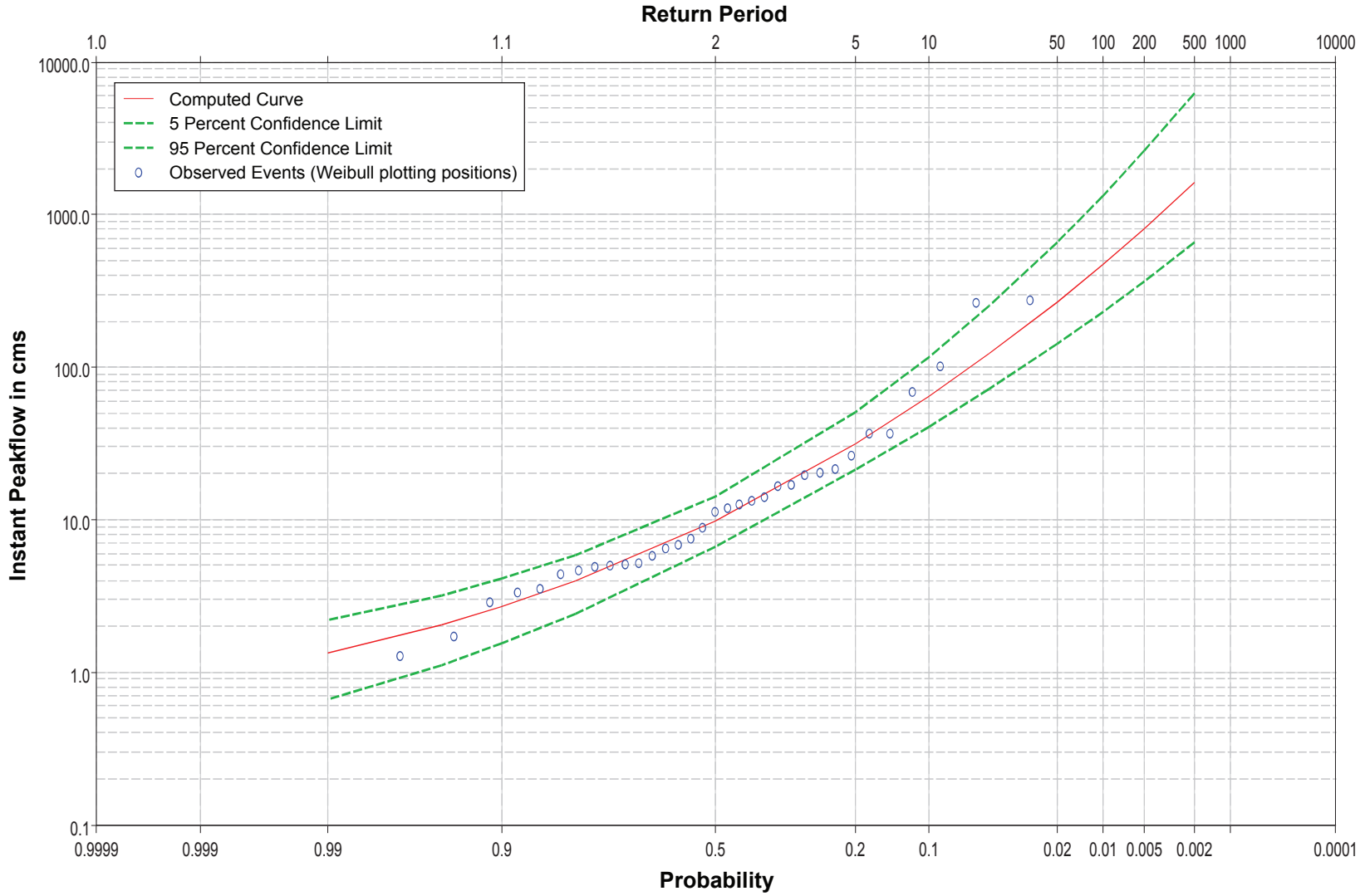



Figure A6-4

MURRAY RIVER COAL PROJECT

## General Frequency Analytical Plot
## WSC07FB004 Dickebusch Creek Peak Flow

Figure A6-4

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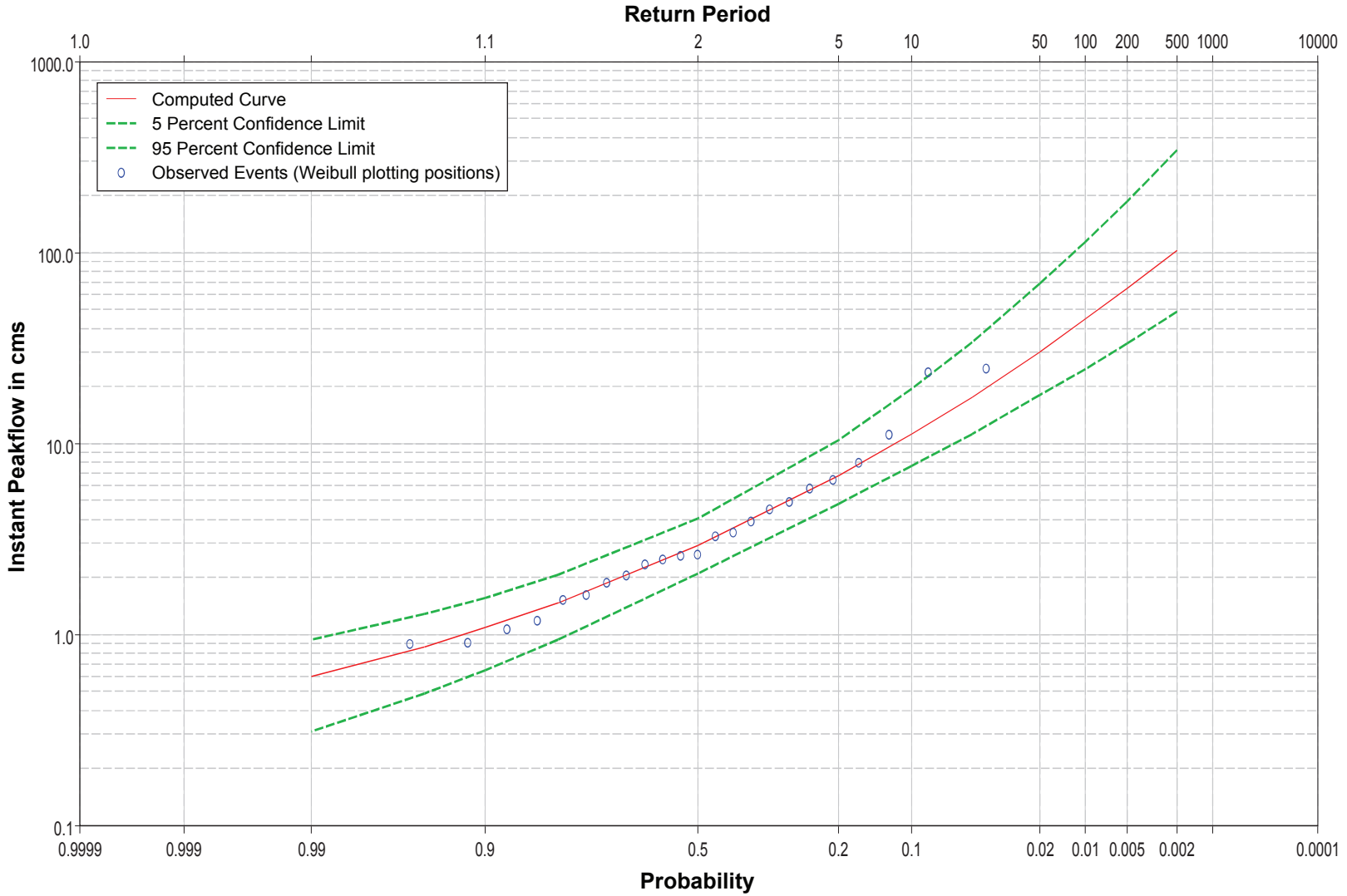



Figure A6-5

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## General Frequency Analytical Plot
## WSC07FB005 Quality Creek Peak Flow

Figure A6-5

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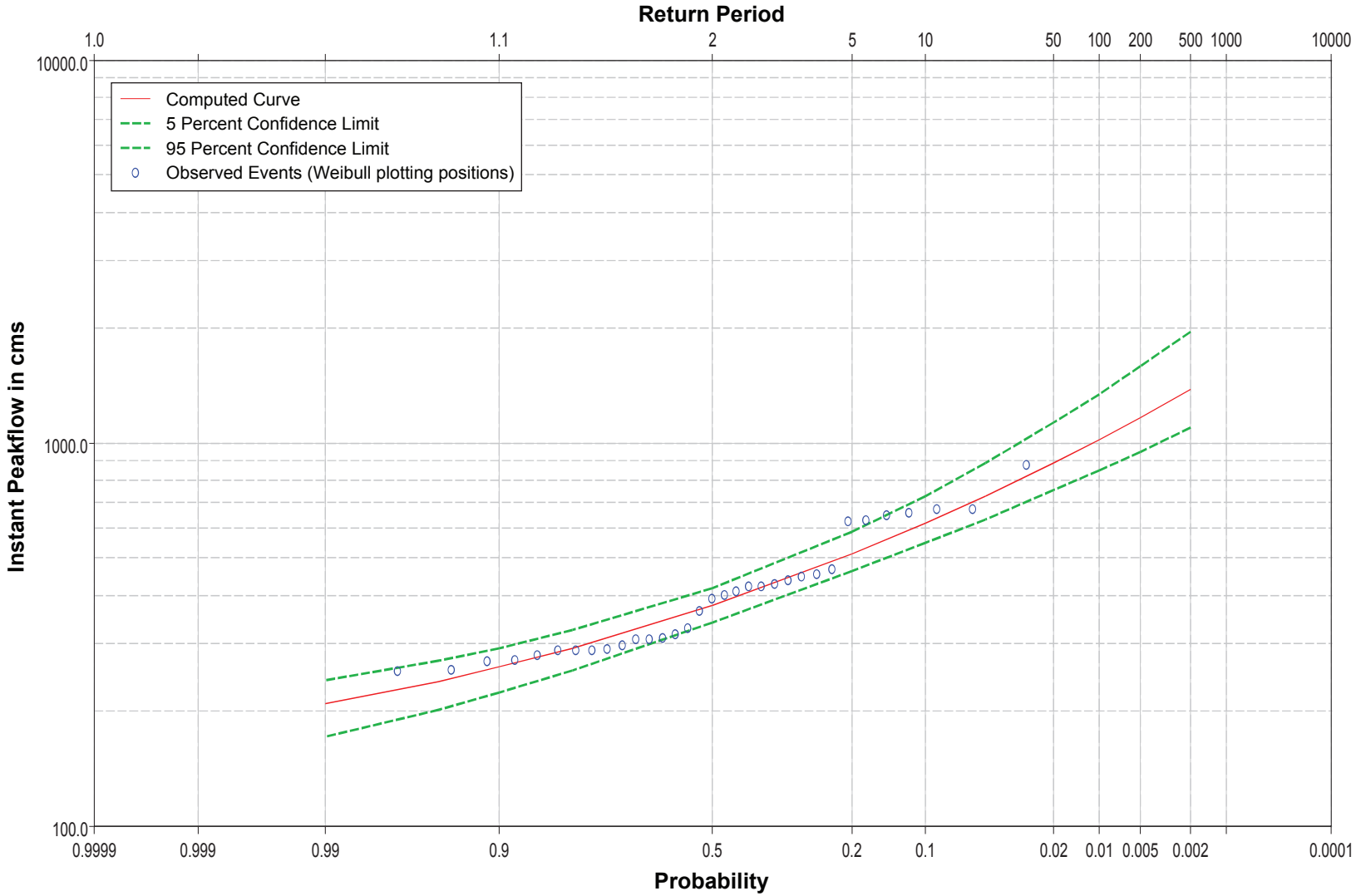



Figure A6-6

MURRAY RIVER COAL PROJECT

# General Frequency Analytical Plot
# WSC07FB006 Murray River above Wolvering River Peak Flow

Figure A6-6

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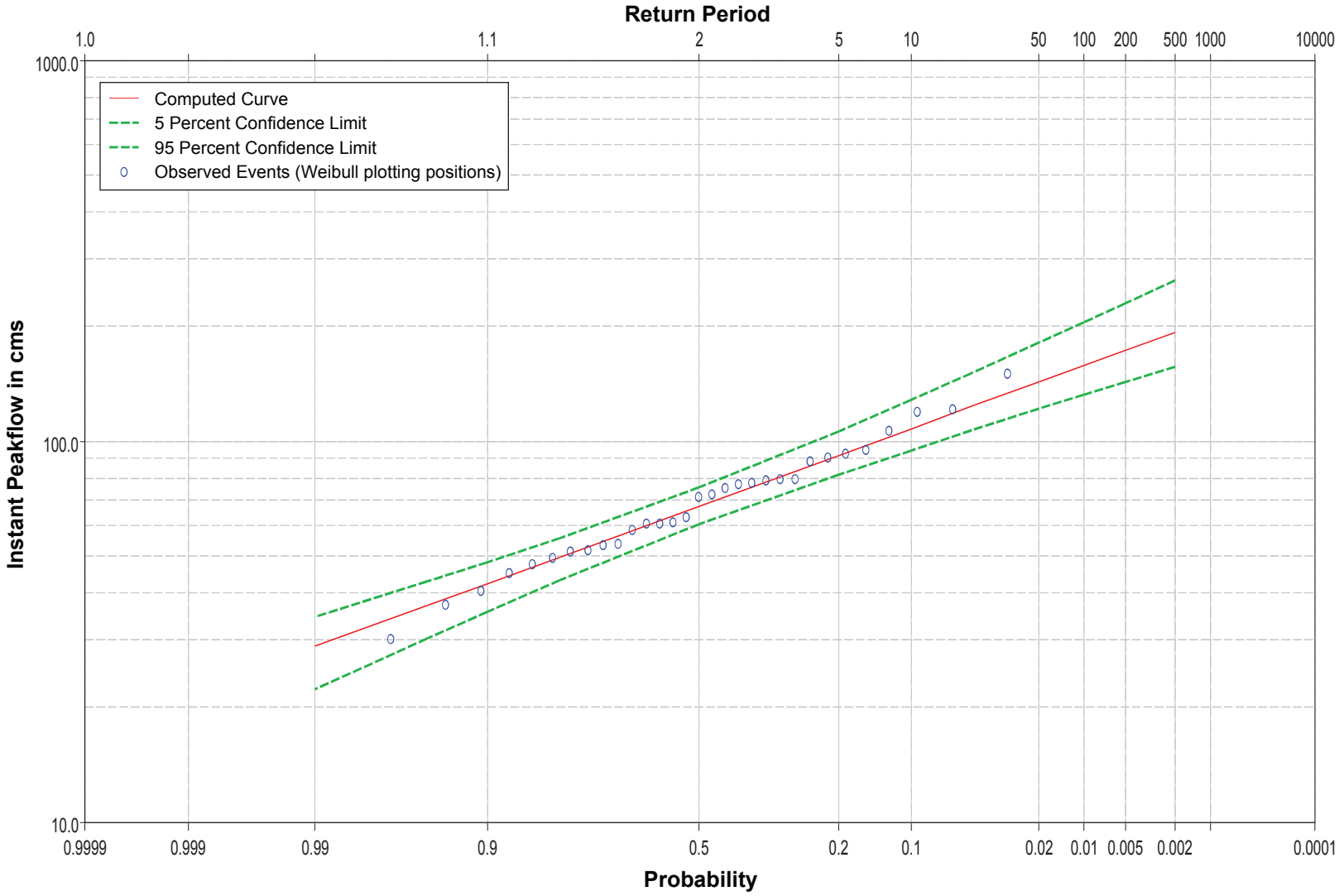



Figure A6-7

MURRAY RIVER COAL PROJECT

## General Frequency Analytical Plot
## WSC07FB008 Moberly River near Fort St. John Peak Flow

Figure A6-7

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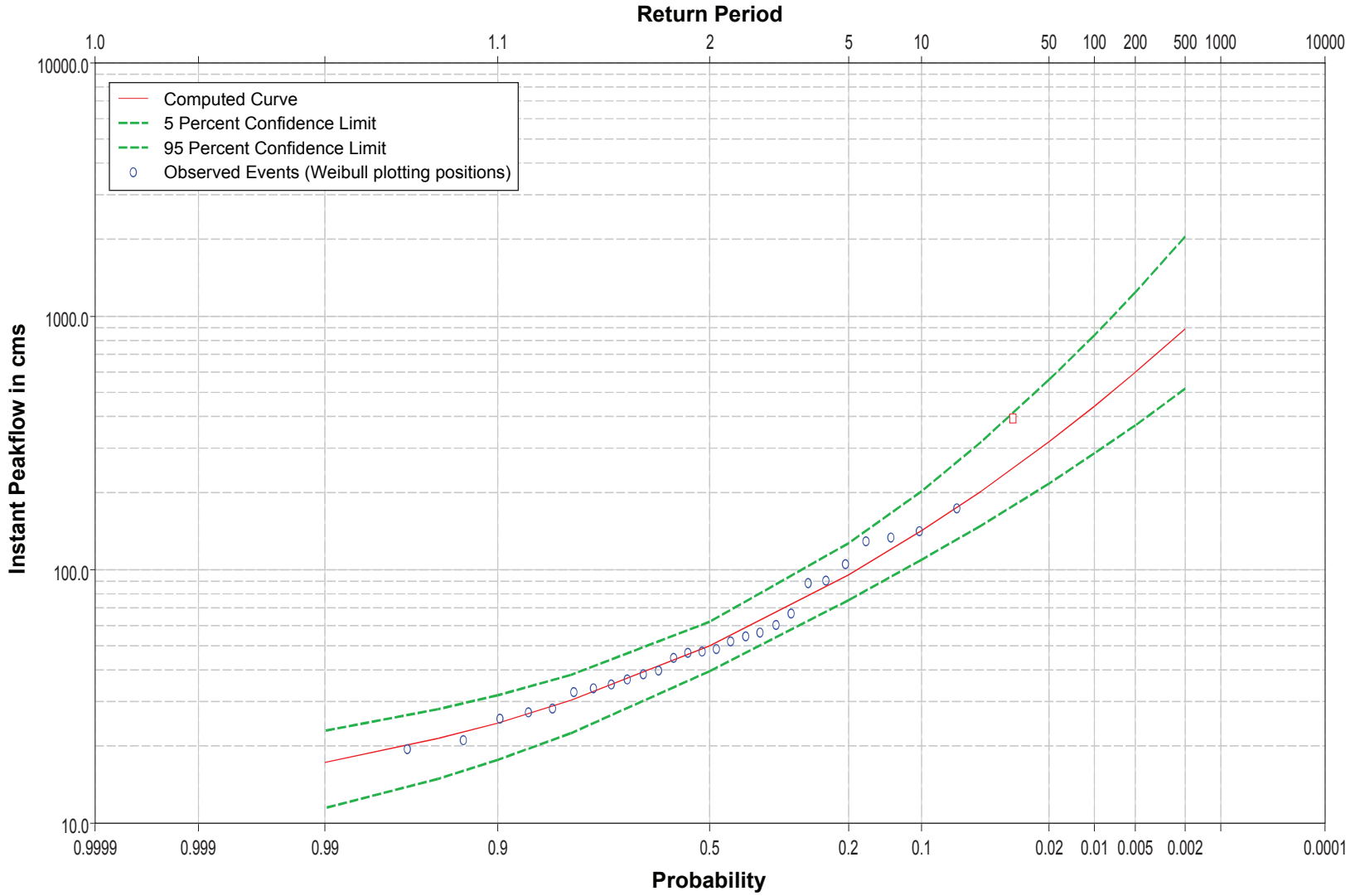



Figure A6-8

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# General Frequency Analytical Plot
# WSC07FB009 FlatBed Creek Peak Flow

Figure A6-8

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# Appendix 7
## Hydrometeorology Report

ERM

# Memorandum

| | | |
|---|---|---|
| **DATE:** | September 24, 2013 | Refer to File No.: B.1 Murray River Hydrometeorology Report.docx |
| **TO:** | Jason Rempel, M.Sc., P.Geo. | |
| **FROM:** | Ali Naghibi, Ph.D., P.Eng., Natasha Cowie, M.Sc. and David Luzi, M.Sc. | |
| **SUBJECT:** | Murray River Hydrometeorology Report | |

## 1. Introduction

### 1.1 Project Description

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

### 1.2 Environmental Setting

#### *1.2.1 Regional and Local Study Areas*

Regional and local study areas (RSA and LSA, respectively) have been developed to define the scope of baseline studies (Figure 1.2-1). The RSA (2,277 $km^2$) is intended to encompass an area beyond which effects of the Project would not be expected. The LSA (77.5 $km^2$) encompasses an area surrounding the proposed Project infrastructure within which direct effects from the Project may be anticipated. For consistency, the same RSA and LSA are used for all baseline environmental studies.

The Project area and LSA are in the Murray River watershed, which has a drainage area of 6,436 $km^2$ (Figure 1.2-2). The Murray River flows north into the Pine River, 40 km downstream from Chetwynd, BC. Both the Pine and Murray rivers are part of the larger Peace River drainage system, which flows into the Slave River, a tributary of the Mackenzie River. The Mackenzie River drains into the Beaufort Sea in the Arctic Ocean.

The LSA encompasses the mainstream of Murray River, Camp Creek (M20 Creek), Twenty Creek, Mast Creek, M17 Creek, and M19 Creek. Camp and Twenty creeks on the west side and M17 and M19 creeks on the east side flow into the Murray River. Mast Creek is one of tributaries of the Wolverine River, which flows into the Bullmoose River at Tumbler Ridge, and continues to flow northeast and downstream into the Murray River.

