SUMMER 2008 BASEFLOW STUDY

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Executive Summary

In the summer of 2007 the Ausable Bayfield (ABCA) and Maitland Valley (MVCA) Conservation Authorities began a multi-year baseflow study under the Drinking Water Source Protection Project. A total of four river systems were monitored, including: the Ausable River, Bayfield River, Maitland River and Nine Mile River. In 2008, the study continued to compare flow information between years. This data will assist in the development of a water budget for these watersheds, as well in the delineation of Significant Recharge Areas for the Source Water Protection Program.

Measuring baseflow provides information about the quantity and spatial distribution of groundwater in the area. The optimal time to monitor baseflows are between July and September when ambient temperature is high and there are fewer precipitation events.

The collected flow data has been expressed in mm/day, which relates the amount of discharge (m^3/s) to the size of the sites' catchment area (m^2). This helps to identify whether the groundwater discharge in that area is significant.

Summary of Findings

Over a four month monitoring period, 51 sites were measured manually, complimented by an additional 22 sites with permanent gauges. Unfortunately, due to more frequent precipitation events, the summer 2008 baseflow study yielded fewer baseflow values than 2007. This increase in precipitation also caused flow values to be higher at all monitoring sites in 2008 when compared to 2007. Through each monitoring season, discharge values gradually decreased. (Appendix D)

The influence that precipitation had on flow values varied from site to site. At some sites, flow trends were closely linked to precipitation events while with others this trend was not as apparent. (Appendix C)

The comparison of manually measured values in 2008 to the Water Survey of Canada (WSC) rating curve values produced a different trend than 2007. In the 2007 study, permanent gauge values were consistently higher than that of the manually measured values; this was not the case in 2008. Overall, the difference between manual and gauged values was much lower in 2008. That might suggest the rating curves could reflect higher flow conditions.

Acknowledgements

Funding for this study was provided by the Drinking Water Source Protection Project of the Ausable Bayfield Maitland Valley Source Protection Region.

The author would like to thank the staff of both the Ausable Bayfield and Maitland Valley Conservation Authorities for their assistance throughout this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Introduction

In the summer of 2008, under The Drinking Source Water Protection (DWSP) Project, the Ausable Bayfield Conservation Authority (ABCA) and the Maitland Valley Conservation Authority (MVCA) continued the baseflow study which began in the previous year. The purpose of this study is to collect information on the contribution of baseflow in four major watercourses, the Ausable, Bayfield, Maitland and Nine Mile Rivers. This data will assist in the development of a water budget for these watersheds, also in the delineation of Significant Recharge Areas for the Source Water Protection Program.

1.1 What is Baseflow?

The term *baseflow* or *low flow*, refers to the discharge of groundwater to surface water streams, rivers, and other water bodies. This groundwater discharge helps to sustain the flow of water during extended dry periods of little or no precipitation.

Typically, the best time of year to measure baseflow is between July and September, when temperatures are high and when there are fewer precipitation events. During this period, baseflows are generally the dominant contributor to stream discharge. For more information on understanding baseflow refer to Section 1 of the 2007 Baseflow Study report. (Boorse & Napper, 2007)

1.2 Why is Baseflow Important?

Monitoring baseflow is an important tool in assessing not only the quantity of groundwater but also its spatial distribution (Hinton, 1995). Understanding which areas contribute the most baseflow can add to our understanding of local groundwater recharge, flow and discharge. Additionally, measuring flows manually can help compare and improve existing rating curves and flow models.

This movement of groundwater supplies rivers and streams with water during times of limited rainfall which helps to sustain both terrestrial and aquatic ecosystems (Hinton, 1998). The information collected in this study will provide a more clear idea of the groundwater budget in this area and could potentially be used in future land use planning decisions.

1.3 Goals

- To determine the relative contribution of volumetric baseflow in higher order streams to the Ausable, Bayfield, Maitland, and Nine Mile river systems.
- To locate baseflow contribution areas.
- Identify basis with high groundwater discharge and Significant Recharge Areas for DWSP.

1.4 Tasks

- Express flow values as mm/day in order to identify areas of significant groundwater discharge/recharge.
- Illustrate flow values as percent of total flow based on downstream reference point
- Compare 2007 and 2008 results.
- Determine which measurements would be considered baseflow based on daily precipitation data
- Summarize and analyze findings in a technical report.

2.0 Methodology

2.1 Site Determination

In the early stages of the 2007 study, staff from ABCA and MVCA selected a total of 73 sites: 24 in the Ausable River, 10 in the Bayfield River, 34 in the Maitland River, and 5 in the Nine Mile River. These sites were monitored throughout the entire 2008 study with a few revisions (See Section 3.1). For more detailed information on the site selection process refer to the Summer 2007 Baseflow Study Report (Boorse & Napper, 2007).

2.2 Baseflow Calculations

Flow Values

In order to measure discharge values, staff followed the Hinton Methodology (2005) with the following modification:

- Labeling of stream cross-sections commenced from left bank to right bank facing upstream instead of left to right facing downstream

Each stream cross section is divided into panels of equal width. By measuring the depth and velocity of each panel, individual discharge values can be determined as m^3/s (Area x Velocity). The discharge of the entire stream cross section is determined by simply adding the individual panel discharges together. For a more detailed description of Hinton's method, refer to the Summer 2007 Baseflow Study Section 2.4. (Boorse & Napper, 2007)

Upstream Catchment Flow mm/day

Discharge values along with the catchment area for each monitoring site are used to convert flow values into mm/day. To calculate mm/day the following equation was used, with the assumption that measured flow values were constant for the day.

Upstream Catchment Flow (mm/day) =

$$[\text{Flow } (m^3/s) / \text{ Upstream Catchment Area } (m^2)] \times 1{,}000 \times 86{,}400$$

where: 1000 and 86,400 are factors for converting m to mm and seconds to days.

Expressing measurements in mm/day helps to isolate areas of significant recharge/discharge. For example, BAF-006 contributes a considerable amount of flow relative to the size of its catchment area (Figure 2-1). However, if BAF-006 was represented in m^3/s its significance is reduced (Figure 2-2).

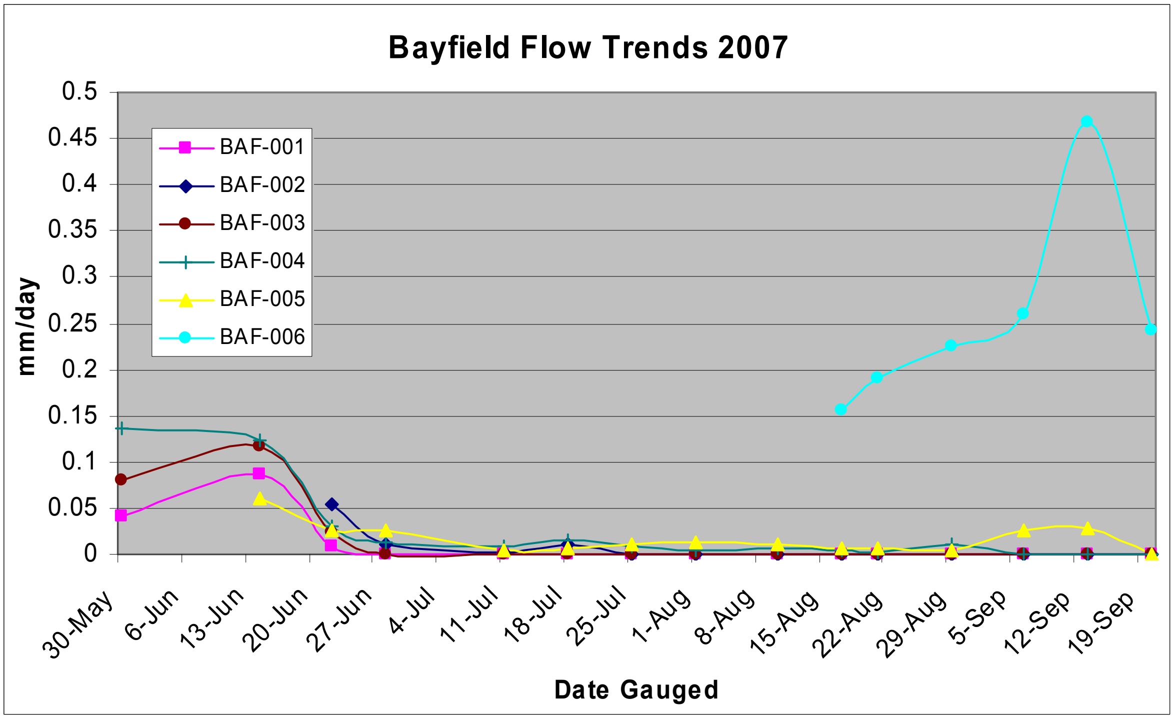


Figure 2-1: 2007 Bayfield River Flow Trends expressed in mm/day

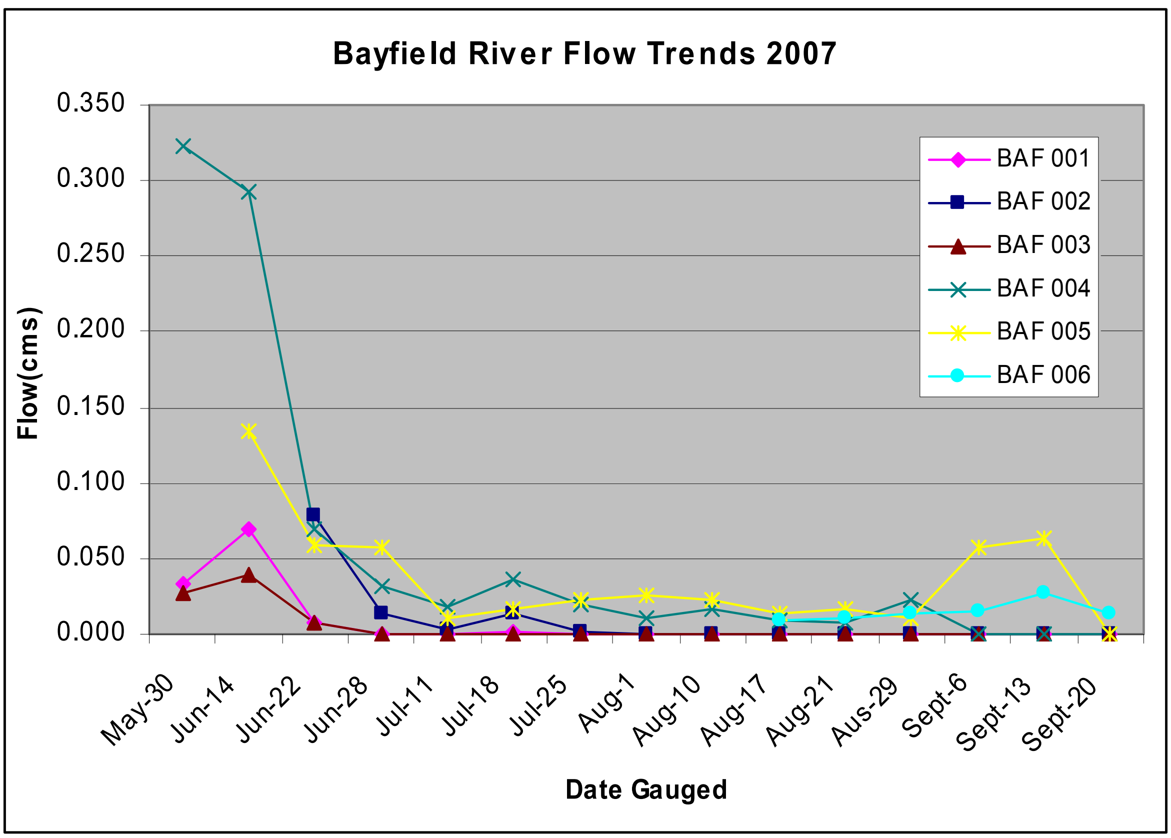


Figure 2-2: 2007 Bayfield River Flow Trends expressed in m^3/s

2.3 Returning to Baseflow

Baseflow conditions are highly dependent on recent rainfall events. The size of a site's catchment area determines how long after a rainfall it takes for the flows to return to baseflow. Using the size of each site's catchment area, the number of days to wait was determined using the following equation:

$$\text{Days to Wait} = 0.827\text{Area}(km^2) \wedge 0.2 \text{ (Fetter, 2001).}$$

This formula yielded "Days to Wait" ranging between 1-4 days for the locations in this study. In order to determine if measured flow values were baseflows, the Basin Runoff Forecast Unit (which uses distributed precipitation values) was used to determine if the catchment area had received any rain in the days prior to gauging. If there was no observed rain in the site's catchment area for a period longer than the "Days to Wait", the value was considered baseflow. This analysis was conducted for every measurement over the course of the 2007 and 2008 studies.

2.4 Permanent Gauge Data

Permanent Gauge Values

A total of twenty-two permanent gauges, from the ABCA and MVCA watersheds, were used in this study with a total of 279 measurements. These automated gauges continually collect flow values on an hourly basis. This increases the amount of information available and helps to analyze baseflow more closely. Maps of the permanent gauge locations are in Appendix A.

For each date which sites were manually measured, 12:00 noon values from the permanent gauges were gathered for comparison. These values have been tabulated in Appendix B, labeled permanent gauge values.

QA/QC Permanent Gauge Values

In the Summer 2007 Baseflow Study (Boorse and Napper, 2007), four permanent gauge locations (Belgrave, Ethel, Lakelet and Summerhill) were randomly selected and measured on a weekly basis for Quality Assurance/Quality Control purposes. Comparing manual measurements and measurements from the gauge is necessary to confirm the consistency of the gauged vs. manually measured values. Further, if the two methods are comparable the gauge stations can provide additional information.

Using the Basin Runoff Forecast Unit (BRFU) software, flow values were collected at each of the four QA/QC gauging locations for times when manual measurements were taken. Since flow values are collected on an hourly basis at the permanent gauge, a measurement could be obtained from a time that was very close to when manual measurements were taken. Refer to Appendix B for tabulated QA/QC data.

3.0 Changes from 2007

3.1 Monitoring Site Addition/Removal

Bayfield/Goderich Gullies

During the 2007 monitoring season, 33 gullies between Bayfield and Goderich were visually evaluated. Each site was identified as either: flowing, pooled or dry. In the summer of 2008, nine of the sites identified as "flowing" were monitored for the duration of the season on a weekly basis. For a detailed map of monitoring site locations refer to Appendix A.

AUS-020

Late in the 2008 monitoring season, a series of wells were decommissioned east of Exeter. In order to document any changes in baseflows, site AUS-020 added in the Ausable Headwaters (Appendix A). This site will continue to be monitored in the 2009 season.

Incorrect Sites

A total of five monitoring locations in the 2008 season were sampled at incorrect locations. Therefore the data between 2007 and 2008 can not be compared for these sites. The new sites sampled in 2008 have been renamed with an added "b" (eg. AUS 014b) and the data will be archived. However, for future studies the 2007 sites will continue to be used and not the new "b" sites of 2008. Refer to Appendix E for a detailed map and description of the sites.

3.2 Monitoring Schedule

In the later stages of the 2007 study, multiple monitoring locations either stopped flowing or dried up. These sites were then deemed insignificant baseflow contributors. This lack of flow at certain sites allowed for the addition of more monitoring locations.

With this information a new monitoring schedule was used in the 2008 monitoring season. The thirty (30) sites that were identified as significant baseflow contributors in 2007 were sampled weekly, while the remaining twenty one (21) sites were sampled monthly. In the 2008 monitoring season, a total of 356 flow values were measured manually.

3.3 Soil and Water Assessment Tool

As part of the analysis of the 2007 baseflow study, a hydrologic model called the Soil and Water Assessment Tool (SWAT) generated values for each location and served as a comparison with the manually measured values. However, this has not been completed for the 2008 data.

3.4 Baseflow Determination

In the 2007 Baseflow Report (Boorse & Napper, 20007), daily precipitation was not analyzed to determine whether measurements were taken during baseflow conditions. All measurements were assumed to be baseflow. However, using BRFU, daily precipitation records for 2007 and 2008 were analyzed to help determine which measurements are considered baseflow.

3.5 Stage Measurements

In the 2008 monitoring season, the stage was measured for the sites that are at bridges or culverts. Over time these values may be used to develop a rating curve for each of the monitoring locations.

Sewage Treatment Plant Values
The 2007 study used flow values from five sewage treatment plants throughout the ABCA and MVCA watersheds. However, in 2008 this information was not available for the analysis.

4.0 Findings

<u>Precipitation</u>
Using the Exeter and Blyth precipitation gauge data for 2007 and 2008, .Figures 4-1 and 4-2 illustrate the total monthly precipitation values and compare them to 'Normal' values. The 'Normal' precipitation values for each individual month are based on the thirty year normal's (1971-2000) Percent of normal precipitation was determined by dividing the monthly 2008 value by the 'Normal' value. This data can be accessed for various gauges via the Environment Canada website.

In the 2007 monitoring season, every month had below average precipitation values which resulted in more measurements taken during baseflow conditions. However, for 2008 most months had greater than normal precipitation (except August) which resulted in fewer measurements taken during baseflow conditions.

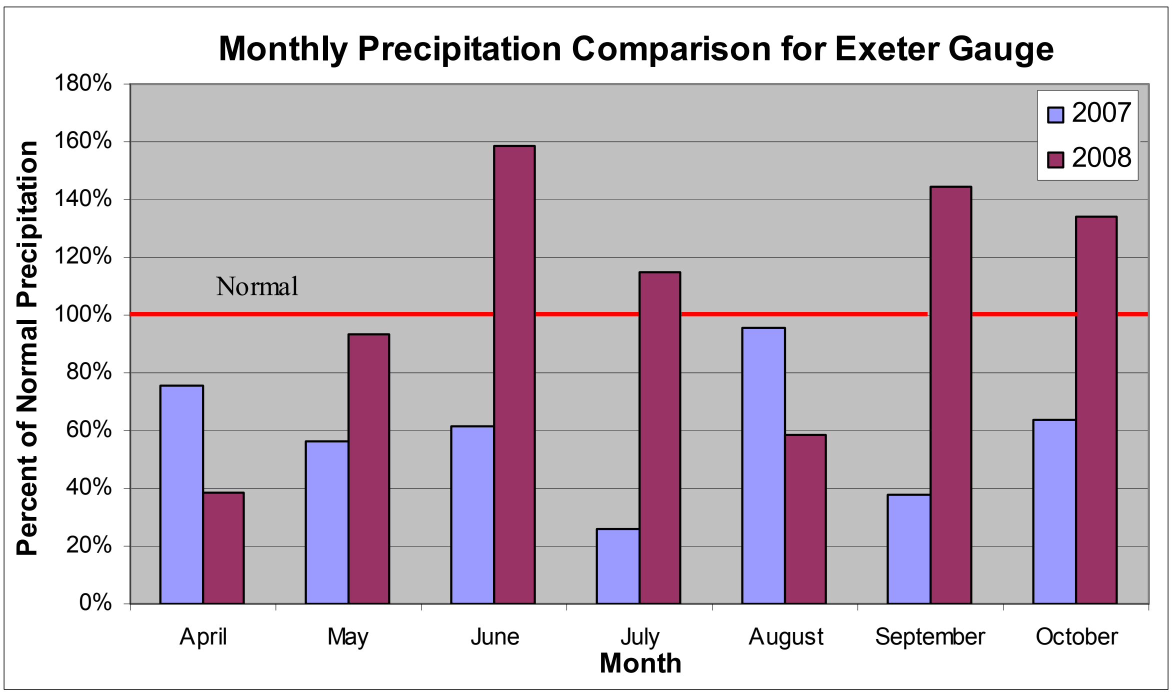


Figure 4-1: 2007/2008 Percent of Normal Precipitation for Exeter

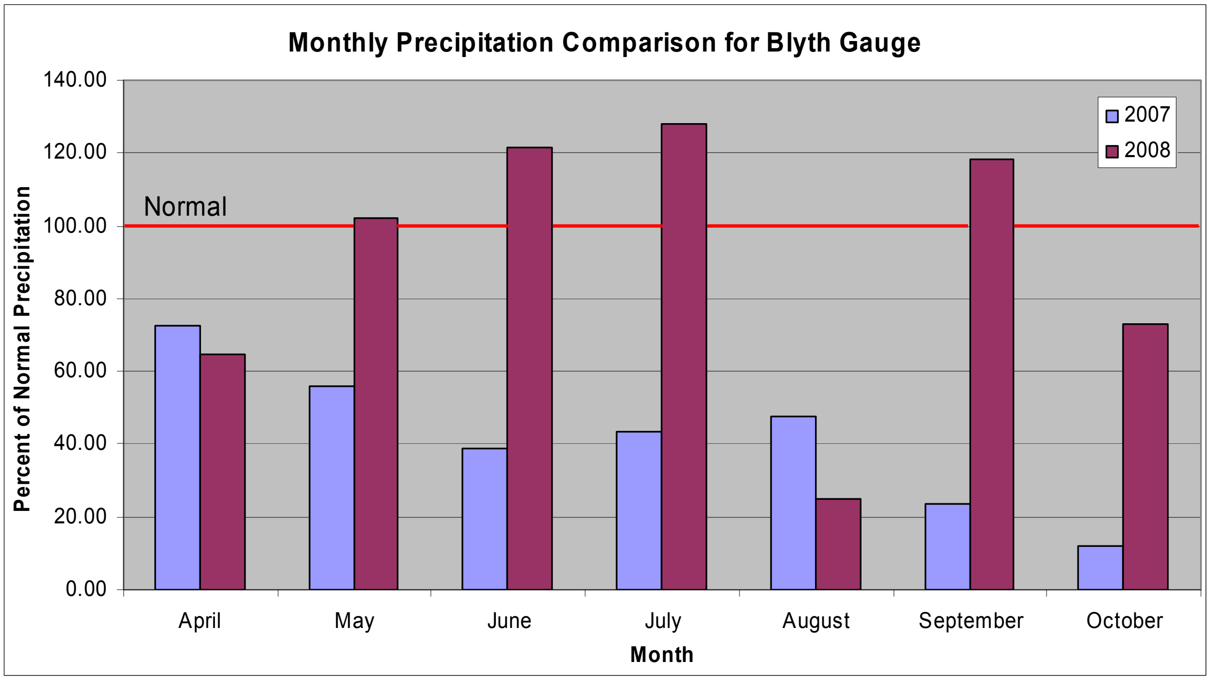


Figure 2-2 2007/2008 Percent of Normal Precipitation for Blyth

Graphs with all recorded flow values in mm/day, with precipitation included can be viewed in Appendix C. These graphs help to show how the fluctuation of flow measurements can be attributed to recent precipitation events. Using the BRFU module, the amount of precipitation that fell into the catchment area for each site was averaged for a week prior to the gauging date.

Annual Comparison

The collected data has been compiled into a series of site specific graphs comparing the flow trends between the 2007 and 2008 monitoring seasons. Measurements taken during baseflow conditions are represented by enlarged data points (refer to Figure 4-3 below). Similar graphs for each site are in Appendix D. The Y axes vary among graphs; sites contributing significant amounts of baseflow will have larger mm/day values on this axis.

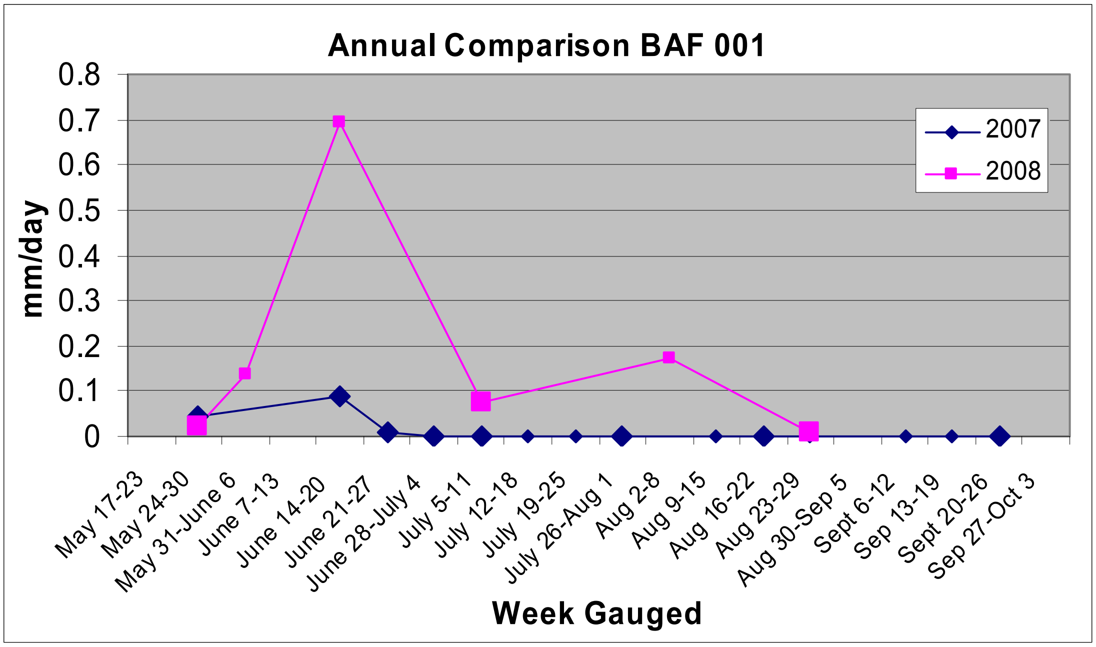


Figure 4-3: Example Annual Comparison Graph

Percent Contribution Flowcharts

Similar to the 2007 report, a percent contribution flow chart has been created for each of the main river systems. These charts illustrate the flow contributions for each monitoring site (e.g. Figure 4-4). The percent contribution was determined by comparing the flow values of each site to the values of the most downstream site. Therefore the most downstream site will always be 100%. Accompanying each flow chart is a percent contribution table, which compares percent contribution values for each site at similar dates in 2007 and 2008. All percent contribution data is also tabulated for each monitoring date in Appendix B.