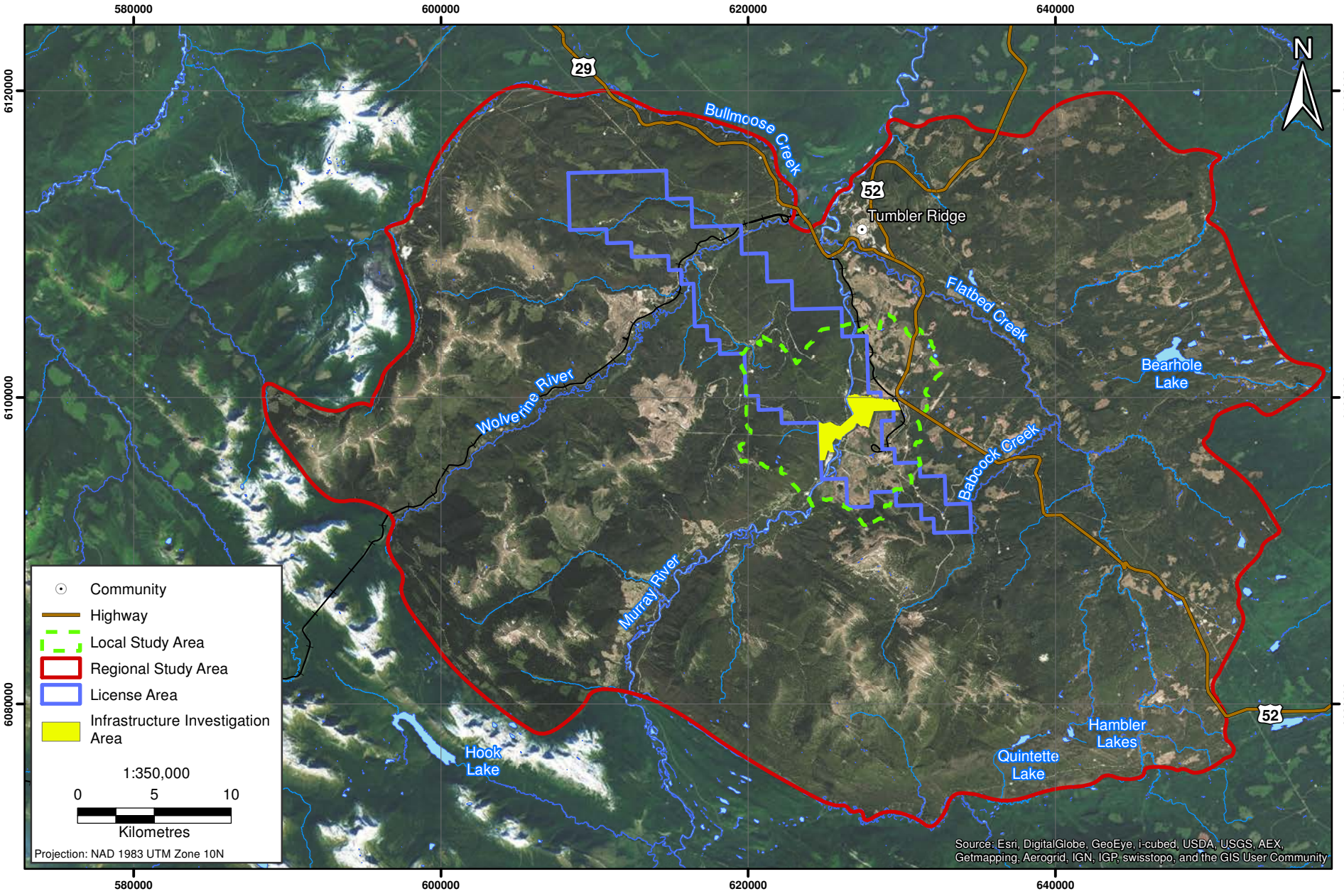



Figure 1.2-1

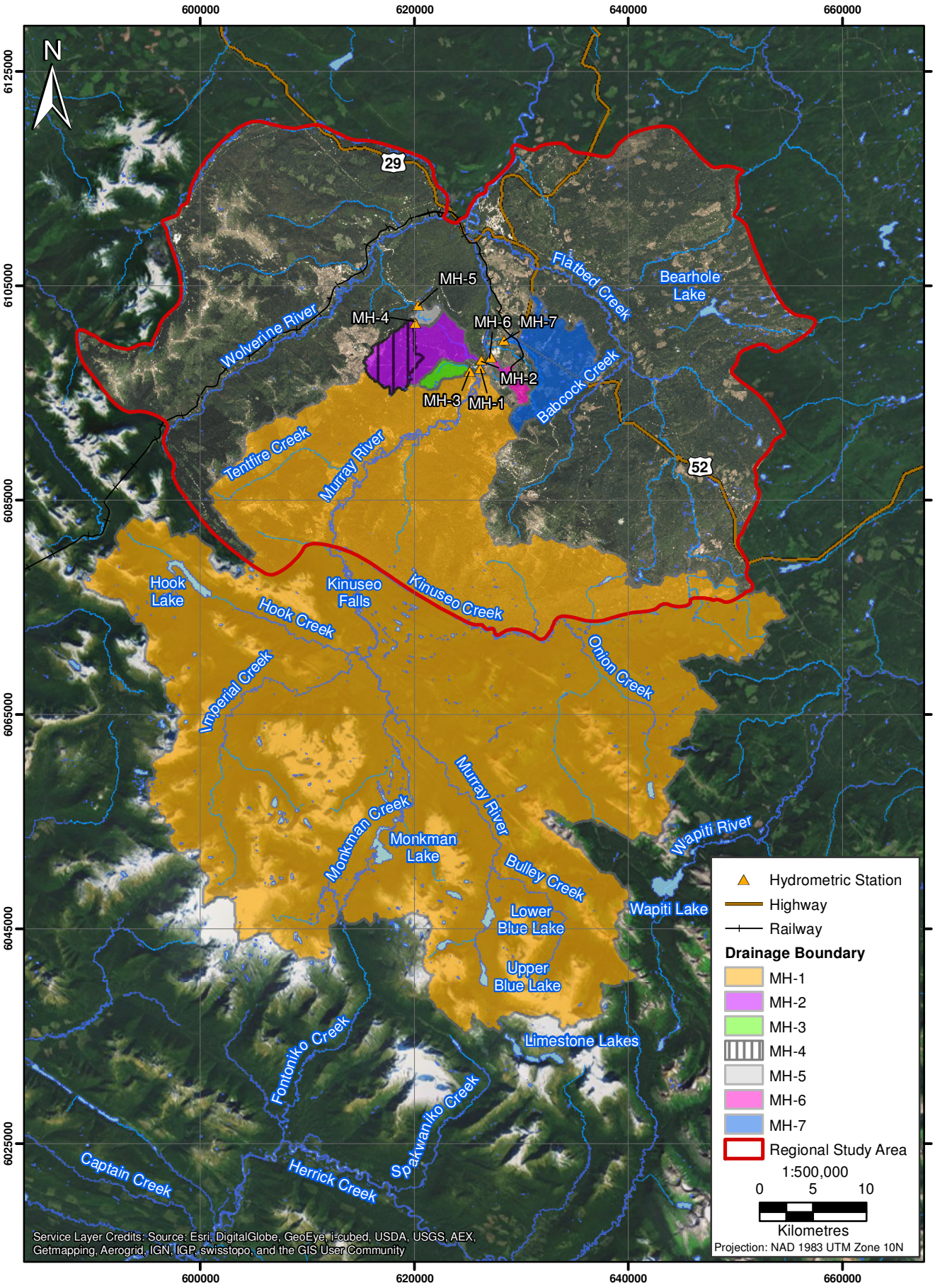
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# Project Study Boundaries

Figure 1.2-1

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# Drainage Basins within the Study Area

Figure 1.2-2

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### *1.2.2 Regional Meteorological and Hydrological Characteristics*

The proposed Murray River Coal Project is in the Southern Rocky Mountain Foothills hydrologic zone (British Columbia Hydrologic Zone 7; Obedkoff 2003). The zone is characterized by a continental climate with low precipitation, moderately warm summers, and cold winters.

Complexities of topography and air movement create a high degree of spatial and temporal variability in precipitation. In general, precipitation increases with elevation due to the orographic effect resulting when Pacific air streams reach the western slopes of the Rocky Mountains. The elevation change forces moisture-laden air up the slopes. As the air rises and cools it is less capable of holding moisture and releases it as rain or snow. On the eastern side of the Rockies, air descends and warms, dispersing clouds and rain through evaporation. The Project region is therefore characterized by both elevational and east-west precipitation gradients.

Drainage basins in northeastern British Columbia typically exhibit characteristics of both snowmelt (nival) and rainfall (pluvial) hydrologic regimes. These are referred to as mixed-regime or hybrid-regime basins (Eaton and Moore 2010). Glacial contributions to runoff are minimal or nonexistent in the Rocky Mountain foothills. Streamflow tends to peak during freshet between May and July, driven by snowmelt in May and rainfall in June and July (Figure 1.2-3). Low flows occur during the winter and early spring. Many streams, especially in smaller catchments, have almost no flow from November to March.

## 1.3 Scope of Report

This report summarizes the meteorological and hydrological regional analyses that were conducted based on long-term data from Meteorological Service of Canada (MSC) and Water Survey of Canada (WSC) stations. Results of such analyses were combined with meteorological and hydrological data collected during the baseline monitoring program to estimate key parameters within the Project watersheds. These parameters include:

- Mean annual precipitation and evaporation within the Project watersheds,
- Extreme rainfall events with different return periods within the Project watersheds,
- Annual runoff values during wet and dry years,
- Peak flow events with different return periods,
- Low flow estimates, i.e., 7-day annual low flow and 7-day low flow during June to September.

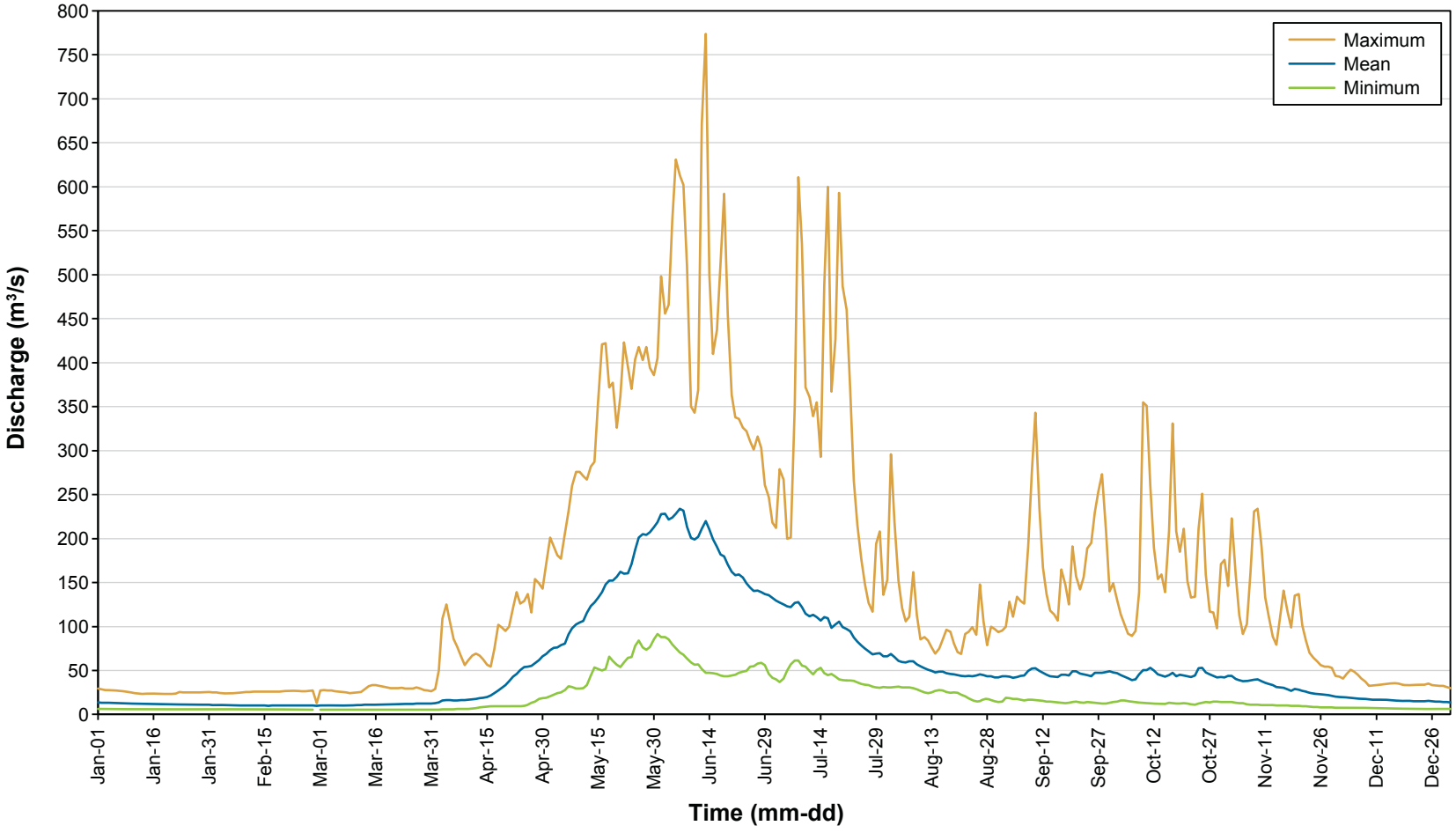
These parameters are important in different effects assessment studies including hydrogeology and water quality modeling, fish habitat assessment, and engineering design.

## 1.4 Water Balance Components

Within a watershed, for any time period of length Δt, the water balance equation can be written as (Dingman 2008):

$$P + \Delta G - Q - EVAP = \Delta S$$

Where $P$ is precipitation, $\Delta G$ is the difference between groundwater outflow and inflow (i.e., discharge and recharge), $Q$ is stream outflow, EVAP is the evaporation loss, and $\Delta S$ is the change in all forms of water storage within the watershed. The dimensions of these quantities are L (i.e., volume divided by drainage area).




*Note: based on the 1977 – 2010 records of Water Survey of Canada Station Murray River Above Wolverine (07FB006).*

Figure 1.2-3

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# Typical Annual Discharge Hydrograph of the Rocky Mountain Foothills

Figure 1.2-3

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If these quantities are averaged over a long-term period (e.g., 20 years), in which there are no significant climate trends or geological changes and no anthropogenic inputs, outputs, or storage modifications, one may usually assume that net changes in storage (ΔS) will be effectively zero.

Groundwater catchment areas may be different from those of the surface water watersheds; therefore, *ΔG* is not always zero. However, for large watersheds, it is common to assume that *ΔG* is zero, knowing that such a commonly used assumption may be associated with uncertainty.

Given these assumptions, the water balance equation may be simplified to:

$$MAP - MAR - EVAP = 0$$

Where MAP, *MAR*, and EVAP are the mean annual precipitation, mean annual runoff, and evaporation over a long period of time.

Given the quality of available meteorological and hydrologic data for the study area, runoff is the most reliable, and evaporation is the most uncertain, components of the water balance equation. Uncertainty around precipitation data lies at some point in between the other two components.

# 2. Meteorology

## 2.1 Overview

Meteorological data have been collected in the Project area since 2011 as part of the baseline monitoring program. The main objective of the 2011-2012 meteorology baseline program was to document the Project site baseline meteorology conditions to a suitable level of detail to support Project planning, engineering, and environmental assessment.

## 2.2 Methodology

The Murray River meteorological station was installed on March 8, 2011 in a laydown area beside the Mast Road near kilometre four. Data collection commenced on March 9, 2011. The station was installed in accordance with guidelines developed by the Meteorological Service of Canada (MSC 2004). These guidelines closely follow standards set by the World Meteorological Organization (WMO 1983) and were established to promote standardization and describe practices, procedures, and specifications for proper siting of instruments, precision and accuracy of measurements, and archive formats. The station consists of a standard 10 metre meteorological tower with instrumentation to measure a number of climate parameters, including air temperature and precipitation. Further details of station instrumentation are provided in the *2011-2012 Meteorology Baseline Report* (Rescan 2013b).

Data from seven meteorological stations in the region surrounding the Project have been evaluated for this report to characterize temperature and precipitation at the Murray River project site and to provide regional and historical context for the project data. Six of the regional stations are operated by the Meteorological Service of Canada (MSC) and one station is operated by the Wildfire Management Branch of the BC Ministry of Forests (MOF). Table 2.2-1 provides details of the Murray River and regional stations. Station locations are displayed in Figure 2.2-1.

Climate normals (meteorological data averaged over a timespan of at least 15 years between 1971 and 2000) are available for four of the regional stations (Denison Plant Site, Tumbler Ridge, Bullmoose, and Chetwynd A). Data from 2011 and 2012 are available for three of the regional stations (Tumbler (Denison), Chetwynd A, and Dawson Creek A). Climate normals were used to characterize air temperature at regional stations. Long-term climate averages (1988-2003) were used to characterize precipitation at regional stations.

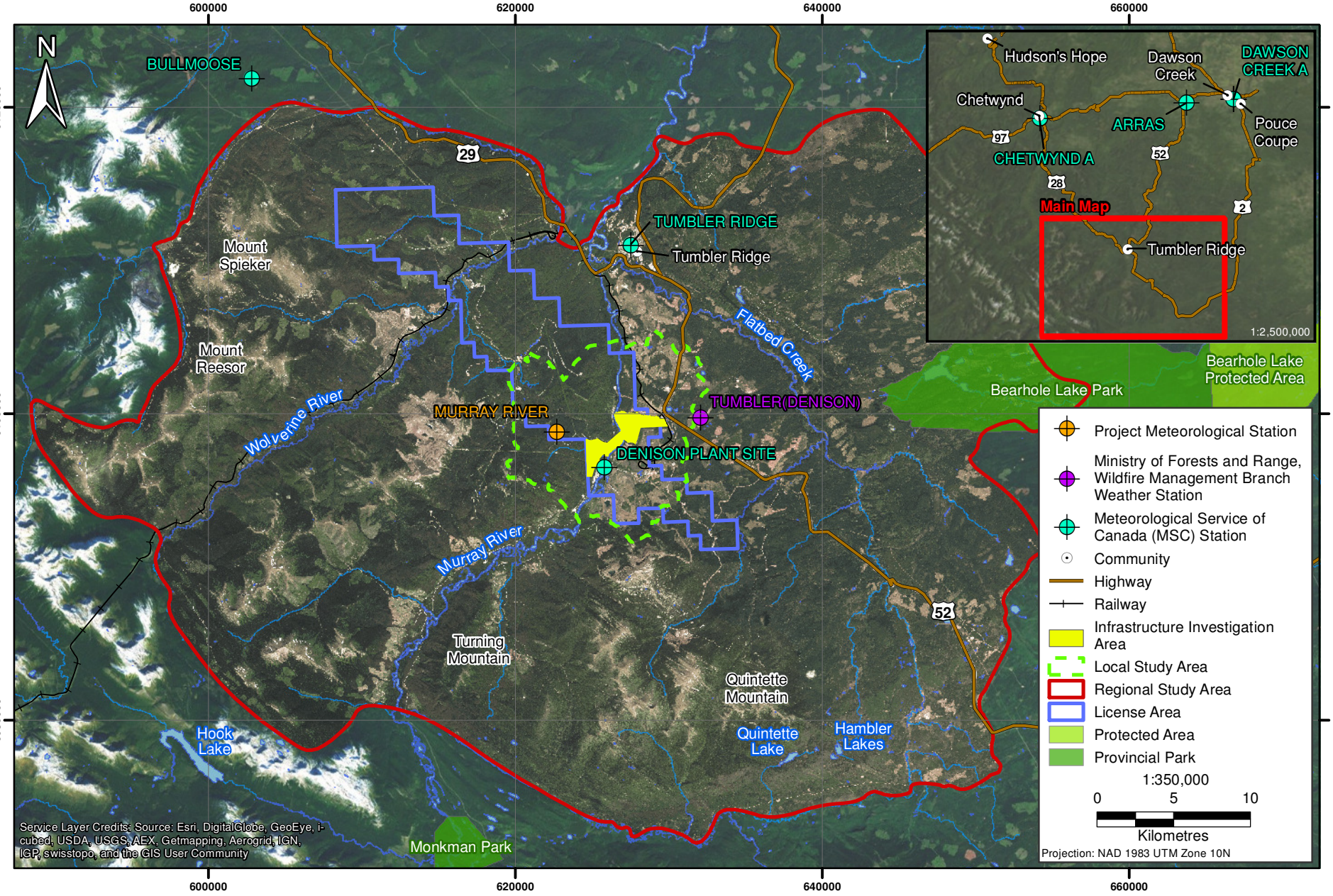



Figure 2.2-1

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## Locations of the Murray River and Regional Meteorological Stations

Figure 2.2-1

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**Table 2.2-1. Automated Climate Stations in the Murray River Project Region**

| Station ID | Station Name | Location | | | | Period of Record | Status |
|---|---|---|---|---|---|---|---|
| | | UTM Coordinates[a] | | Elevation (m asl) | Distance from Murray River Station | | |
| | | Easting | Northing | | | | |
| n/a | Murray River[b] | 619302 | 6100094 | 1055 | n/a | 2011-present | Active |
| 1182427 | Denison Plant Site | 624730 | 6096530 | 854 | 3.8 km SE | 1982-1998 | Inactive |
| 1188297 | Tumbler Ridge[d] | 626178 | 6120696 | 824 | 13.2 km N-NE | 1985-2003 | Inactive |
| 1181120 | Bullmoose | 576346 | 6119559 | 1102 | 25.8 km NW | 1982-2003 | Inactive |
| 1181508 | Chetwynd A | 559019 | 6223181 | 610 | 81.9 km NW | 1982-present | Active |
| 1180490 | Arras | 654881 | 6179157 | 677 | 86.7 km NE | 1970-1988 | Inactive |
| 1182289 | Dawson Creek A | 676900 | 6180925 | 655 | 98.0 km NE | 1968-present | Active |
| n/a | Tumbler (Denison)[c] | 592636 | 6101316 | 942 | 9.5 km E | 1982-present | Active |

*Notes: Stations are operated by the Meteorological Service of Canada, unless otherwise noted.*
*[a] NAD83, Zone 10N*
*[b] Operated by Rescan.*
*[c] Operated by the BC Ministry of Forests, Lands, and Natural Resource Operations.*
*[d] The MSC's reported position of Tumbler Ridge station is incorrect based on knowledge from previous studies. The listed position is an estimate of the correct location based on the location of the town of Tumbler Ridge and its topography.*

The mountainous terrain of the region generates significant spatial variation in meteorological conditions. In regional analysis, it is therefore important to use data from stations as close as possible to the Project, located in comparable terrain and at a similar elevation. Seven regional stations were selected on the basis of their proximity to the Project. Three of the MSC stations were located within or close to the border of the RSA. Tumbler (Denison) station is the closest station to the Project that is still active and is considered to be the most representative regional station for the Project area due to its close proximity and similar elevation to the Murray River station.

Data from regional climate stations were processed to fill data gaps and to differentiate rainfall and snowfall values. Mean annual precipitation (MAP) values for years of incomplete data (e.g., data gaps caused by instrument damage or malfunction) were replaced with estimates derived from regression equations relating concurrent data for nearby stations. Table 2.2-2 summarizes the results of correlation analysis for incomplete station records with neighbouring stations.

**Table 2.2-2. Correlation Analysis Summary for Estimation of Murray River and Regional Climate Station Mean Annual Precipitation (MAP) and Mean Annual Rainfall**

| Climate Station (Reference Station) | Concurrent Years | Correlation Equation | | $R^2$ | | Estimated Years |
|---|---|---|---|---|---|---|
| | | MAP | Rainfall | MAP | Rainfall | |
| Bullmoose (Dawson Creek A) | 1983, 1986-2002 | y = 0.9401x + 334.65 | y = 0.885x + 168.76 | 0.39 | 0.65 | 1982, 1984, 1985, 2003 |
| Dawson Creek A (Chetwynd A) | 1983-1996, 1998-2005 | y = 0.6881x + 146.1 | y = 0.6848x + 96.7 | 0.42 | 0.55 | 2006-2009 |
| Chetwynd A (Dawson Creek A) | 1983-1996, 1998-2005 | y = 0.6145x + 167.01 | y = 0.8008x + 62.255 | 0.42 | 0.55 | 1982, 1997 |
| Tumbler Ridge (Denison Plant) | 1986-1990, 1992-1994, 1996, 1997 | y = 0.6455x + 122.14 | y = 0.8853x + 15.154 | 0.54 | 0.91 | 1991, 1995 |
| Tumbler (Denison) (Denison Plant) | 1989-1997 | y = 1.0687x - 142.54 | y = 0.9174x - 33.412 | 0.45 | 0.56 | 1988 |

The entire records for Murray River and Tumbler (Denison) stations, and the records for the years 2010-2012 at the Dawson Creek A station, do not differentiate rainfall values from total precipitation. Additionally, no snow gauge was installed at the Tumbler (Denison) station until winter 2012/2013, meaning that winter precipitation records prior to this time are unreliable (E. Meyer pers. com. 2013). For these three stations, annual rainfall was extracted from MAP by applying a rain:total precipitation ratio (Table 2.2-3). The rain:total precipitation ratio at Dawson Creek A was derived from the station record for 1969-2005. The rain:total precipitation ratios for Murray River and Tumbler (Denison) stations were derived from the Denison Plant Site station record for 1989-1997. The Denison Plant Site was selected due to its close proximity and similar elevation to both the Murray River and Tumbler (Denison) stations.

**Table 2.2-3. Regression Analysis Summary for Estimation of Murray River and Regional Climate Station Mean Annual Precipitation (MAP) and Mean Annual Rainfall**

| Climate Station (Reference Station) | Period Used to Develop Ratio | Estimated Years | Total Annual Rain: Total Annual Precipitation | May-Sept Rain: Total Annual Rain | May-Sept Rain: Total Annual Precipitation |
|---|---|---|---|---|---|
| Murray River (Denison Plant Site) | 1989-1997 | 2011-2012 | n/a | 0.80 | 0.50 |
| Tumbler (Denison) (Denison Plant Site) | 1989-1997 | 1989-2012 | n/a | 0.80 | 0.50 |
| Dawson Creek A (Dawson Creek A) | 1969-2005 | 2010-2012 | 0.67 | n/a | n/a |

Because winter precipitation measurements at both Murray River and Tumbler (Denison) stations were incomplete, May-September rain:total rain and May-September rain:total precipitation ratios were used for these stations. For example, at the Denison Plant Site station, May-September precipitation (assumed to fall as rain) represented 80% of total annual rain, and 50% of total annual precipitation (rain and snow combined) over the period from 1989-1997.