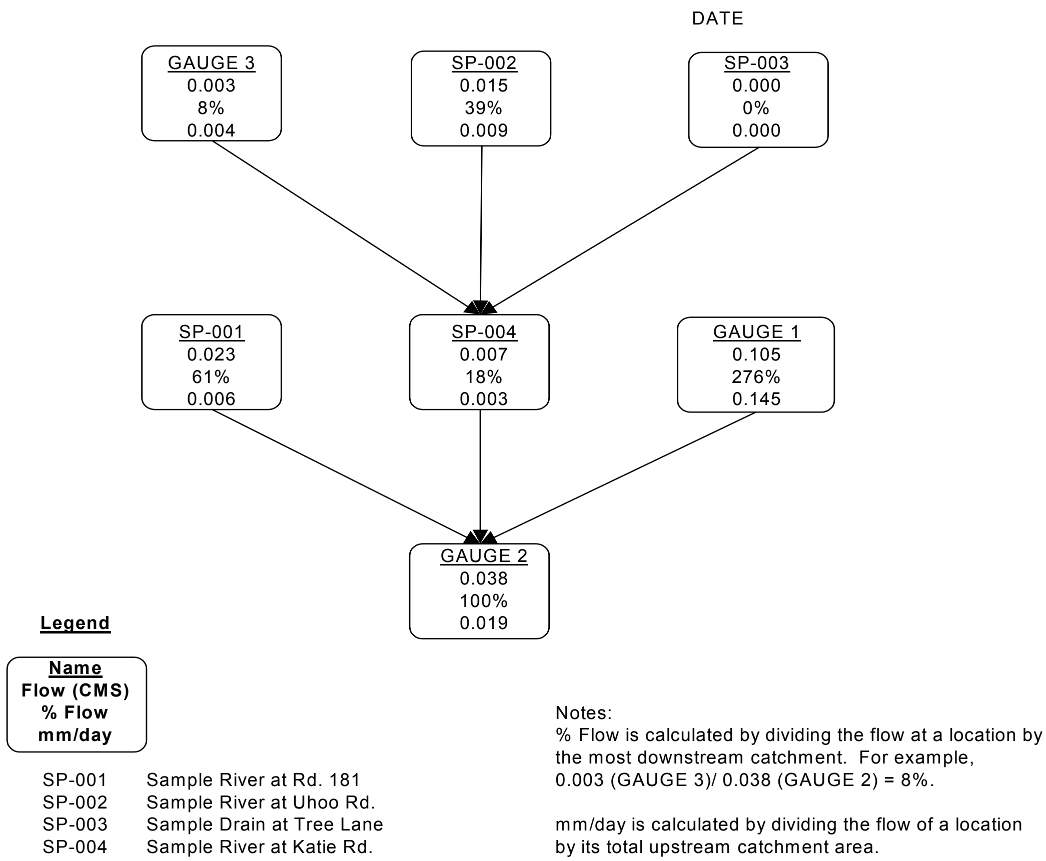


Figure 4-4: Example Percent Contribution Flowchart

4.1 Ausable River

There are a total of twenty five (25) monitoring locations throughout the Ausable River watershed. The sites were determined by Authority staff and other professionals prior to monitoring in 2007. Of the twenty five sites, twenty (20) were manually measured, while the remaining five (5) are permanent gauge locations. A detailed map of the monitoring locations can be found in Appendix A.

Figure 4-5 illustrates the flow contribution of the four main tributaries of the Ausable River (Black Creek, Little Ausable, Nairn Creek, and Adelaide Creek). Similar to 2007, Nairn Creek contributed the most baseflow with 30% in the example below (34% in 2007). Percentage values do not always add up to 100%, this could be attributed to evaporation and/or the geology of the area causing water to be lost or gained from an aquifer. For this particular example the flow percentage actually decreases between Springbank and AUS 002, by 11%. This may indicate that water is being lost to an aquifer. Refer to Appendix B for percent contribution values for each monitoring date. Flow charts for each monitoring date can be created using the “Flowchart” spreadsheets in Appendix E.

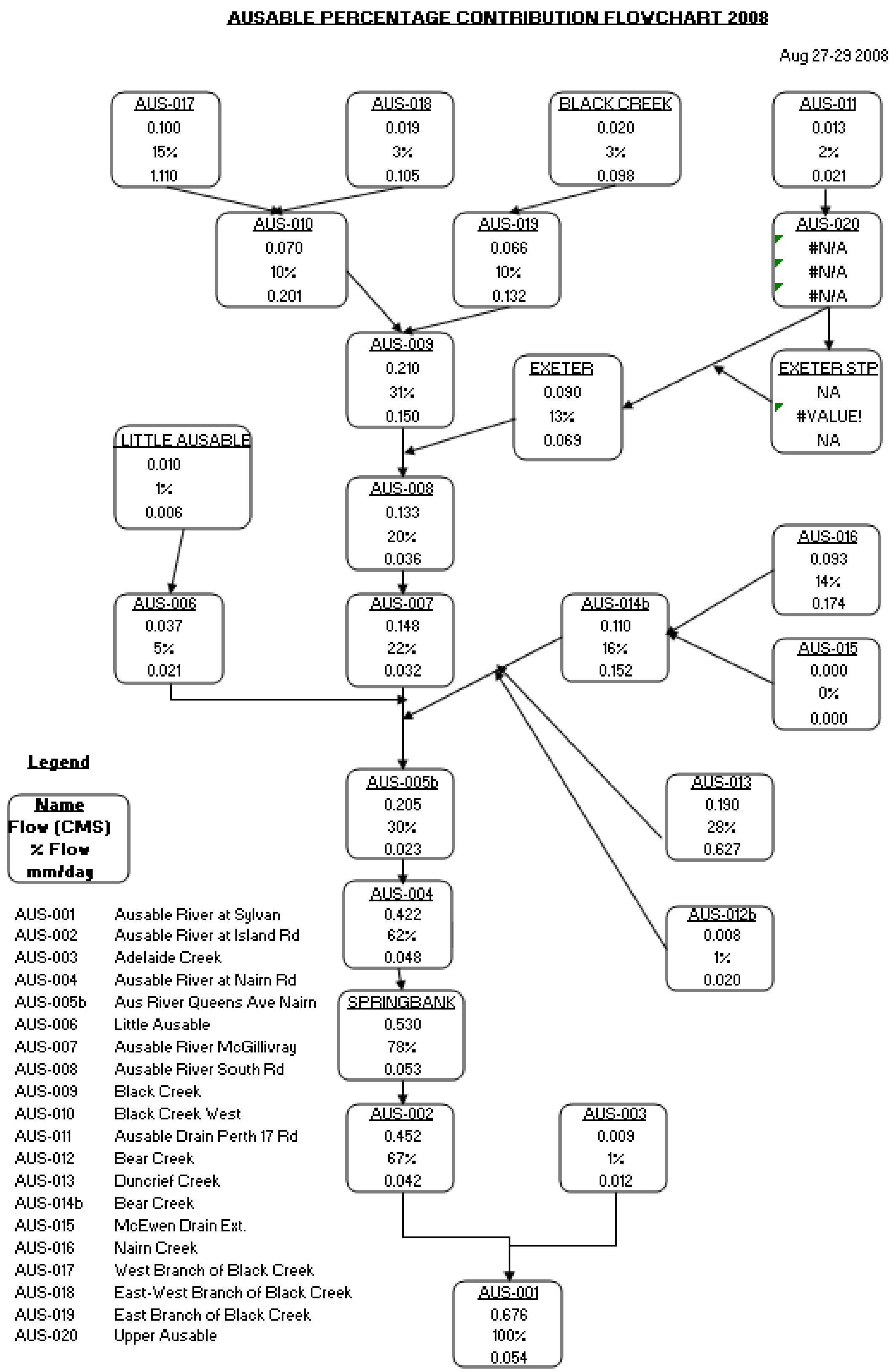


Figure 4-5: Ausable River Flowchart

Table 1: Ausable River Percent Contribution Comparison

Site	Aug 30 2007	Aug 27 2008
AUS 001*	100%	100%
AUS 002	62%	67%
AUS 003	1%	1%
AUS 004	63%	62%
AUS 005b	34%	30%
AUS 006	0%	5%
AUS 007	24%	22%
AUS 008	18%	20%
AUS 009	5%	31%
AUS 010	7%	10%
AUS 011	0%	2%
AUS 012b	0%	1%
AUS 013	17%	28%
AUS 014b	1%	-
AUS 015	0%	0%
AUS 016	24%	14%
AUS 017	5%	15%
AUS 018	1%	3%
AUS 019	0%	10%
AUS 020	-	-
Black Creek	6%	3%
Exeter	19%	13%
Little Ausable	3%	1%
Springbank	58%	78%

*Reference Site

Table 1 above compares the percent contribution values of 2007 and 2008 for each monitoring site in late August. AUS 001 is 100% in both years since it was the reference site in which all percent calculations were based on. Generally values are fairly consistent; slight differences could possibly be caused by localized rain events, evaporation, water taking practices, or monitoring errors.

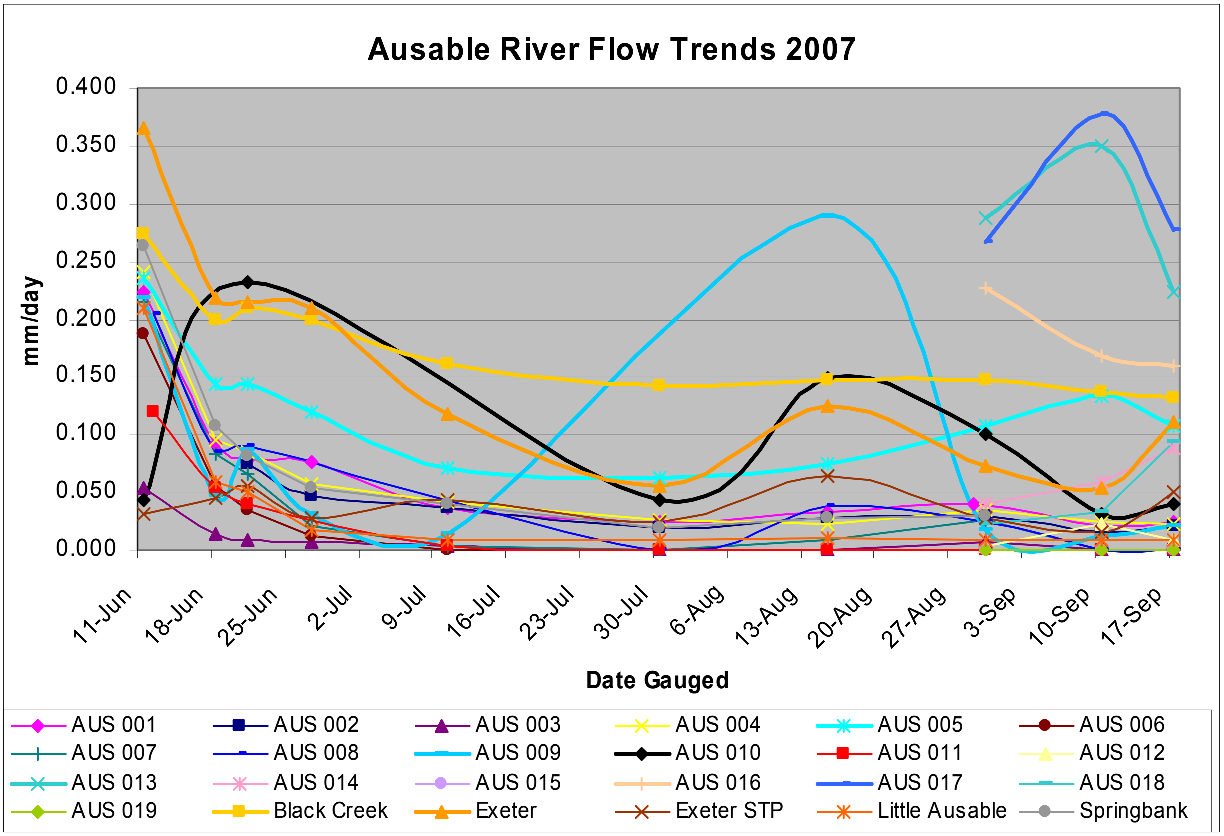


Figure 4-6: Ausable Flow Trends 2007

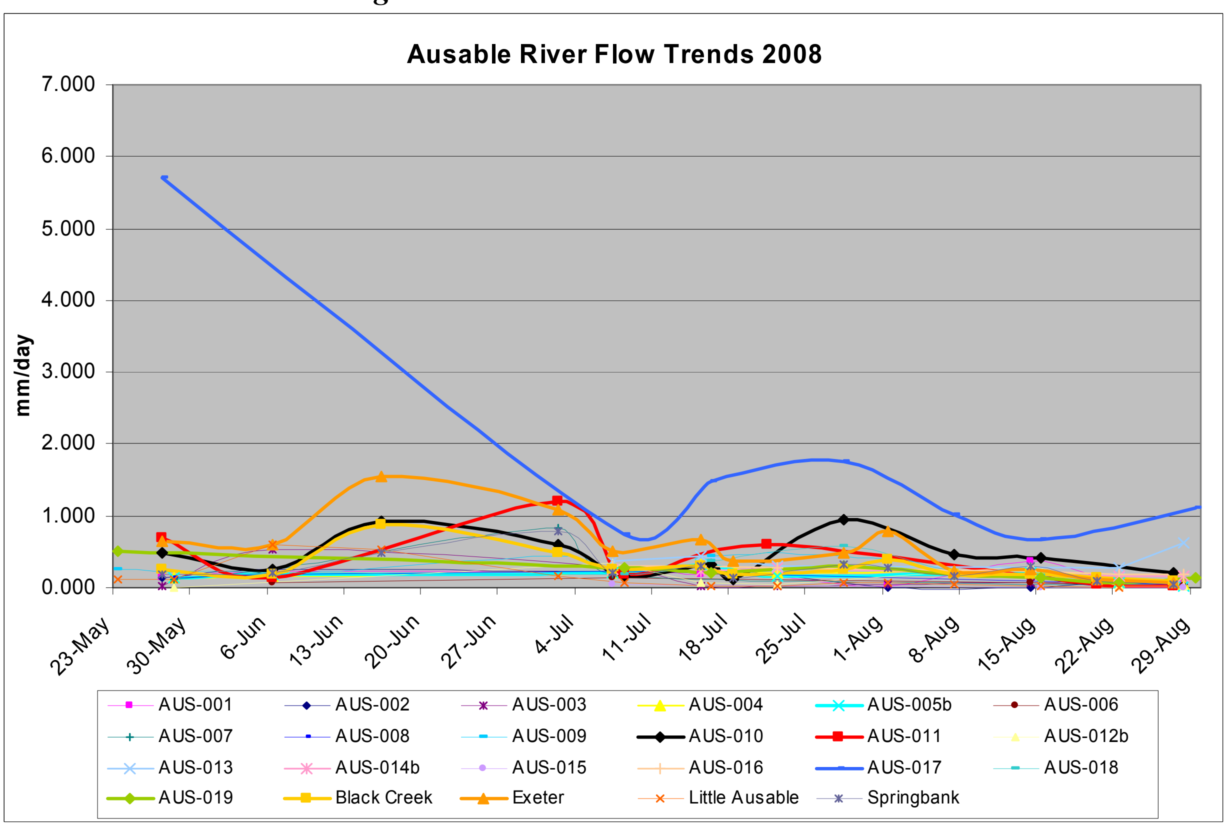


Figure 4-7: Ausable River Flow Trends 2008

2007 vs. 2008 Comparison

Figures 4-6 to 4-7 help illustrate which sites contribute more flow relative to the size of their catchment area. In 2008, flow values were much higher than that of 2007 for the duration of the monitoring period. In some instances, flow values were an order of magnitude higher in 2008 compared to 2007. Reduced precipitation and high ambient temperatures in July and August resulted in a general decreasing flow trend in both years. Site specific comparison graphs for each monitoring location can be found in Appendix D.

The Exeter gauging location was consistently higher (relative to other sites) in both seasons, while Black Creek was quite high only in 2007. In 2007, AUS 005, AUS 010, AUS 013, AUS 016 and AUS 017 had among the highest mm/day values in the Ausable River. Meanwhile in 2008, AUS 005, AUS 010, AUS 011, AUS 017 and AUS 019 had consistently high mm/day values for the Ausable River. There is an obvious trend starting to develop of sites contributing high flow values. However, in 2007 AUS 019 was blocked by a beaver dam and not measured until September.

4.2 Bayfield River

Along the Bayfield River there were nine (9) monitoring locations measured in 2008. Six (6) were measured manually and the remaining three (3) have permanent gauges. Refer to Appendix A for a detailed map of all monitoring locations and gauges found in the Bayfield River.

Using data collected on August 27th 2008, Figure 4-8 illustrates the percent contribution for each monitoring location in the Bayfield River. Notice the percent contribution for BAF 004, BAF 005 and Tricks Creek combined exceed 100%. Evaporation and/or water loss to groundwater aquifers could explain this trend. However, little is known about water taking permits in this area, which could also contribute to this loss of flow. Similar to AUS 001, Varna served as the most downstream “reference site” so its percent contribution is always 100%.

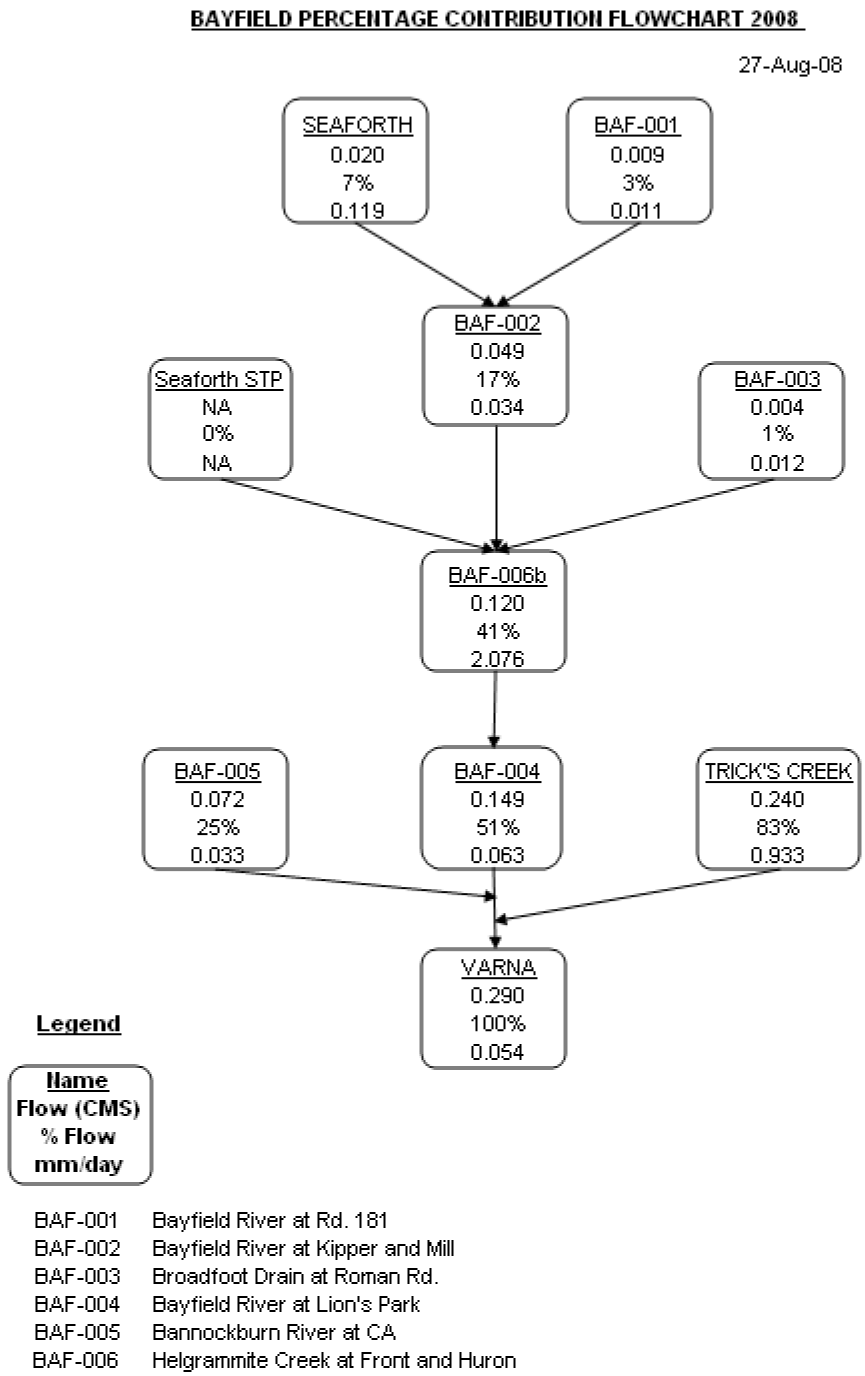


Figure 4-8: Bayfield River Flow Chart

Table 2: Bayfield River Percent Contribution Comparison

Site	Aug 21 2007	Aug 27 2008
BAF 001	0%	3%
BAF 002	0%	17%
BAF 003	0%	1%
BAF 004	9%	51%
BAF 005	17%	25%
BAF 006	12%	-
BAF 006b	-	41%
Seaforth	17%	7%
Tricks Creek	246%	83%
Varna*	100%	100%

* Reference Site

Table 2 compares the percent contribution data for similar dates in the 2007 and 2008 monitoring seasons. Late in the 2007 monitoring season BAF 001, BAF 002 and BAF 003 stopped flowing which did not happen in 2008. In 2007, Tricks Creek values are consistently greater than Varna values, whereas in 2008 the percent contribution never exceeded Varna values. These changes in percent contribution are likely due to the wetness of 2008 resulting in other tributaries (BAF 001 to BAF 004) contributing more flow than they did in 2007. Percent contribution values have been calculated for each monitoring date where Varna was measured and can be found in Appendix B.

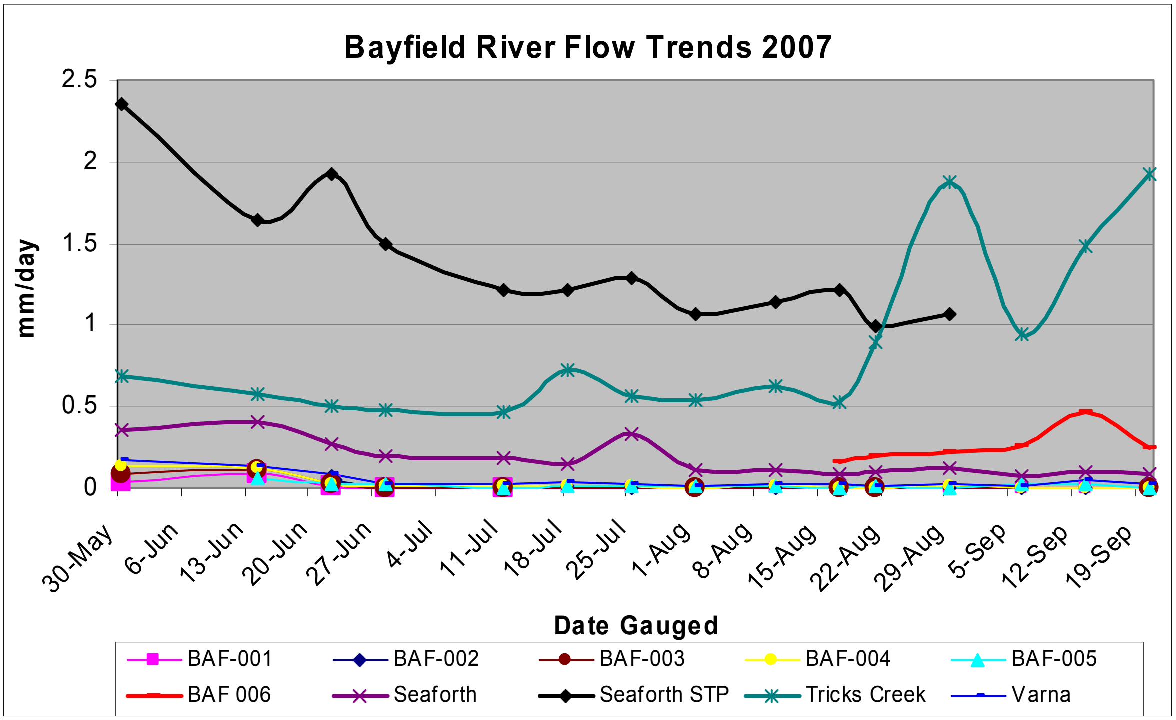


Figure 4-9: Bayfield River Flow Trends 2007

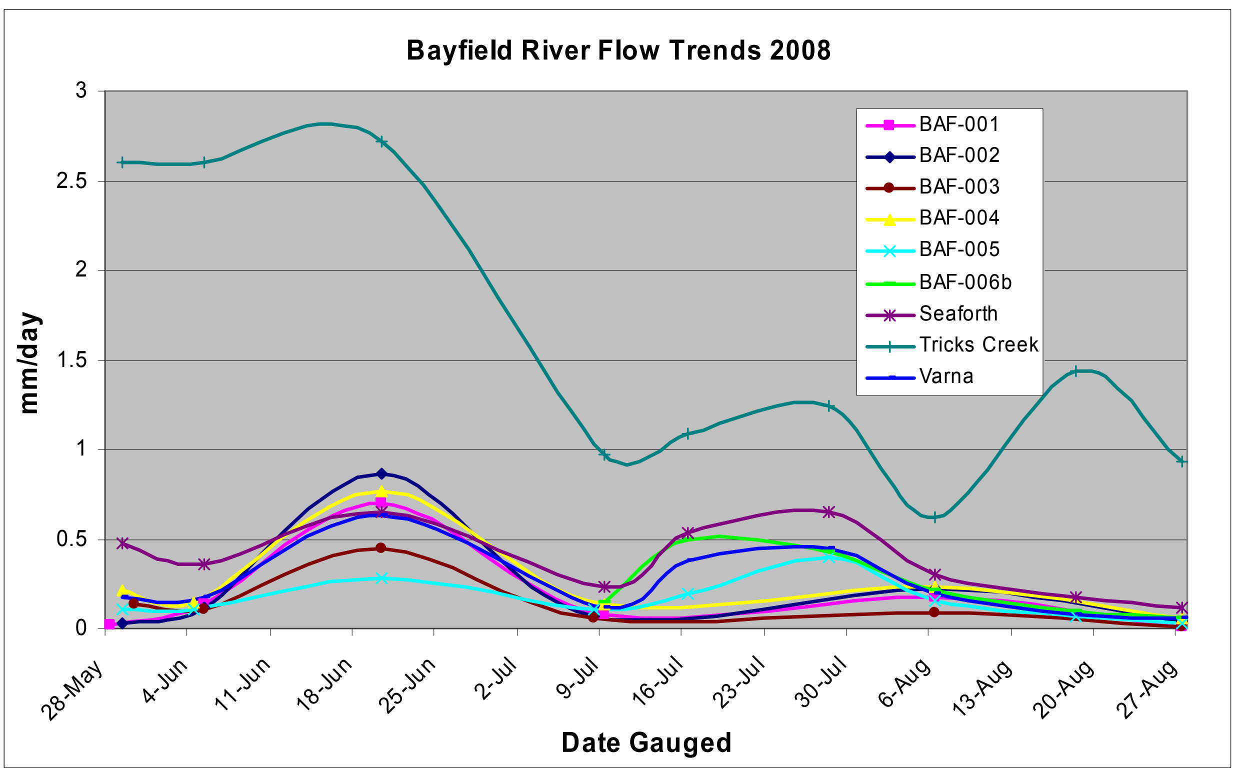


Figure 4-10: Bayfield River Flow Trends 2008

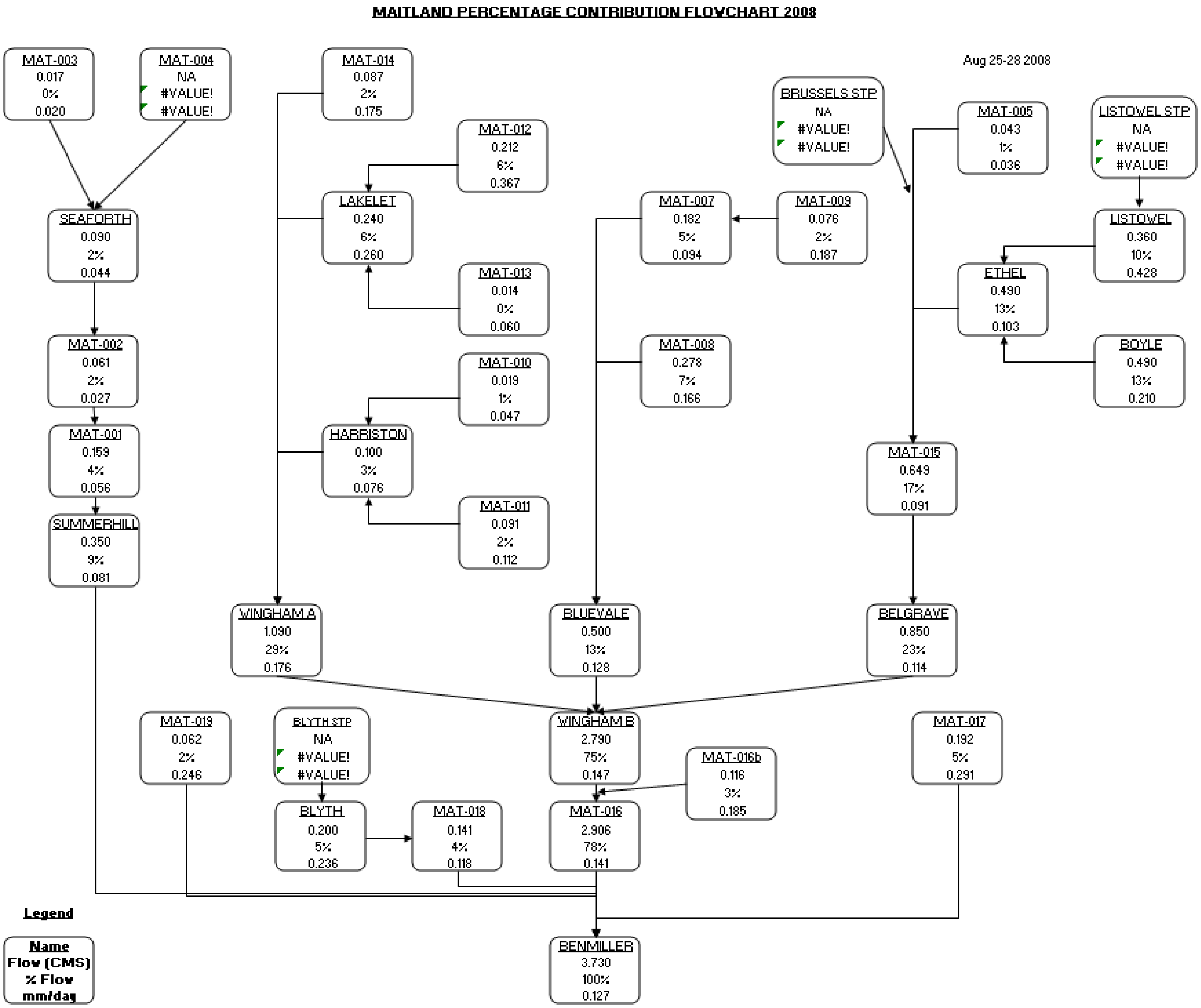
2007 vs. 2008 Comparison

Figures 4-9 and 4-10 illustrate flow trends for both 2007 and 2008 monitoring seasons. In 2007, the manually measured sites had very similar flow values and trends, excluding BAF-006 which wasn't sampled until the end of summer but had much higher mm/day values. Unfortunately, in 2008 BAF-006 was sampled at the incorrect location (BAF 006b above) and Seaforth STP values were not available, these comparisons can not be made. However, in both years Tricks Creek permanent gauge had higher mm/day values than the other sites in the Bayfield River. For a more detailed view of flow trends, refer to the annual comparison graphs in Appendix D.

4.3 Maitland River

The Maitland River has the most monitoring locations of the four major river systems in this study, with a total of 31. For the 2008 study, twenty-two (22) of the locations were measured manually while thirteen (13) have permanent gauges. Four sites were measured manually and by gauges for QA/QC purposes. A detailed map of the monitoring locations can be found in Appendix A.

Figure 4-11 uses measurements taken in late August of 2008 and illustrates the percent contribution values for each monitoring site, using Benmiller as the most downstream reference site. The percent contribution values do not indicate many areas where substantial amounts of water is lost or gained. Contribution values gradually increase from the top of the watershed to the bottom.



MAT-001	South Maitland below HPWA	MAT-007	Little Maitland South	MAT-012	Blind Lake Creek	MAT-016b	Belgrave Creek
MAT-002	South Maitland above HPWA	MAT-008	Little Maitland Palmerston	MAT-013	Lakelet Creek	MAT-017	Sharpes Creek
MAT-003	South Maitland above McEwan	MAT-009	Little Maitland Molesworth	MAT-014	Salem Creek	MAT-018	Blyth Brook
MAT-004	McEwan Creek	MAT-010	Harriston Stream	MAT-015	Middle Maitland at Cty Rd 16	MAT-019	Unknown S. of Blyth Brook
MAT-005	Beauchamp Creek	MAT-011	North Maitland above Harriston	MAT-016	Maitland River at Belgrave Creek		

Figure 4-11: Maitland River Flowchart

Note that MAT 016 is an estimated value which was calculated by adding Wingham B and MAT 016b discharge values.

Table 3: Maitland River Percent Contribution Comparison

Site	Aug 22 2007	Aug 25- 28 2008
MAT 001	0%	4%
MAT 002	0%	2%
MAT 003	0%	0%
MAT 004	0%	-
MAT 005	0%	1%
MAT 007	0%	5%
MAT 008	3%	7%
MAT 009	0%	2%
MAT 010	0%	1%
MAT 011	0%	2%
MAT 012	14%	6%
MAT 013	0%	0%
MAT 014	1%	2%
MAT 015	14%	17%
MAT 016	97%	**78%
MAT 016b	**59%	3%
MAT 017	8%	5%
MAT 018	5%	4%
MAT 019	1%	2%
Belgrave	19%	23%
Benmiller*	100%	100%
Bluevale	9%	13%
Blyth	2%	5%
Boyle	4%	13%
Ethel	14%	13%
Harriston	2%	3%
Lakelet	16%	6%
Listowel	7%	10%
Summerhill	7%	9%
Upper Seaforth	4%	2%
Wingham A	37%	29%
Wingham B	38%	75%

* Reference Site
** Estimated Value

Table 3 is a comparison between percent contribution values for the Maitland River in 2007 and 2008. In 2007, MAT 001 to MAT 005 were not measured due to insignificant flow. Generally, there is a slight difference in the percent contribution values between years. The largest difference was MAT 016b which was estimated (difference between Wingham B and MAT 016) to contribute 59% to the flow contribution. However, in 2008 when the site was manually measured it contributed a mere 3% of flow. Percent contribution values for all monitoring dates with a Benmiller reading have been included in Appendix B.

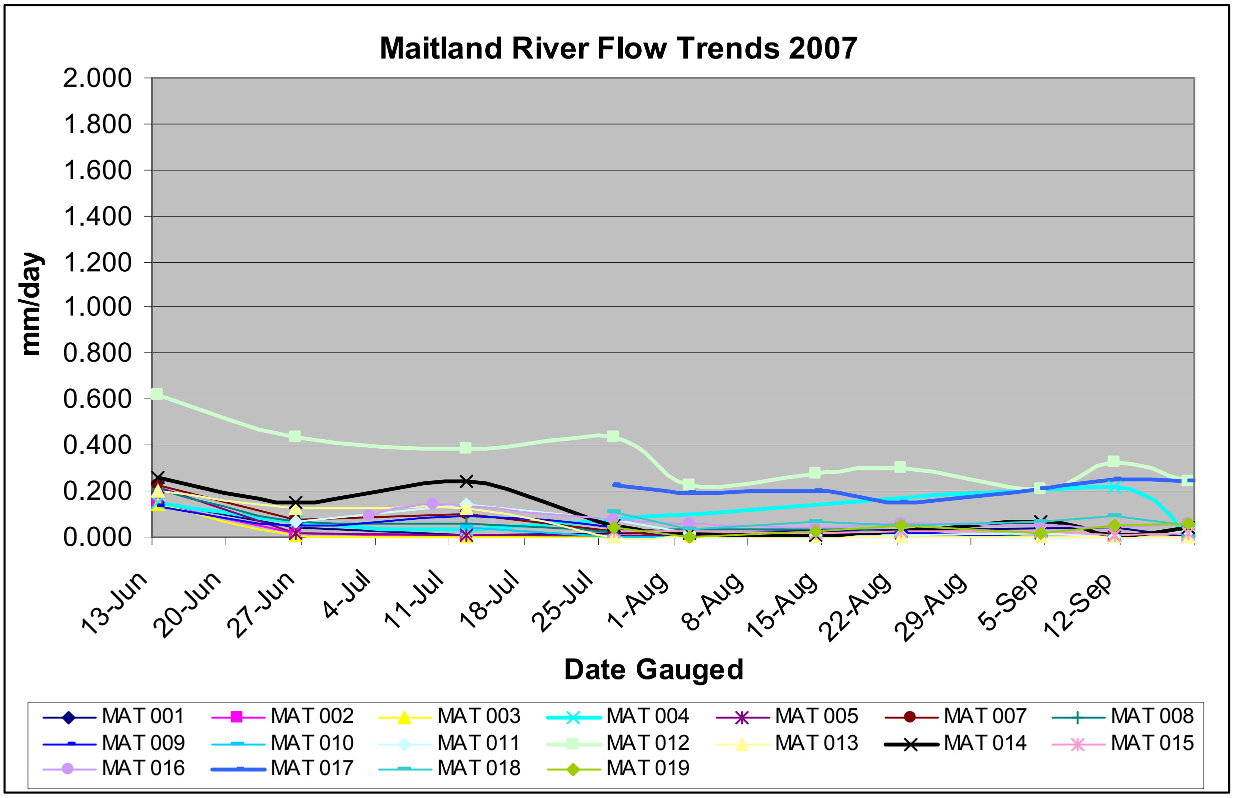


Figure 4-12: Maitland River Flow Trends 2007

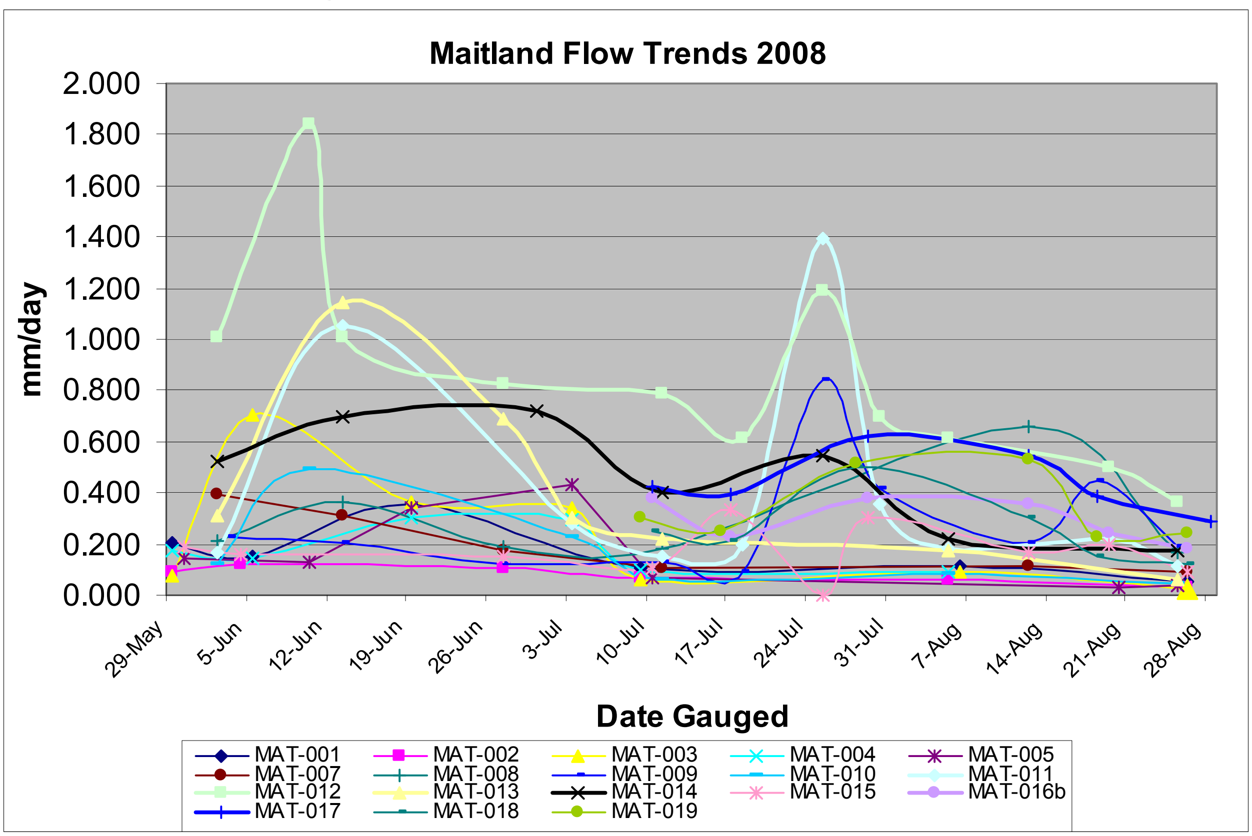


Figure 4-13: Maitland River Flow Trends 2008

2007 vs. 2008 Comparison

Similar to the trends in the Ausable and Bayfield rivers, values were also consistently higher in 2008 compared to 2007. Figures 4-12 and 4-13 illustrate how MAT-012 contributes more baseflow in mm/day (in most instances) than all other monitoring sites. In 2007 there is a general negatively sloping trend from June to early September. However, this trend is not as evident in 2008 since there were multiple rain events which resulted in numerous fluctuations (refer to Appendix C). In 2007, there are multiple sites that are consistently higher than others, these include MAT 012, MAT 014, MAT016b (estimate), MAT 017 and MAT 019. However in 2008, the higher values were in sites: MAT 011, MAT 012, MAT 013, MAT 014 and MAT 017. Data from various years will help isolate areas of significant baseflow. Refer to Appendix B for tabulated mm/day, flow, and percent contribution values for all monitoring dates.

4.4 Nine Mile River

The Nine Mile River has five (5) monitoring locations which is the fewest of the four major rivers in this study. Of the five sites, three are measured manually while two sites have permanent gauges. For detailed locations of each of the monitoring sites refer to Appendix A, Map 2.

Figure 4-14 shows the percent contribution values for the Nine Mile River measured on August 28^{th} 2008. Similar to the 2007 values, Lucknow B contributes a significant amount of flow which is not represented downstream at NIM 002. NIM 001 is the most downstream of the monitoring sites, therefore it is used as the reference point for all percent contribution calculations. Flow charts from any monitoring date can be created using the “Flowchart” spreadsheet in Appendix E.

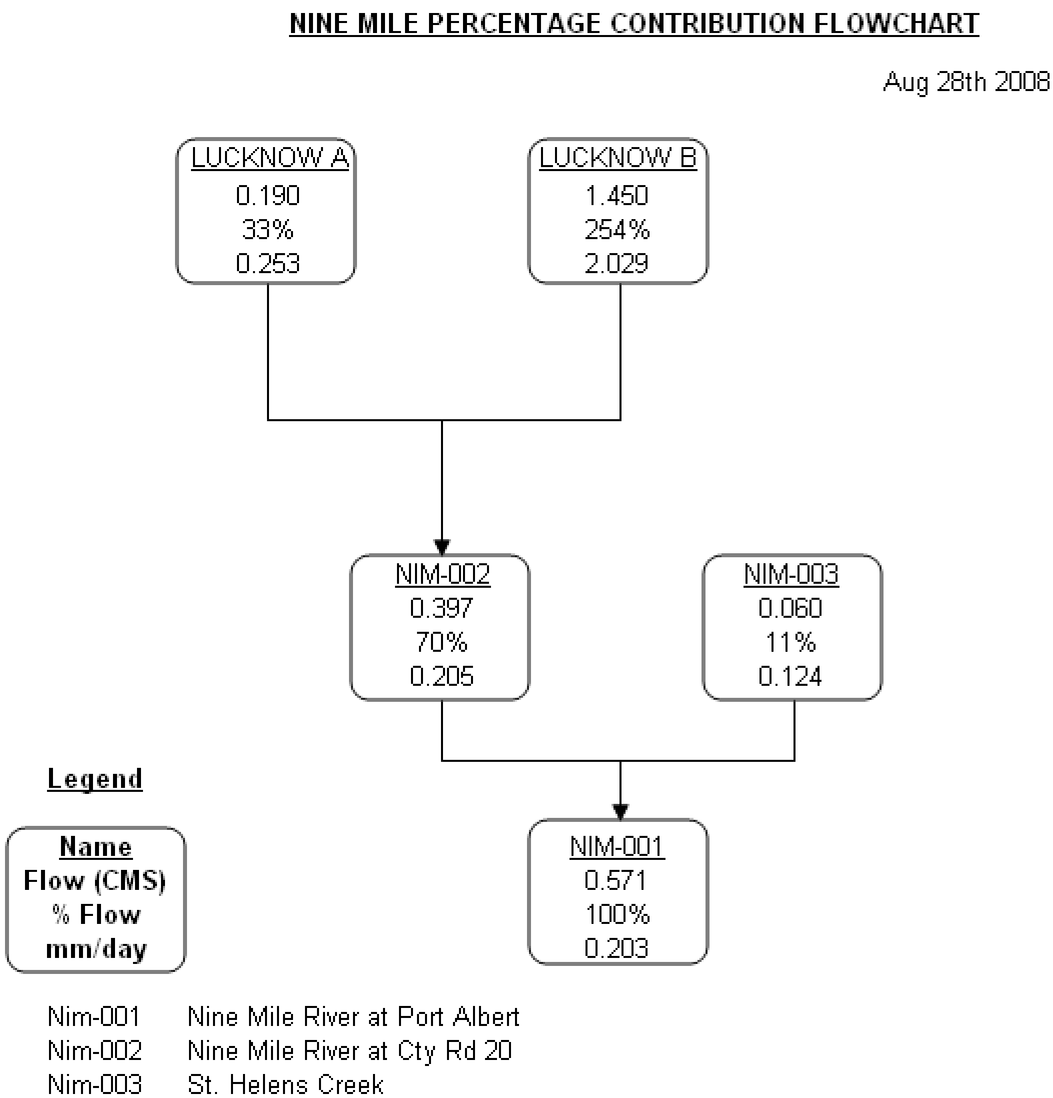


Figure 4-14: Nine Mile River Flowchart 2008

Table 4: Nine Mile River Percent Contribution Comparison

Site	September 5th 2007	August 28th 2008
NIM 001*	100%	100%
NIM 002	77%	70%
NIM 003	8%	11%
Lucknow A	47%	33%
Lucknow B	444%	254%

*Reference Site

Table 4 compares percent contribution values in the Nine Mile River watershed for 2007 and 2008. The Lucknow B permanent gauge had flow readings considerably higher than any other site in the Nine Mile River watershed. This substantial loss could be a result of evaporation and/or recharging of an underground aquifer. Otherwise, there may be issues with the Lucknow B rating curve, causing in exaggerated flow value.

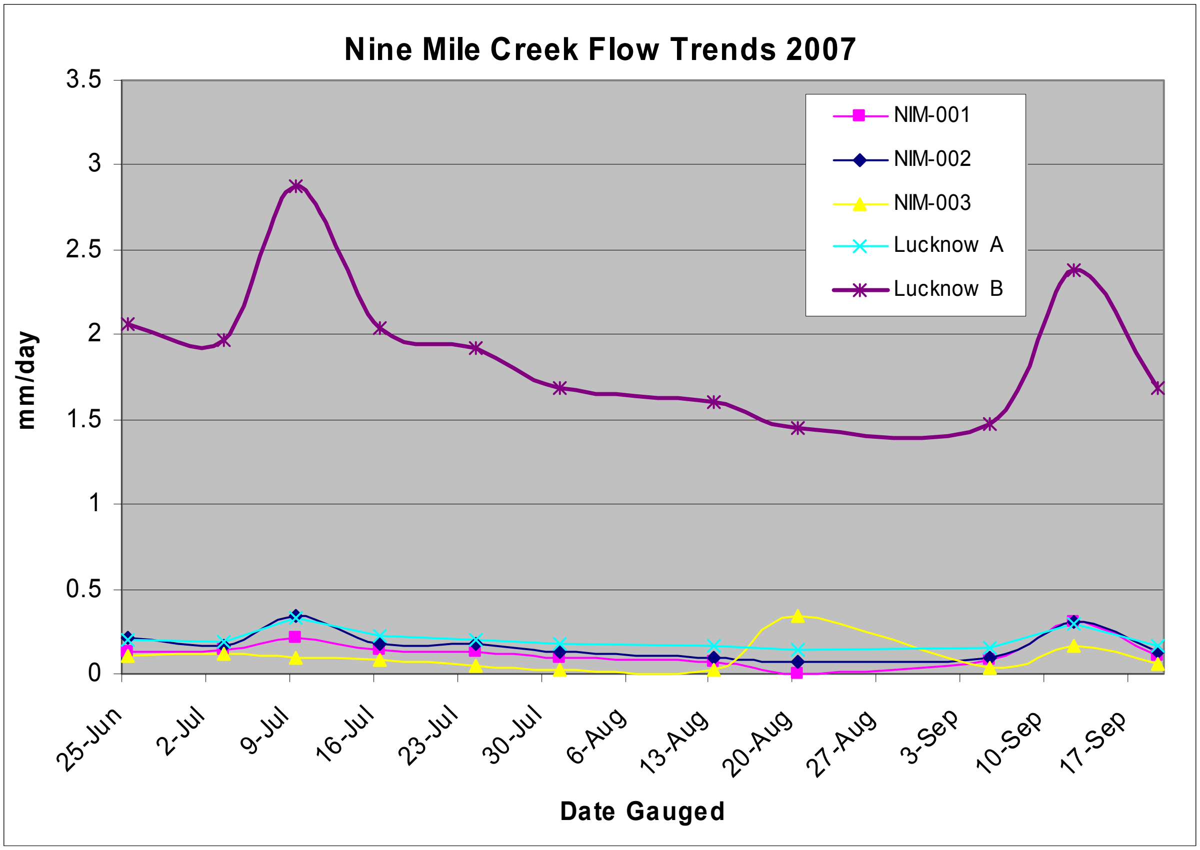


Figure 4-15: Nine Mile River Flow Trends 2007

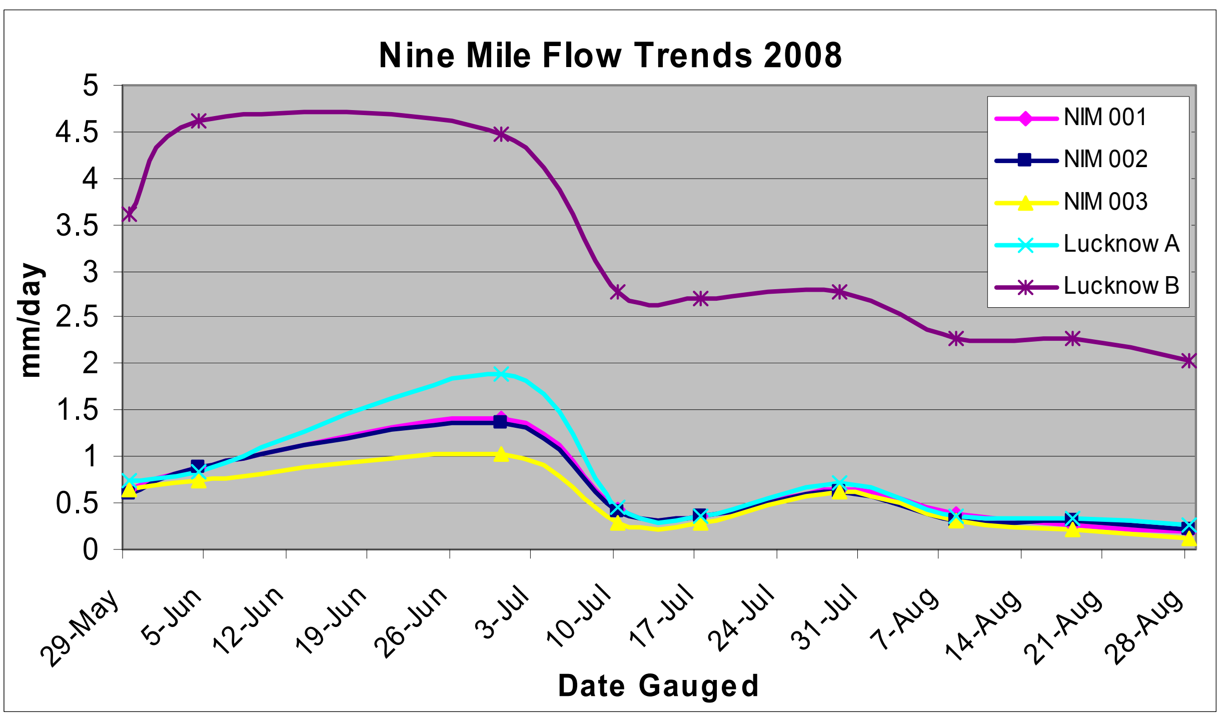


Figure 4-16: Nine Mile River Flow Trends 2008

2007 vs. 2008 Comparison

Figures 4-15 and 4-16 illustrate flow values (expressed in mm/day) for the 2007 and 2008 monitoring seasons. Each year, all sites (excluding Lucknow B) have very similar mm/day values with 2008 values being higher than 2007. Lucknow B seems to contribute considerably more flow than any other site relative to the size of its catchment area. Annual comparison graphs for each site (baseflow values indicated) can be found in Appendix D.