A final step in data processing involved adjusting each station's MAP and mean annual rainfall values to represent a common 16-year period from 1988 to 2003. This adjustment eliminates biases caused by temporal variations in climate, because any temporal variation will be reflected identically by the concurrent time series.

Precipitation tends to be correlated with elevation in mountainous regions (Loukas and Quick 1993). An empirical equation was developed between long-term MAP (1988-2003) and elevation of four regional climate stations (Chetwynd A, Dawson Creek A, Tumbler Ridge, and Bullmoose). Criteria for station selection included proximity to the Project area and length of record. The period of record for the selected stations ranged from 19-45 years.

A linear regression was fitted to the points representing stations with the most reliable data series, of the form:

$$P = 0.696E - 19.54$$

where *P* is mean annual precipitation (mm) and *E* is median watershed elevation (masl). As expected, MAP was positively correlated with higher elevations ($R^2$ = 0.9145). This equation was used to estimate MAP for each of the Project watersheds on the basis of median watershed elevation.

## 2.3 Results

Murray River climate station air temperature and precipitation data are presented in this section and summarized on a monthly basis in Table 2.3-1.

**Table 2.3-1. 2011-2012 Murray River Climate Station Monthly Temperature and Precipitation**

| | Average Temperature (˚C) | | Mean Daily Minimum Temperature (˚C) | | Mean Daily Maximum Temperature (˚C) | | Total Precipitation (mm) | |
|---|---|---|---|---|---|---|---|---|
| **Month** | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** |
| Jan | n/a[a] | -7.7 | n/a[a] | -11.2 | n/a[a] | -3.8 | n/a[a] | n/a[b] |
| Feb | n/a[a] | -4.2 | n/a[a] | -8.7 | n/a[a] | 0.6 | n/a[a] | n/a[b] |
| Mar | 4.9 | -3.2 | -8.9 | -8.3 | 0.6 | 2.4 | 27.9 | 32.8 |
| Apr | 0.9 | 2.3 | -3.8 | -2.8 | 5.3 | 7.4 | 0.0 | 10.2 |
| May | 7.7 | 7.5 | 2.0 | 1.4 | 13.1 | 12.7 | 66.6 | 19.6 |
| Jun | 10.7 | 11.2 | 5.5 | 6.5 | 15.6 | 15.7 | 97.5 | 90.9 |
| Jul | 12.1 | 16.1 | 8.5 | 9.0 | 16.2 | 22.4 | 121.2 | 67.6 |
| Aug | 13.1 | 14.2 | 7.3 | 7.3 | 18.3 | 20.7 | 6.6 | 32.5 |
| Sep | 10.7 | 12.3 | 5.2 | 5.5 | 16.0 | 18.4 | 4.1 | 3.6 |
| Oct | 3.3 | -1.7 | 0.3 | -5.4 | 6.6 | 2.2 | 0.3 | 119.4 |
| Nov | -4.9 | -7.5 | -8.6 | -11.0 | -1.4 | -3.5 | 23.4 | 64.8 |
| Dec | -2.2 | -12.9 | -5.9 | -17.3 | 1.2 | -8.9 | 39.9 | 43.4 |
| **Average** | 5.6 | 2.2 | 0.2 | -2.9 | 9.2 | 7.2 | 38.7 | 48.5 |
| **Max** | 13.1 | 16.1 | 8.5 | 9.0 | 18.3 | 22.4 | 121.2 | 119.4 |
| **Min** | -4.9 | -12.9 | -8.9 | -17.3 | -1.4 | -8.9 | 0.0 | 3.6 |
| **Total** | n/a | n/a | n/a | n/a | n/a | n/a | 387.4 | 484.6 |

[a] *Murray River station was not operational until March 9, 2011*
[b] *Precipitation gauge malfunction generated erroneous data*
*n/a: data not available*

### *2.3.1 Air Temperature*

Daily mean, maximum, and minimum temperatures for the Murray River climate station in 2011 and 2012 are presented in graphical form in Figure 2.3-1. Daily temperatures for 2012 were characterized by a slightly greater range than 2011, with a warmer summer and colder winter. Table 2.3-2 and Figure 2.3-2 summarize the 2011-2012 monthly mean air temperatures at the Murray River and regional stations and the 1971-2000 climate normal monthly mean air temperatures at regional stations. Air temperatures recorded at the Murray River station in 2011 and 2012 were generally similar to temperatures recorded at regional stations. In general, maximum monthly average temperatures occurred in July and minimum monthly average temperatures occurred in December or January.

The Murray River station, at 1055 masl, is higher than most of the regional stations (with the exception of Bullmoose, at 1102 masl). The relatively lower summer temperatures at the Murray River station are likely due to its higher altitude (200-400 m higher) in comparison to the regional stations, which are located in valley bottoms.

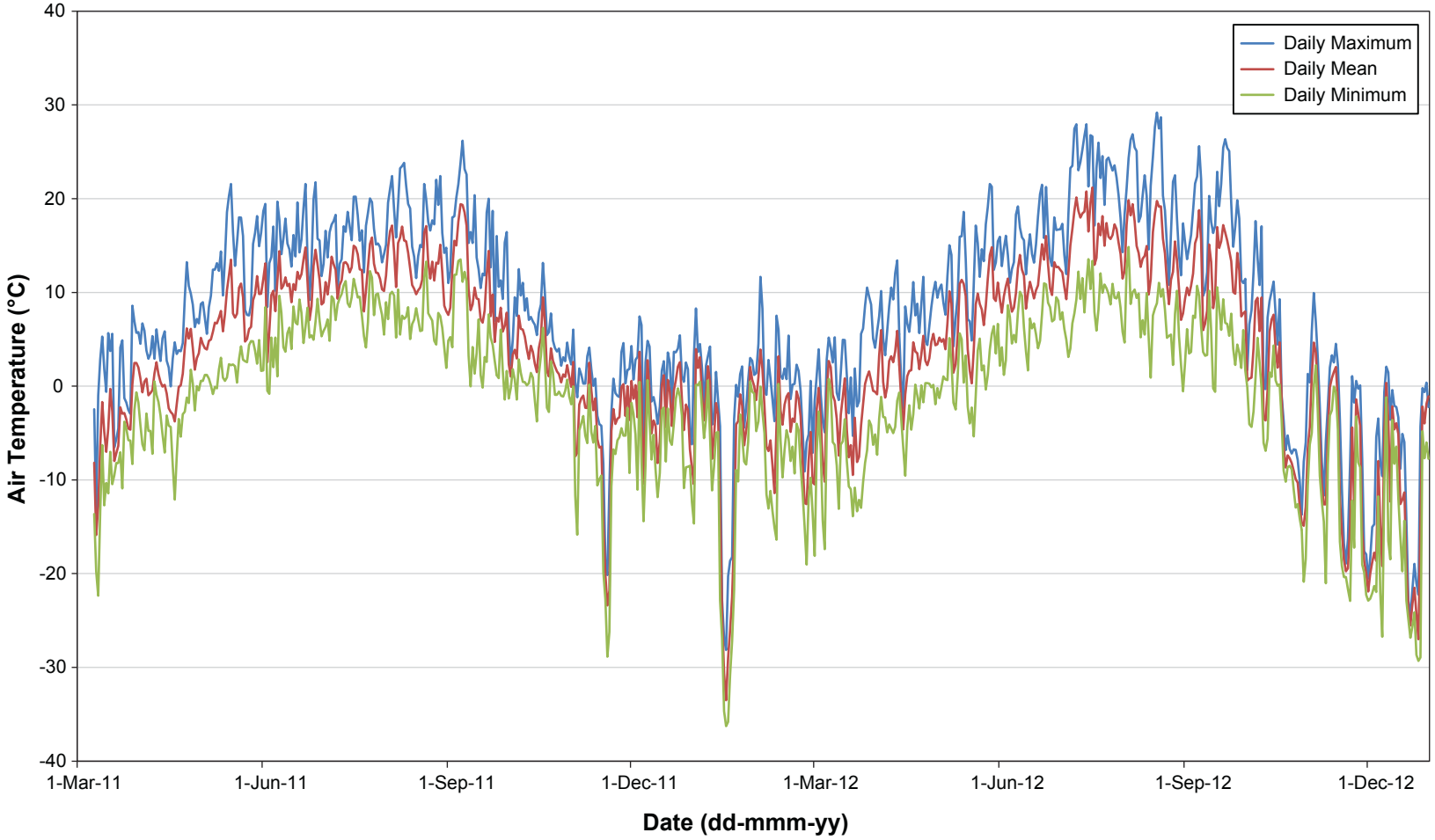



Figure 2.3-1

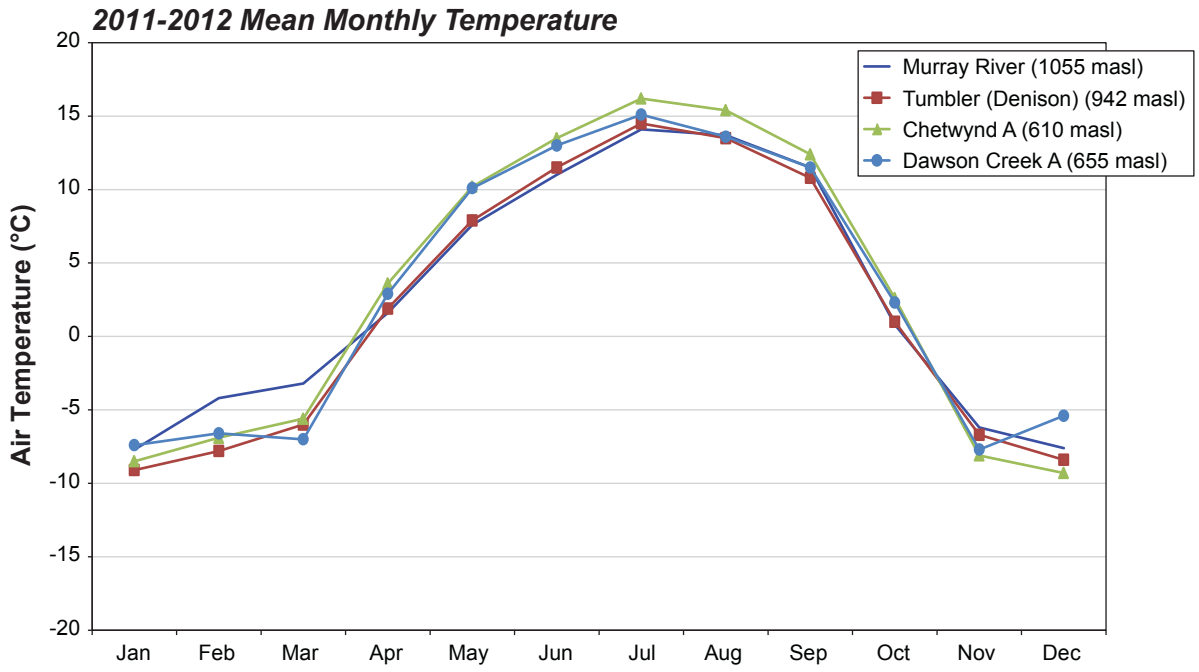
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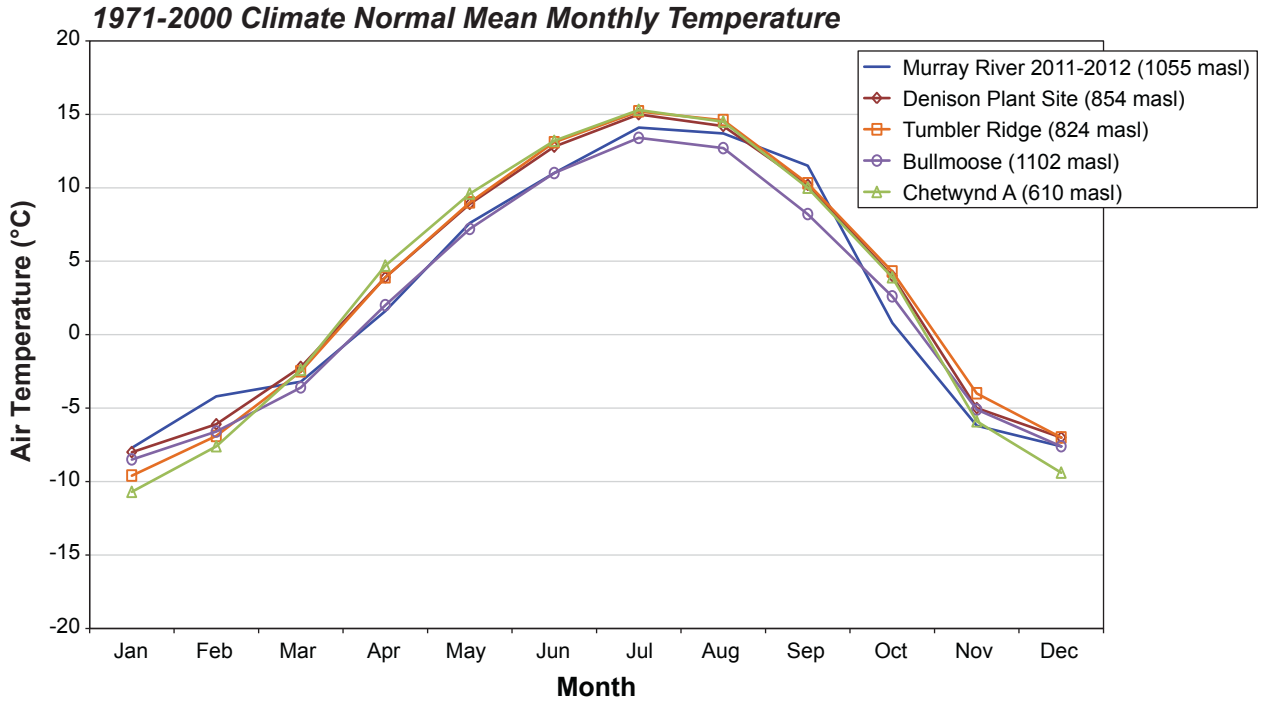
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## 2011 to 2012 Murray River Climate Station Daily Air Temperatures

Figure 2.3-1

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**Comparison of Murray River and Regional Mean Monthly Air Temperatures**

Figure 2.3-2

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**Table 2.3-2. Murray River and Regional Mean Monthly Air Temperatures (˚C)**

| Month | 2011-2012 | | | | Climate Normals | | | |
|---|---|---|---|---|---|---|---|---|
| | Murray River | Tumbler (Denison) | Chetwynd A | Dawson Creek A | Denison Plant Site (1982 - 1997) | Tumbler Ridge (1985 - 2002[b]) | Bullmoose (1971 - 2000) | Chetwynd A (1971 - 2000) |
| Jan | -7.7[a] | -9.1 | -8.5 | -7.4 | -8.0 | -9.6 | -8.5 | -10.7 |
| Feb | -4.2[a] | -7.8 | -6.9 | -6.6 | -6.1 | -6.9 | -6.6 | -7.6 |
| Mar | -3.2[a] | -6.0 | -5.6 | -7.0 | -2.2 | -2.5 | -3.6 | -2.4 |
| Apr | 1.6 | 1.9 | 3.6 | 2.9 | 3.9 | 3.9 | 2.0 | 4.7 |
| May | 7.6 | 7.9 | 10.2 | 10.1 | 8.9 | 9.0 | 7.2 | 9.6 |
| Jun | 11.0 | 11.5 | 13.5 | 13.0 | 12.8 | 13.1 | 11.0 | 13.2 |
| Jul | 14.1 | 14.5 | 16.2 | 15.1 | 15.0 | 15.2 | 13.4 | 15.3 |
| Aug | 13.7 | 13.5 | 15.4 | 13.6 | 14.2 | 14.6 | 12.7 | 14.5 |
| Sep | 11.5 | 10.8 | 12.4 | 11.5 | 10.2 | 10.3 | 8.2 | 10.0 |
| Oct | 0.8 | 1.0 | 2.6 | 2.3 | 4.0 | 4.3 | 2.6 | 3.9 |
| Nov | -6.2 | -6.7 | -8.1 | -7.7 | -5.0 | -4.0 | -5.1 | -5.9 |
| Dec | -7.6 | -8.4 | -9.3 | -5.4 | -7.0 | -7.0 | -7.6 | -9.4 |
| **Average** | 2.6 | 1.9 | 3.0 | 2.9 | 3.4 | 3.4 | 2.1 | 2.9 |
| **Max** | 14.1 | 14.5 | 16.2 | 15.1 | 15.0 | 15.2 | 13.4 | 15.3 |
| **Min** | -7.7[a] | -9.1 | -9.3 | -7.7 | -8.0 | -9.6 | -8.5 | -10.7 |

*[a] Data are from 2012 only; Murray River station was not operational until March 9, 2011*
*[b] Data from 1985 to 2002 were summarized for long term averages to represent climate normals*
*n/a: data not available*

Table 2.3-3 presents the extreme temperature values recorded at the Murray River and regional meteorological stations. For the 2011-2012 period of record at the Murray River meteorological station, the extreme mean daily maximum air temperature of 29.2˚C was recorded on August 18, 2012, and the extreme mean daily minimum air temperature recorded was -36.3˚C on January 17, 2012. Among regional stations, the historic extremes were both recorded at Chetwynd A and ranged from a maximum of 33.8˚C on August 15, 1991 to a minimum of -52.0˚C on January 25, 1997.

**Table 2.3-3. Murray River and Regional Extreme Temperature Values (˚C)**

| | 2011-2012 | | | Climate Normals | | | |
|---|---|---|---|---|---|---|---|
| | Murray River | Chetwynd A | Dawson Creek A | Denison Plant Site (1982 - 1997) | Tumbler Ridge (1985 - 2002[b]) | Bullmoose (1971 - 2000) | Chetwynd A (1971 - 2000) |
| Extreme Maximum (˚C) | 29.2 | 33.7 | 31.5 | 33.0 | 35.5 | 32.5 | 33.8 |
| Date | 18-Aug-12 | 17-Aug-12 | 9-Jul-12 | 13-Aug-92 | 13-Aug-92 | 1-Sep-87 | 15-Aug-91 |
| Extreme Minimum (˚C) | -36.3 | -37.4 | -37.6 | -46.0 | -46.0 | -39.5 | -52.0 |
| Date | 17-Jan-12 | 1-Mar-11 | 17-Jan-12 | 26-Nov-85 | 17-Jan-96 | 31-Jan-90 | 25-Jan-97 |

*[a] Data from 1985 to 2002 were summarized for long term averages to represent climate normal*

### *2.3.2 Precipitation*

#### *2.3.2.1 Average Precipitation*

Mean monthly precipitation values for the Murray River climate station are presented alongside long-term (1988-2003) averages for regional stations in Figure 2.3-3. The majority of the precipitation in the Project region falls as rain during the summer. June and July often receive the highest annual rainfall as a result of convective precipitation (Eaton and Moore 2010, Rescan 2013b). Fall rainstorms may also provide substantial contributions to annual precipitation. From November to April, most precipitation falls as snow. Relative contributions from snowfall tend to be more significant at higher elevation stations (e.g., Murray River at 1055 masl and Bullmoose at 1102 masl).

Mean annual precipitation for the Murray River station and regional climate stations are presented in Table 2.3-4. A complete annual record of precipitation data for the Murray River station is unavailable due to the timing of station installation and precipitation sensor malfunction. Estimated 2011-2012 MAP for the Murray River station was 514.7 mm, derived from the record at the Tumbler (Denison) station (methodology described in section 2.2).

**Table 2.3-4. Mean Annual Precipitation (mm) for Murray River and Regional Climate Stations**

| Climate Station | Elevation (masl) | Mean Annual Precipitation (mm) | | |
|---|---|---|---|---|
| | | 2011-2012 | 1988-2003 | Period of Record |
| Murray River | 1055 | 514.7[a] | n/a[b] | n/a[b] |
| Chetwynd A | 610 | 554.4 | 428.3 | 444.3 |
| Dawson Creek A | 656 | 358.3 | 455.8 | 455.0 |
| Tumbler Ridge | 824 | n/a[c] | 483.4 | 471.2 |
| Bullmoose | 1102 | n/a[c] | 776.8 | 770.1 |

[a] *Due to the incomplete years of record at Murray River, estimated annual values were derived from a May-September rain:total annual precipitation ratio established for the 1989-1997 record at Denison Plant Site station.*
[b] *Station established in March 2011.*
[c] *Station not in operation in 2011-2012.*

The linear relation between MAP and elevation established for the regional climate stations (section 2.2) was used to model MAP values for the Murray River project watersheds (Table 2.3-5). For this calculation, the median elevation of each watershed was used in the regional regression equation derived in section 2.2 (MAP = 0.696xElev – 19.54). Mean annual precipitation ranged from 753 mm for the MH-2 (Lower camp Creek) watershed (1109 masl) to 902 mm for the MH-1 (Murray River) watershed (1460 masl).

**Table 2.3-5. Modeled Mean Annual Precipitation (mm) for Murray River Project Watersheds**

| Hydrometric Station | Drainage Area ($km^2$) | Median Elevation (masl) | Mean Annual Precipitation (mm) |
|---|---|---|---|
| MH-1 | 2242.0 | 1323 | 902 |
| MH-2 | 43.1 | 1109 | 753 |
| MH-3 | 6.8 | 1126 | 764 |
| MH-4 | 21.0 | 1351 | 921 |
| MH-5 | 4.1 | 1198 | 815 |

Extreme daily rainfall values for the Murray River and regional stations are listed in Table 2.3-6. The highest daily rainfall amount recorded at the Murray River station was 45.2 mm on July 8, 2011. In historical and regional comparison, the closest MSC climate station, Denison Plant Site (3.8 km away), recorded a maximum rainfall value of 59.8 mm on July 13, 1982.

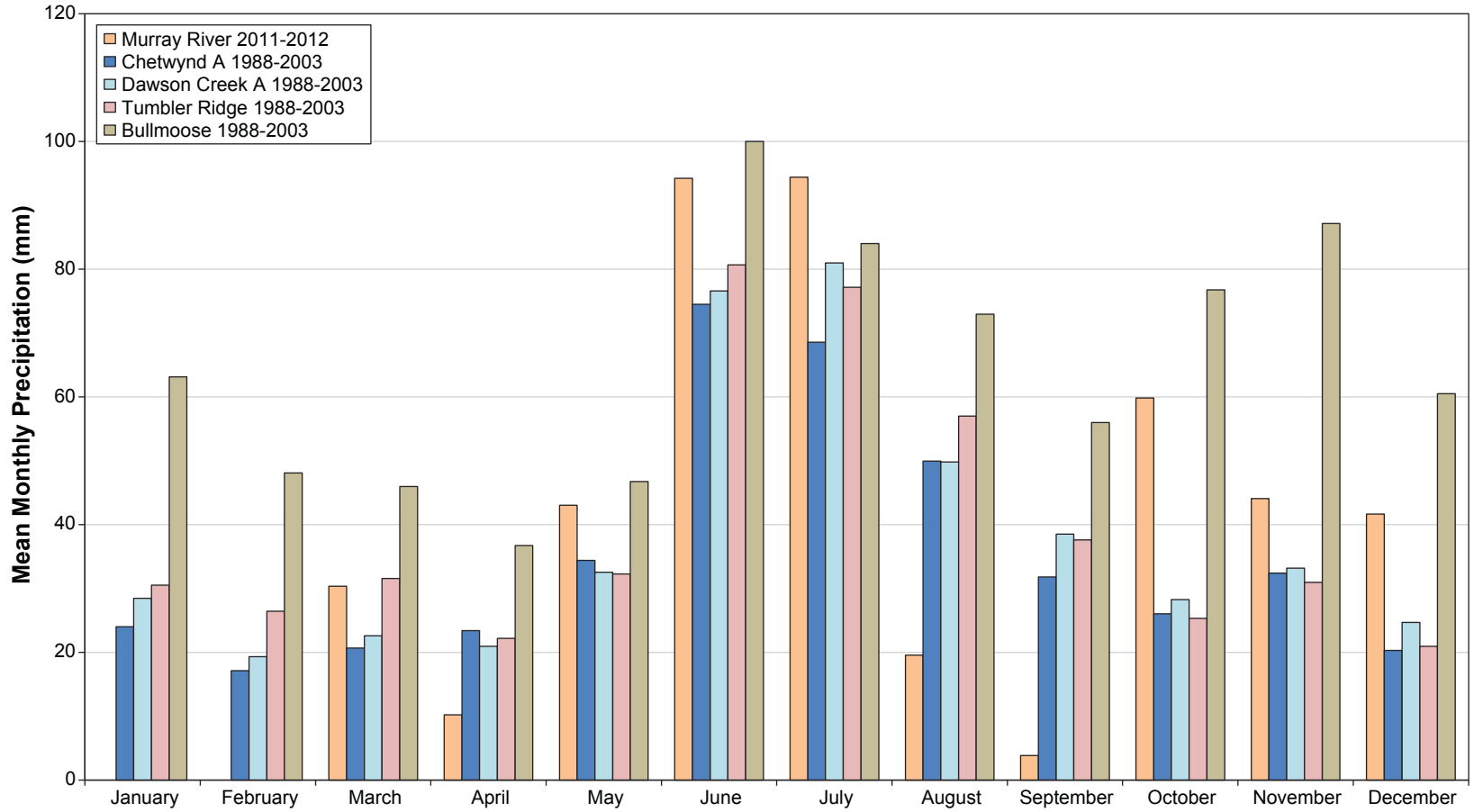



Figure 2.3-3

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## Mean Monthly Precipitation at Murray River (2011 to 2012) and Regional Stations (1988 to 2003)

Figure 2.3-3

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**Table 2.3-6. Murray River and Regional Extreme Daily Rainfall Values (mm)**

| | 2011-2012 | | | Climate Normals | | | |
|---|---|---|---|---|---|---|---|
| | Murray River | Chetwynd A | Dawson Creek A | Denison Plant Site (1982 - 1997) | Tumbler Ridge (1985 - 2002[b]) | Bullmoose (1971 - 2000) | Chetwynd A (1971 - 2000) |
| Extreme Rainfall (mm) | 45.2 | 72.0 | 54.4 | 59.8 | 51.0 | 76.0 | 64.4 |
| Date | 8-Jul-11 | 24-Jun-11 | 24-Jun-11 | 13-Jul-82 | 17-Jul-01 | 31-Jul-87 | 31-Jul-87 |

*[a] Data from 1985 to 2002 were summarized for long term averages to represent climate normals*
*n/a: data not available*

### *2.3.2.2 Extreme Precipitation*

Environment Canada has published Intensity-Duration-Frequency (IDF) data for Stations Dawson creek a (based on 1969 to 2002 data) and Chetwynd A (based on 1970 to 2005 data). The mean values of annual maximum rainfall events with durations of 5 min, 10 min, 15 min, 30 min, 1 hr, 2 hr, 6 hr, 12 hr, and 24 hr were increased to account for higher elevations at the Project watersheds using the ratio of each watershed to the reference station (i.e., Dawson Creek A or Chetwynd A) annual precipitation. The resultant mean values for maximum rainfall events (5 min to 24 hr) were then used with the same standard deviation and probability distribution (i.e., Gumbel Distribution) as the reference stations to estimate the IDF data for the watersheds within the Project area.

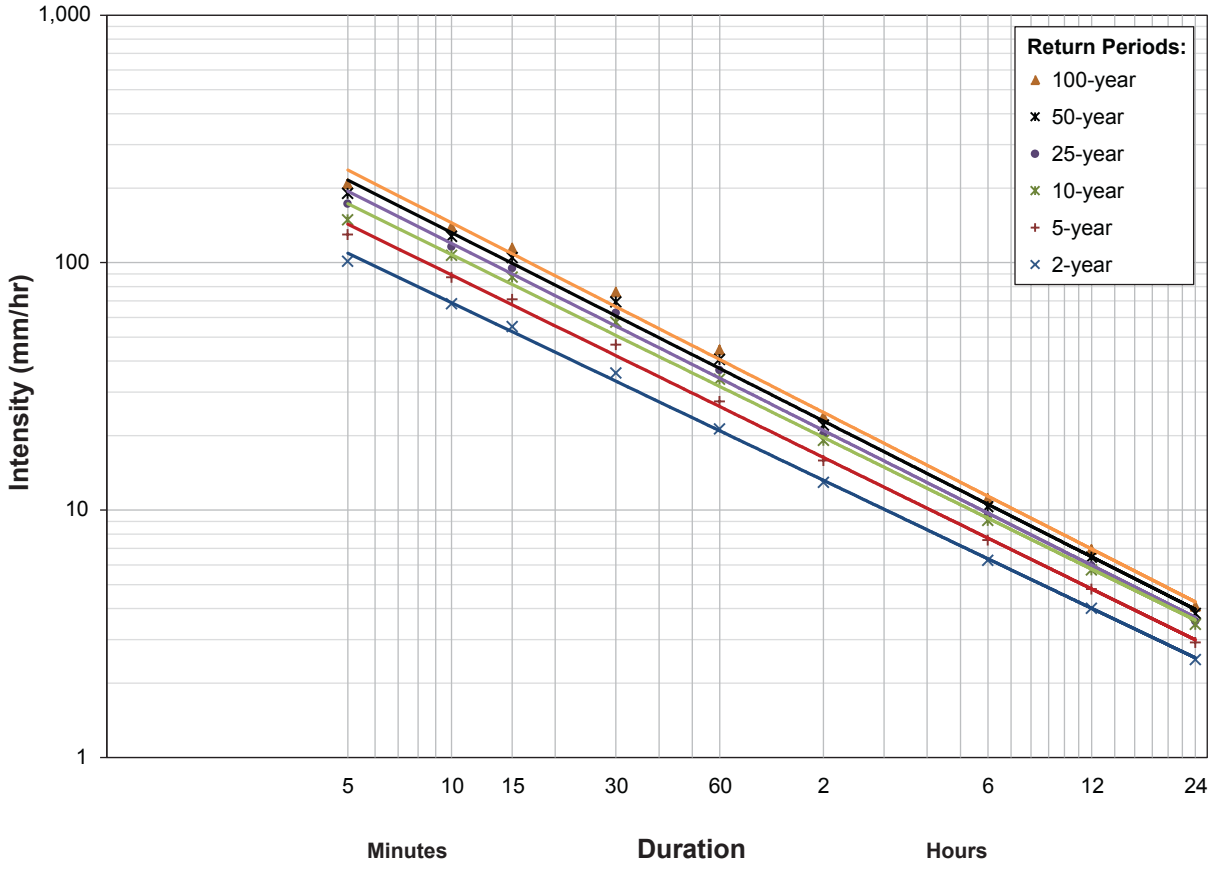
The results showed that the analysis based on Dawson Creek A Station would estimate extreme rainfall events that were slightly more conservative than those based on Chetwynd A Station. The IDF results, based on Dawson Creek A Station, for two locations of interest are provided here. These include the Murray River meteorology station, 1055 masl (Table 2.3-7; Figure 2.3-4), and an arbitrary point within the Murray River watershed at an elevation equivalent to the median elevation of MH-1 Watershed, 1323 masl, (Table 2.3-8; Figure 2.3-5).

**Table 2.3-7. Rainfall Intensity (mm/h) for Murray River Meteorology Station (1055 masl)**

| | Return Period | | | | | |
|---|---|---|---|---|---|---|
| Duration | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 5 min | 101 | 130 | 149 | 173 | 190 | 208 |
| 10 min | 68 | 87 | 107 | 116 | 128 | 139 |
| 15 min | 55 | 71 | 87 | 95 | 105 | 115 |
| 30 min | 36 | 47 | 57 | 63 | 69 | 76 |
| 1 hr | 21 | 27 | 34 | 37 | 41 | 44 |
| 2 hr | 13 | 16 | 19 | 20 | 22 | 24 |
| 6 hr | 6.3 | 7.6 | 9.1 | 10 | 10 | 11 |
| 12 hr | 4.0 | 4.8 | 5.7 | 6.0 | 6.4 | 6.9 |
| 24 hr | 2.5 | 2.9 | 3.5 | 3.6 | 3.8 | 4.1 |

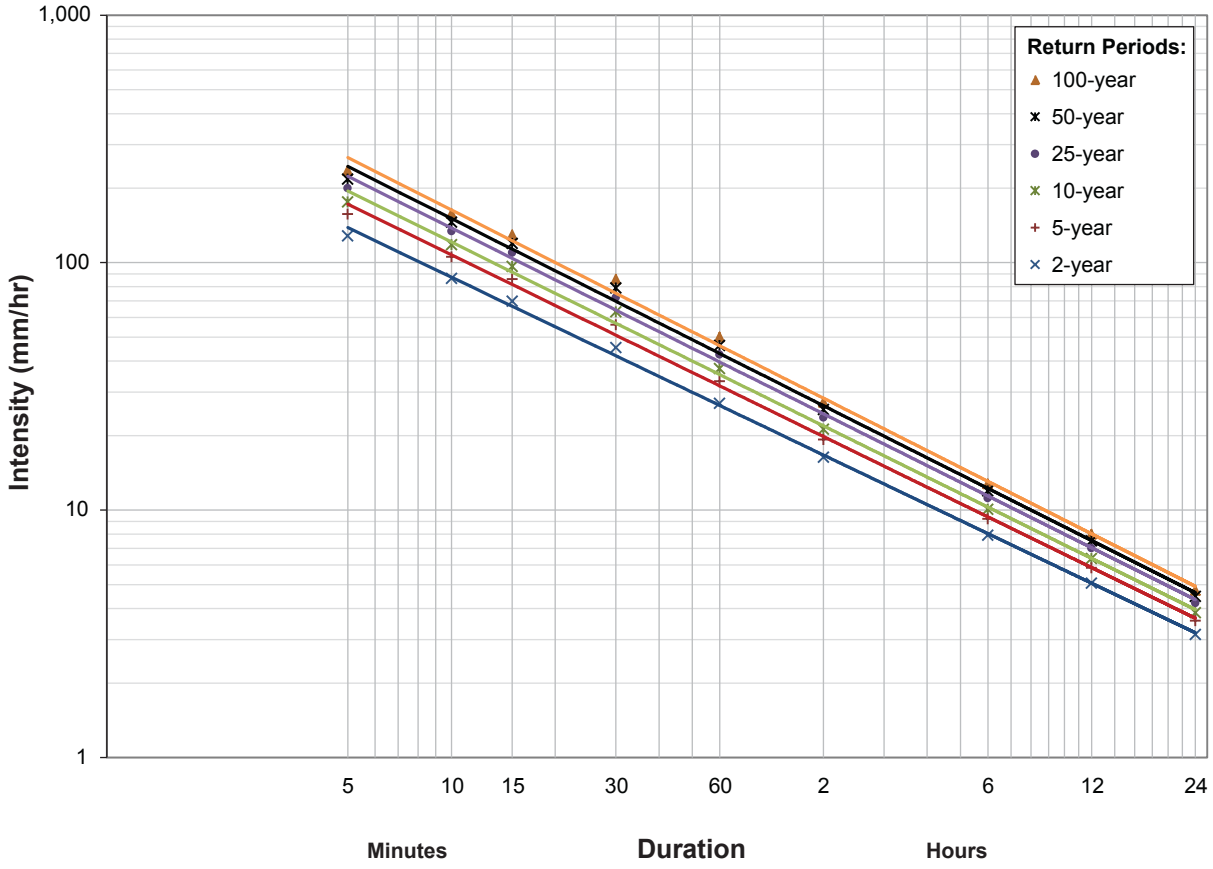
## *2.3.3 Evaporation Losses*

Evaporation losses are not available from direct observations or modelling at the Project area. Long-term evaporation data are not available at the Meteorological Service of Canada (MSC) regional stations with climate conditions similar to the Project area.




Rainfall Intensity-Duration-Frequency Curve for Murray River Meteorology Station (1055 masl)

Figure 2.3-4




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**Rainfall Intensity-Duration-Frequency Curve for MH-1 (Median Elevation 1323 masl)**

Figure 2.3-5

**Table 2.3-8. Rainfall Intensity (mm/h) for Median Elevation (1323 masl) of MH-1 Watershed**

| Duration | Return Period | | | | | |
|---|---|---|---|---|---|---|
| | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
| 5 min | 142 | 171 | 190 | 214 | 231 | 249 |
| 10 min | 96 | 115 | 127 | 143 | 155 | 167 |
| 15 min | 77 | 93 | 104 | 117 | 127 | 137 |
| 30 min | 50 | 61 | 68 | 77 | 84 | 91 |
| 1 hr | 30 | 36 | 40 | 45 | 49 | 53 |
| 2 hr | 18 | 21 | 23 | 25 | 27 | 29 |
| 6 hr | 8.8 | 10 | 11 | 12 | 13 | 14 |
| 12 hr | 5.6 | 6.4 | 6.9 | 7.6 | 8.0 | 8.5 |
| 24 hr | 3.5 | 3.9 | 4.2 | 4.5 | 4.8 | 5.1 |

Estimates of evaporation are only available through published studies at neighbouring projects in the region, i.e., Quintette Project and Roman Mine Project, both of which referred to the same modelling and estimation procedure and results. However, such the modelling and estimation procedure used was not documented and/or published, nor were quantified QA/QC processes provided. Therefore, although the evaporation estimates from these projects are used in the current document as first-cut approximations, it is acknowledged that these values may be associated with a significant level of uncertainty.

In the hydrologic assessment of Quintette and Roman Mine projects, lake evaporation and evapotraspiration losses were estimated to be 550 mm and 290 mm at the reference elevation of 800 masl (Teck 2012). It was also assumed that evaporation losses would decrease by 10% for a 350 increase in elevation.

Based on these assumptions, the evaporation losses for the median elevation of Murray River watershed (i.e., drainage area of hydrometric station MH-1) are expected to be 15% less than these estimates. That is, lake evaporation and evaporaspiration losses are expected to be 470 and 250 mm, respectively. Monthly distribution of evaporation based on Quintette and Roman project studies are provided in (Table 2.3-9).

**Table 2.3-9. Monthly Distribution of Evaporation Loss (% of Annual Loss)**

| Month | Percent of Annual Evaporation |
|---|---|
| January | 0 |
| Februrary | 0 |
| March | 4 |
| April | 10 |
| May | 17 |
| June | 20 |
| July | 21 |
| August | 17 |
| September | 8 |
| October | 3 |
| November | 0 |
| December | 0 |
| **Annual** | **100** |

# 3. Hydrology

## 3.1 Overview

The baseline hydrological monitoring program in the Project area began in 2011. The objectives of the 2011-2012 hydrology baseline program were to establish an understanding of the surface hydrology of the area in order to assess Project effects on the environment, as well as for the design and implementation of an appropriate and effective water management plan.

Regional hydrologic analysis was conducted to supplement the data collected in the baseline monitoring program. The inclusion of regional hydrologic data allows locally collected data for the Project to be evaluated in a broader spatial and temporal context. It also enables the calculation of long-term streamflow predictions for the Project area.

## 3.2 Methodology

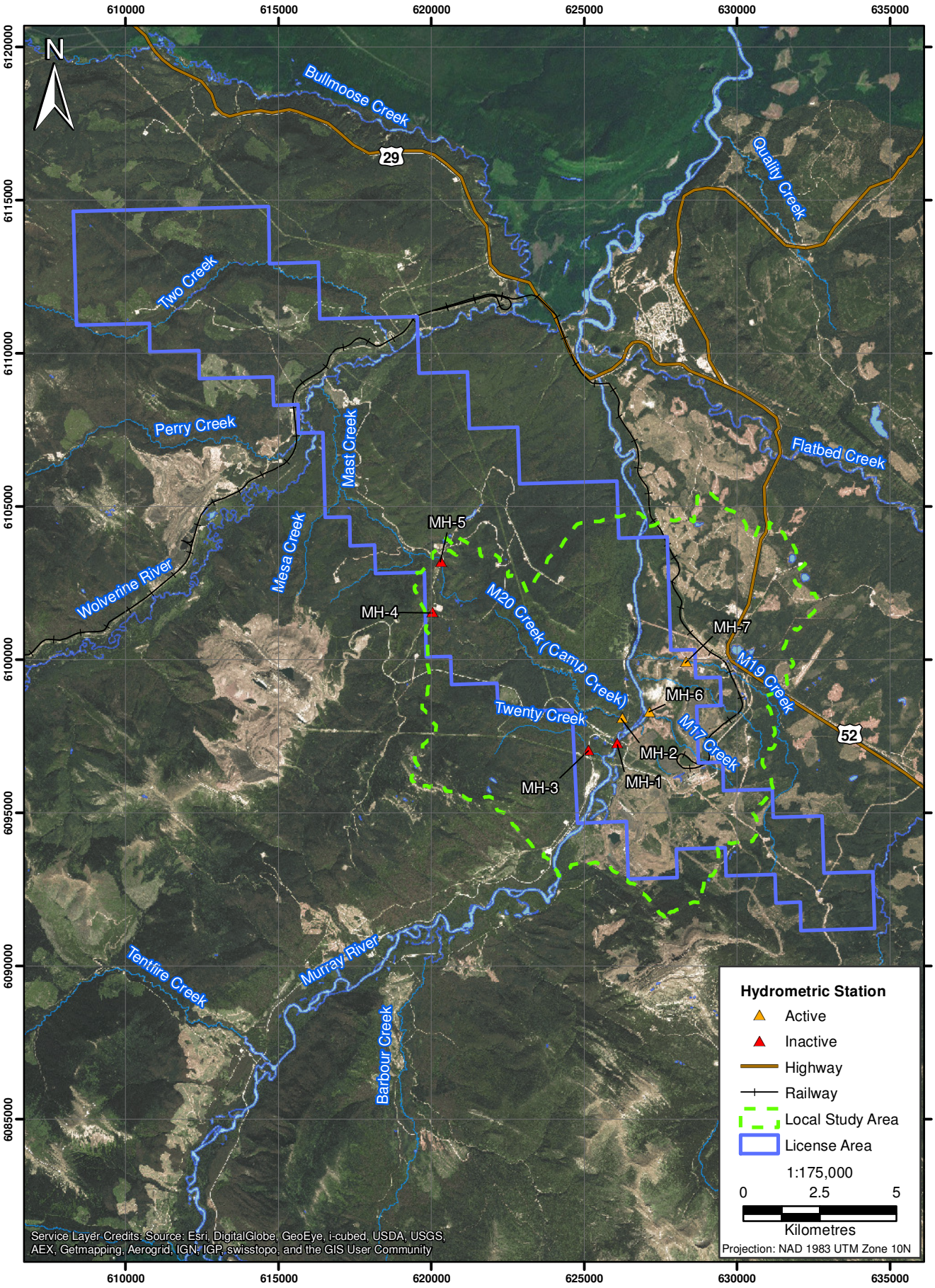
In 2011, a network of five hydrometric monitoring stations was established in the LSA (Figure 3.2-1). The automated stations recorded stream water level data at ten minute intervals during the open water season. The network was expanded to seven stations in 2012. At the time of this report, the data records from the two stations added to the network in September 2012 (MH-6 and MH-7) were not yet sufficient for inclusion in analysis and they are therefore not discussed further here. Due to changes in the Project infrastructure plan, the network was reduced to three stations at the end of 2012. A summary of all stations (active and inactive) is provided in Table 3.2-1. Additional details of the hydrometric monitoring program are available in the *2011-2012 Hydrology Baseline Report* (Rescan 2013a).

**Table 3.2-1. 2011-2012 Hydrometric Monitoring Network in the Murray River Project Area**

| Hydrometric Station | Location | UTM Coordinates[a] | | Drainage Area ($km^2$) | Period of Operation[b] | Status |
|---|---|---|---|---|---|---|
| | | Easting | Northing | | | |
| MH-1 | Murray River | 626091 | 6097291 | 2242.0 | Jan 2011-Nov 2012 | Inactive |
| MH-2[c] | Lower Camp Creek | 626256 | 6097951 | 43.1 | May 2011-present | Active |
| MH-3[d] | Twenty Creek | 625519 | 6096897 | 6.8 | May 2011-Nov 2012 | Inactive |
| MH-4 | Upper Camp Creek | 620078 | 6101730 | 21.0 | May 2011-Nov 2012 | Inactive |
| MH-5 | Mast Creek | 620306 | 6103205 | 4.1 | May 2011-Nov 2012 | Inactive |
| MH-6[e] | Mile 17 Creek | 627134 | 6098319 | 6.1 | Sep 2012-present | Active |
| MH-7[e] | Mile 19 Creek | 628335 | 6099938 | 52.6 | Sep 2012-present | Active |

[a] *NAD83, Zone 10N*
[b] *Stations demobilized for winter to prevent ice damage.*
[c] *Relocated approximately 150 m upstream in April 2012. New location: 626246 E, 6098122 N, drainage area 42.9 $km^2$. The calculations in this report use the original (2011) drainage area for the station.*
[d] *Relocated approximately 150 m upstream in April 2012. New location: 625141 E, 6097069 N, drainage area 6.6 $km^2$. The calculations in this report use the original (2011) drainage area for the station.*
[e] *Due to recent station installation, data records for stations MH-6 and MH-7 were insufficient for inclusion in this report.*

Hydrometric data collected in the Project LSA were supplemented by regional and frequency analyses in order to describe the general hydrological characteristics of the surrounding region and to allow Project area data to be evaluated in the context of broader patterns and trends. Historical streamflow data were collected, compiled, and verified for 16 Water Survey of Canada (WSC) hydrometric stations (Figure 3.2-2, Table 3.2-2). Hydrologic indices including annual and monthly discharge and runoff, peak flows, and low flows were extracted from the data record for each station.