4.5 Gullies

In August of 2007, 33 gullies north of Bayfield and south of Goderich were visually assessed and reported to be either: dry, pooled or flowing. In 2008, from late July to mid October, nine gullies with flow were monitored to support data requirements for DWSP's water budget project. Figure 4-17 below demonstrates flow trends in mm/day for the 2008 monitoring season. For a detailed map of the monitoring sites refer to Appendix A.

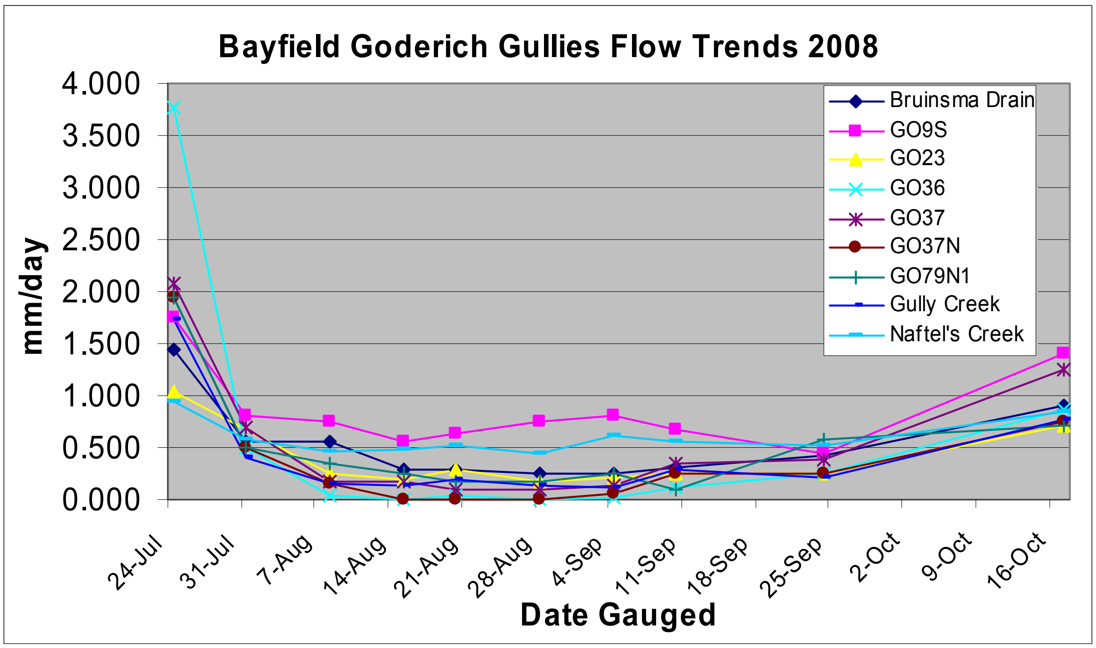


Figure 4-17: Bayfield/Goderich Gullies Flow Trends 2008

There is a very similar trend across all nine monitoring sites. Values decreased in late July and then to increased in late September. Site GO9S had consistently higher mm/day values than the other gullies. It is recommended to continue monitoring these sites in order to create a comprehensive comparison over multiple years. A detailed chart of flow values for these sites can be found in Appendix B.

4.6 Gauge Differences (QA/QC)

For the 2007 study, four permanent gauge locations (Belgrave, Ethel, Lakelet and Summerhill) were chosen to be monitored manually as well. These permanent gauges collect discharge values on an hourly basis. Since the field crew recorded the time and date for each manual measurement, the discharge value from the permanent gauge could be collected from a time very close to when it was measured manually. These values were used to represent the accuracy of the manual flow measurements.

In 2007 (Figure 4-18), permanent gauge values are consistently higher than the manual measurements. However, the 2008 values (Figure 4-19) do not follow this pattern. Generally in 2007 from July to September there was a gradually decreasing trend, however in 2008 this trend is less obvious due to more frequent rainfall events. A more detailed analysis of this comparison is available in Appendix D.

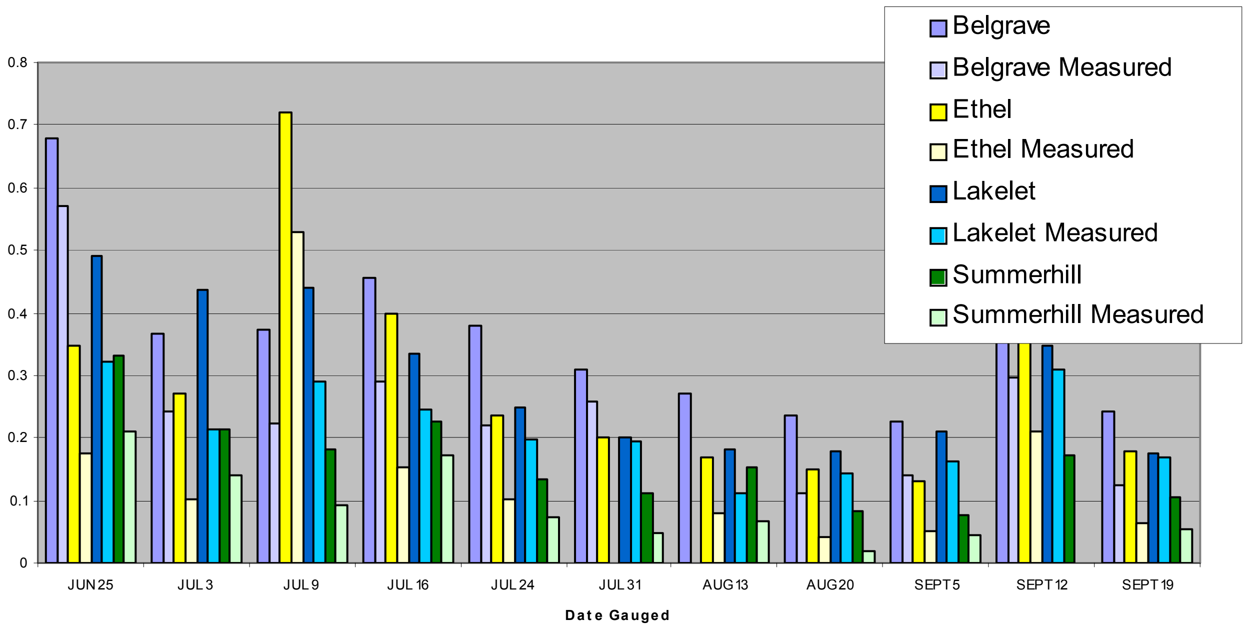


Figure 4-18: QA/QC Comparison of Manual and Gauged Values 2007

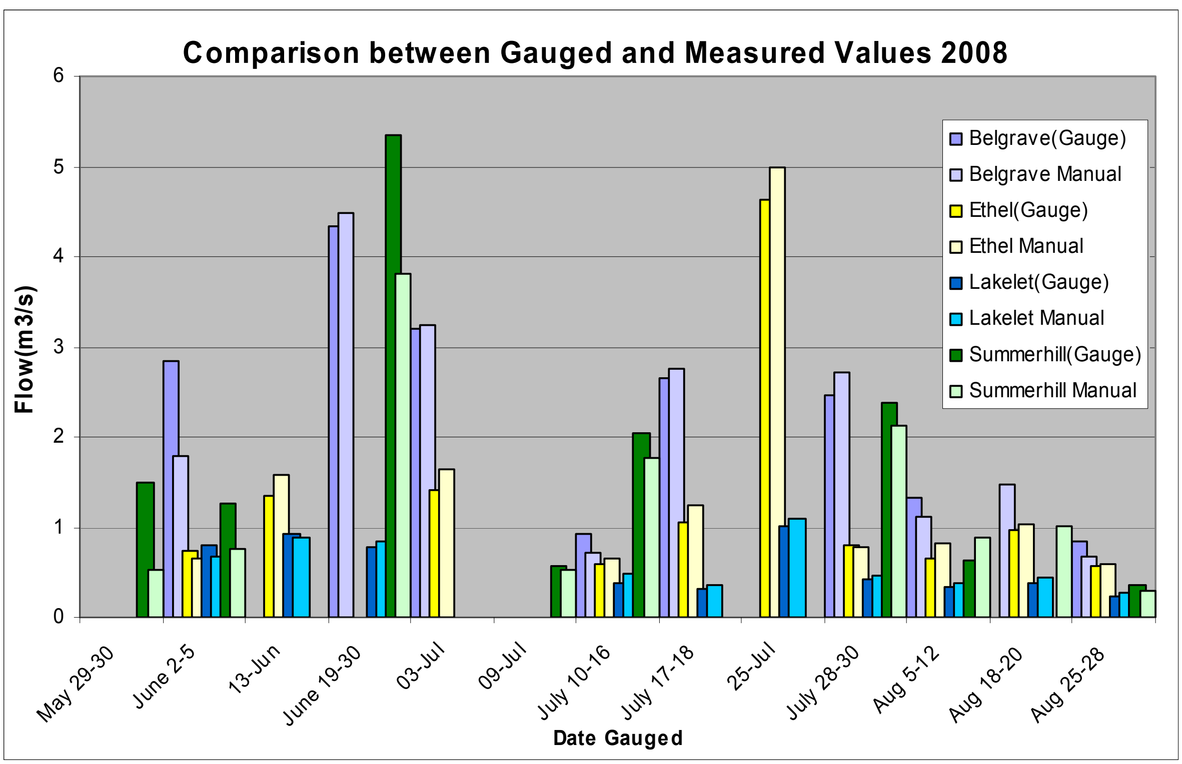


Figure 4-19: QA/QC Comparison of Manual and Gauged Values 2008

Note: In 2008 there were no measurements with a value of zero, blank areas on the chart indicate that measurements were not taken on that particular day.

Figures 4-20 and 4-21 show the correlation between flow from the manual and gauged measurements of 2007 and 2008. In 2007, all permanent gauge values were higher than the manually measured values (under 1:1 ratio line). However, in 2008 the gauged values were much closer to the manually measure values, as indicated by measured and gauged values falling on the 1:1 line. Also, flow values were generally higher in 2008 when compared to 2007.

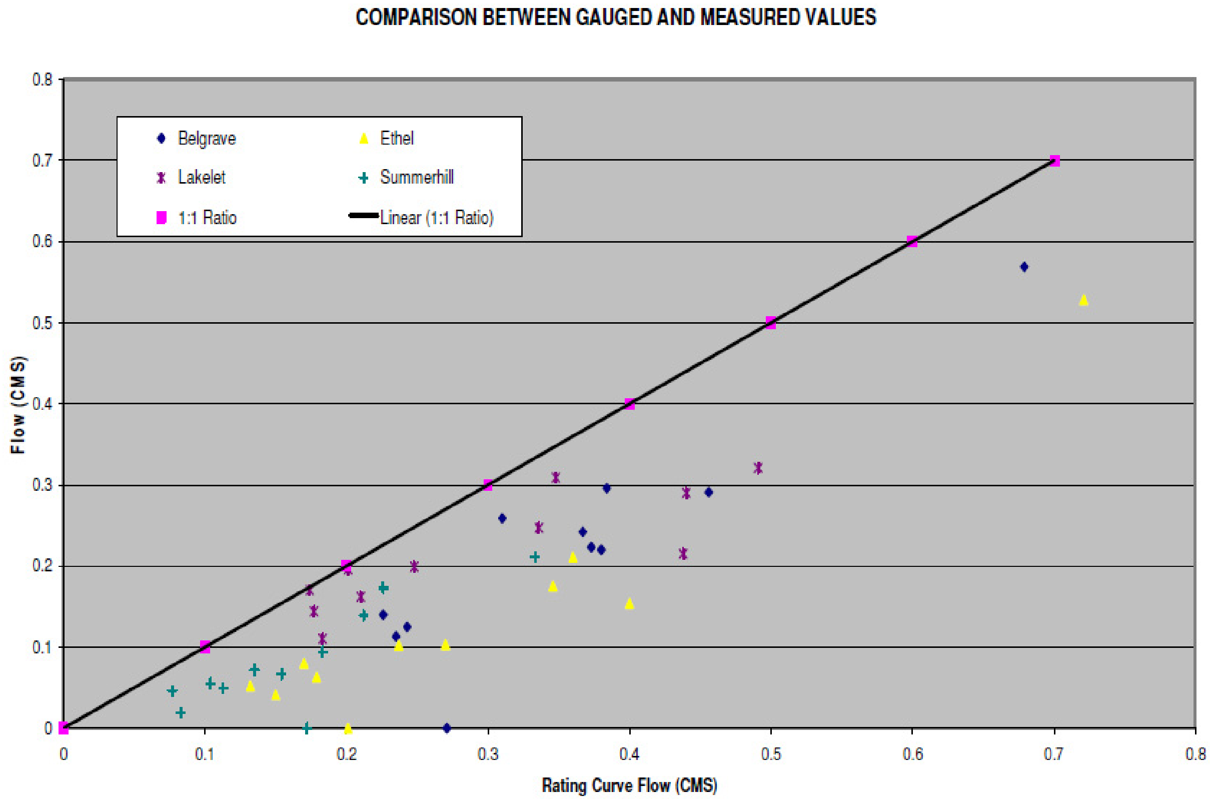


Figure 4-20 Comparison between Manual and Gauged Values 2007

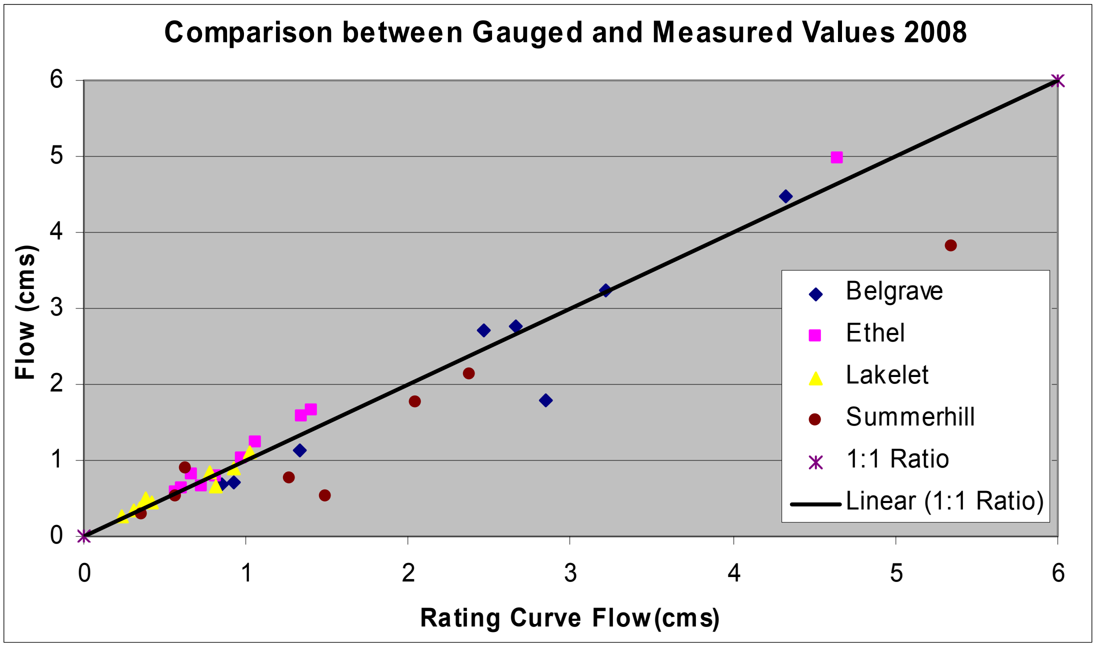


Figure 4-21 Comparison between Gauged and Measured Values 2008

5.0 Discussion

<u>Determining Baseflow</u>

There has been much discussion about how baseflow conditions should be determined. The methodology for this report is described in Section 3.3. A "Days to Wait" value (Fetter, 2001) was calculated for each site, and it ranged from 1-4 days after a rain event. For the flow values to be considered baseflow the "Days since last rain" had to exceed the "Days to Wait" value regardless of precipitation volume. This method resulted in 40% of the measured flow values in 2007 to be considered baseflow, and 20% for 2008.

The sporadic nature of rainfall events makes it difficult to be certain which areas received rain, even with our rain-gauge network. This created some issues when determining baseflow. For example, on July 25th, 2008 there was a substantial rainfall event throughout the watershed; however some gauges did not receive any rain. This resulted in some spikes of flow being considered baseflow (refer specifically to AUS 18 and MAT 11 in Appendix D). The baseflow determination method could potentially be revised for future studies.

Other suggested means of determining baseflow is to ensure that the catchment area has not received rain for 3 days prior to gauging (Stoneman & Jones, 1996). This method does not take catchment area size or precipitation volume into account. A site with a small catchment area will return to baseflow in less than three days, and a large catchment area could take more than 3 days.

Another concern that has been suggested is how the volume of rain will influence flows. If there is a very light rainfall of 1mm this would result in very little impact on flows, especially in a dry year. However, neither of the methods suggested above take precipitation amounts into consideration. This could result in lost baseflow data if light rainfall events had no effect on water levels. Perhaps by monitoring permanent gauge hourly flow values, the impact of each rainfall event can be assessed. If the rainfall event had no impact on flows, it could be discounted, resulting in more baseflow values. Having a method to determine baseflow conditions on a consistent and accurate basis to be applied each year is essential for this study.

Distributed Precipitation Values

The BRFU software uses the twenty four rain gauges and produces distributed precipitation values for the BRFU sub-basins within the two watersheds. Unfortunately, the sporadic nature of rainfall events makes it difficult to be certain which areas received rain, even with our rain-gauge network. On July 25th, 2008 there was a substantial rainfall event throughout the watershed; however some gauges did not receive any rain. This resulted in some spikes of flow being considered baseflow (refer specifically to AUS 18 and MAT 11 in Appendix D). This issue needs to be addressed when determining baseflow conditions. Perhaps permanent gauge flow trends could be used with the distributed rain values to determine whether the river system reacted to certain rain events.

Field Crews

One of the primary issues with the monitoring of baseflows from 2007 to 2008 is that there was a different field crew each year. This resulted in confusion over some sample locations, and data that could not be compared. It is recommended to construct a very clear guide to finding each site accurately so the sites will be consistent from year to year in order to construct a complete dataset. The primary benefit of having one field crew do the monitoring for the entire area is that monitoring was done in a consistent manner for the entire summer. This helps to reduce any error that may be associated with varying techniques. If however, there are dry periods with little precipitation, sending out two field crews to collect data could be beneficial.

Parkhill Creek and Gully Watersheds

In the 2007 season, there was one monitoring site in Parkhill Creek. However, in 2008 this site was not measured since the Parkhill Dam upstream of the site had such an impact on the flow. In 2008, nine gullies were monitored along Bluewater Highway between Bayfield and Goderich, while the gullies between Grand Bend and Bayfield have not been monitored. These gullies and Parkhill Creek require closer examination in future baseflow studies.

Water Taking Permits

Little is known about the extent of water taking permits issued in the study area. Large volumes of water taken from the system could result in lower than usual baseflows and help to explain situations of unexplained water loss or low flows.

Baseflow Trends

As was expected for both monitoring seasons, flow trends declined in July and August due to high ambient temperature and dryer conditions. However, due to the amount of precipitation in 2008, flow values were much higher and there were fewer baseflow values. All collected flow data has been complied into site specific charts in Appendix D (Note: enlarged data points represent baseflow values).

Comparison between measured vs. WSC gauged values

The manually measured flow values were compared with the Water Survey Canada (WSC) rating curve data and produced some interesting trends at four locations. Since any flow measurements can be used (not just baseflow), much more data was available. In the summer of 2007, the WSC rating curve values were consistently higher than the manually measured values. However, in 2008 this trend was not evident; in fact the measured values were closer to the rating curve values in 2008 than 2007. Since flow values were higher in 2008, this suggests that perhaps the WSC ratings curves are more accurate for periods of higher flows.

Limitations

One limitation of monitoring specific sites through this study is applying point flow values to an entire watershed. Particularly, areas that have high permeable soils and geology could gain or lose large amounts of water to aquifers. Monitoring sites in this study may be added or removed as more information becomes available in order to better understand this complex system.

Another limitation to this study is measuring baseflow during dry periods. Between a dry year such as 2007 and a wet year like 2008, it is evident that some sites only contribute baseflow when the water table is high (*eg.* BAF-001 to BAF-005, Appendix D). Since this study measures mainly during dry periods, this flow is often missed. Future studies may use baseflow values derived from a hydrograph and compare them with spot measurements.

6.0 Recommendations

In order to obtain a more detailed and complete dataset, this study needs to be conducted over a period of many years. The difference in 2007 and 2008 measurements confirmed that baseflow values are not static. Further studies need to be conducted in order to capture the baseflow range for each monitoring site. With a more complete dataset, this information could potentially be used in future land use planning decisions.

Recommendations for future studies are as follows:

- Continue monitoring these locations on an annual basis, especially between the months of July and September
- Increase the number of field staff when practical in order to increase the baseflow dataset
- Continue with the QA/QC each year comparing manual measured values with the permanent gauge values
- Work with Water Survey of Canada technicians to evaluate data collected in 2008 and data to be collected in future years
- Research and adjust the methods for determining baseflow conditions for future studies.
- Create a clear and comprehensive guide of each monitoring site so each year the same sites are measured, ensuring an accurate dataset
- Review data collected to determine how it may be used to support other programs at the Conservation Authorities. For example, baseflow information could be used to prioritize wetland creation or enhancement projects
- Research the extent local water taking permits and how water taking might impact the flow measurements taken in the area.
- Investigate areas where streams seem to disappear and then re-appear during dry years.
- Explore options to compare spot flow measurements from this study to baseflow separation techniques from a hydrograph analysis.
- Continue to search for a method to archive and summarize baseflow readings annually (*ie* LFlow)

- Continue to investigate anomolies of extreme water gains/losses; for example, does Lucknow B have a correctly adjusted rating curve?
- Review Parkhill Creek and Gullies for possible baseflow monitoring.