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# Hydrometric Station Locations

Figure 3.2-1

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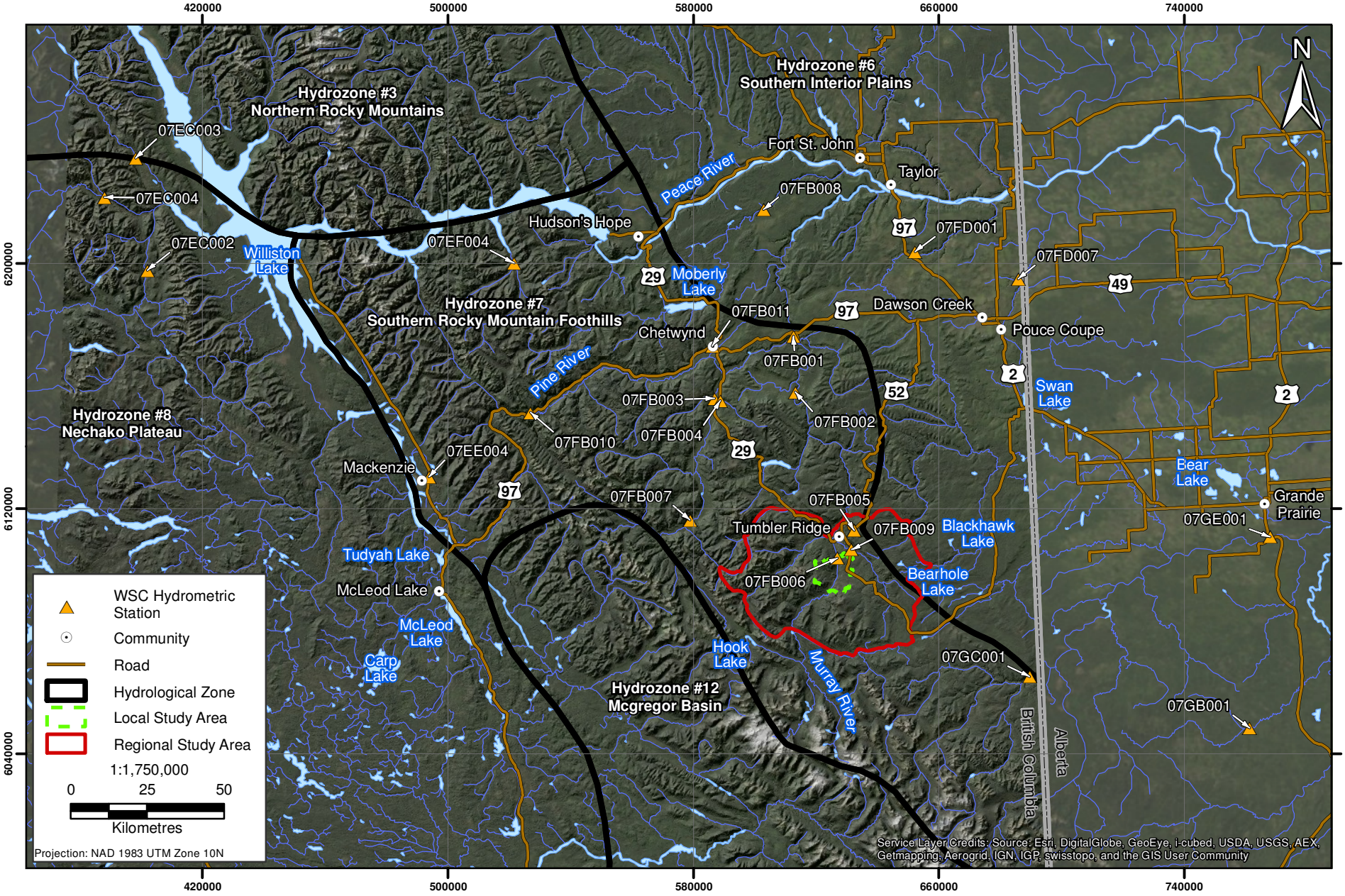



Figure 3.2-2

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# Locations of Water Survey of Canada Hydrometric Stations Relevant to the Project

Figure 3.2-2

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**Table 3.2-2. Water Survey of Canada (WSC) Hydrometric Stations Included in Regional Analysis**

| Station ID | Station Name | UTM Coordinates (NAD83) | | | Hydrologic Zone | Drainage Area ($km^2$) | Period of Record[a] |
|---|---|---|---|---|---|---|---|
| | | Zone | Easting | Northing | | | |
| 07FB008 | Moberly River near Fort St. John | 10N | 602844 | 6217668 | 6 | 1520 | 1980-2010 |
| 07FD001 | Kiskatinaw River near Farmington | 10N | 652173 | 6203971 | 6 | 3630 | 1966-2010 |
| 07FD007 | Pouce Coupe River below Henderson Creek | 10N | 685883 | 6195014 | 6 | 2860 | 1971-2010 |
| 07FB001 | Pine River at East Pine | 10N | 612577 | 6176372 | 7 | 12100 | 1961-2010 |
| 07FB002 | Murray River near the mouth | 10N | 613275 | 6158173 | 7 | 5550 | 1977-2010 |
| 07FB003 | Sukunka River near the mouth | 10N | 586797 | 6156053 | 7 | 2590 | 1977-2010 |
| 07FB004 | Dickebusch Creek near the mouth | 10N | 588707 | 6155256 | 7 | 82 | 1978-2010 |
| 07FB005 | Quality Creek near the mouth | 10N | 632349 | 6112988 | 7 | 30 | 1978-2001 |
| 07FB006 | Murray River above Wolverine River | 10N | 626922 | 6103861 | 7 | 2370 | 1977-2010 |
| 07FB009 | Flatbed Creek at km 110 Heritage Hwy | 10N | 631473 | 6106652 | 7 | 486 | 1983-2010 |
| 07EF004 | Carbon Creek near the mouth | 10N | 521425 | 6200166 | 7 | 741 | 1998-2010[d] |
| 07EC002 | Omineca River above Osilinka River | 10N | 402031 | 6197853 | 8 | 5560 | 1976-2010 |
| 07EC003 | Mesilinka River above Gopherhole Creek | 10N | 398161 | 6234439 | 8 | 3060 | 1976-2010 |
| 07EC004 | Osilinka River near End Lake | 10N | 388026 | 6221639 | 8 | 1950 | 1981-2010 |
| 07GB001 | Cutbank River near Grande Prairie | 11N | 372926 | 6042658 | n/a[b] | 842 | 1970-2010[c] |
| 07GE001 | Wapiti River near Grande Prairie | 11N | 384890 | 6104190 | n/a[b] | 11300 | 1961-2010 |

[a] *For some stations, between one and four years of data have been excluded from the listed period of record due to incomplete data*
[b] *British Columbia hydrologic zone classification not applicable, station is located in Alberta*
[c] *Data not available for this station in winter; excluded from annual low flow analysis*
[d] *Data from this station only used for peak and low flow frequency analysis; not used for mean annual runoff analysis*

## 3.3 Results

Hydrometric indices for the stations in the Project baseline monitoring network are summarized on an annual basis in Table 3.3-1. The indices include mean annual discharge (MAD) ($m^3/s$), mean annual runoff (MAR) (mm), instantaneous and daily peak flow ($m^3/s$), and annual and summer (June-September) seven-day low flow ($m^3/s$). For further details on the calculation of hydrometric indices for the Project hydrometric monitoring stations, see the *2011-2012 Hydrology Baseline Report* (Rescan 2013a).

**Table 3.3-1. Summary of 2011-2012 Hydrometric Indices for Murray River Project Watersheds**

| Hydrometric Station | Year | Mean Annual Discharge ($m^3/s$) | Mean Annual Runoff (mm) | Peak Flow ($m^3/s$) | | Seven-Day Low Flow ($m^3/s$) | |
|---|---|---|---|---|---|---|---|
| | | | | Instantaneous | Daily | Annual | Summer (June-Sept) |
| MH-1 | 2011 | 70.6 | 998 (924[b]) | 479 | 445 | 7.6 | 31.3 |
| | 2012 | 66.3 | 935 (808[b]) | 426 | 405 | 10.4 | 18.6 |
| | Mean | 68.5 | 967 (866[b]) | 453 | 425 | 9.0 | 25.0 |
| MH-2 | 2011 | 0.43 | 319 | 12.3 | 7.1 | 0.03 | 0.04 |
| | 2012 | 0.42 | 305 | 8.1 | 6.1 | 0.01 | 0.01 |
| | Mean | 0.43 | 312 | 10.2 | 6.7 | 0.02 | 0.03 |
| MH-3[a] | 2012 | 0.03 | 135 | 0.48 | 0.39 | 0.0 | 0.0 |
| MH-4 | 2011 | 0.27 | 401 | 4.3 | 2.6 | 0.03 | 0.03 |
| | 2012 | 0.23 | 341 | 3.9 | 2.7 | 0.02 | 0.02 |
| | Mean | 0.25 | 371 | 4.1 | 2.7 | 0.03 | 0.03 |

*(continued)*

**Table 3.3-1. Summary of 2011-2012 Hydrometric Indices for Murray River Project Watersheds (completed)**

| Hydrometric Station | Year | Mean Annual Discharge ($m^3/s$) | Mean Annual Runoff (mm) | Peak Flow ($m^3/s$) | | Seven-Day Low Flow ($m^3/s$) | |
|---|---|---|---|---|---|---|---|
| | | | | Instantaneous | Daily | Annual | Summer (June-Sept) |
| MH-5 | 2011 | 0.06 | 433 | 0.90 | 0.83 | 0.002 | 0.005 |
| | 2012 | 0.02 | 134 | 0.25 | 0.25 | 0 | 0 |
| | Mean | 0.04 | 283 | 0.57 | 0.54 | 0.001 | 0.002 |

[a] *Hydrograph not developed for MH-3 in 2011 due to insufficient data; water levels too low for continuous measurement from July 2011 until station demobilization in November 2011*
[b] *Adjusted value based on WSC Station 07FB006 (Murray River above Wolverine River). See section 3.3.2 for details*

### *3.3.1 Discharge Hydrographs*

Annual mean daily discharge hydrographs were generated for the Project area monitoring stations. During the 2011-2012 monitoring period, mean annual discharge for stations with two years of data ranged from 0.04 $m^3/s$ in 2012 at station MH-5, with a drainage area of 4.1 $km^2$, to 68.5 $m^3/s$ at station MH-1, with a drainage area of 2,242.0 $km^2$ (Table 3.3-1). Larger watersheds produce greater volumes of discharge due to the correlation between discharge and drainage area. Discharge hydrographs for the Project stations are presented in Figures 3.3-1 to 3.3-3.

### *3.3.2 Monthly and Annual Mean Runoff*

Runoff amounts are normalized values of discharge. Normalizing discharge to drainage area allows direct comparison between watersheds. Monthly and annual runoff values for the Project area hydrometric stations are provided in Tables 3.3-2 and 3.3-3 (as depth in mm and percent of total annual runoff, respectively) and displayed graphically in Figure 3.3-4.

**Table 3.3-2. 2011-2012 Monthly and Annual Runoff (mm) for Project Hydrometric Stations**

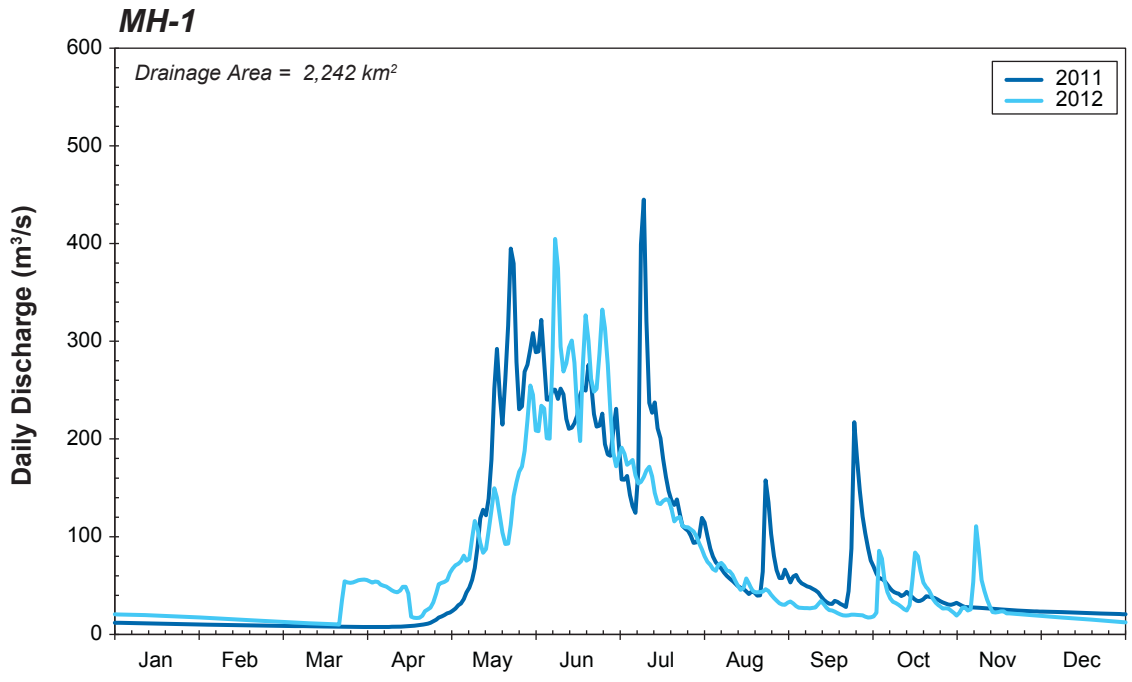
| Station | Elevation (masl) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH-1 | 1323 | 17 | 12 | 11 | 18 | 166 | 269 | 172 | 66 | 48 | 45 | 24 | 20 | 867 |
| MH-2 | 1109 | 2 | 2 | 3 | 18 | 122 | 96 | 45 | 8 | 3 | 8 | 4 | 2 | 312 |
| MH-3[a] | 1126 | 0 | 0 | 1 | 14 | 42 | 65 | 13 | 0 | 0 | 0 | 0 | 0 | 135 |
| MH-4 | 1351 | 6 | 5 | 7 | 26 | 121 | 89 | 81 | 10 | 4 | 7 | 9 | 6 | 371 |
| MH-5 | 1198 | 2 | 2 | 3 | 22 | 117 | 57 | 63 | 8 | 3 | 4 | 2 | 2 | 283 |

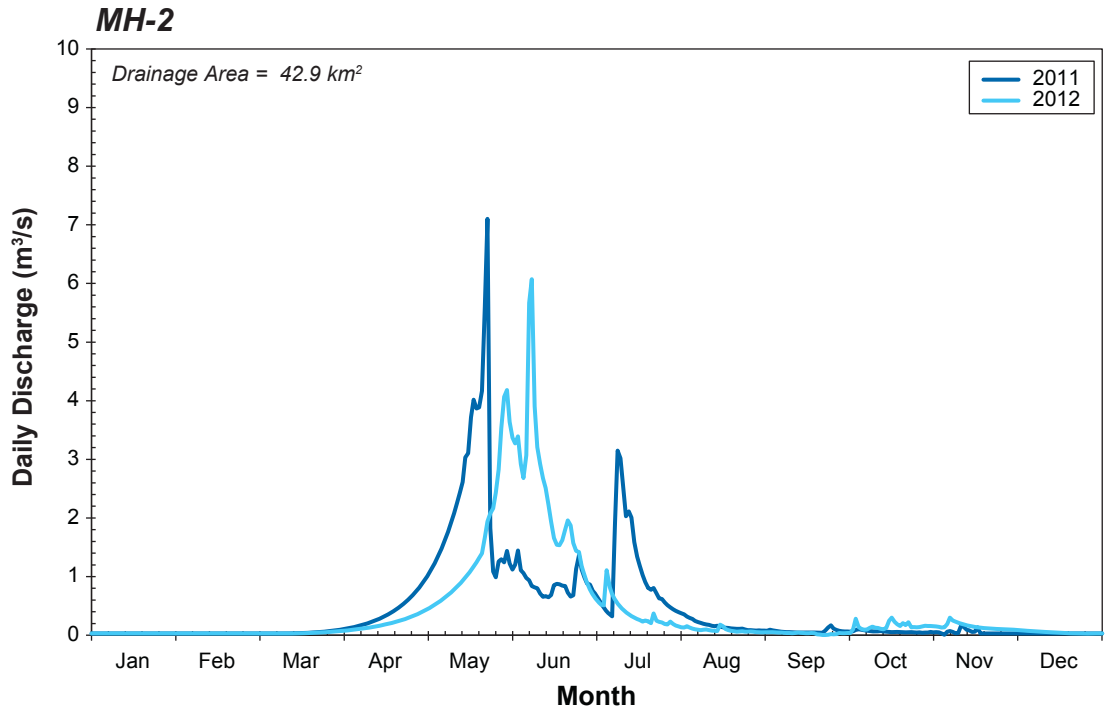
[a] *Runoff values are for 2012 only; water levels too low for continuous measurement from July 2011 until station demobilization in November 2011*

**Table 3.3-3. 2011-2012 Monthly and Annual Runoff (%) for Project Hydrometric Stations**

| Station | Elvation (masl) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH-1 | 1323 | 2 | 1 | 2 | 3 | 19 | 30 | 19 | 7 | 5 | 5 | 3 | 3 |
| MH-2 | 1109 | 1 | 1 | 1 | 6 | 39 | 31 | 14 | 2 | 1 | 3 | 1 | 1 |
| MH-3[a] | 1126 | 0 | 0 | 1 | 10 | 31 | 48 | 9 | 0 | 0 | 0 | 0 | 0 |
| MH-4 | 1351 | 2 | 1 | 2 | 7 | 32 | 25 | 21 | 3 | 1 | 2 | 2 | 2 |
| MH-5 | 1198 | 1 | 1 | 1 | 9 | 40 | 23 | 17 | 3 | 1 | 2 | 1 | 1 |

[a] *Runoff values are for 2012 only; water levels too low for continuous measurement from July 2011 until station demobilization in November 2011*
*Notes: Monthly values may not sum to 100% due to rounding*




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**Annual Hydrographs at MH-1 and MH-2 Hydrometric Monitoring Stations, 2011 - 2012**

Figure 3.3-1

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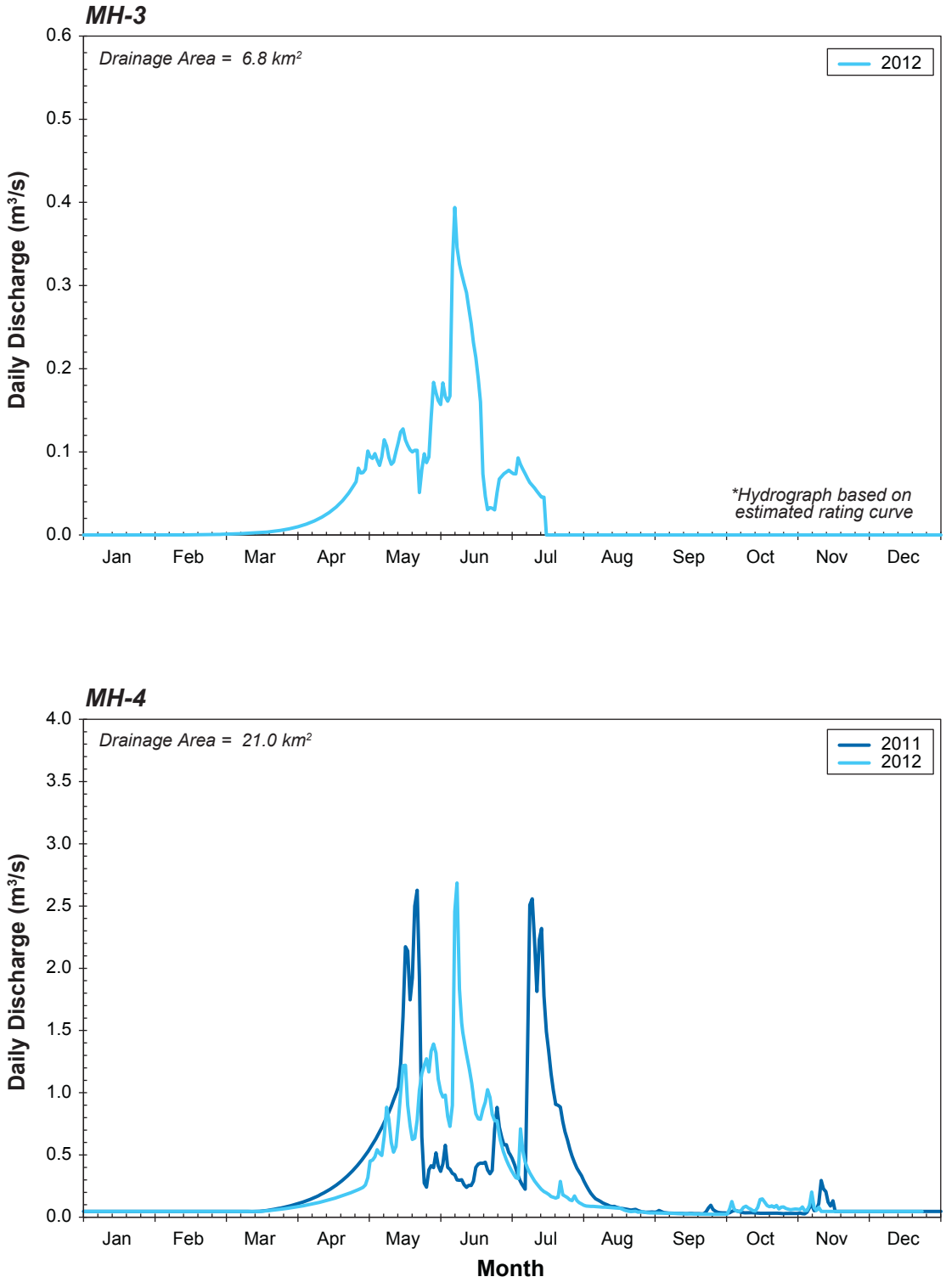
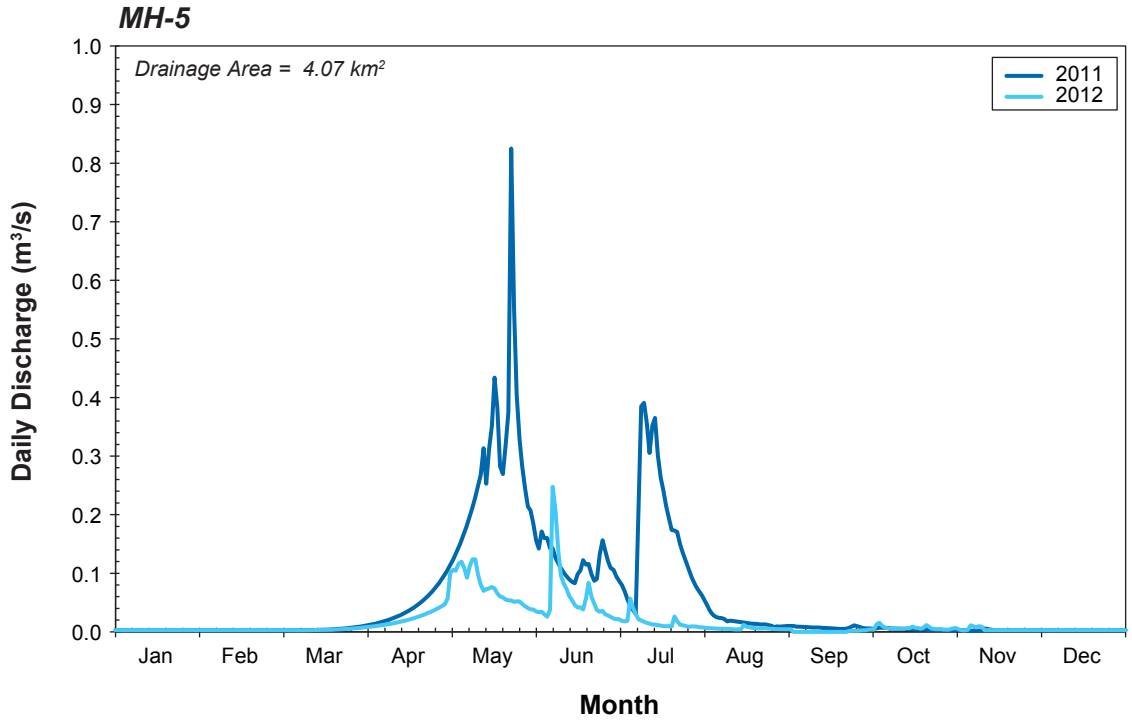



Figure 3.3-2

Annual Hydrographs at MH-3 and MH-4 Hydrometric Monitoring Stations, 2011 - 2012

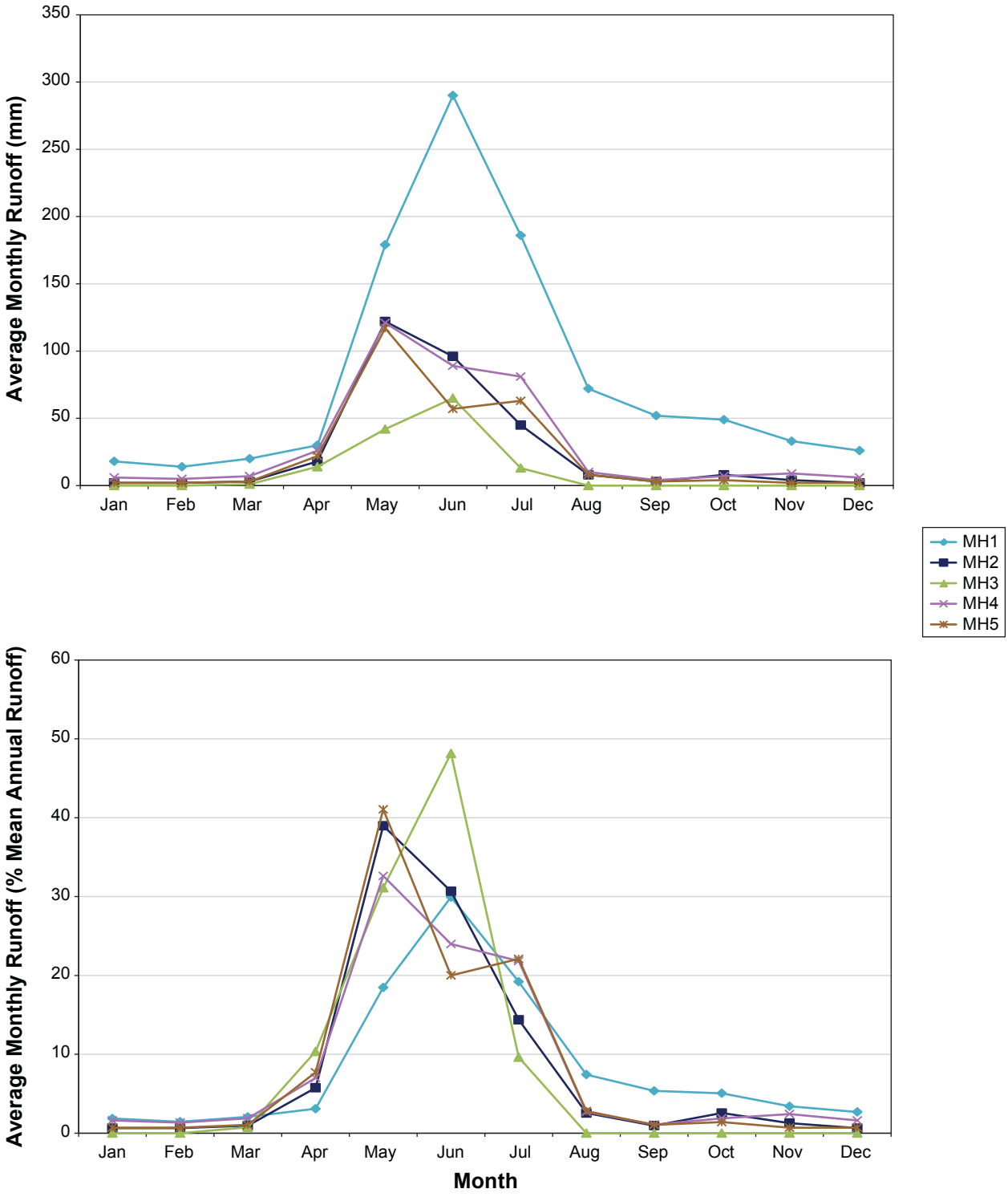
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## Annual Hydrographs at MH-5 Hydrometric Monitoring Station, 2011 - 2012

Figure 3.3-3




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## 2011 to 2012 Mean Monthly Runoff and Runoff Distribution for Project Hydrometric Stations

Figure 3.3-4

For stations with two years of data, 2011-2012 mean annual runoff ranged from 283 mm at station MH-5 to 967 mm at station MH-1 (Table 3.3-2). The WSC operates Station 07FB006 (Murray River above Wolverine River) approximately 8 km downstream of Station MH-1. Due to the close proximity of these stations, the 2011 and 2012 daily discharge data were used to adjust collected hydrometric data at MH-1 (Figure 3.3-5). The adjustment included exclusion of two local peaks in the hydrograph during April and November, 2012 (Figure 3.3-5), and a reduction factor of 8% to collected data at MH-1 so that the two stations represent similar timeseries of unit daily discharge values with a Nash-Sutcliff Efficiency index of 0.997.