7.0 References

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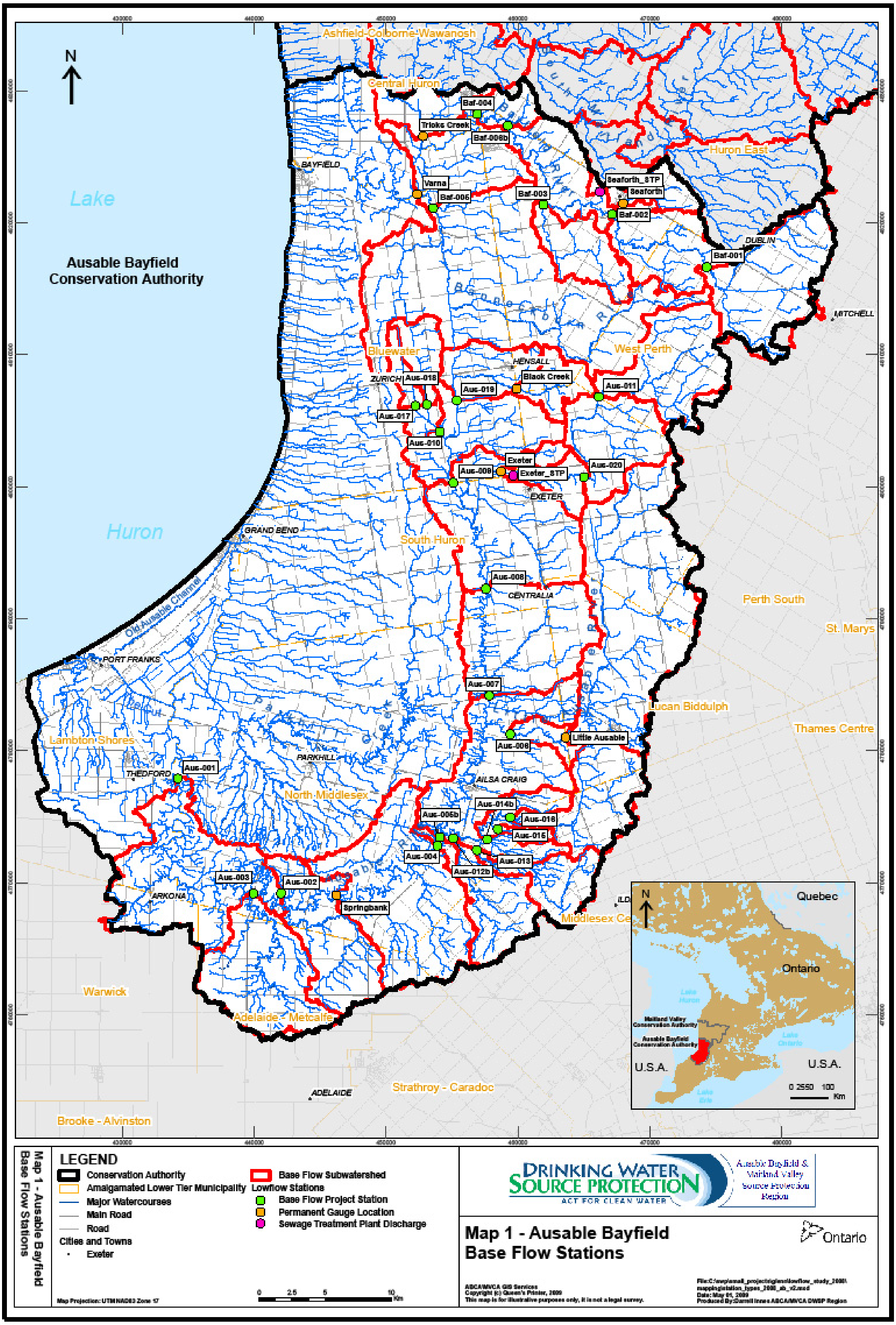
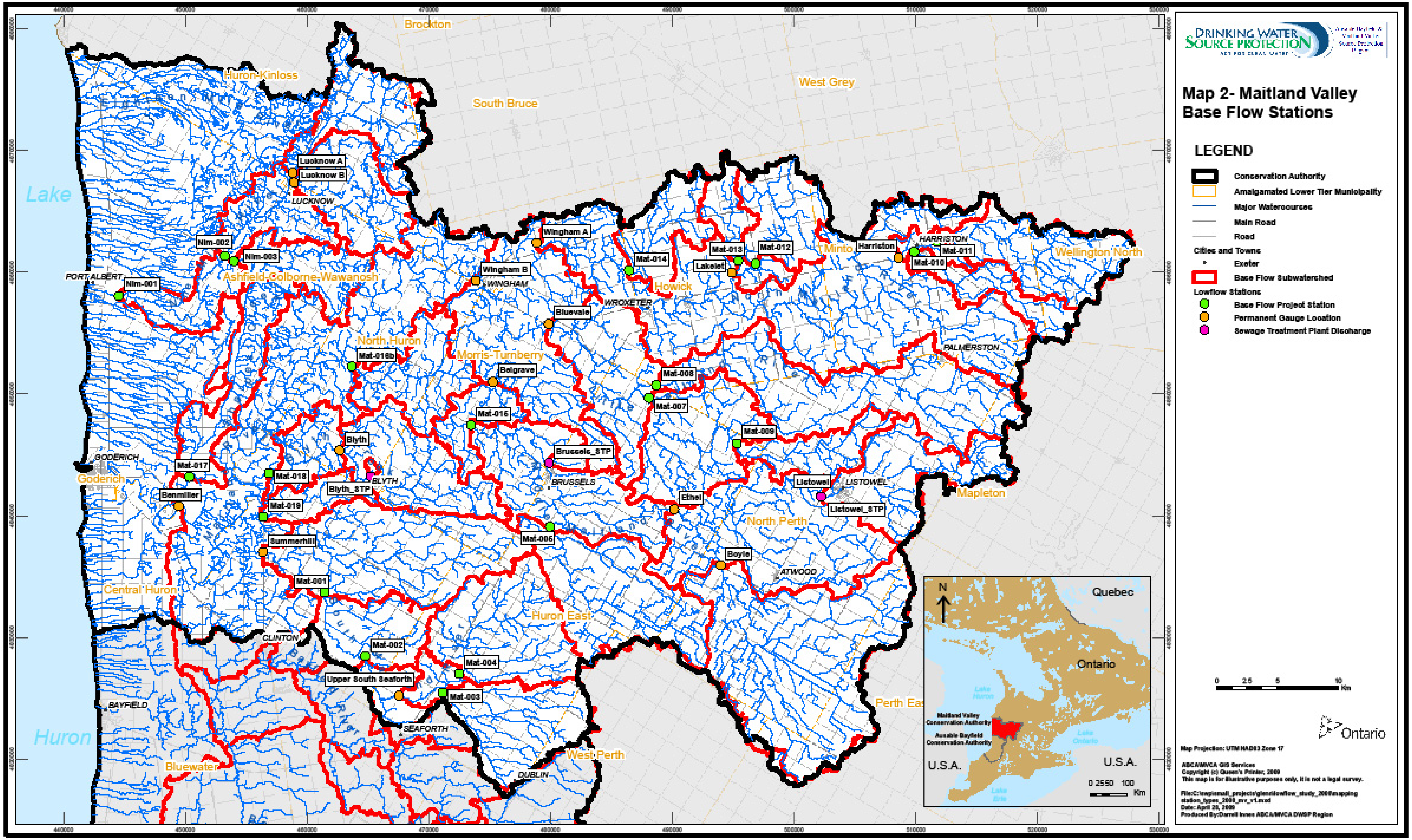
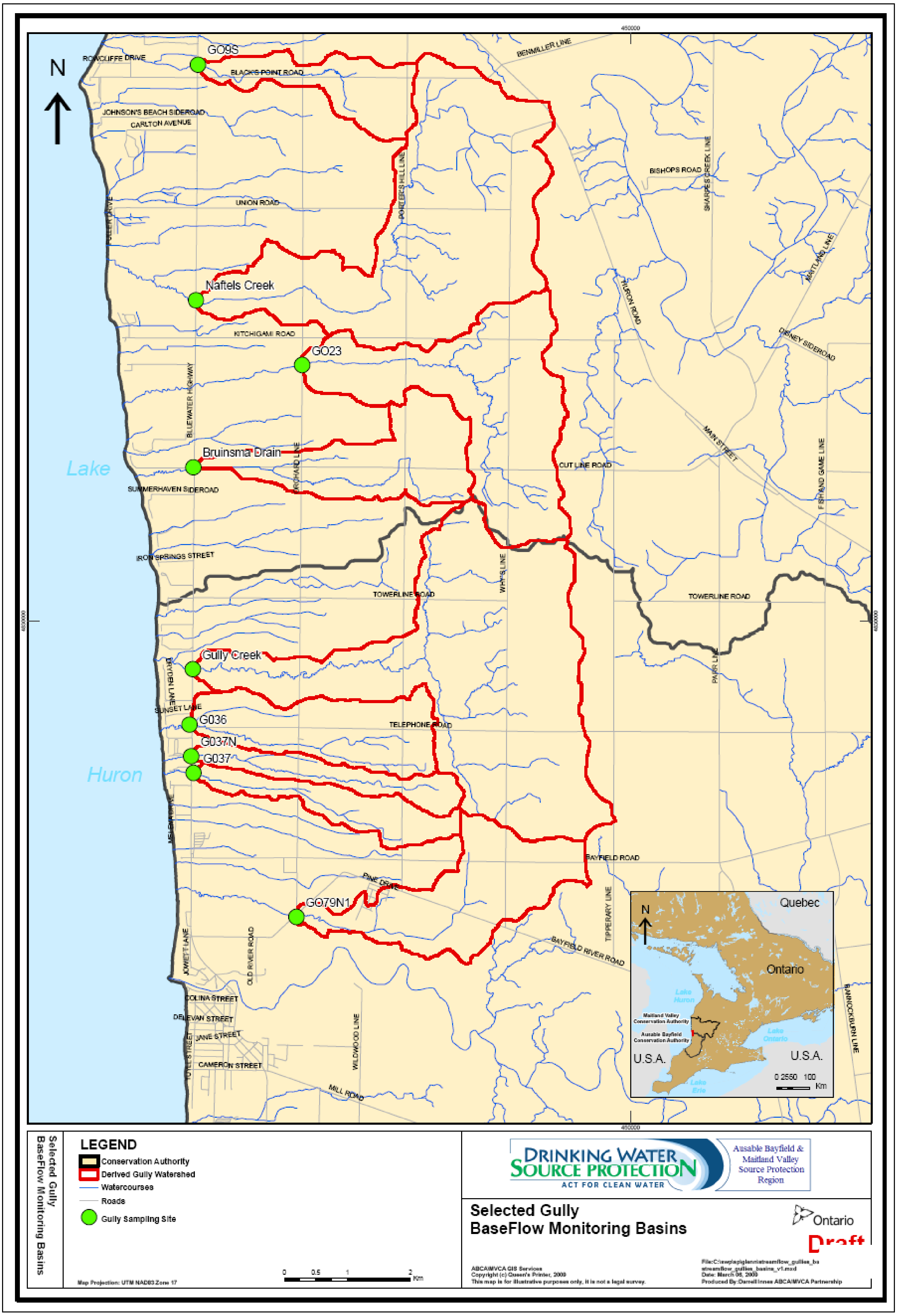
Appendix A: Maps



Lake Huron
Ausable Bayfield Conservation Authority
N
Ashfield-Colborne-Wawanosh
Central Huron
Huron East
Bluewater
West Perth
South Huron
Perth South
St. Marys
Lucan Biddulph
Thames Centre
Lambton Shores
North Middlesex
Middlesex Centre
Warwick
Adelaide - Metcalfe
Strathroy - Caradoc
Brooke - Alvinston
BAYFIELD
DUBLIN
MITCHELL
HENSALL
ZURICH
EXETER
GRAND BEND
CENTRALIA
PORT FRANKS
PARKHILL
AILSA CRAIG
THEDFORD
ARKONA
ADELAIDE
Old Ausable Channel
Baf-004
Tricks Creek
Baf-006b
Varna
Baf-005
Baf-003
Seaforth_STP
Seaforth
Baf-002
Baf-001
Aus-018
Aus-019
Black Creek
Aus-011
Aus-017
Aus-010
Exeter
Aus-009
Exeter_STP
Aus-020
Aus-008
Aus-007
Aus-006
Little Ausable
Aus-001
Aus-014b
Aus-005b
Aus-016
Aus-015
Aus-004
Aus-013
Aus-012b
Aus-003
Aus-002
Springbank
Quebec
Ontario
U.S.A.
U.S.A.
Maitland Valley Conservation Authority
Ausable Bayfield Conservation Authority
0 25 50 100 Km
Map 1 - Ausable Bayfield Base Flow Stations
LEGEND
Conservation Authority
Amalgamated Lower Tier Municipality
Major Watercourses
Main Road
Road
Cities and Towns
Exeter
Base Flow Subwatershed
Lowflow Stations
Base Flow Project Station
Permanent Gauge Location
Sewage Treatment Plant Discharge
Map Projection: UTM NAD83 Zone 17
0 2.5 5 10 Km
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Ausable Bayfield & Maitland Valley Source Protection Region
Map 1 - Ausable Bayfield Base Flow Stations
Ontario
ABCA/MVCA GIS Services
Copyright (c) Queen's Printer, 2009
This map is for illustrative purposes only, it is not a legal survey.



DRINKING WATER SOURCE PROTECTION
Map 2- Maitland Valley Base Flow Stations
LEGEND
Conservation Authority
Amalgamated Lower Tier Municipality
Major Watercourses
Main Road
Road
Cities and Towns
Exeter
Base Flow Subwatershed
Lowflow Stations
Base Flow Project Station
Permanent Gauge Location
Sewage Treatment Plant Discharge
Lake
Huron
Brockton
Huron-Kinloss
South Bruce
West Grey
Wellington North
Minto
Howick
Ashfield-Colborne-Wawanosh
North Huron
Morris-Turnberry
Goderich
Central Huron
Huron East
North Perth
Mapleton
Perth East
West Perth
Bluewater
LUCKNOW
WINGHAM
WROXETER
HARRISTON
PALMERSTON
LISTOWEL
BRUSSELS
BLYTH
GODERICH
PORT ALBERT
CLINTON
SEAFORTH
ATWOOD
DUBLIN
BAYFIELD
Lucknow A
Lucknow B
Nim-001
Nim-002
Nim-003
Wingham A
Wingham B
Mat-014
Mat-013
Mat-012
Lakelet
Harriston
Mat-011
Mat-010
Bluevale
Mat-016b
Belgrave
Mat-008
Mat-007
Mat-015
Mat-009
Blyth
Brussels_STP
Mat-017
Mat-018
Blyth_STP
Benmiller
Mat-019
Listowel
Listowel_STP
Ethel
Mat-006
Summerhill
Boyle
Mat-001
Mat-002
Upper South Seaforth
Mat-004
Mat-003
Quebec
Ontario
U.S.A.
Ontario



N
Lake
Huron
GO9S
Naftels Creek
GO23
Bruinsma Drain
Gully Creek
G036
G037N
G037
GO79N1
ROWCLIFFE DRIVE
BLACK'S POINT ROAD
BENMILLER LINE
JOHNSON'S BEACH SIDEROAD
CARLTON AVENUE
UNION ROAD
BISHOPS ROAD
SHARPES CREEK LINE
KITCHIGAMI ROAD
BLUE WATER HIGHWAY
DONEY SIDEROAD
MAITLAND LINE
HURON ROAD
MAIN STREET
CUT LINE ROAD
SUMMERHAVEN SIDEROAD
IRON SPRINGS STREET
TOWERLINE ROAD
TELEPHONE ROAD
SUNSET LANE
BAYFIELD ROAD
PINE DRIVE
BAYFIELD RIVER ROAD
TIPPERARY LINE
OLD RIVER ROAD
COLINA STREET
JANE STREET
CAMERON STREET
MILL ROAD
WILDWOOD LINE
Quebec
Ontario
U.S.A.
LEGEND
Conservation Authority
Derived Gully Watershed
Watercourses
Roads
Gully Sampling Site
Selected Gully
BaseFlow Monitoring Basins
Map Projection: UTM NAD83 Zone 17
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER
Ausable Bayfield & Maitland Valley Source Protection Region
Selected Gully
BaseFlow Monitoring Basins
Ontario
Draft

Appendix B: Data Summary Tables

Ausable River Summary Chart 2008

I.D.	Location	May 23-28 Flow	May 23-28 %Flow	May 23-28 mm/day	06-Jun Flow	06-Jun %Flow	06-Jun mm/day	16-Jun Flow	16-Jun mm/day	02-Jul Flow	02-Jul mm/day	July 7-8 Flow	July 7-8 %Flow	July 7-8 mm/day	July 15-16 Flow	July 15-16 %Flow	July 15-16 mm/day	July 18-22 Flow	July 18-22 %Flow	July 18-22 mm/day	28-Jul Flow	28-Jul mm/day	01-Aug Flow	01-Aug mm/day	07-Aug Flow	07-Aug mm/day	Aug 14-15 Flow	Aug 14-15 %Flow	Aug 14-15 mm/day	Aug 20-22 Flow	Aug 20-22 %Flow	Aug 20-22 mm/day	Aug 27-29 Flow	Aug 27-29 %Flow	Aug 27-29 mm/day
AUS-001	Ausable River	1.589	100%	0.128	2.749	100%	0.221	-	-	-	-	2.885	100%	0.232	2.250	100%	0.181	1.981	100%	0.159	-	-	-	-	-	-	4.554	100%	0.366	1.000	100%	0.08	0.676	100%	0.054
AUS-002	Ausable River	1.480	93%	0.139	2.643	96%	0.248	-	-	-	-	2.408	83%	0.226	2.970	132%	0.279	2.072	105%	0.195	-	-	0.000	0	-	-	0.000	0%	0	0.651	65%	0.061	0.452	67%	0.042
AUS-003	Adelaide Creek	0.020	1%	0.026	0.400	15%	0.525	-	-	-	-	0.215	7%	0.282	0.020	1%	0.026	0.024	1%	0.031	-	-	0.027	0.035	-	-	0.058	1%	0.08	0.009	1%	0.012	0.009	1%	0.012
AUS-004	Ausable River	1.204	76%	0.136	1.484	54%	0.168	-	-	-	-	1.843	64%	0.209	2.877	128%	0.326	1.762	89%	0.2	-	-	-	-	-	-	1.972	43%	0.223	0.613	61%	0.069	0.422	62%	0.048
AUS-005	Nairn Creek	1.251	79%	0.803	1.541	56%	0.989	-	-	-	-	1.762	61%	1.131	2.890	128%	1.855	1.519	77%	0.975	-	-	-	-	-	-	1.800	40%	1.156	0.518	52%	0.333	0.205	30%	0.132
AUS-006	Little Ausable	-	-	-	0.141	5%	0.08	-	-	-	-	0.261	9%	0.148	-	-	-	-	-	-	-	-	-	-	-	-	0.122	3%	0.069	-	-	-	0.037	5%	0.021
AUS-007	Ausable River	0.558	35%	0.121	1.179	43%	0.255	-	-	3.803	0.823	0.855	30%	0.185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.148	22%	0.032
AUS-008	Ausable River	0.525	33%	0.140	0.655	24%	0.175	-	-	-	-	0.885	31%	0.237	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.133	20%	0.036
AUS-009	Black Creek	0.339	21%	0.243	0.250	9%	0.179	-	-	0.600	0.43	0.273	9%	0.196	0.606	27%	0.434	-	-	-	0.597	0.428	-	-			-	-	-	0.134	13%	0.096	0.210	31%	0.15
AUS-010	Black Creek West	0.173	11%	0.496	0.089	3%	0.255	0.323	0.925	0.208	0.596	0.053	2%	0.152	0.114	5%	0.327	0.040	2%	0.115	0.334	0.957	-	-	0.161	0.461	0.143	3%	0.41	-	-	-	0.070	10%	0.201
AUS-011	Ausable Drain	0.433	27%	0.694	0.087	3%	0.139	-	-	0.747	1.197	0.118	4%	0.189	-	-	-	0.375	19%	0.601	-	-	-	-	-	-	-	-	-	0.027	3%	0.043	0.013	2%	0.021
AUS-012	Bear Creek	0.000	0%	0.000	-	-	-	-	-	-	-	0.138	5%	0.35	0.026	1%	0.066	0.020	1%	0.051	-	-	-	-	-	-	0.121	3%	0.31	0.011	1%	0.028	0.008	1%	0.02
AUS-013	Duncrief Creek	-	-	-	-	-	-	-	-	-	-	0.109	4%	0.36	0.131	6%	0.432	0.090	5%	0.297	-	-	-	-	-	-	-	-	-	0.084	8%	0.277	0.190	28%	0.627
AUS-014b	Watson Drain	-	-	-	-	-	-	-	-	-	-	0.184	6%	0.254	0.166	7%	0.229	0.196	10%	0.270	-	-	-	-	-	-	-	-	-	0.118	12%	0.163	0.110	16%	0.152
AUS-015	McEwen Drain Ext.	-	-	-	-	-	-	-	-	-	-	0.002	0%	0.046	-	-	-	-	-	-	-	-	-	-	-	-	0.000	0%	0	-	-	-	0.000	0%	0
AUS-016	Nairn Creek	-	-	-	-	-	-	-	-	-	-	0.165	6%	0.309	0.165	7%	0.309	0.150	8%	0.281	-	-	-	-	-	-	0.129	3%	0.24	0.101	10%	0.189	0.093	14%	0.174
AUS-017	Black Creek	0.515	32%	5.716	-	-	-	-	-	-	-	0.067	2%	0.744	0.134	6%	1.487	-	-	-	0.159	1.765	-	-	0.091	1.01	0.060	1%	0.666	-	-	-	0.100	15%	1.11
AUS-018	Black Creek	0.042	3%	0.231	-	-	-	-	-	-	-	0.034	1%	0.187	0.066	3%	0.363	-	-	-	0.103	0.567	-	-	0.041	0.226	0.030	1%	0.165	-	-	-	0.019	3%	0.105
AUS-019	Black Creek	0.25	16%	1.622	-	-	-	-	-	-	-	0.136	5%	0.882	0.110	5%	0.714	-	-	-	0.156	1.012	-	-	0.095	0.616	0.075	2%	0.487	0.038	4%	0.247	0.066	10%	0.428
AUS-020	Ausable Headwaters	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.344	17%	0.302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Permanent Gauge Values(Noon)		27-May Flow	27-May % Flow	27-May mm/day	06-Jun Flow	06-Jun % Flow	06-Jun mm/day	16-Jun Flow	16-Jun mm/day	02-Jul Flow	02-Jul mm/day	07-Jul Flow	07-Jul % Flow	07-Jul mm/day	15-Jul Flow	15-Jul % Flow	15-Jul mm/day	18-Jul Flow	18-Jul % Flow	18-Jul mm/day	28-Jul Flow	28-Jul mm/day	01-Aug Flow	01-Aug mm/day	07-Aug Flow	07-Aug mm/day	14-Aug Flow	14-Aug % Flow	14-Aug mm/day	20-Aug Flow	20-Aug % Flow	20-Aug mm/day	27-Aug Flow	27-Aug % Flow	27-Aug mm/day
BLACK CREEK	Perm. Gauge	0.050	3%	0.244	0.040	1%	0.195	0.180	0.880	0.100	0.489	0.050	2%	0.244	0.060	2%	0.293	0.040	3%	0.195	0.050	0.244	0.080	0.391	0.040	0.195	0.040	1%	0.195	0.030	3%	0.147	0.020	3%	0.098
EXETER	Perm. Gauge	0.850	53%	0.650	0.780	28%	0.596	2.040	1.559	1.420	1.085	0.650	23%	0.497	0.880	29%	0.673	0.490	33%	0.374	0.640	0.489	1.030	0.787	0.310	0.237	0.320	7%	0.245	0.160	16%	0.122	0.090	13%	0.069
EXETER STP	Lagoon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LITTLE AUSABLE	Perm. Gauge	0.200	13%	0.121	0.180	7%	0.109	1.000	0.607	0.890	0.540	0.260	9%	0.158	0.130	12%	0.079	0.050	13%	0.030	0.050	0.030	0.120	0.073	0.130	0.079	0.080	2%	0.049	0.020	2%	0.012	0.010	1%	0.006
SPRINGBANK	Perm. Gauge	1.800	113%	0.180	2.150	78%	0.215	4.930	0.493	7.880	0.787	2.050	71%	0.205	2.900	91%	0.290	1.280	103%	0.128	3.340	0.334	2.840	0.284	1.520	0.152	2.980	65%	0.298	0.880	88%	0.088	0.530	78%	0.053

Note certain days do not have Flow % due to the lack of a measurement for the downstream reference point

Red font indicates baseflow

Bayfield River Summary Table 2008

I.D.	Location	May 20-30			June 4-5			20-Jun			July 8-9			16-Jul			28-Jul			06-Aug			18-Aug			27-Aug		
Manual Values		Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day
BAF-001	Bayfield River at Rd. 181	0.017	2%	0.021	0.110	12%	0.139	0.551	16%	0.696	0.061	10%	0.077	-	-	-	-	-	-	0.136	13%	0.172	-	-	-	0.009	3%	0.011
BAF-002	Bayfield River at Kippen and Mill Rd.	0.047	5%	0.032	0.164	18%	0.113	1.248	37%	0.86	0.102	16%	0.07	-	-	-	-	-	-	0.320	31%	0.22	-	-	-	0.049	17%	0.034
BAF-003	Broadfoot Drain at Roman Rd.	0.047	5%	0.139	0.035	4%	0.104	0.152	4%	0.451	0.020	3%	0.059	-	-	-	-	-	-	0.029	3%	0.086	-	-	-	0.004	1%	0.012
BAF-004	Bayfield River at Lion's Park	0.499	54%	0.211	0.344	37%	0.145	1.822	54%	0.77	0.326	51%	0.138	-	-	-	-	-	-	0.555	54%	0.234	-	-	-	0.149	51%	0.063
BAF-005	Bannockburn River at CA	0.236	26%	0.108	0.241	26%	0.11	0.621	18%	0.283	0.234	37%	0.107	0.435	21%	0.198	0.868	36%	0.396	0.347	34%	0.158	0.152	37%	0.069	0.072	25%	0.033
BAF-006b	Bayfield River at Front Rd.	-	-	-	-	-	-	-	-	-	0.316	49%	0.142	1.092	53%	0.492	0.940	39%	0.424	0.478	47%	0.215	0.222	54%	0.100	0.120	41%	0.054

I.D.	Location	29-May			5-Jun			20-Jun			9-Jul			16-Jul			28-Jul			6-Aug			18-Aug			27-Aug		
Permanent Gauge Values		Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day
SEAFORTH	Perm. Gauge	0.080	9%	0.475	0.060	7%	0.356	0.110	3%	0.653	0.040	6%	0.237	0.090	4%	0.534	0.110	5%	0.653	0.050	5%	0.297	0.030	7%	0.178	0.020	7%	0.119
SEAFORTH STP	Sewage Treatment Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRICKS CREEK	Perm. Gauge	0.670	73%	2.604	0.670	73%	2.604	0.700	21%	2.721	0.250	39%	0.972	0.280	14%	1.088	0.320	13%	1.244	0.160	16%	0.622	0.370	90%	1.438	0.240	83%	0.933
VARNA	Perm. Gauge	0.920	100%	0.172	0.920	100%	0.172	3.390	100%	0.634	0.640	100%	0.120	2.050	100%	0.383	2.400	100%	0.449	1.020	100%	0.191	0.410	100%	0.077	0.290	100%	0.054

Red font indicates baseflow

Maitland River Summary Table 2008

I.D. Manual Values	Location	May 29-30 Flow	May 29-30 Flow %	May 29-30 mm/day	June 2-5 Flow	June 2-5 Flow %	June 2-5 mm/day	10-Jun Flow	10-Jun mm/day	13-Jun Flow	13-Jun mm/day	June 19-30 Flow	June 19-30 Flow %	June 19-30 mm/day	03-Jul Flow	03-Jul mm/day	09-Jul Flow	09-Jul Flow %	09-Jul mm/day	July 10-16 Flow	July 10-16 mm/day	July 17-18 Flow	July 17-18 mm/day	25-Jul Flow	25-Jul mm/day	July 28-30 Flow	July 28-30 mm/day	Aug 5-12 Flow	Aug 5-12 Flow %	Aug 5-12 mm/day	Aug 18-20 Flow	Aug 18-20 mm/day	Aug 25-28 Flow	Aug 25-28 Flow %	Aug 25-28 mm/day
MAT-001	South Maitland below HPWA	0.571	4%	0.203	0.430	3%	0.153	-	-	-	-	1.009	3%	0.358	-	-	0.299	4%	0.106	-	-	-	-	-	-	-	-	0.32	5%	0.114	-	-	0.159	4%	0.056
MAT-002	South Maitland above HPWA	0.211	1%	0.093	0.273	2%	0.12	-	-	-	-	0.236	1%	0.104	-	-	0.159	2%	0.07	-	-	-	-	-	-	-	-	0.139	2%	0.061	-	-	0.061	2%	0.027
MAT-003	South Maitland above McEwan	0.062	0%	0.074	0.590	4%	0.708	-	-	-	-	0.306	1%	0.367	0.285	0.342	0.051	1%	0.061	-	-	-	-	-	-	-	-	0.075	1%	0.09	-	-	**0.017**	**0%**	**0.02**
MAT-004	McEwan Creek	0.183	1%	0.173	0.156	1%	0.147	-	-	-	-	0.318	1%	0.3	0.313	0.295	0.102	1%	0.096	-	-	-	-	-	-	-	-	0.097	1%	0.091	-	-	-	-	-
MAT-005	Beauchamp Creek	0.170	1%	0.141	-	-	-	0.151	0.125	-	-	0.412	1%	0.342	0.517	0.429	-	-	-	0.085	0.07	-	-	-	-	-	-	-	-	-	0.038	0.032	0.043	1%	0.036
MAT-007	Little Maitland South	-	-	-	-	-	-	-	-	0.599	0.31	0.331	1%	0.171	-	-	-	-	-	0.205	0.106	-	-	-	-	-	-	0.224	3%	0.116	-	-	**0.182**	**5%**	**0.094**
MAT-008	Little Maitland Palmerston	-	-	-	-	-	-	-	-	0.611	0.364	**0.316**	**1%**	**0.188**	-	-	-	-	-	0.311	0.185	-	-	-	-	-	-	1.102	16%	0.657	-	-	0.278	7%	0.166
MAT-009	Little Maitland Molesworth	-	-	-	-	-	-	-	-	0.082	0.201	0.05	0%	0.123	-	-	-	-	-	0.053	0.13	0.038	0.093	0.344	0.845	0.171	0.42	**0.084**	**1%**	**0.206**	0.182	0.447	**0.076**	**2%**	**0.187**
MAT-010	Harriston Stream	-	-	-	-	-	-	0.197	0.492	-	-	-	-	-	0.09	0.225	-	-	-	0.023	0.057	-	-	-	-	-	-	0.032	0%	0.08	-	-	**0.019**	**1%**	**0.047**
MAT-011	North Maitland above Harriston	-	-	-	-	-	-	0.854	1.052	-	-	-	-	-	0.23	0.283	-	-	-	0.122	0.15	0.161	0.198	**1.135**	**1.398**	0.292	0.36	0.15	2%	0.185	0.181	0.223	**0.091**	**2%**	**0.112**
MAT-012	Blind Lake Creek	-	-	-	-	-	-	1.064	1.842	0.582	1.007	0.477	1%	0.826	-	-	-	-	-	0.457	0.791	0.353	0.611	**0.689**	**1.193**	0.401	0.694	0.356	5%	0.616	0.288	0.499	**0.212**	**6%**	**0.367**
MAT-013	Lakelet Creek	-	-	-	-	-	-	-	-	0.265	1.145	0.16	0%	0.691	0.07	0.302	-	-	-	0.051	0.22	-	-	-	-	-	-	0.04	1%	0.173	-	-	**0.014**	**0%**	**0.06**
MAT-014	Salem Creek	-	-	-	**0.262**	**2%**	**0.526**	-	-	0.349	0.7	0.357	1%	0.716	-	-	-	-	-	0.199	0.399	-	-	**0.272**	**0.546**	-	-	0.108	2%	0.217	-	-	**0.087**	**2%**	**0.175**
MAT-015	Middle Maitland at Cty Rd 16	1.368	9%	0.192	1.113	7%	0.157	-	-	-	-	1.075	3%	0.151	-	-	-	-	-	0.733	0.103	2.35	0.331	0	0	2.171	0.305	1.171	17%	0.165	1.401	0.197	**0.649**	**17%**	**0.091**
MAT-016	Maitland River at Belgrave Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAT-016b	Belgrave Creek at Nature Centre Rd.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.235	0.011	0.14	0.007	-	-	0.236	0.011	0.224	3%	0.011	0.152	0.007	0.116	3%	0.006
MAT-017	Sharpes Creek	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.282	0.427	0.26	0.394	-	-	**0.409**	**0.62**	0.362	5%	0.548	0.254	0.385	0.192	5%	0.291
MAT-018	Blyth Brook	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.297	0.249	0.252	0.211	-	-	0.601	0.503	0.363	5%	0.304	0.184	0.154	0.141	4%	0.118
MAT-019	Unknown south of Blyth Brook	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.077	1%	0.305	0.063	0.25	-	-	-	-	0.13	0.515	0.134	2%	0.531	0.057	0.226	**0.062**	**2%**	**0.246**
BELGRAVE	Perm. Gauge	-	-	-	1.796	-	0.242	-	-	4.476	0.602	-	-	-	3.241	0.436	-	-	-	0.718	0.097	2.762	0.372	-	-	2.718	0.366	1.119	-	0.151	1.472	0.198	0.679	-	0.091
ETHEL	Perm. Gauge	-	-	-	0.649	-	0.136	-	-	1.573	0.331	-	-	-	1.648	0.346	-	-	-	0.644	0.135	1.244	0.262	4.980	1.047	0.785	0.165	0.822	-	0.173	1.034	0.217	0.581	-	0.122
LAKELET	Perm. Gauge	-	-	-	0.666	-	0.722	-	-	0.894	0.969	0.845	-	0.916	-	-	-	-	-	0.492	0.533	0.355	0.385	1.103	1.196	0.454	0.492	0.378	-	0.410	0.448	0.486	0.275	-	0.298
SUMMERHILL	Perm. Gauge	0.528		0.122	0.762	-	0.176	-	-	-	-	3.811	-	0.882	-	-	0.526	-	0.122	1.768	0.409	-	-	-	-	2.127	0.492	0.883	-	0.204	1.004	0.232	0.290	-	0.067

**Note Flow Values are expressed in m3/s

Note: Red font indicates baseflow

Maitland River Permanent Gauge Summary Table 2008

Date

Permanent Gauge Values		29-May			02-Jun			10-Jun		13-Jun		19-Jun			03-Jul	
		Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	mm/day	Flow	mm/day	Flow	Flow %	mm/day	Flow	mm/day
BELGRAVE	Perm. Gauge	3.090	19%	0.416	2.850	18%	0.384	2.630	0.354	3.470	0.467	4.330	12%	0.583	3.150	0.424
BENMILLER	Perm. Gauge	16.040	100%	0.545	16.160	100%	0.549	23.740	0.807	31.250	1.063	36.360	100%	1.236	17.480	0.594
BLUEVALE	Perm. Gauge	**1.920**	**12%**	**0.492**	2.070	13%	0.530	2.350	0.602	2.490	0.637	4.010	11%	1.027	1.700	0.435
BLYTH	Perm. Gauge	**1.230**	**8%**	**1.450**	**1.130**	**7%**	**1.332**	3.490	4.114	1.620	1.910	1.720	5%	2.027	1.110	1.308
BOYLE	Perm. Gauge	0.270	2%	0.116	0.260	2%	0.111	0.700	0.300	**1.200**	**0.514**	1.510	4%	0.647	1.410	0.604
ETHEL	Perm. Gauge	0.850	5%	0.179	0.790	5%	0.166	0.980	0.206	1.330	0.280	2.120	6%	0.446	1.440	0.303
HARRISTON	Perm. Gauge	**0.350**	**2%**	**0.264**	0.510	3%	0.385	1.870	1.412	0.850	0.642	1.210	3%	0.914	0.330	0.249
LAKELET	Perm. Gauge	0.810	5%	0.878	**0.810**	**5%**	**0.878**	1.310	1.420	0.930	1.008	1.090	3%	1.182	0.500	0.542
LISTOWEL	Perm. Gauge	**0.310**	**2%**	**0.368**	**0.310**	**2%**	**0.368**	1.170	1.390	**0.480**	**0.570**	0.770	2%	0.915	**0.430**	**0.511**
SUMMERHILLL	Perm. Gauge	1.480	9%	0.342	1.310	8%	0.303	3.160	0.731	2.550	0.590	2.760	8%	0.639	1.790	0.414
UPPER SEAFORTH	Perm. Gauge	0.750	5%	0.367	0.610	4%	0.299	0.380	0.186	0.740	0.362	0.760	2%	0.372	0.640	0.313
WINGHAM A	Perm. Gauge	1.070	7%	0.173	3.010	19%	0.487	4.210	0.681	4.810	0.778	7.250	20%	1.173	2.950	0.477
WINGHAM B	Perm. Gauge	7.090	44%	0.373	9.340	58%	0.491	10.300	0.542	12.720	0.669	18.990	52%	0.999	8.910	0.469

Permanent Gauge Values		09-Jul			16-Jul		18-Jul		25-Jul		30-Jul		05-Aug			18-Aug		26-Aug		
		Flow	Flow %	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	Flow %	mm/day	Flow	mm/day	Flow	Flow %	mm/day
BELGRAVE	Perm. Gauge	**1.030**	**14%**	**0.139**	3.930	0.529	1.720	0.231	11.210	1.509	2.190	0.295	1.160	16%	0.156	0.000	0.000	0.850	23%	0.114
BENMILLER	Perm. Gauge	7.190	100%	0.244	15.680	0.533	8.590	0.292	52.650	1.790	10.260	0.349	7.050	100%	0.240	8.840	0.301	3.730	100%	0.127
BLUEVALE	Perm. Gauge	0.850	12%	0.218	0.810	0.207	0.610	0.156	2.850	0.730	0.900	0.230	0.540	8%	0.138	1.310	0.335	**0.500**	**13%**	**0.128**
BLYTH	Perm. Gauge	0.810	11%	0.955	0.720	0.849	0.570	0.672	**1.950**	**2.299**	1.200	1.414	0.670	10%	0.790	0.360	0.424	**0.200**	**5%**	**0.236**
BOYLE	Perm. Gauge	**0.650**	**9%**	**0.279**	2.170	0.930	1.210	0.518	1.770	0.758	0.540	0.231	0.380	5%	0.163	0.820	0.351	**0.490**	**13%**	**0.210**
ETHEL	Perm. Gauge	**0.440**	**6%**	**0.093**	2.050	0.431	1.030	0.217	4.440	0.934	0.810	0.170	0.450	6%	0.095	1.240	0.261	**0.490**	**13%**	**0.103**
HARRISTON	Perm. Gauge	0.160	2%	0.121	**0.210**	**0.159**	0.210	0.159	1.820	1.374	0.370	0.279	0.170	2%	0.128	0.190	0.143	**0.100**	**3%**	**0.076**
LAKELET	Perm. Gauge	0.330	5%	0.358	**0.340**	**0.369**	0.310	0.336	**1.050**	**1.138**	0.410	0.444	0.340	5%	0.369	0.370	0.401	**0.240**	**6%**	**0.260**
LISTOWEL	Perm. Gauge	**0.340**	**5%**	**0.404**	**0.440**	**0.523**	**0.410**	**0.487**	0.800	0.950	0.410	0.487	**0.240**	**3%**	**0.285**	**0.610**	**0.725**	**0.360**	**10%**	**0.428**
SUMMERHILLL	Perm. Gauge	0.560	8%	0.130	2.160	0.500	1.160	0.268	8.140	1.883	1.710	0.396	0.740	10%	0.171	#N/A		0.350	9%	0.081
UPPER SEAFORTH	Perm. Gauge	0.170	2%	0.083	0.870	0.426	0.480	0.235	1.960	0.959	0.420	0.206	0.190	3%	0.093	0.120	0.059	0.090	2%	0.044
WINGHAM A	Perm. Gauge	1.650	23%	0.267	**2.240**	**0.362**	1.690	0.273	9.030	1.461	2.170	0.351	1.670	24%	0.270	2.000	0.324	**1.090**	**29%**	**0.176**
WINGHAM B	Perm. Gauge	4.000	56%	0.210	7.920	0.417	4.410	0.232	27.360	1.439	5.710	0.300	3.730	53%	0.196	6.000	0.316	2.790	75%	0.147

Flow values are expressed in m3/s
Note certain days are missing Flow % since there is no measurement for the downstream reference point
Note: Red font indicates baseflow

Nine Mile River Summary Table 2008

		Date																									
I.D.	Location	29-May			04-Jun			30-Jun			10-Jul			17-Jul			29-Jul			08-Aug			18-Aug			28-Aug		
Manual Gauge		Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day
NIM-001	Nine Mile River at Port Albert	1.798	100%	0.64	2.483	100%	0.884	3.962	100%	1.41	1.238	100%	0.441	1.019	100%	0.363	1.838	100%	0.654	1.092	100%	0.389	0.756	100%	0.269	0.571	100%	0.203
NIM-002	Nine Mile River at Cty Rd 20	1.145	64%	0.59	1.718	69%	0.886	2.635	67%	1.358	0.806	65%	0.415	0.697	68%	0.359	1.195	65%	0.616	0.601	55%	0.31	0.608	80%	0.313	0.397	70%	0.205
NIM-003	St. Helens Creek	0.315	18%	0.649	0.364	15%	0.75	0.496	13%	1.022	0.142	11%	0.293	0.137	13%	0.282	0.305	17%	0.629	0.151	14%	0.311	0.100	13%	0.206	0.060	11%	0.124

I.D.	Location	29-May			4-Jun			30-Jun			10-Jul			17-Jul			29-Jul			8-Aug			18-Aug			28-Aug		
Perm Gauges		Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day	Flow	Flow %	mm/day
LUCKNOW A	Lucknow River	0.550	31%	0.731	0.630	25%	0.837	1.420	36%	1.887	0.350	28%	0.465	0.270	26%	0.359	0.540	29%	0.718	0.270	25%	0.359	0.260	34%	0.346	0.190	33%	0.253
LUCKNOW B	Dickies Creek	2.580	143%	3.610	3.300	133%	4.617	3.200	81%	4.478	1.980	160%	2.770	1.940	190%	2.715	1.990	108%	2.784	1.630	149%	2.281	1.630	216%	2.281	1.450	254%	2.029

Note Flow Values are expressed in m^3/s

Note: Red font indicates baseflow

2008 Bayfield Goderich Gully Summary

	Date																			
	24-Jul		31-Jul		8-Aug		15-Aug		20-Aug		28-Aug		4-Sep		10-Sep		24-Sep		17-Oct	
Location	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day	Flow	mm/day
Bruinsma Drain	0.064	1.435	0.025	0.560	0.025	0.560	0.013	0.291	0.013	0.291	0.011	0.247	0.011	0.247	0.014	0.314	0.019	0.426	0.040	0.897
GO9S	0.047	1.744	0.022	0.816	0.020	0.742	0.015	0.557	0.017	0.631	0.020	0.742	0.022	0.816	0.018	0.668	0.012	0.445	0.038	1.410
GO23	0.090	1.037	-	-	0.022	0.254	0.017	0.196	0.025	0.288	0.015	0.173	0.019	0.219	0.022	0.254	0.021	0.242	0.061	0.703
GO36	0.163	3.773	0.022	0.509	0.002	0.046	0.000	0.000	0.002	0.046	0.000	0.000	0.001	0.023	0.005	0.116	0.011	0.255	0.037	0.856
GO37	0.048	2.080	0.016	0.693	0.004	0.173	0.004	0.173	0.002	0.087	0.002	0.087	0.003	0.130	0.008	0.347	0.009	0.390	0.029	1.257
GO37N	0.039	1.951	0.010	0.500	0.003	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.050	0.005	0.250	0.005	0.250	0.015	0.750
GO79N1	0.104	1.939	0.027	0.503	0.019	0.354	0.013	0.242	0.009	0.168	0.009	0.168	0.013	0.242	0.005	0.093	0.031	0.578	0.038	0.708
Gully Creek	0.281	1.727	0.066	0.406	0.026	0.160	0.021	0.129	0.032	0.197	0.022	0.135	0.020	0.123	0.046	0.283	0.034	0.209	0.124	0.762
Naftel's Creek	0.133	0.948	0.081	0.578	0.065	0.463	0.068	0.485	0.072	0.513	0.063	0.449	0.085	0.606	0.077	0.549	0.073	0.521	0.120	0.856

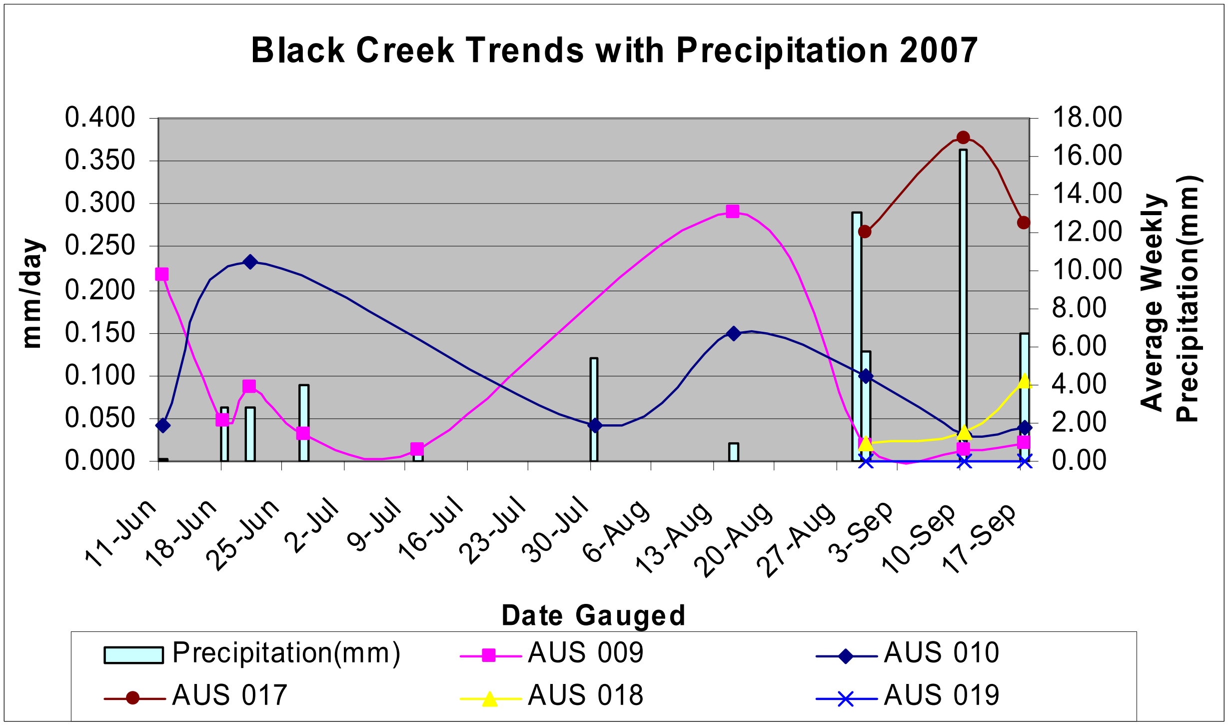
Flow is expressed in m3/s

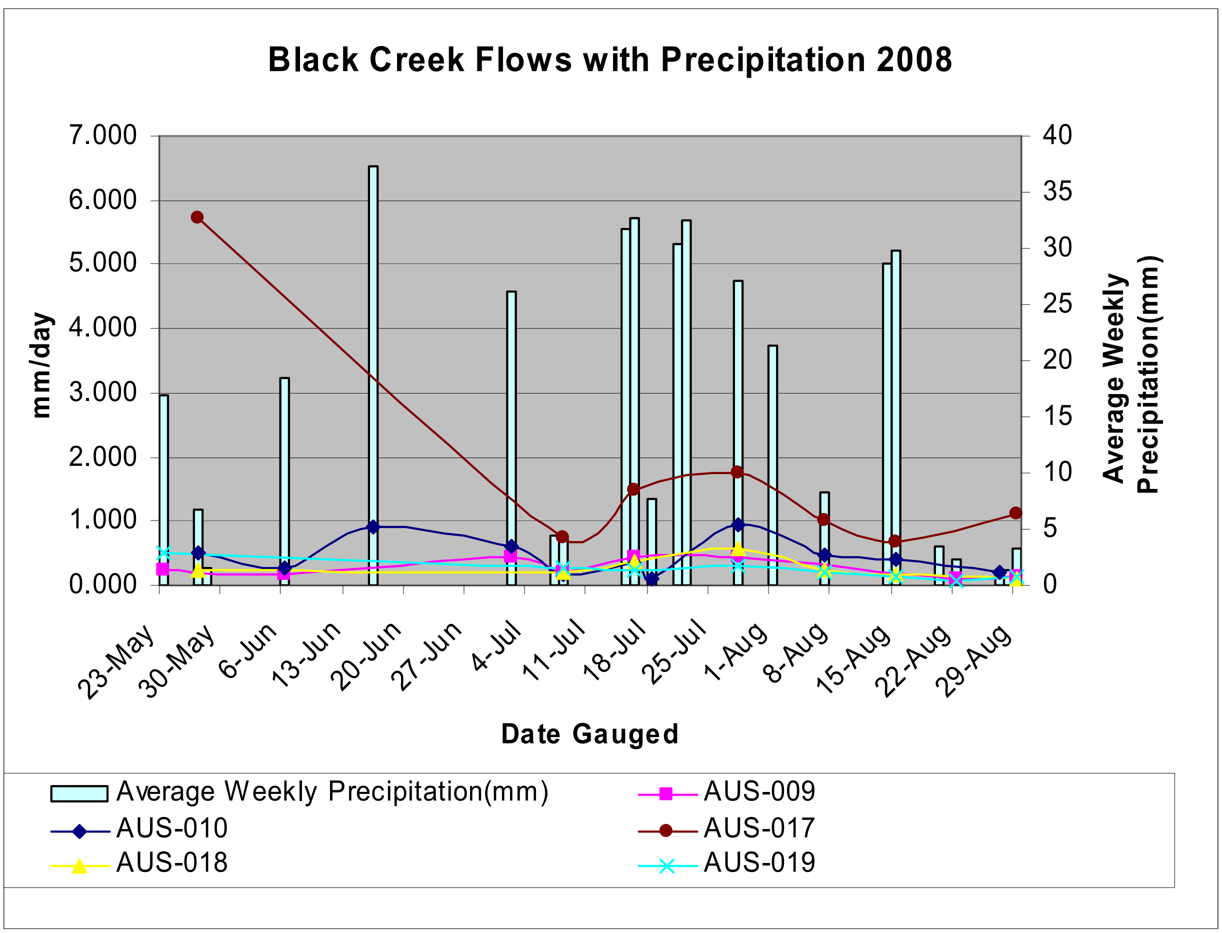
Note: Red font indicates baseflow

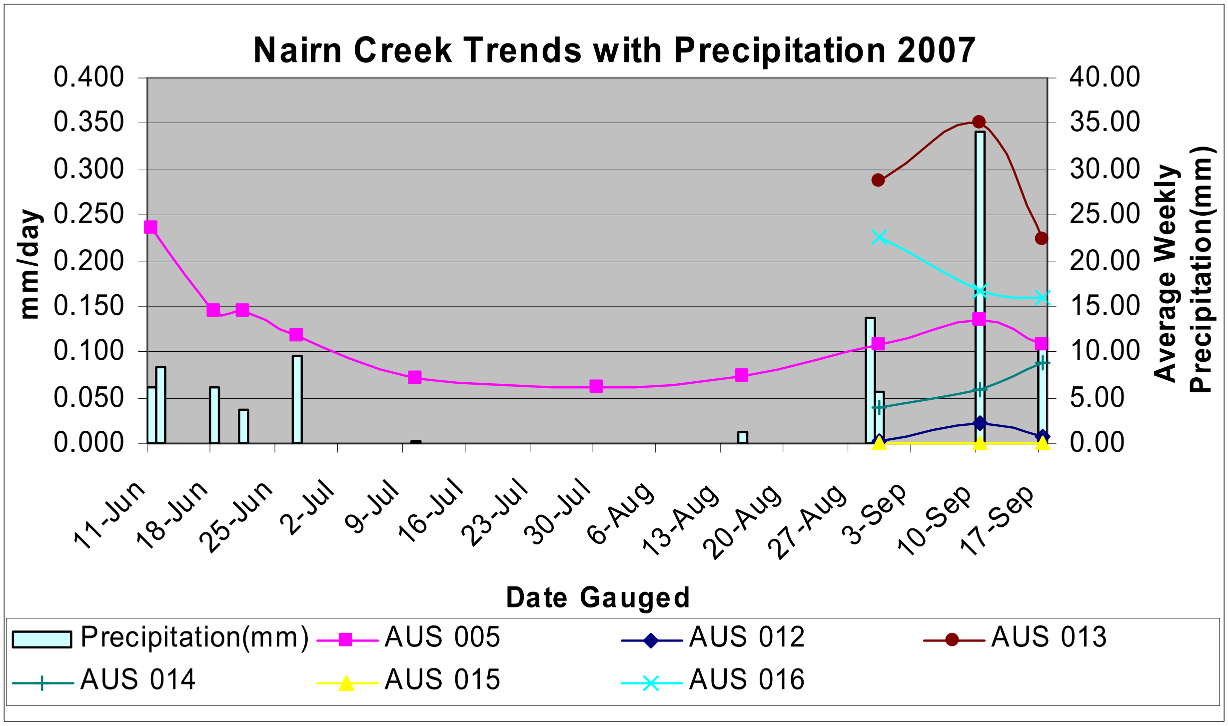
QA/QC Permanent Gauge Flow Values vs. Manual Measured Values