Mean annual runoff was similar at stations MH-2, MH-4, and MH-5, an expected result as their drainage areas are within a relatively small region with similar climate and physical characteristics on the leeward side of the valley. (Station MH-3 is excluded from this discussion, as there is only one year of data available.) The significantly larger annual runoff in the MH-1 watershed is likely due to its relatively higher median elevation and greater proportion of windward slopes, both of which would be expected to result in higher annual precipitation.

In 2011 and 2012, the majority (68-89%) of annual runoff for all stations in the Project area occurred during the period from May to July. Runoff was lowest between January and March, with this winter period accounting for 1-5% of annual runoff for all Project stations.

For comparison to the Project area, monthly and annual runoff values for the WSC hydrometric stations used in regional analysis are provided in Tables 3.3-4 and 3.3-5 (as depth in mm and percent of total annual runoff, respectively) and displayed graphically in Figures 3.3-6 (BC Hydrologic Zone 7) and 3.3-7 (other hydrologic zones). Runoff values for the regional stations are averaged over the period of record for the station (see Table 3.2-2 for WSC station periods of record).

**Table 3.3-4. Period of Record Monthly and Annual Runoff (mm) for Hydrometric Stations used in Regional Analysis**

| Station | Elevation (masl) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *BC Hydrologic Zone 6* | | | | | | | | | | | | | | |
| 07FB008 | 926 | 3 | 2 | 3 | 10 | 55 | 74 | 38 | 17 | 11 | 10 | 7 | 5 | 235 |
| 07FD001 | 920 | 1 | 1 | 1 | 13 | 27 | 17 | 14 | 6 | 5 | 4 | 2 | 1 | 91 |
| 07FD007 | 792 | 0 | 0 | 1 | 19 | 20 | 11 | 9 | 4 | 3 | 2 | 1 | 0 | 70 |
| *BC Hydrologic Zone 7* | | | | | | | | | | | | | | |
| 07FB001 | 1120 | 8 | 6 | 8 | 23 | 122 | 139 | 67 | 29 | 26 | 32 | 21 | 11 | 492 |
| 07FB002 | 1160 | 8 | 6 | 8 | 24 | 102 | 124 | 72 | 35 | 31 | 31 | 20 | 11 | 472 |
| 07FB003 | 1190 | 10 | 8 | 10 | 39 | 189 | 182 | 77 | 29 | 34 | 45 | 30 | 13 | 665 |
| 07FB004 | 1050 | 1 | 1 | 2 | 18 | 63 | 49 | 44 | 19 | 13 | 8 | 4 | 2 | 225 |
| 07FB005 | 1100 | 2 | 1 | 2 | 27 | 49 | 38 | 36 | 17 | 13 | 9 | 5 | 3 | 201 |
| 07FB006 | 1300 | 14 | 11 | 13 | 33 | 157 | 204 | 116 | 57 | 50 | 51 | 34 | 19 | 759 |
| 07FB009 | 1130 | 3 | 2 | 3 | 26 | 83 | 59 | 37 | 14 | 14 | 12 | 8 | 4 | 266 |
| *BC Hydrologic Zone 8* | | | | | | | | | | | | | | |
| 07EC002 | 1260 | 9 | 6 | 7 | 12 | 109 | 175 | 77 | 31 | 25 | 30 | 19 | 12 | 510 |
| 07EC003 | 1410 | 8 | 6 | 6 | 9 | 68 | 148 | 90 | 42 | 30 | 27 | 15 | 11 | 461 |
| 07EC004 | 1340 | 10 | 8 | 8 | 12 | 106 | 201 | 98 | 42 | 32 | 31 | 18 | 13 | 579 |
| *Alberta* | | | | | | | | | | | | | | |
| 07GB001 | 1150 | n/a | n/a | n/a | n/a | 50 | 38 | 34 | 18 | 13 | 10 | n/a | n/a | 294 |
| 07GE001 | 1010 | 3 | 3 | 3 | 19 | 59 | 70 | 44 | 21 | 16 | 15 | 7 | 5 | 266 |

*[a] Winter data not available for station 07GB001.*
*Note: Station periods of record are provided in Table 3.2-2*

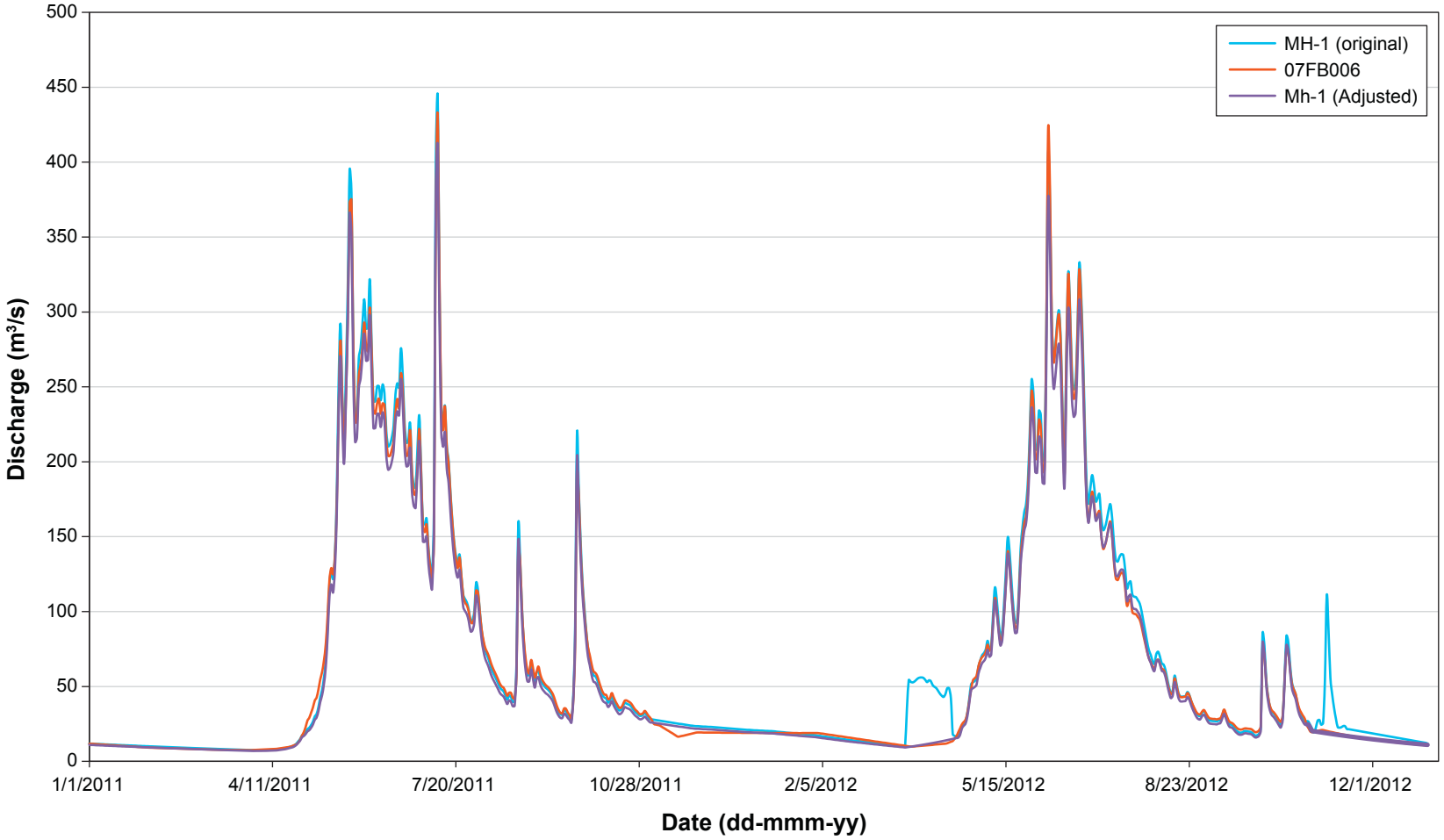



Figure 3.3-5

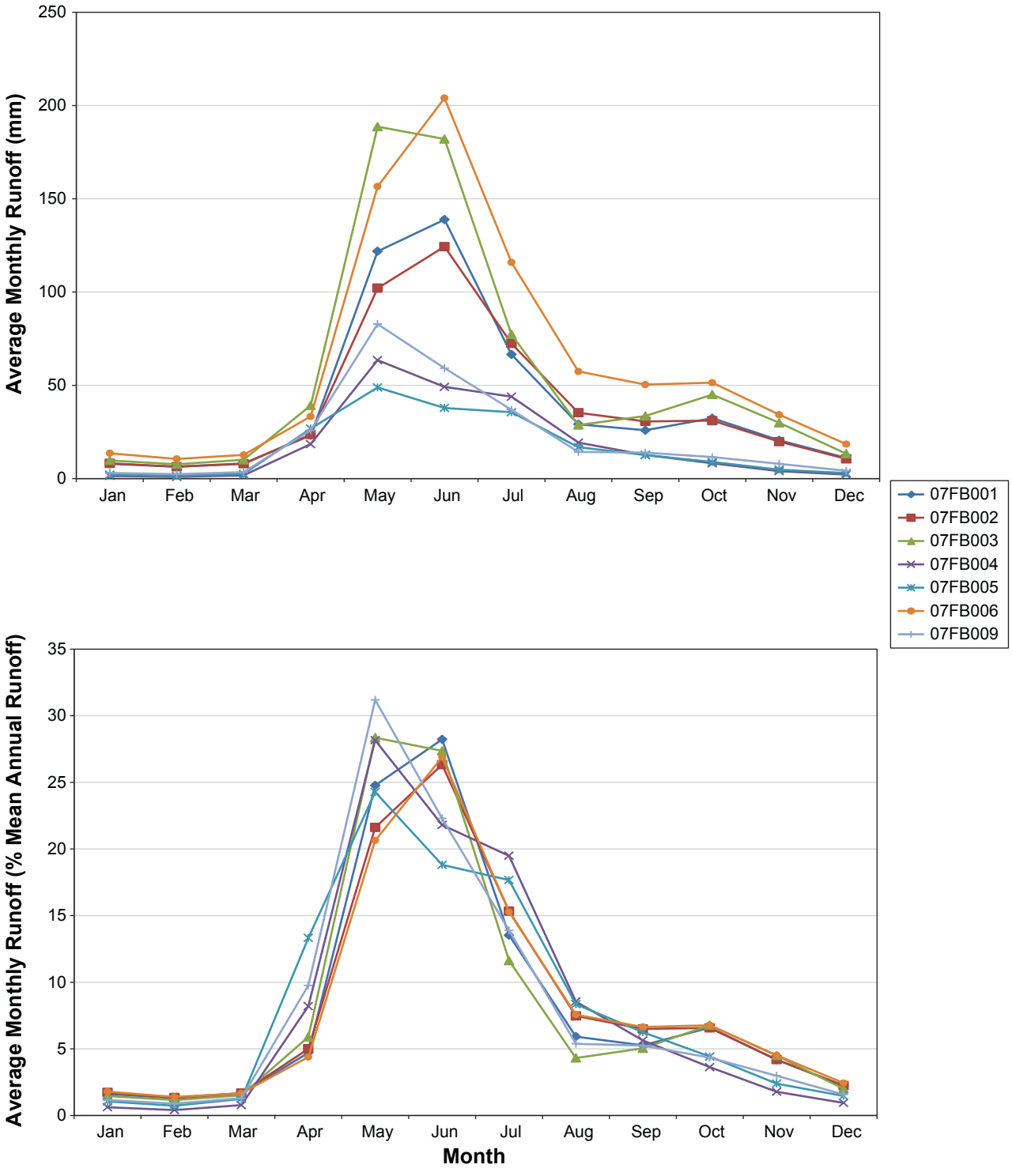
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## Adjustment of MH-1 Hydrograph based on WSC 07FB006 Hydrograph

Figure 3.3-5

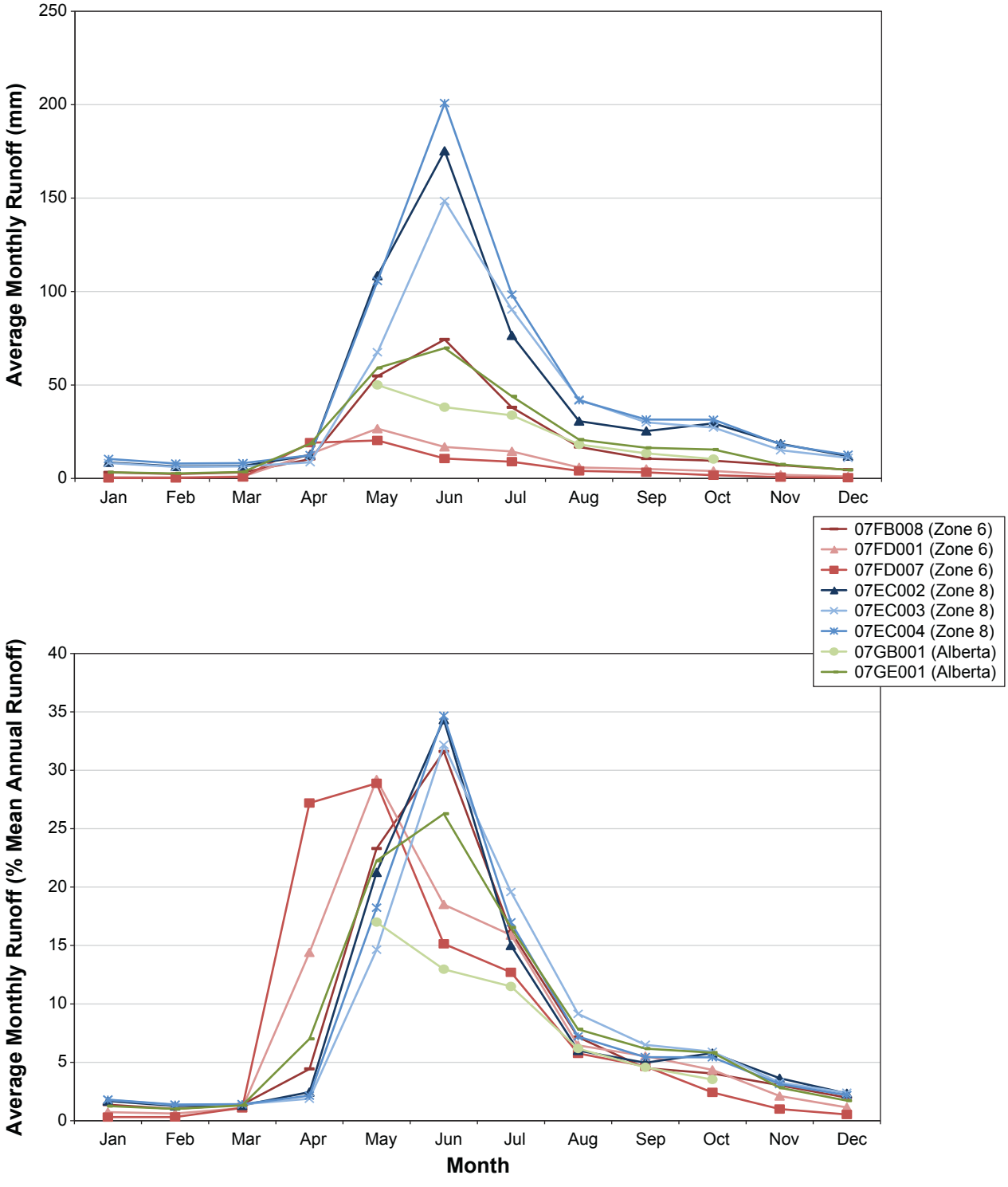
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# Period of Record Mean Monthly Runoff and Runoff Distribution for Selected Stations in BC Hydrologic Zone 7

Figure 3.3-6




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# Period of Record Mean Monthly Runoff and Runoff Distribution for Selected Stations in BC Hydrologic Zones 6 and 8 and the Alberta Prairie Region

Figure 3.3-7

**Table 3.3-5. Period of Record Monthly and Annual Runoff (%) for Hydrometric Stations used in Regional Analysis**

| Station | Elevation (masl) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *BC Hydrologic Zone 6* | | | | | | | | | | | | | |
| 07FB008 | 926 | 1 | 1 | 1 | 4 | 23 | 32 | 16 | 7 | 5 | 4 | 3 | 2 |
| 07FD001 | 920 | 1 | 1 | 1 | 14 | 29 | 19 | 16 | 6 | 6 | 4 | 2 | 1 |
| 07FD007 | 792 | 0 | 0 | 1 | 27 | 29 | 15 | 13 | 6 | 5 | 2 | 1 | 1 |
| *BC Hydrologic Zone 7* | | | | | | | | | | | | | |
| 07FB001 | 1120 | 2 | 1 | 2 | 5 | 25 | 28 | 14 | 6 | 5 | 7 | 4 | 2 |
| 07FB002 | 1160 | 2 | 1 | 2 | 5 | 22 | 26 | 15 | 7 | 6 | 7 | 4 | 2 |
| 07FB003 | 1190 | 1 | 1 | 2 | 6 | 28 | 27 | 12 | 4 | 5 | 7 | 4 | 2 |
| 07FB004 | 1050 | 1 | 0 | 1 | 8 | 28 | 22 | 19 | 9 | 6 | 4 | 2 | 1 |
| 07FB005 | 1100 | 1 | 1 | 1 | 13 | 24 | 19 | 18 | 8 | 6 | 4 | 2 | 1 |
| 07FB006 | 1300 | 2 | 1 | 2 | 4 | 21 | 27 | 15 | 8 | 7 | 7 | 5 | 2 |
| 07FB009 | 1130 | 1 | 1 | 1 | 10 | 31 | 22 | 14 | 5 | 5 | 4 | 3 | 2 |
| *BC Hydrologic Zone 8* | | | | | | | | | | | | | |
| 07EC002 | 1260 | 2 | 1 | 1 | 2 | 21 | 34 | 15 | 6 | 5 | 6 | 4 | 2 |
| 07EC003 | 1410 | 2 | 1 | 1 | 2 | 15 | 32 | 20 | 9 | 7 | 6 | 3 | 2 |
| 07EC004 | 1340 | 2 | 1 | 1 | 2 | 18 | 35 | 17 | 7 | 5 | 5 | 3 | 2 |
| *Alberta* | | | | | | | | | | | | | |
| 07GB001[a] | 1150 | n/a | n/a | n/a | n/a | 17 | 13 | 11 | 6 | 5 | 4 | n/a | n/a |
| 07GE001 | 1010 | 1 | 1 | 1 | 7 | 22 | 26 | 17 | 8 | 6 | 6 | 3 | 2 |

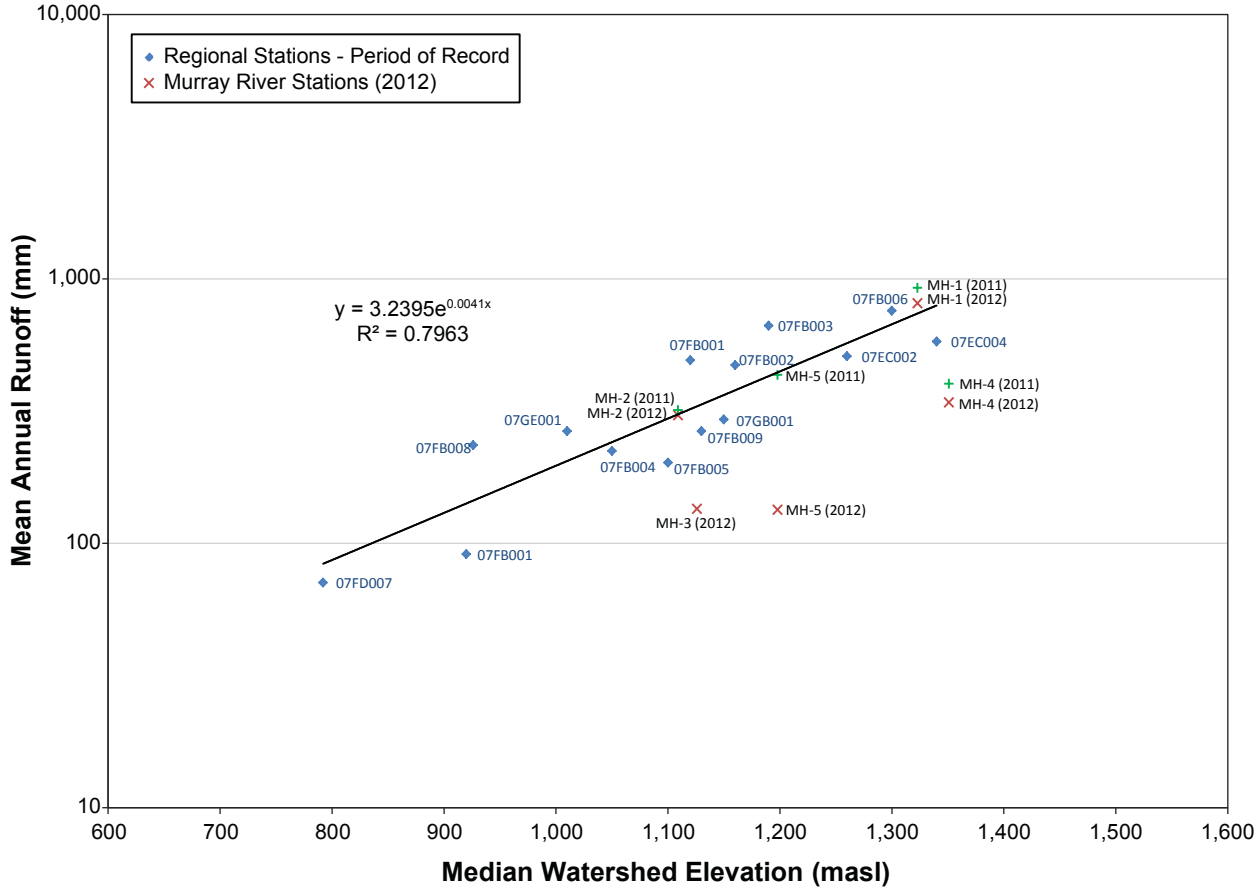
*[a] Winter data not available for station 07GB001.*
*Notes: Monthly values may not sum to 100% due to rounding*
*Station periods of record are provided in Table 3.2-2*

Among the regional WSC stations selected for analysis, annual mean runoff over the station period of record ranged from a minimum of 71 mm at station 07FD007 (Pouce Coupe River below Henderson Creek) to a maximum of 758 mm at station 07FB006 (Murray River above Wolverine River). Among the regional stations, higher median watershed elevation generally correlated with greater annual runoff. Station 07EC003 was excluded from the analysis because it would show as an outlier in the regional plot. The Zone 8 stations are among the highest elevation watersheds in the dataset. Runoff at these stations is greater than runoff for most of the other watersheds (Table 3.3-4, Figures 3.3-6 and 3.3-7), with the exception of several relatively high elevation watersheds in Zone 7 (07FB001, 07FB002, 07FB003, and 07FB006).