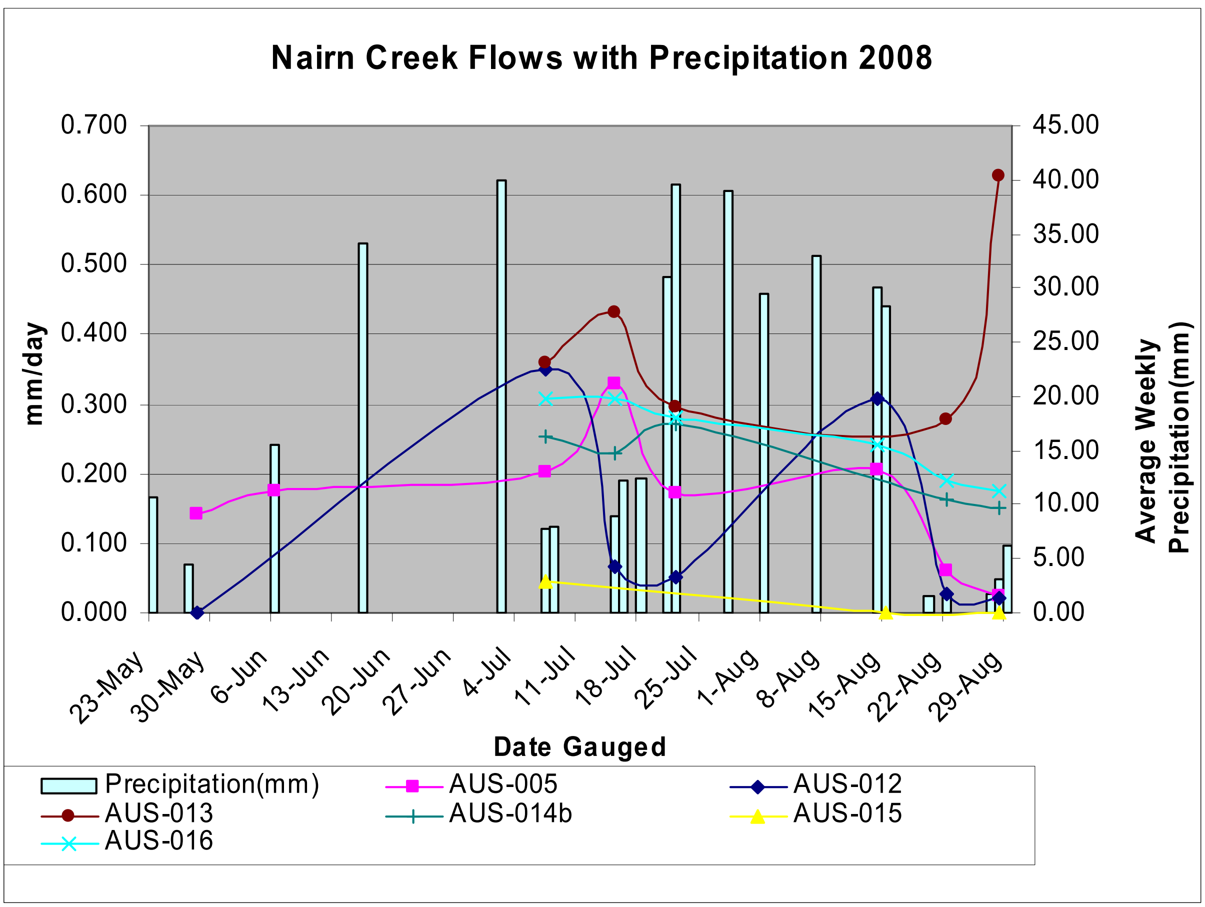
		Date												
		May 29-30	June 2-5	13-Jun	June 19-30	03-Jul	09-Jul	July 10-16	July 17-18	25-Jul	July 28-30	Aug 5-12	Aug 18-20	Aug 25-28
	Area m2	Flow	Flow	Flow	Flow	Flow	Flow	Flow	Flow	Flow	Flow	Flow	Flow	Flow
BELGRAVE Manual	642023816.89	-	1.796	-	4.476	3.241	-	0.718	2.762	-	2.718	1.119	1.472	0.679
BELGRAVE BRFU	642023816.89	-	2.85	-	4.33	3.21	-	0.92	2.66	10.61	2.46	1.33	-	0.85
Percent Difference		**-**	**45.37%**	**-**	**3.32%**	**0.96%**	**-**	**24.66%**	**3.76%**	**-**	**9.97%**	**17.23%**	**-**	**22.37%**
ETHEL Manual	410934908.51	-	0.649	1.573	-	1.648	-	0.644	1.244	4.98	0.785	0.822	1.034	0.581
ETHEL BRFU	410934908.51	-	0.71	1.34	-	1.41	-	0.6	1.06	4.64	0.81	0.66	0.97	0.57
Percent Difference		**-**	**8.98%**	**16.00%**	**-**	**15.57%**	**-**	**7.07%**	**15.97%**	**7.07%**	**3.13%**	**21.86%**	**6.39%**	**1.91%**
LAKELET Manual	79696703.43	-	0.666	0.894	0.845	-	-	0.492	0.355	1.103	0.454	0.378	0.448	0.275
LAKELET BRFU	79696703.43	-	0.82	0.93	0.78	-	-	0.38	0.31	1.02	0.42	0.34	0.38	0.24
Percent Difference		**-**	**20.73%**	**3.95%**	**8.00%**	-	**-**	**25.69%**	**13.53%**	**7.82%**	**7.78%**	**10.58%**	**16.43%**	**13.59%**
SUMMERHILL Manual	373405779.33	0.528	0.762	-	3.811	-	0.526	1.768	-	-	2.127	0.883	1.004	0.29
SUMMERHILL BRFU	373405779.33	1.49	1.27	-	5.35	-	0.57	2.05	-	-	2.38	0.63	-	0.36
Percent Difference		**95.34%**	**50.00%**	**-**	**33.60%**		**8.03%**	**14.77%**	**-**	**-**	**11.23%**	**33.44%**	**-**	**21.54%**
Note: Red Font Indicates Baseflow Conditions														

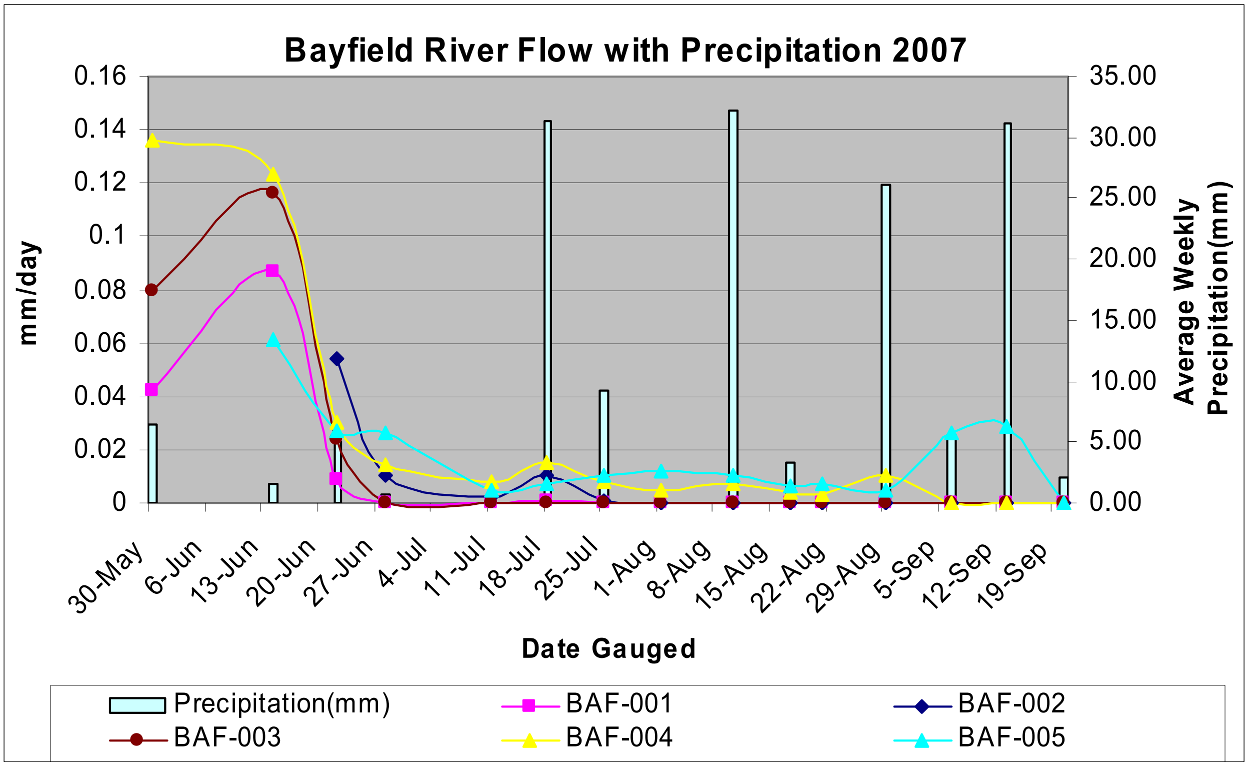
Appendix C: 2008 Flow Trends with Precipitation

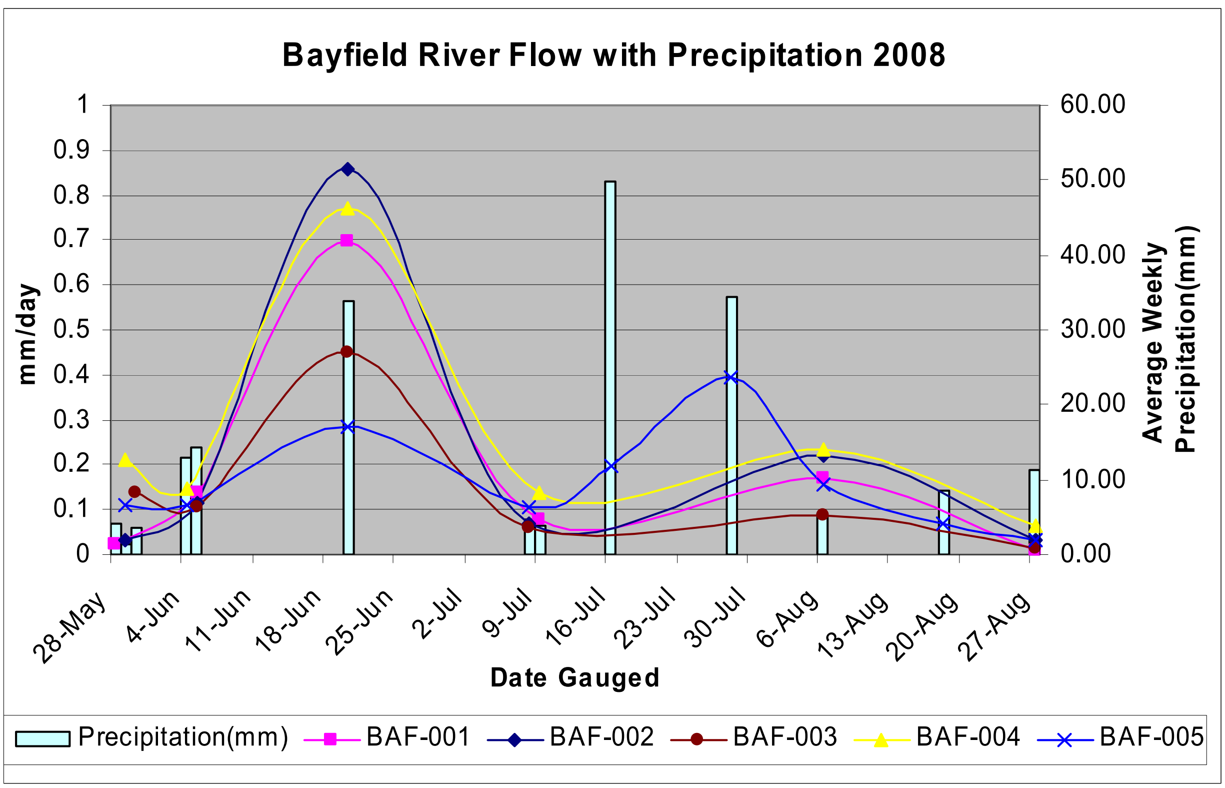

Black Creek Trends with Precipitation 2007
mm/day
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Average Weekly Precipitation(mm)
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Date Gauged
Precipitation(mm)
AUS 009
AUS 010
AUS 017
AUS 018
AUS 019

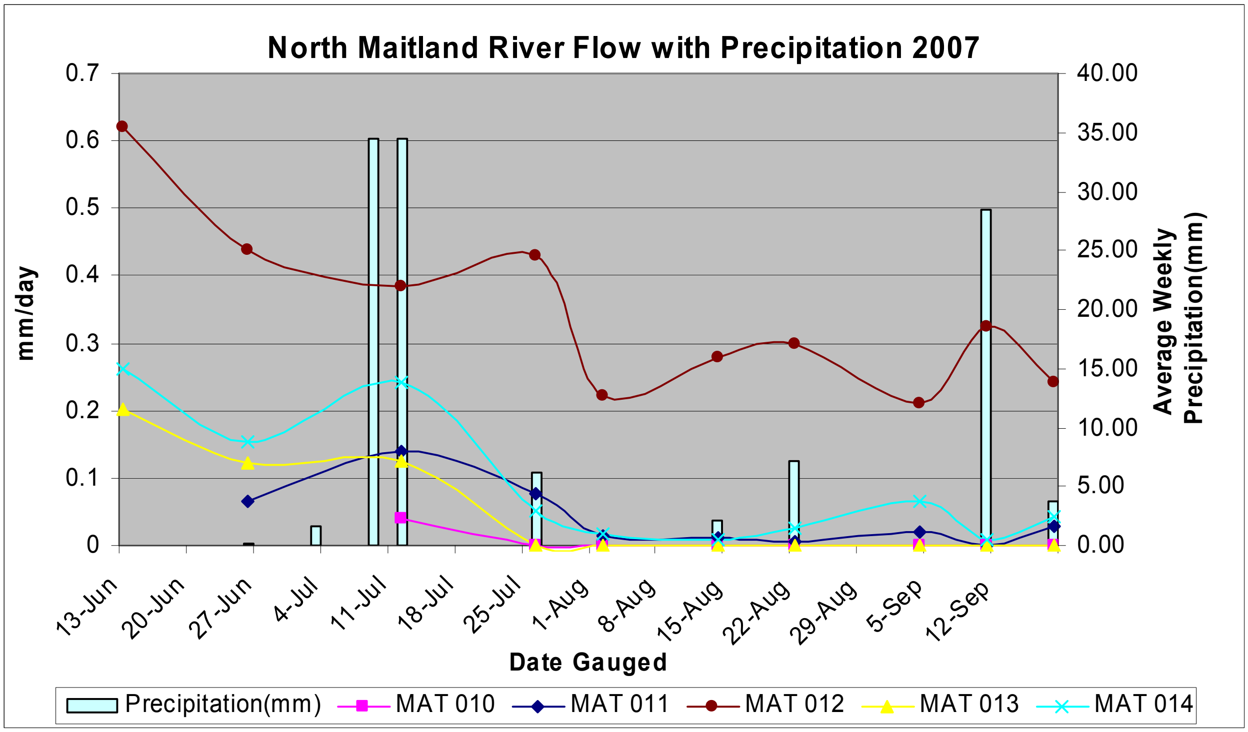

Black Creek Flows with Precipitation 2008
mm/day
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
40
35
30
25
20
15
10
5
0
Average Weekly Precipitation(mm)
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
15-Aug
22-Aug
29-Aug
Date Gauged
Average Weekly Precipitation(mm)
AUS-009
AUS-010
AUS-017
AUS-018
AUS-019


Nairn Creek Trends with Precipitation 2007
mm/day
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Average Weekly Precipitation(mm)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Date Gauged
Precipitation(mm)
AUS 005
AUS 012
AUS 013
AUS 014
AUS 015
AUS 016

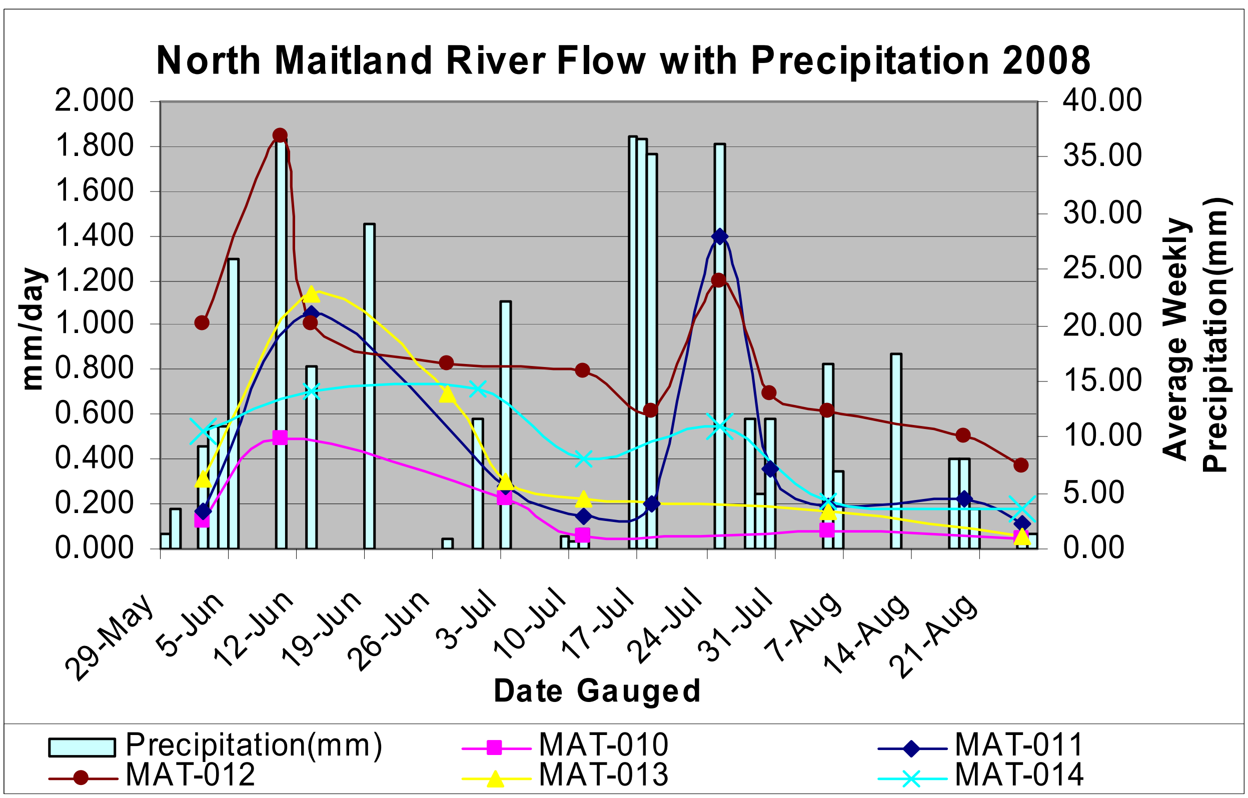

Nairn Creek Flows with Precipitation 2008
mm/day
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Average Weekly Precipitation(mm)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
23-May
30-May
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
15-Aug
22-Aug
29-Aug
Date Gauged
Precipitation(mm)
AUS-005
AUS-012
AUS-013
AUS-014b
AUS-015
AUS-016


Bayfield River Flow with Precipitation 2007
mm/day
Average Weekly Precipitation(mm)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
30-May
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
15-Aug
22-Aug
29-Aug
5-Sep
12-Sep
19-Sep
Date Gauged
Precipitation(mm)
BAF-001
BAF-002
BAF-003
BAF-004
BAF-005

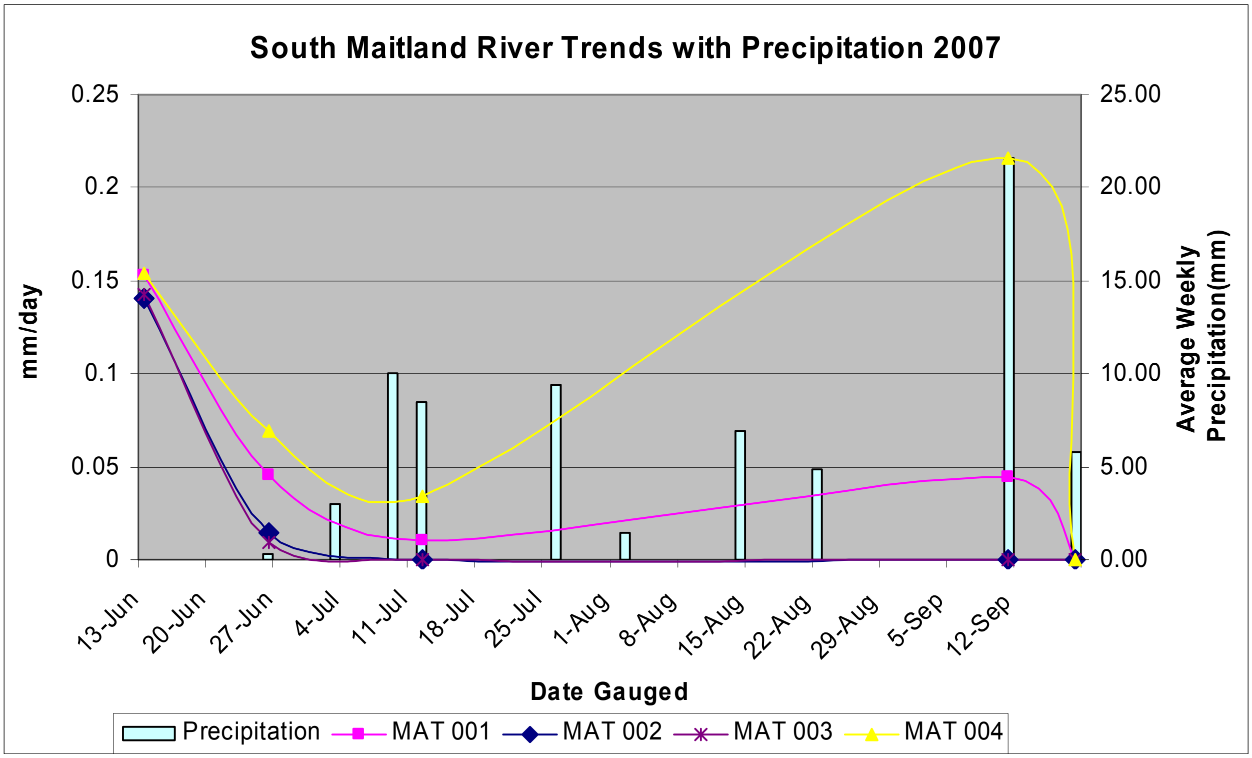

Bayfield River Flow with Precipitation 2008
mm/day
Average Weekly Precipitation(mm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
60.00
50.00
40.00
30.00
20.00
10.00
0.00
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
Date Gauged
Precipitation(mm)
BAF-001
BAF-002
BAF-003
BAF-004
BAF-005