For the eight stations in BC Hydrologic Zone 7 (Table 3.3-2, Figure 3.3-4), the majority of runoff occurred between May and July, with this period accounting for 61-70% of annual runoff. January to March was the low discharge period, contributing less than 5% of annual runoff for all stations.

Runoff for watersheds in other hydrologic zones had generally similar timing to runoff in Zone 7 watersheds, with the majority of runoff (57-71%) occurring between May and July and the low flow period from January to March contributing less than 5% of annual runoff for all stations.

Baseline monitoring studies in the Project area were recently initiated, and there are as yet no long-term Project-specific data available. In order to determine long-term mean annual runoff estimates for the Project area, a regional relation was developed between median watershed elevation and mean annual runoff. This relation is displayed on a semi-logarithmic plot in Figure 3.3-8.




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## Median Watershed Elevation-Mean Annual Runoff Relation for Regional Hydrometric Stations

Figure 3.3-8

It is seen that the regional regression line is close to the 2011 and 2012 data from Stations MH-1 and MH-2. Based on available daily discharge data at WSC 07FB006, it is assumed that the 2011 and 2012 annual runoff values are 21.4% and 5.3% above the long-term annual runoff values, respectively. These ratios are used to estimate the long-term MAR estimates for watersheds MH-1 and MH-2 (the last column in Table 3.3-6). These estimates are close to the ones based on the regional regression analysis.

**Table 3.3-6. Observed (2011-2012) and Calculated (Long-Term) Mean Annual Runoff (mm) for Project Hydrometric Stations**

| Hydrometric Station | Drainage Area ($km^2$) | Median Elevation (masl) | Mean Annual Runoff (mm) | | |
|---|---|---|---|---|---|
| | | | 2011-2012 | MAR based on the Regional Equation | MAR Estimate for the Watershed |
| MH-1 | 2242.0 | 1323 | 967 (866[b]) | 734 | 764 |
| MH-2 | 43.1 | 1109 | 312 | 305 | 276 |
| MH-3 | 6.8 | 1126 | 135[a] | 327 | n/a |
| MH-4 | 21.0 | 1351 | 371 | 824 | n/a |
| MH-5 | 4.1 | 1198 | 283 | 440 | n/a |

[a] *Hydrograph not developed for MH-3 in 2011 due to insufficient data; water levels too low for continuous measurement from July 2011 until station demobilization in November 2011*
[b] *Adjusted value based on WSC Station 07FB006 (Murray River above Wolverine River)*

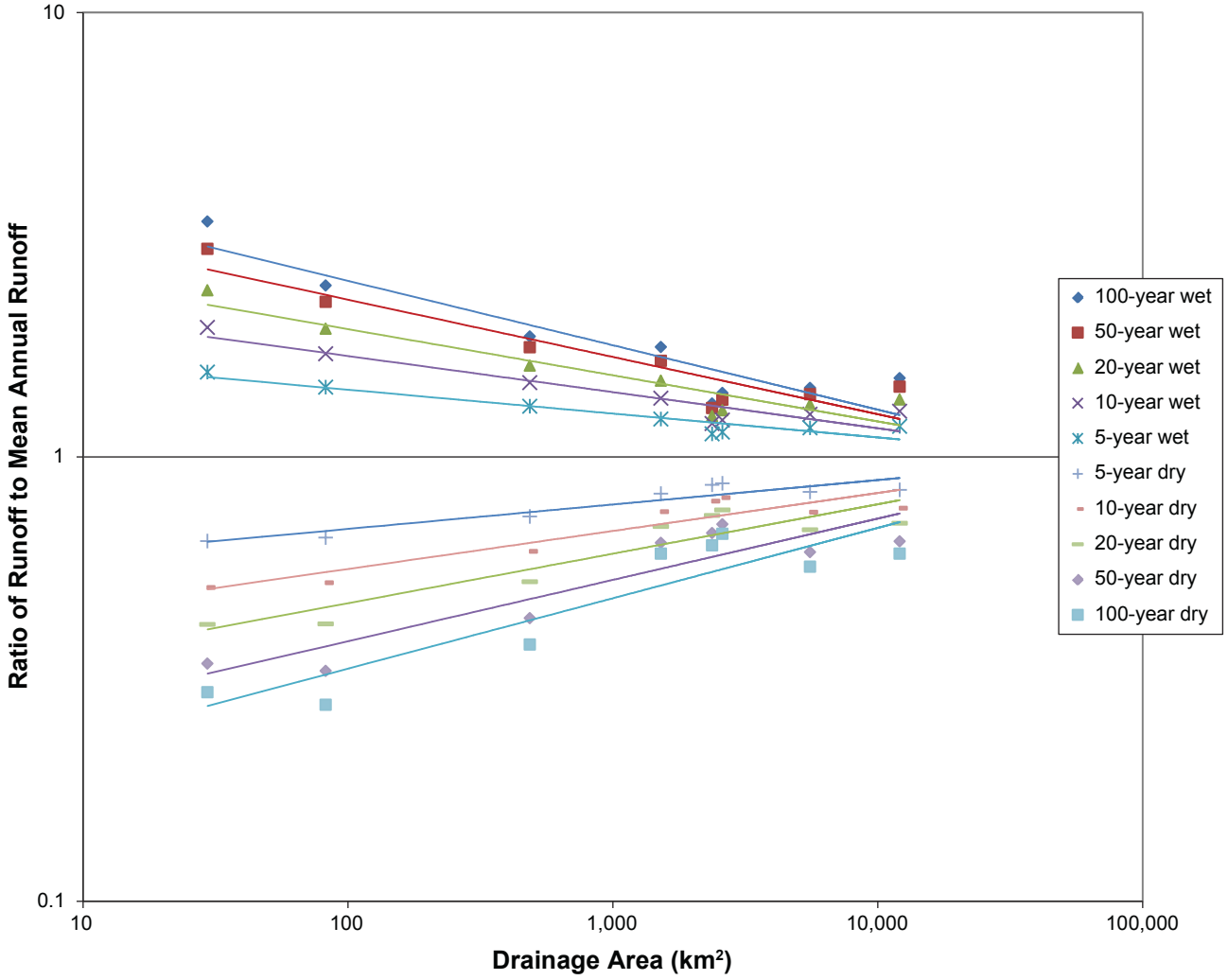
For smaller watersheds (MH-3, MH-4, and MH4) the MAR based on the regional regression analysis is significantly higher than the 2011 and 2012 collected data. A long-term MAR is not estimated for these watersheds because a) the watersheds are significantly smaller than the majority of regional stations; b) site specific and regional data are significantly different; c) site specific data are not complete at MH-3; d) collected data during 2011 are significantly different from the 2012 data at MH-5; and e) hydrometric stations at all these watersheds are inactive, and more data is not expected to be collected to augment the existing data.

Previous statistical frequency analysis work established estimated annual runoff quantities for a variety of recurrence intervals for the regional WSC stations. The analysis procedures are described in the *2011-2012 Hydrology Baseline Report* (Rescan 2013a). For the regional stations, the ratio of recurrence interval runoff to mean annual runoff was found to correlate well with drainage area (Figure 3.3-9, Table 3.3-7). Power equations ($Ratio = aA^b$, where $A$ is the drainage area in $km^2$ and $a$ and $b$ are the coefficient and exponent as described in Table 3.3-7) for each return interval were derived from this correlation (Table 3.3-7). These equations were used to calculate scaling factors for return intervals at each of the Project stations (Table 3.3-8).

**Table 3.3-7. Regression Analysis Summary for Annual Runoff Recurrence Ratio as a Function of Drainage Area**

| | Recurrence (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Wet | | | | | Dry | | | | |
| | 100 | 50 | 20 | 10 | 5 | 5 | 10 | 20 | 50 | 100 |
| Coefficient (*a*) | 4.857 | 4.090 | 3.128 | 2.453 | 1.814 | 0.535 | 0.378 | 0.281 | 0.204 | 0.161 |
| Exponent (*b*) | -0.145 | -0.129 | -0.104 | -0.081 | -0.054 | 0.055 | 0.086 | 0.111 | 0.138 | 0.158 |
| $R^2$ | 0.857 | 0.866 | 0.874 | 0.881 | 0.886 | 0.870 | 0.862 | 0.852 | 0.831 | 0.822 |

*Note: Equations are of the form $y = a*(x^b)$*




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**Ratio of Annual Recurrence Period Runoff to Mean Annual Runoff as a Function of Drainage Area**

Figure 3.3-9

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**Table 3.3-8. Mean Annual Runoff Return Period Scaling Factors for Project Watersheds**

| Hydrometric Station | Area ($km^2$) | Recurrence (years) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wet | | | | | Mean | Dry | | | | |
| | | 100 | 50 | 20 | 10 | 5 | 2 | 5 | 10 | 20 | 50 | 100 |
| MH-1 | 2242.0 | 1.59 | 1.51 | 1.40 | 1.31 | 1.20 | 1 | 0.82 | 0.73 | 0.66 | 0.59 | 0.55 |
| MH-2 | 43.1 | 2.81 | 2.52 | 2.11 | 1.81 | 1.48 | 1 | 0.66 | 0.52 | 0.43 | 0.34 | 0.29 |

The scaling factors listed in Table 3.3-8 were applied to the estimated long-term MAR MH-1 and MH-2 watersheds (Table 3.3-6) in order to provide return period runoff values. Annual runoff frequency results are summarized in Table 3.3-9 alongside 2011-2012 annual runoff for the Project watersheds. The mean values represent runoff at a cumulative probability of 0.5 (50% of years are greater and 50% are less than this value) and are associated with a two-year recurrence interval. Dry years are represented by cumulative probabilities below 0.5, while wet years have a cumulative probability greater than 0.5.

**Table 3.3-9. Predicted Return Period Runoff and 2011-2012 Annual Runoff (mm) for Project Hydrometric Stations**

| Hydrometric Station | Median Elevation (masl) | Recurrence (years) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wet | | | | | Mean | Dry | | | | | | |
| | | 100 | 50 | 20 | 10 | 5 | 2 | 5 | 10 | 20 | 50 | 100 | 2011 | 2012 |
| MH-1 | 1323 | 1212 | 1155 | 1071 | 1003 | 914 | 764 | 624 | 558 | 506 | 452 | 418 | 924[b] | 808[b] |
| MH-2 | 1109 | 777 | 695 | 584 | 500 | 409 | 276 | 182 | 144 | 118 | 95 | 81 | 319 | 305 |

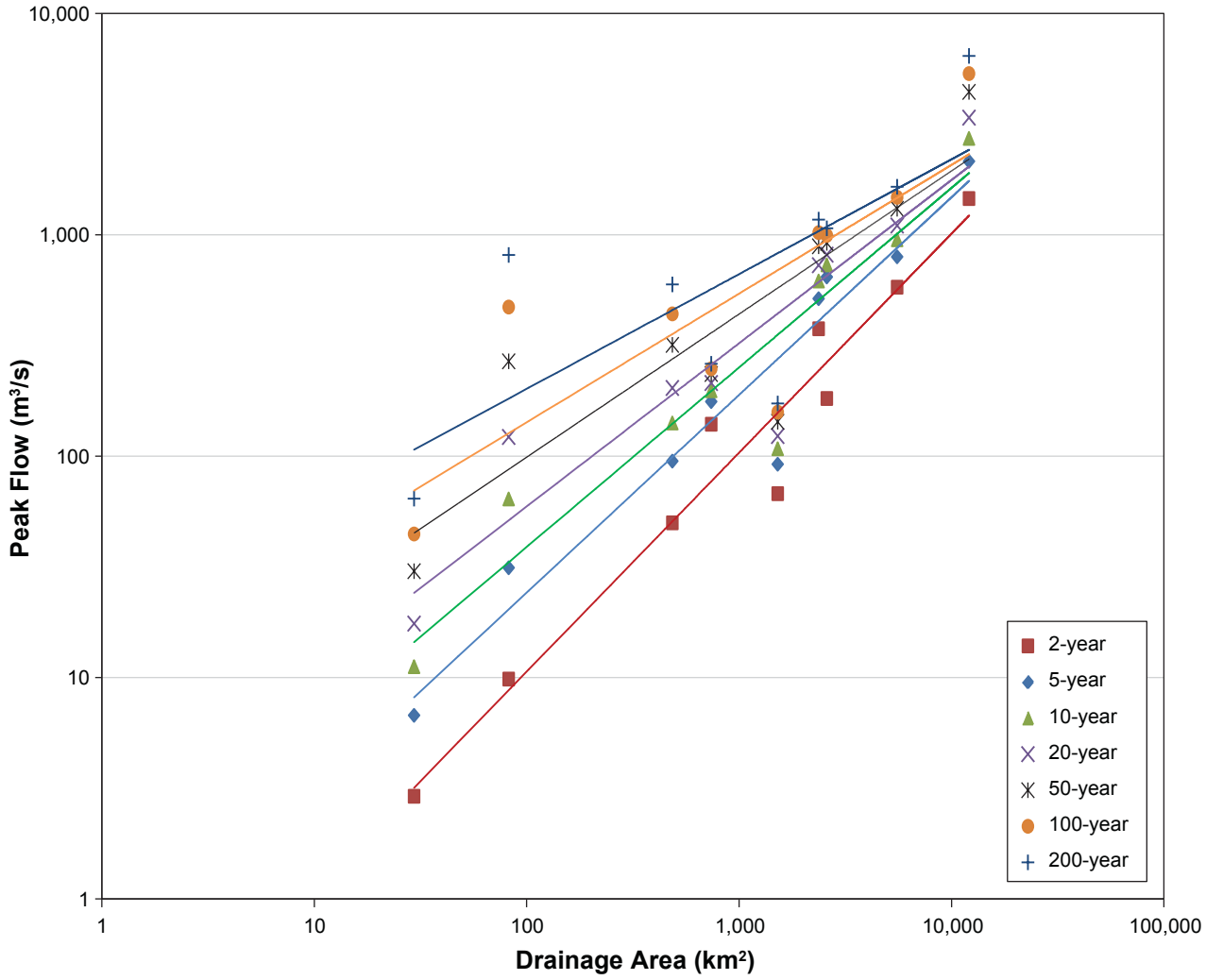
[a] *Complete year of data not available; station installed in May 2011*
[b] *Adjusted value based on WSC Satiotn 07FB006 (Murray River above Wolverine River)*

### *3.3.3 Peak Flow*

Peak flows represent the maximum water discharge that can be produced from a drainage area during a year, in response to precipitation events and snowmelt. Long-term predictions of peak flows for a variety of recurrence intervals are important to project design.

Frequency analyses were carried out on instantaneous peak flows for the regional WSC stations as part of a previous study (Rescan 2013a). Peak flow frequency data previously produced, with the addition of station 07EF004, are plotted on a log-log graph in Figure 3.3-10. This figure shows the relations between the annual maximum instantaneous discharge of various recurrence intervals and corresponding watershed drainage area.

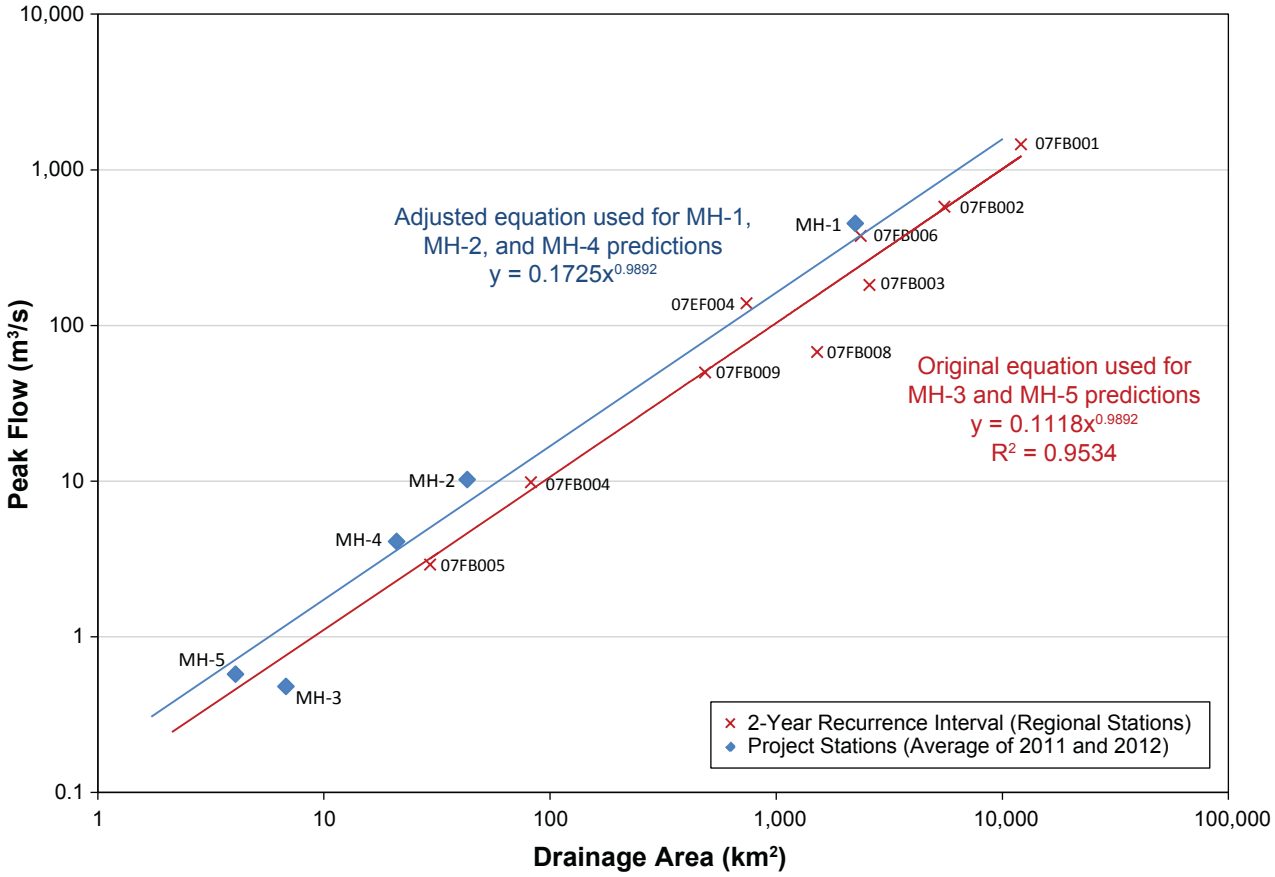
Regression equations were fit to the peak flow-drainage area relation for a variety of recurrence intervals (*Peak Flow* = $aA^b$, where *A* is the drainage area in $km^2$ and *a* and *b* are the coefficient and exponent as described in Table 3.3-10). When plotted with 2011-2012 averages for the Project stations, the regional regression equations underestimated peak flow at MH-1, MH-2, and MH-4. To ensure that peak flow predictions are conservative, the coefficients of the equations were adjusted for these stations so that the regional lines pass through station 07FB006 (Figure 3.3-11, Table 3.3-10). Station MH-1 is approximately 8 km upstream of station 07FB006, and due to the close proximity of these stations, station 07FB006 was considered to be a reliable proxy for long-term averages at station MH-1. The adjusted equation was used for predictions of return period peak flows at stations MH-1, MH-2, and MH-4 to prevent underestimation. However, the original equation did not underestimate peak flow for smaller watersheds (i.e., MH-3 and MH-5) and so it was used for these stations. As previously mentioned, hydrometric stations at smaller watersheds (MH-3, MH-4, and MH-5) are discontinued and further data is not expected to be available.




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## Recurrence Interval Peak Flow as a Function of Drainage Area for Regional Hydrometric Stations

Figure 3.3-10




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**Adjustments to Peak Flow Prediction Equation**

Figure 3.3-11

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**Table 3.3-10. Regression Analysis Summary for Peak Flow as a Function of Drainage Area**

| | Recurrence (years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2** | **5** | **10** | **20** | **50** | **100** | **200** |
| Coefficient (*a*) | 0.11 | 0.40 | 0.93 | 1.99 | 5.04 | 9.78 | 18.49 |
| Adjusted Coefficient[a] | *0.17* | *0.50* | *1.13* | *2.37* | *5.84* | *11.14* | *20.76* |
| Exponent (*b*) | 0.989 | 0.893 | 0.811 | 0.737 | 0.646 | 0.581 | 0.518 |
| $R^2$ | 0.953 | 0.934 | 0.902 | 0.852 | 0.756 | 0.661 | 0.553 |

*Notes: Equations are of the form* $y = a*(x^b)$
[a] *Coefficients adjusted for stations MH-1, MH-2, and MH-4; italics added to differentiate adjusted from original coefficients*

The regression equations developed from regional data were used to predict recurrence interval peak flows for the Project area, which are listed alongside peak flow data for the Project stations in 2011 and 2012 in Table 3.3-11. In general, peak flows in 2011 and 2012 were slightly above average (between a 2- and 5-year recurrence interval). However, peak flows for the smaller watersheds MH-3 and MH-5 were slightly below average in 2012.

**Table 3.3-11. Frequency Analysis Summary of Annual Instantaneous Peak Flow Estimates ($m^3/s$)**

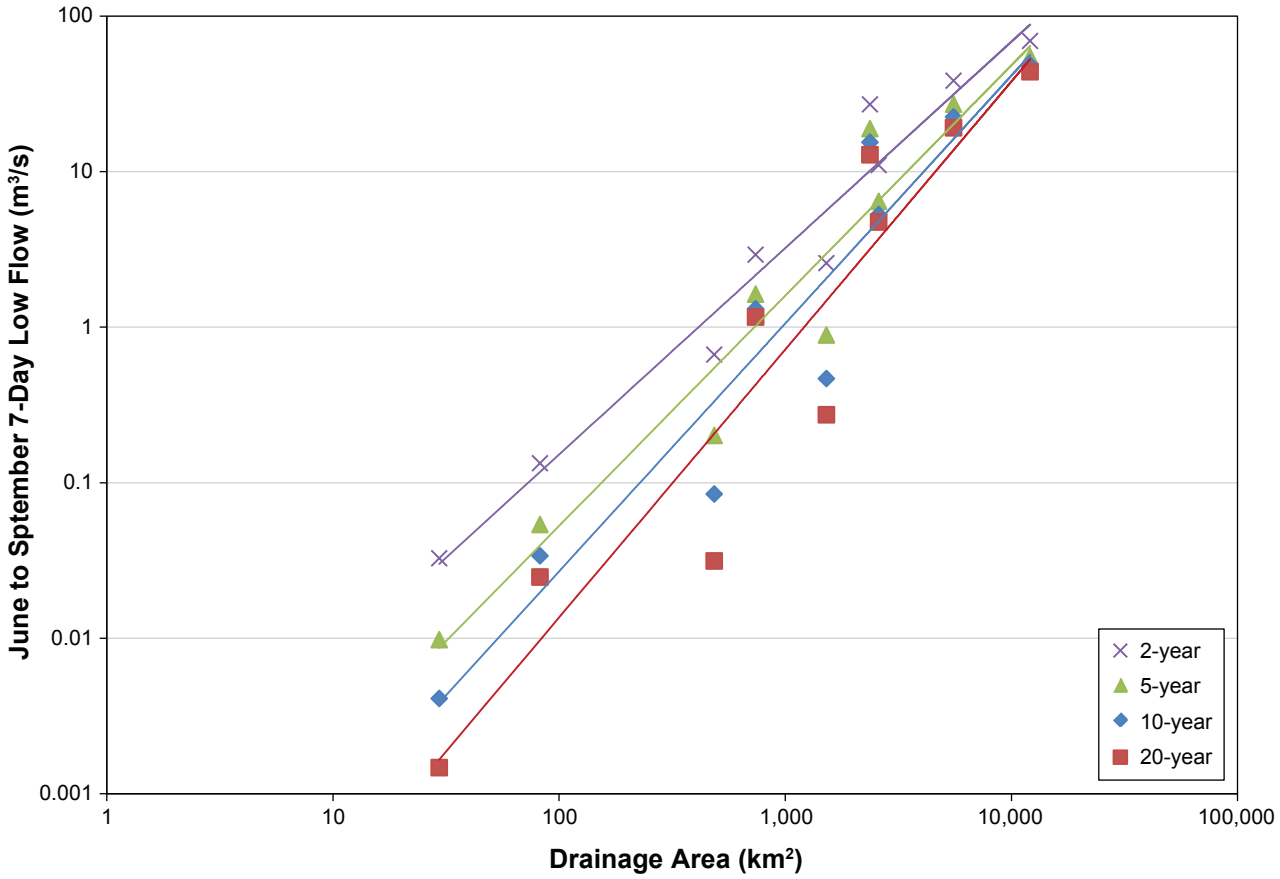
| Hydrometric Station | Drainage Area ($km^2$) | Recurrence (years) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **2** | **5** | **10** | **20** | **50** | **100** | **200** | **2011** | **2012** |
| MH-1 | 2242.0 | 356 | 488 | 590 | 699 | 856 | 988 | 1134 | 479 | 426 |
| MH-2 | 43.1 | 7.1 | 14.3 | 23.9 | 37.9 | 66.5 | 99.3 | 146.1 | 12.3 | 8.1 |
| MH-3 | 6.8 | 0.7 | 2.2 | 4.4 | 8.2 | 17.4 | 29.8 | 50.0 | n/a[a] | 0.5 |
| MH-4 | 21.0 | 3.5 | 7.5 | 13.4 | 22.3 | 41.8 | 65.4 | 100.7 | 4.3 | 3.9 |
| MH-5 | 4.1 | 0.4 | 1.4 | 2.9 | 5.6 | 12.5 | 22.1 | 38.3 | 0.9 | 0.3 |

### *3.3.4 Seven-day Low Flows*

Low flows provide an estimate of the baseflow conditions of a stream during the open water season and winter period. Annual low flows typically occur in the winter, because a large percentage of water is stored as snow or ice. A second low flow period occurs in the warmer and drier summer months when the volume of available surface water decreases and levels tend toward base flow conditions. Predictions of recurrence intervals for extreme low flows are important for the management of water resources due to potential effects on fish and aquatic species, as well as to mitigate possible drought conditions.

Measurements of low flows are typically expressed as a seven-day low flow period, defined as the minimum value of average flows over any consecutive seven days. Seven-day low flows at a variety of recurrence intervals were previously calculated for eight regional WSC hydrometric stations and used to predict seven-day summer (June to September) low flows for hydrometric stations in the Project area (Rescan 2013a). The previous frequency analysis has been revised in this report with the addition of WSC station 07EF004, and expanded to generate predictions of annual as well as summer low flows. The results of the updated analysis are provided in Table 3.3-12.

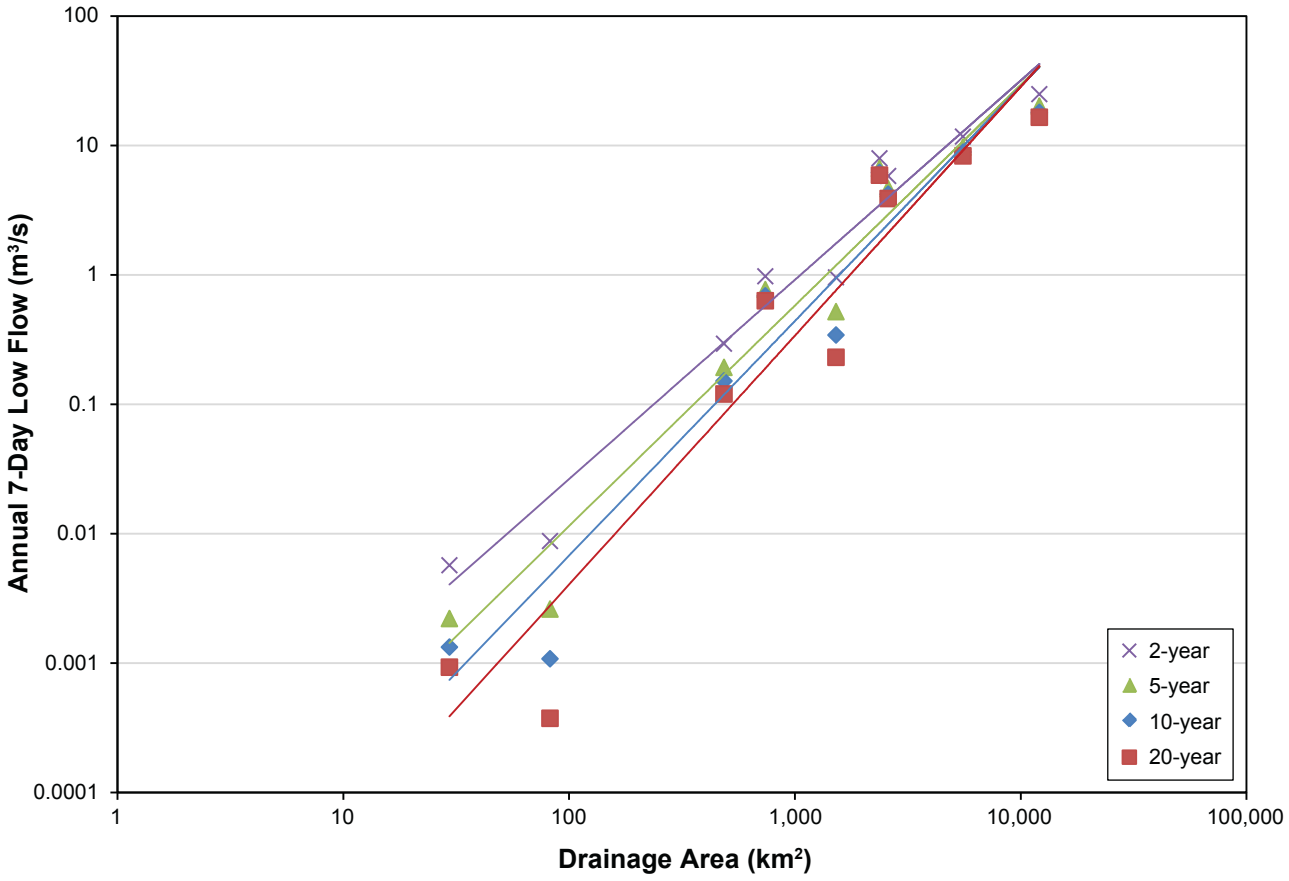
Using the low flow predictions generated by the frequency analysis, regression equations describing the relation between drainage area and seven-day low flow for a variety of recurrence intervals were fit for both summer and annual low flows ($Low\ Flow = aA^b$, where $A$ is the drainage area in $km^2$ and $a$ and $b$ are the coefficient and exponent as described in Table 3.3-13). Results of the regression are summarized in Table 3.3-13. The drainage area-low flow relation is displayed on log-log plots in Figures 3.3-12 (summer) and 3.3-13 (annual).




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# Recurrence Interval Summer (June to September) Seven-Day Low Flow as a Function of Drainage Area for Regional Stations

Figure 3.3-12




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## Recurrence Interval Annual Seven-Day Low Flow as a Function of Drainage Area for Regional Stations

Figure 3.3-13

**Table 3.3-12. Frequency Analysis of Seven-Day Low Flow ($m^3/s$) for Regional WSC Stations**

| Station | Drainage Area ($km^2$) | Recurrence (years) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Annual | | | | Summer (June to September) | | | |
| | | 2 | 5 | 10 | 20 | 2 | 5 | 10 | 20 |
| 07FB001 | 12,100 | 24.9 | 20.1 | 18.0 | 16.5 | 69.2 | 54.6 | 48.4 | 43.8 |
| 07FB002 | 5550 | 11.7 | 9.7 | 8.9 | 8.3 | 38.4 | 27.1 | 22.4 | 19.1 |
| 07FB003 | 2590 | 5.8 | 4.6 | 4.2 | 3.9 | 11.0 | 6.4 | 5.3 | 4.7 |
| 07FB004 | 82 | 0.009 | 0.003 | 0.001 | 0.0004 | 0.133 | 0.054 | 0.034 | 0.025 |
| 07FB005 | 30 | 0.006 | 0.002 | 0.001 | 0.001 | 0.033 | 0.010 | 0.004 | 0.002 |
| 07FB006 | 2370 | 8.0 | 6.7 | 6.2 | 5.9 | 27.0 | 18.9 | 15.4 | 12.8 |
| 07FB008 | 1520 | 0.95 | 0.52 | 0.34 | 0.23 | 2.58 | 0.89 | 0.47 | 0.27 |
| 07FB009 | 486 | 0.29 | 0.19 | 0.15 | 0.12 | 0.66 | 0.20 | 0.08 | 0.03 |
| 07EF004 | 741 | 0.97 | 0.77 | 0.69 | 0.63 | 2.92 | 1.63 | 1.31 | 1.16 |

**Table 3.3-13. Regression Analysis Summary for Seven-Day Low Flow as a Function of Drainage Area**

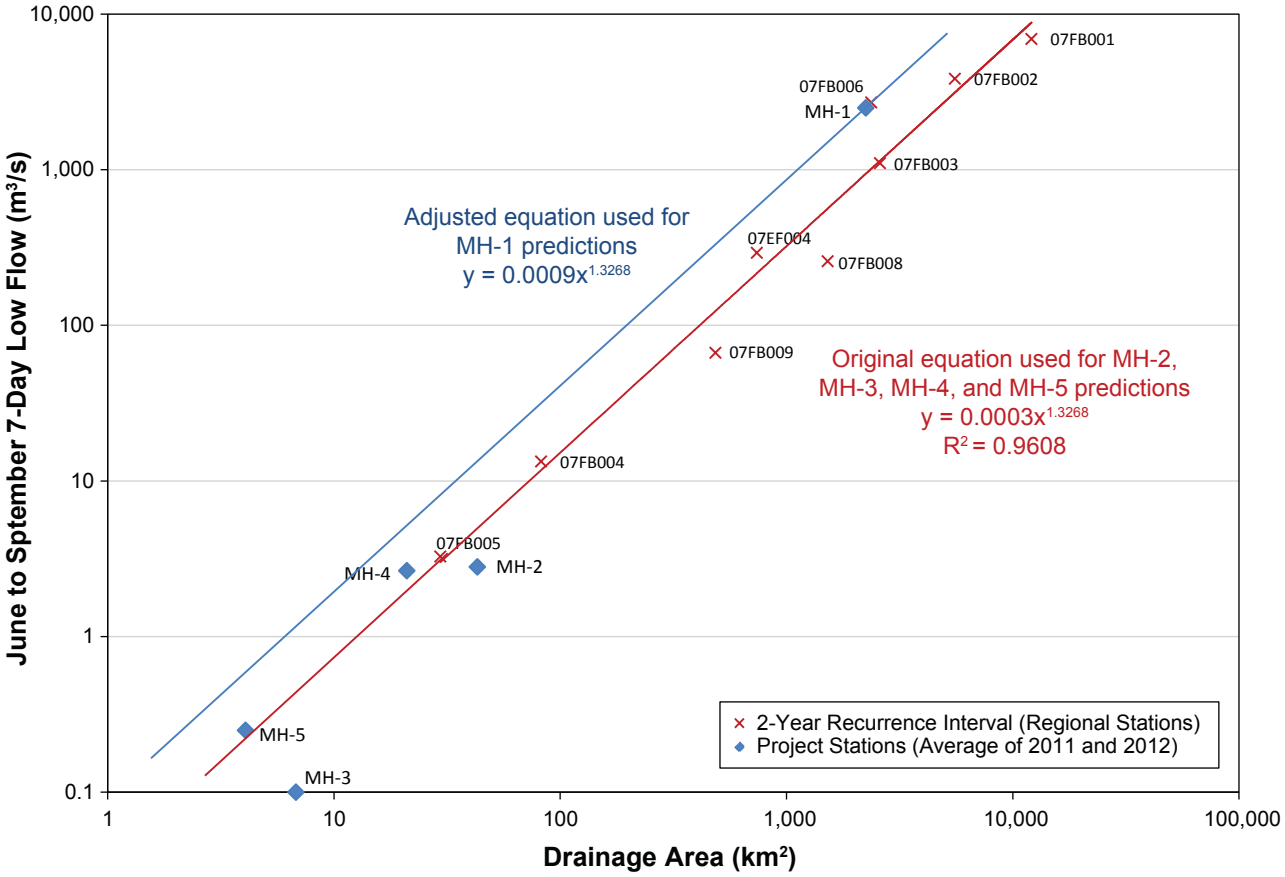
| | Recurrence (years) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Summer (June-September) | | | | Annual | | | |
| | 2 | 5 | 10 | 20 | 2 | 5 | 10 | 20 |
| Coefficient (*a*) | $3 \times 10^{-4}$ | $6 \times 10^{-5}$ | $2 \times 10^{-5}$ | $5 \times 10^{-6}$ | $2 \times 10^{-5}$ | $4 \times 10^{-6}$ | $2 \times 10^{-6}$ | $6 \times 10^{-7}$ |
| Adjusted Coefficient (*a*)[a] | *$9.0 \times 10^{-4}$* | *$1.9 \times 10^{-4}$* | *$6.4 \times 10^{-5}$* | *$2.0 \times 10^{-5}$* | *$5.1 \times 10^{-5}$* | *$1.2 \times 10^{-5}$* | *$4.7 \times 10^{-6}$* | *$1.9 \times 10^{-6}$* |
| Exponent (*b*) | 1.327 | 1.481 | 1.594 | 1.723 | 1.539 | 1.704 | 1.813 | 1.923 |
| $R^2$ | 0.961 | 0.939 | 0.920 | 0.896 | 0.966 | 0.951 | 0.937 | 0.915 |

*Notes: Equations are of the form $y = a*(x^b)$*
[a] *Coefficients adjusted for station MH-1; italics added to differentiate adjusted from original coefficients*

When plotted with 2011-2012 averages for the Project stations, the regional regression equations underestimated both summer and annual low flow at MH-1 (Figures 3.3-14 and 3.3-15). To correct for this underestimation, the coefficients of the equations were adjusted for MH-1 so that the regional lines pass through station 07FB006 (Figures 3.3-14 and 3.3-15, Table 3.3-13). Due to the close proximity of these stations (MH-1 is approximately 8 km upstream from 07FB006), station 07FB006 was considered to be a reliable proxy for station MH-1.

Annual and summer seven-day low flow predictions for the Project stations are provided in Tables 3.3-14 and 3.3-15, respectively. In 2011, both summer and annual low flows were slightly greater than the 2-year return period prediction for all active stations, indicating, as explained in section 3.3.2, that 2011 was a wetter than average year. Please note that this is based on the assumption that the probability distributions of the low flows are symmetric, i.e., mean and 2-year return period events are identical. However, summer 2012 was drier than average. The seven-day summer low flow at station MH-1 was between a 2- and 5-year return interval, and summer low flows at station MH-2 were between a 5- and 10-year return interval. The streams at stations MH-3 and MH-5 dried up completely during summer 2012, indicating a minimum of a 5-year return interval. Only station MH-4 experienced an above-average seven-day low flow in 2012.

Despite the dry summer in 2012, annual low flows were greater than the 2-year return prediction at stations MH-1, MH-2, and MH-4. Stations MH-3 and MH-5, on smaller watersheds (6.6 $km^2$ and 4.1 $km^2$, respectively), had an annual low flow of 0.0 $m^3/s$ in both 2011 and 2012, which is predicted to be average.

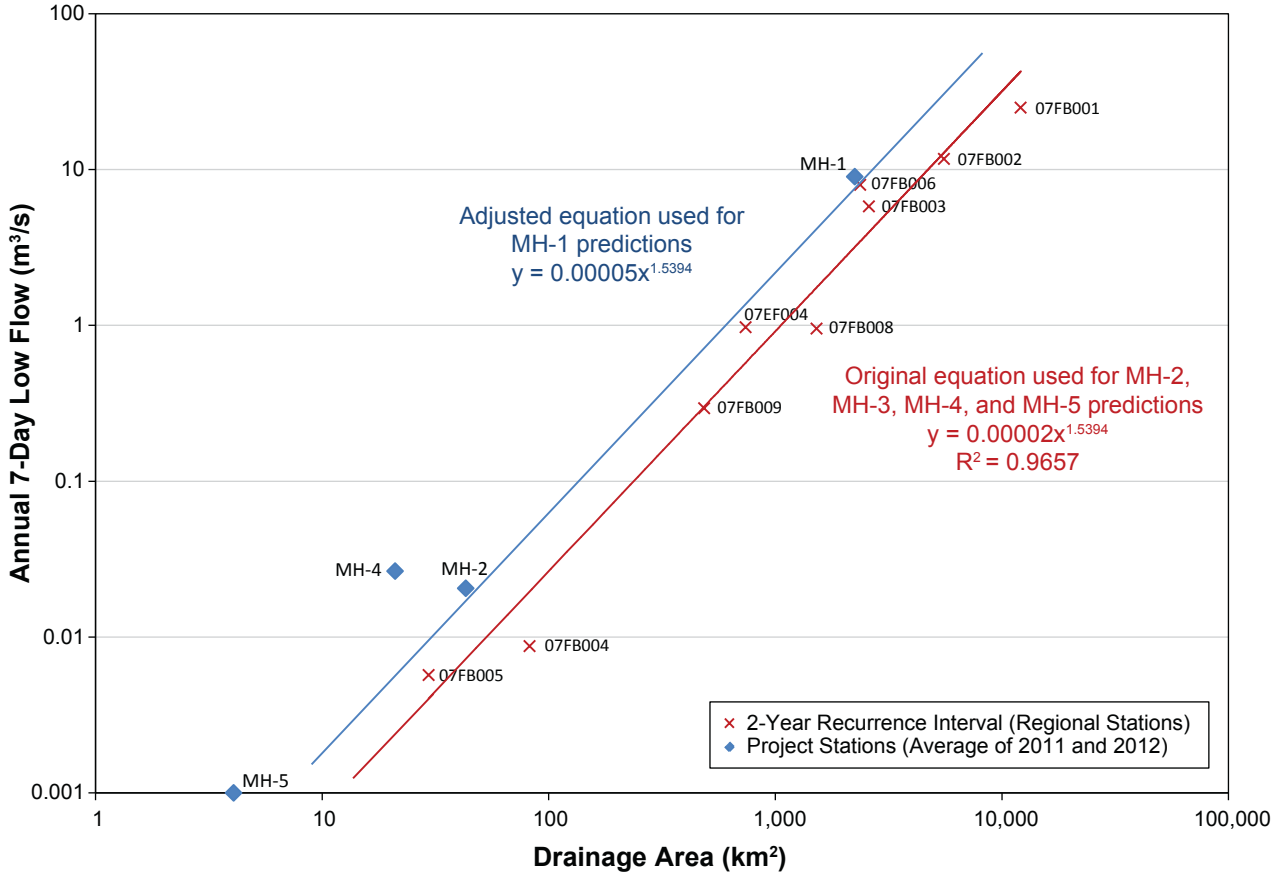



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## Adjustments to Summer (June to September) Seven-Day Low Flow Prediction Equation

Figure 3.3-14

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# Adjustments to Annual Seven-Day Low Flow Prediction Equation

Figure 3.3-15

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**Table 3.3-14. Estimated Summer (June-September) Seven-Day Low Flows ($m^3/s$) for Project Hydrometric Stations**

| Hydrometric Station | Drainage Area ($km^2$) | Recurrence (years) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 | 5 | 10 | 20 | 2011 | 2012 |
| MH-1 | 2242 | 25.1 | 17.4 | 14.1 | 11.6 | 31.3 | 18.6 |
| MH-2 | 43.1 | 0.044 | 0.016 | 0.008 | 0.003 | 0.04 | 0.01 |
| MH-3 | 6.1 | 0.004 | 0.001 | 0.000 | 0.000 | 0 | 0 |
| MH-4 | 21.0 | 0.017 | 0.005 | 0.003 | 0.001 | 0.03 | 0.02 |
| MH-5 | 4.1 | 0.002 | 0.000 | 0.000 | 0.000 | 0.005 | 0 |

**Table 3.3-15. Estimated Annual Seven-Day Low Flows ($m^3/s$) for Project Hydrometric Stations**

| Hydrometric Station | Drainage Area ($km^2$) | Recurrence (years) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 | 5 | 10 | 20 | 2011 | 2012 |
| MH-1 | 2242.0 | 7.30 | 6.05 | 5.59 | 5.28 | 7.6 | 10.4 |
| MH-2 | 43.1 | 0.007 | 0.002 | 0.002 | 0.001 | 0.03 | 0.01 |
| MH-3 | 6.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0 | 0 |
| MH-4 | 21.0 | 0.002 | 0.001 | 0.000 | 0.000 | 0.03 | 0.02 |
| MH-5 | 4.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0 |

Similar to annual runoff and peak flow values, low flow data collected from discontinued hydrometric stations at smaller watersheds (MH-3, MH-4, and MH-5) may not be conclusively interpreted.

# 4. Summary of Water Balance Compents

The three components of the simplified water balance equation (refer to Section 1.4) are not balanced for the Murray River watershed at hydrometric station MH-1. The *MAP*, *MAR*, and EVAP were estimated to be 902 mm (Table 2.3-5), 764 mm (Table 3.3-6), and 250 mm (Section 2.3.3). The imbalance of 112 mm may be due to:

- Uncertainty in the simplifying assumption that groundwater recharge and discharge volumes are equal within the watershed (i.e., $\Delta G$); and
- Potentially significant uncertainty in evaporation estimates (see section 2.3.3 for details), moderate uncertainty in precipitation estimates (due to extrapolation of regional data).

The imbalance in the simplified water balance equation is acknowledged here, but the equation components are intentionally not adjusted. Different (and even opposite) adjustment schemes may be required for different uses of these data (e.g., for engineering design and for water quality modelling). Therefore, the adjustments, if required, are left to be undertaken by the users of these estimates.

## Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

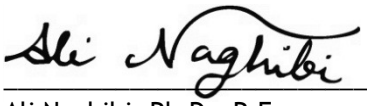
| | |
|---|---|
| **Baseflow** | The groundwater component of flow discharge that is attributed to soil moisture and groundwater drainage into a channel. |
| **Climate normal** | Climatological data averaged over a prescribed 30-year interval. |
| **Flood frequency** | The frequency that a flood of a specified magnitude occurs, inversely related to flood return period. |
| **Freshet** | In channels, the relatively high annual peak water discharge period resulting from spring/summer meltwater runoff of the winter snowpack. |
| **Hydrograph** | A graphical plot of water discharge versus time. |
| **IDF** | Intensity-Duration-Frequency |
| **LSA** | Local Study Area |
| **MAD** | Mean annual discharge ($m^3/s$) |
| **MAP** | Mean annual precipitation (mm) |
| **MAR** | Mean annual runoff (mm) |
| **masl** | metres above sea level |
| **MSC** | Meteorological Service of Canada |
| **NAD83** | North American Datum 1983. A datum is a reference system for computing or correlating the results of a survey. The NAD83 datum is based on the spheroid (GRS80). |
| **PRC** | Peace River Coalfield |
| **Precipitation** | Liquid or solid products of the condensation of water vapour falling from the clouds which include rain, sleet, hail, snow, and other forms of water. |
| **Return period** | The average interval at which an event occurs, calculated from the probability of its occurrence in a given year. |
| **RSA** | Regional Study Area |
| **Runoff** | Runoff is the part of precipitation that appears in surface streams and is a measure of the hydrologic response of a watershed. It is the quantity of water that is discharged (“runs off”) from a watershed during a given time period. It is commonly presented as a depth of water over an entire watershed, in millimeters. |
| **Seven-day low flow** | The minimum average seven-day flow that occurs over a specified period, such as a month, season, or year. |
| **UTM** | Universal Transverse Mercator |
| **Watershed** | The entire geographical area drained by a river and its tributaries; an area characterized by all runoff being conveyed to the same outlet. |

| | |
|---|---|
| **WSC** | Water Survey of Canada |
| **WMO** | World Meteorological Organization |

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