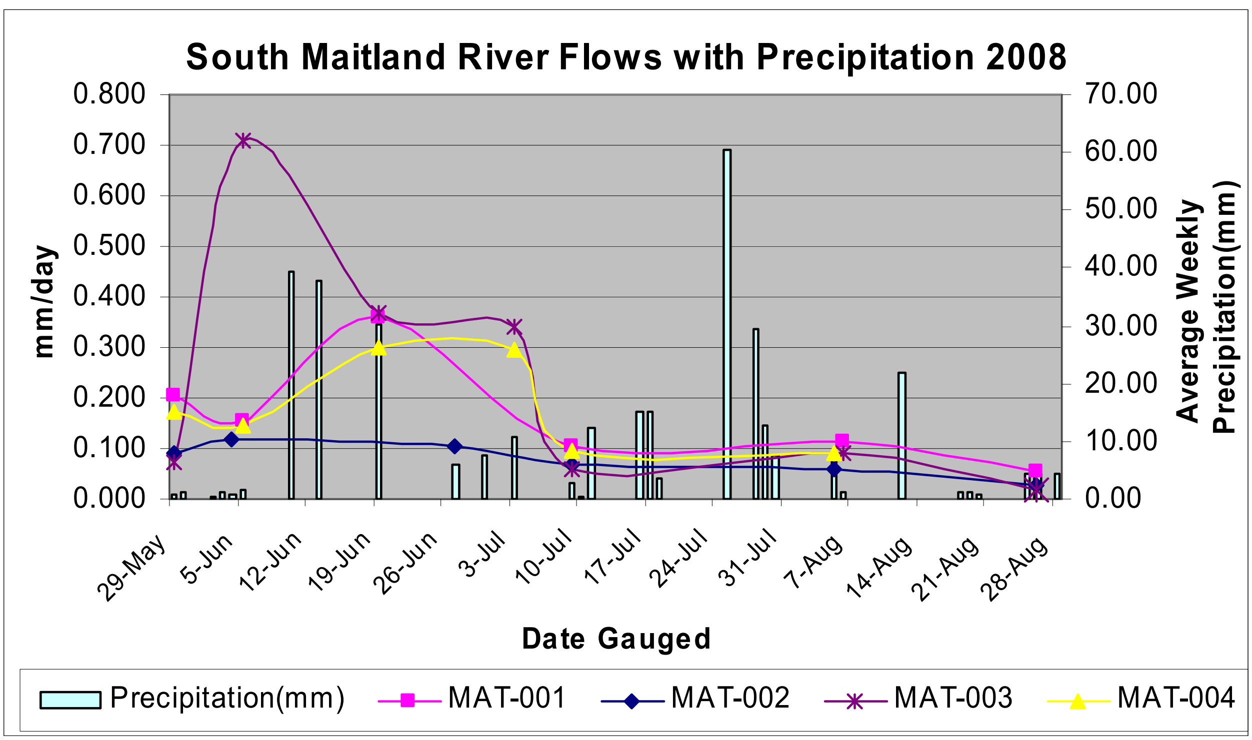


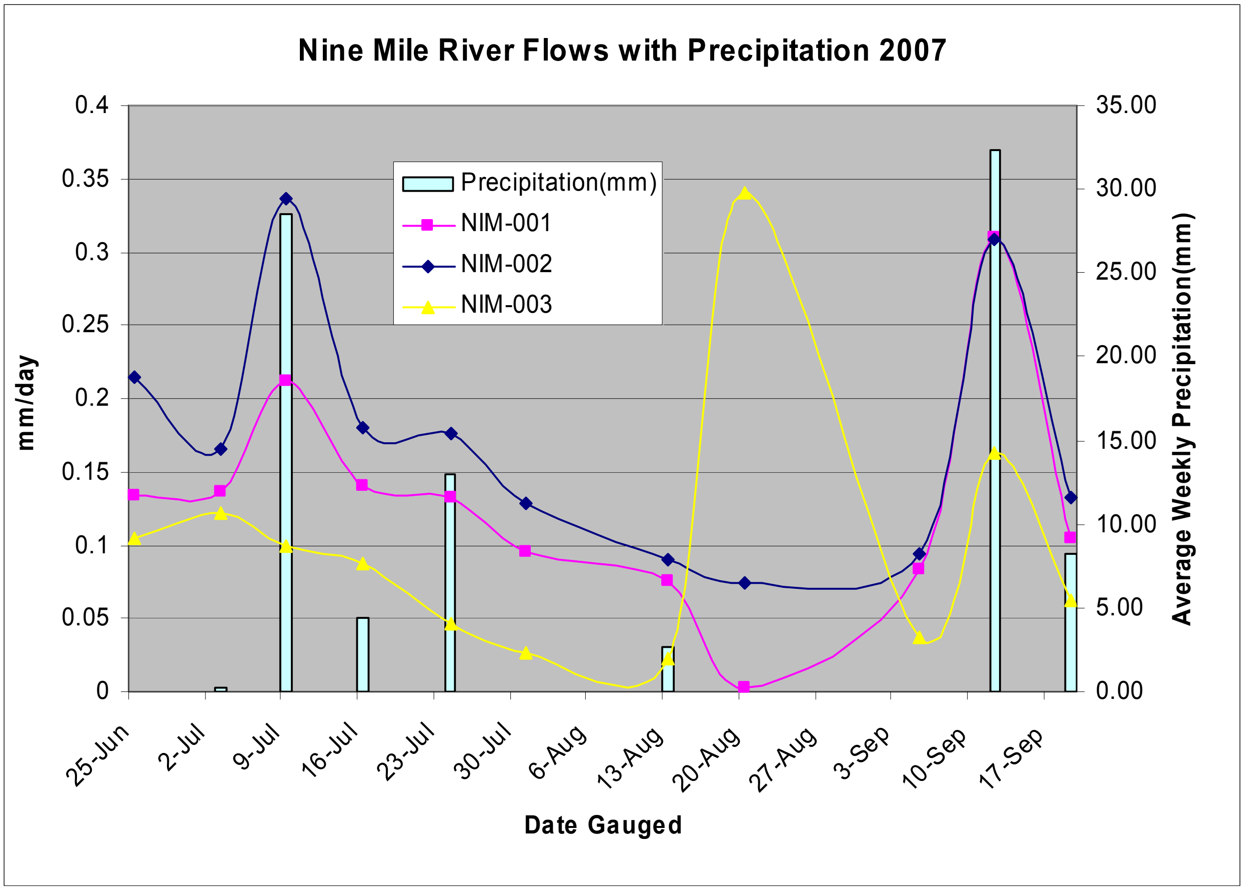
North Maitland River Flow with Precipitation 2007
mm/day
Average Weekly Precipitation(mm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
15-Aug
22-Aug
29-Aug
5-Sep
12-Sep
Date Gauged
Precipitation(mm)
MAT 010
MAT 011
MAT 012
MAT 013
MAT 014

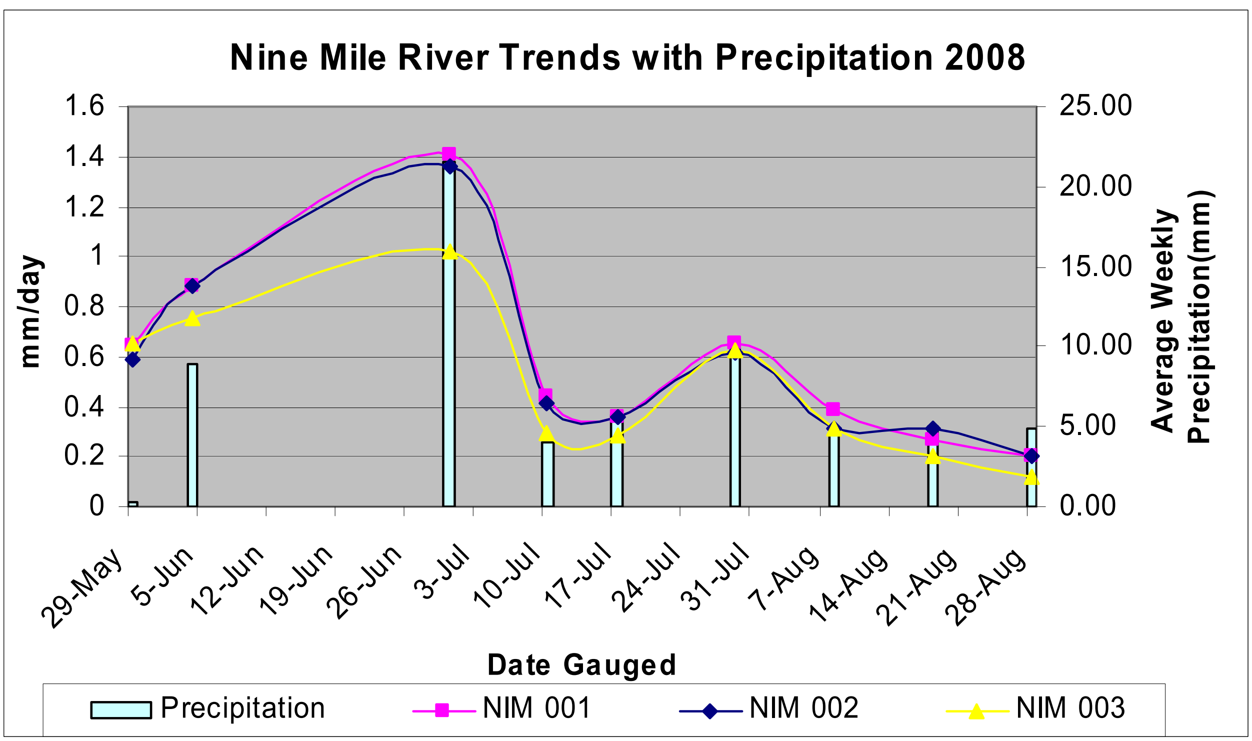


North Maitland River Flow with Precipitation 2008
mm/day
Average Weekly Precipitation(mm)
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
29-May
5-Jun
12-Jun
19-Jun
26-Jun
3-Jul
10-Jul
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
Date Gauged
Precipitation(mm)
MAT-010
MAT-011
MAT-012
MAT-013
MAT-014


South Maitland River Trends with Precipitation 2007
mm/day
0.25
0.2
0.15
0.1
0.05
0
Average Weekly Precipitation(mm)
25.00
20.00
15.00
10.00
5.00
0.00
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
15-Aug
22-Aug
29-Aug
5-Sep
12-Sep
Date Gauged
Precipitation
MAT 001
MAT 002
MAT 003
MAT 004


South Maitland River Flows with Precipitation 2008
mm/day
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Average Weekly Precipitation(mm)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
29-May
5-Jun
12-Jun
19-Jun
26-Jun
3-Jul
10-Jul
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug
Date Gauged
Precipitation(mm)
MAT-001
MAT-002
MAT-003
MAT-004

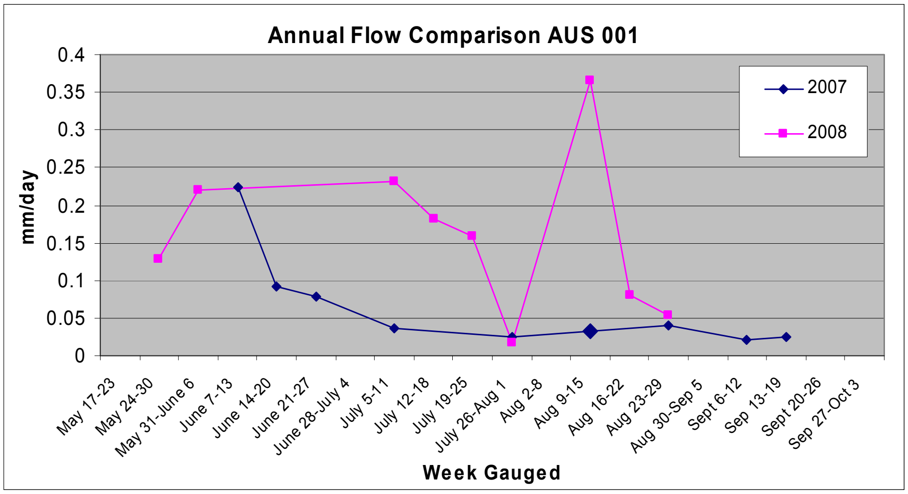

Nine Mile River Flows with Precipitation 2007
Precipitation(mm)
NIM-001
NIM-002
NIM-003
mm/day
Average Weekly Precipitation(mm)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Date Gauged

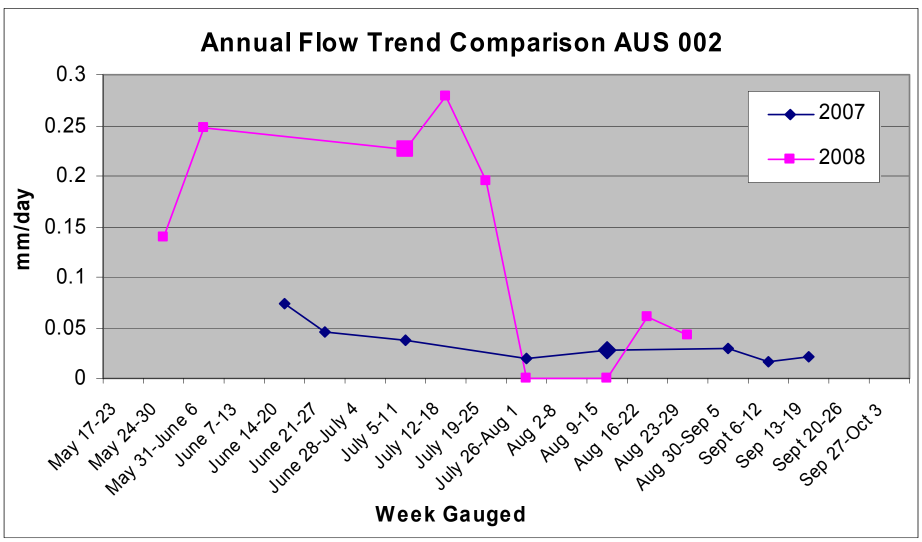

Nine Mile River Trends with Precipitation 2008
mm/day
Average Weekly Precipitation(mm)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
25.00
20.00
15.00
10.00
5.00
0.00
29-May
5-Jun
12-Jun
19-Jun
26-Jun
3-Jul
10-Jul
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug
Date Gauged
Precipitation
NIM 001
NIM 002
NIM 003

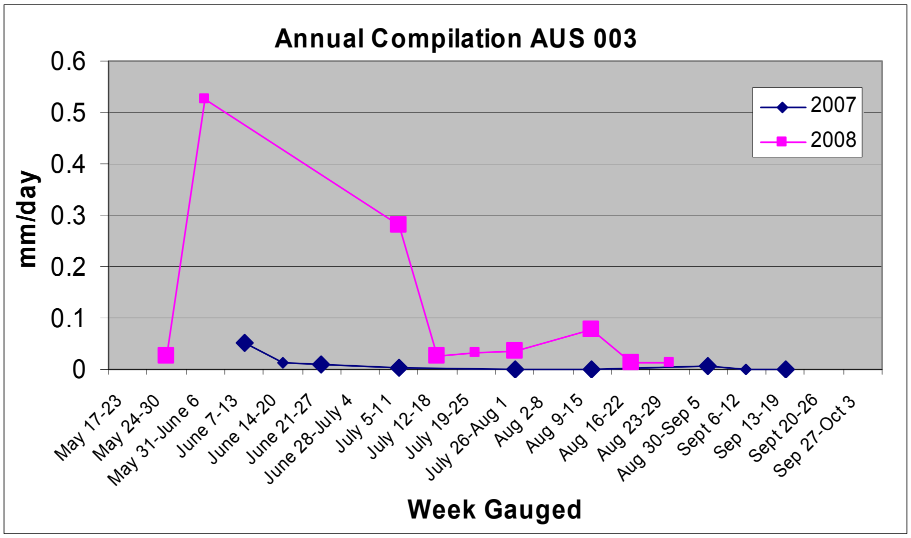
Appendix D: Annual Comparisons

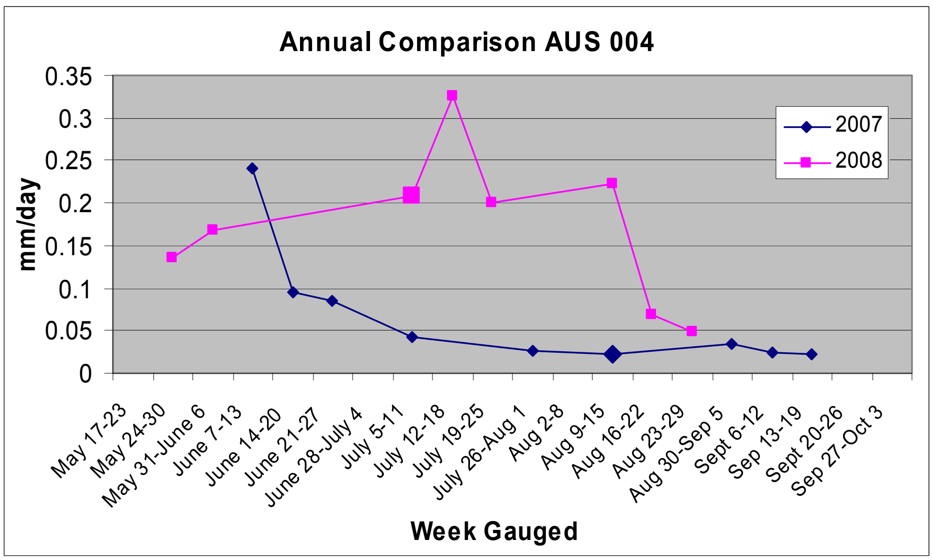
Ausable River Annual Comparison Graphs

Note these graphs help illustrate the differences between years. Enlarged data points represent baseflow conditions. Pay close attention to the Y-axis in order to determine which sites contribute most flow relative to its catchment area.

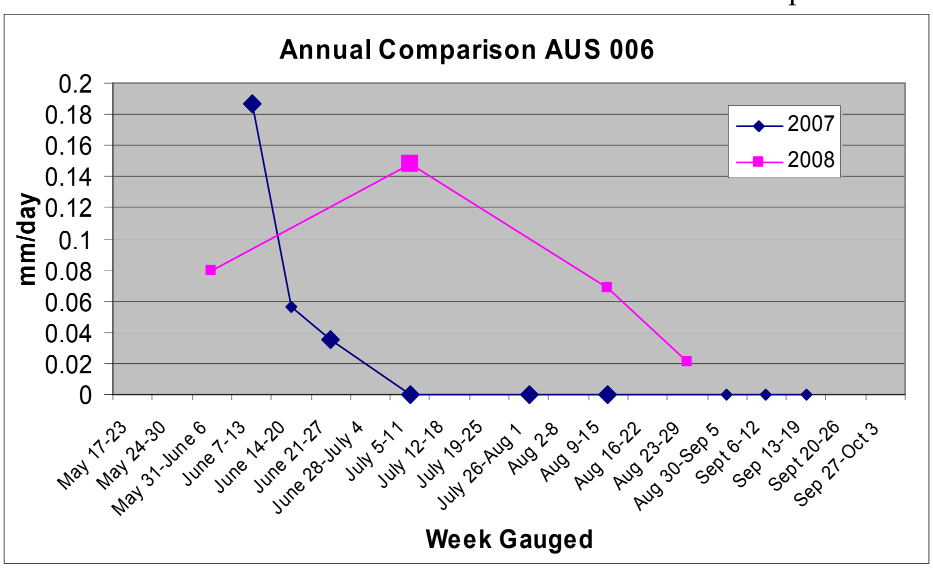


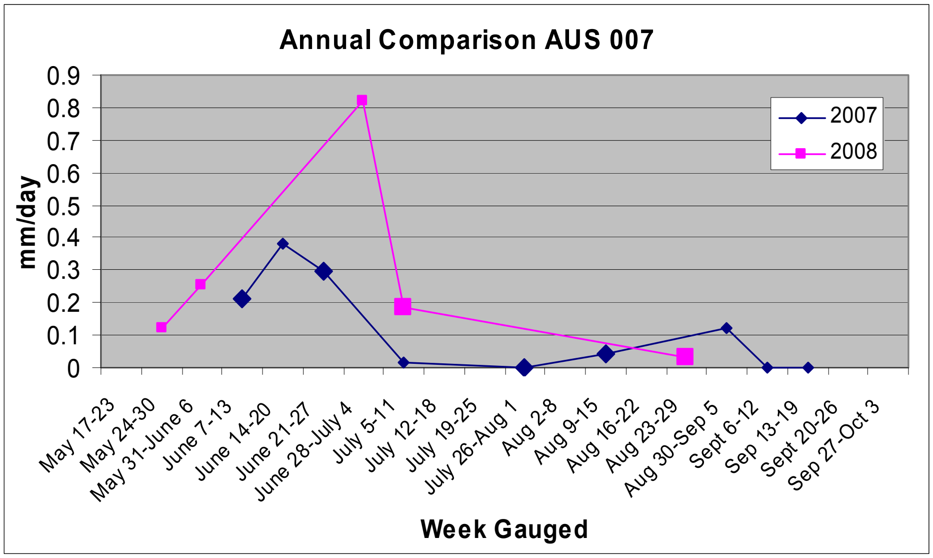


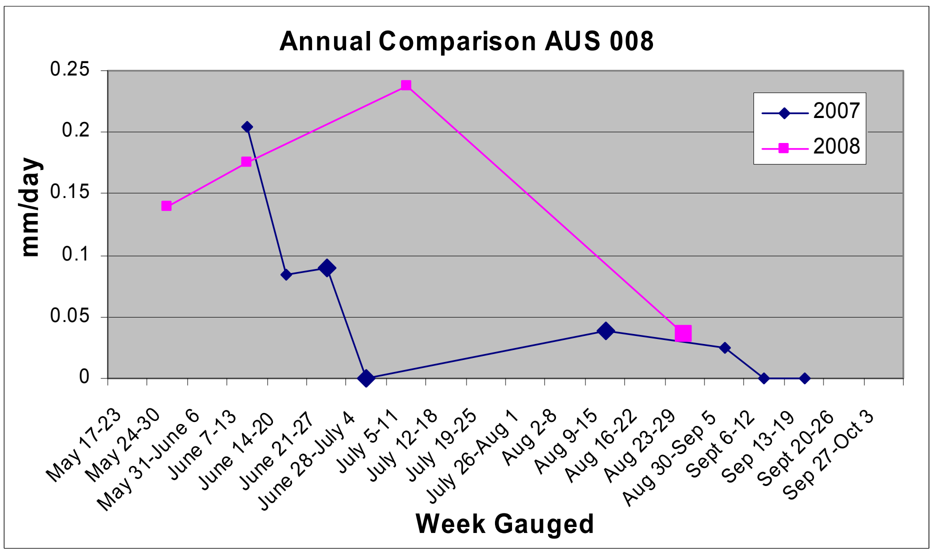


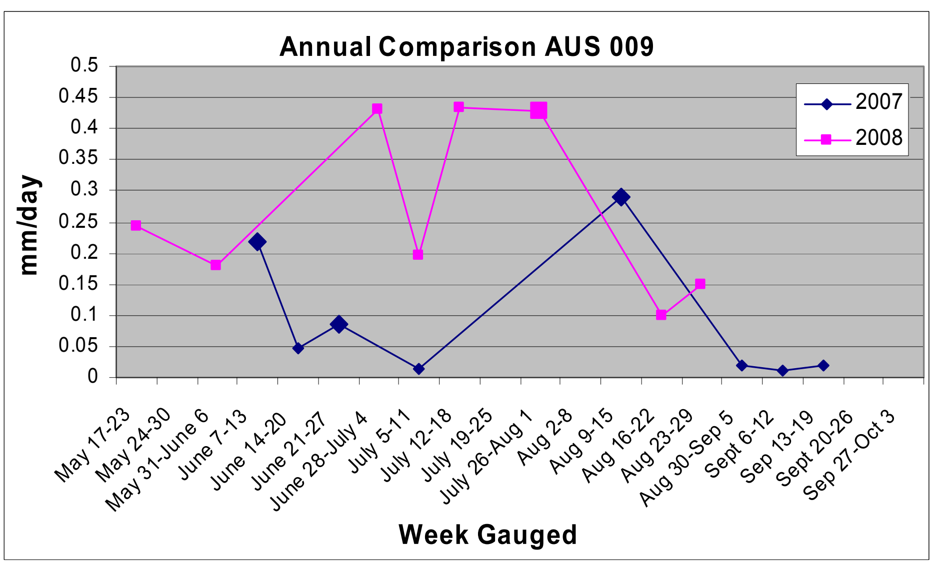


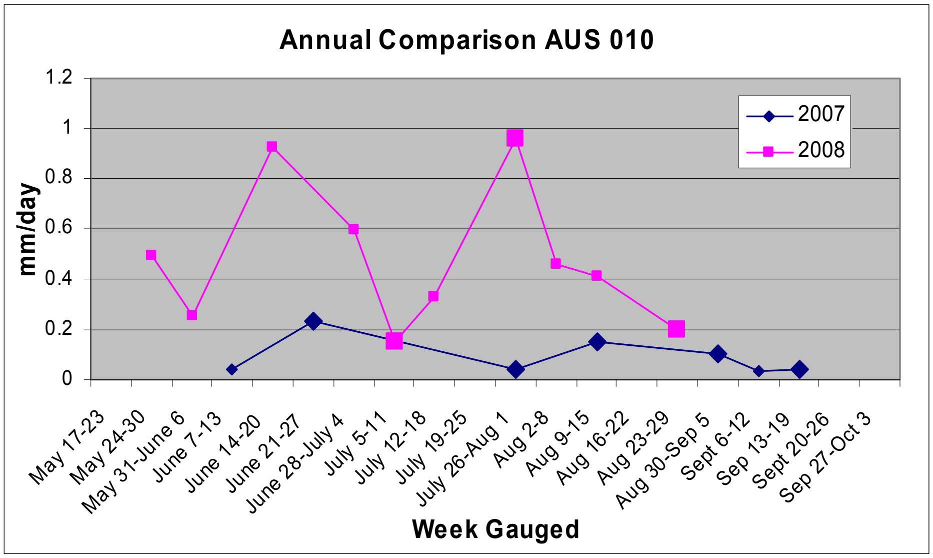
Note: AUS 005 was measured at the incorrect location in 2008 so a comparison isn't available

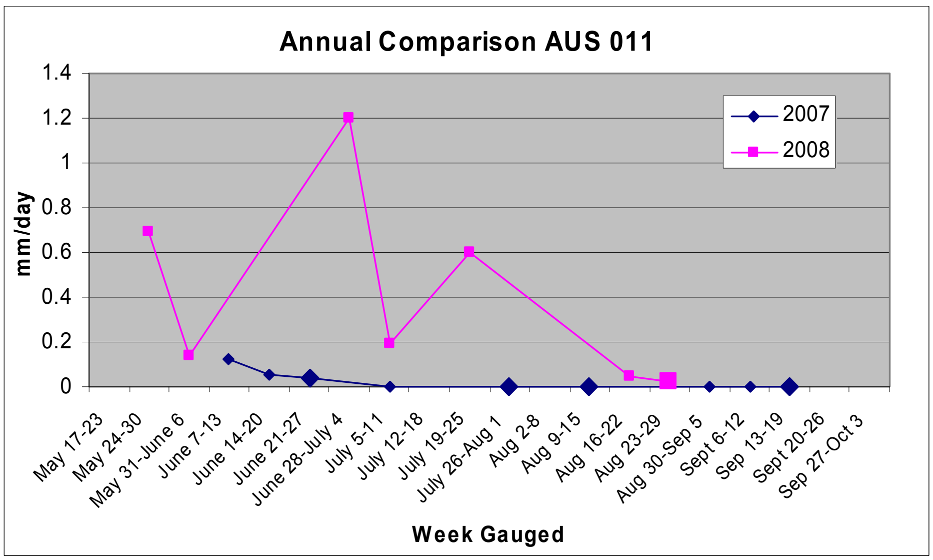


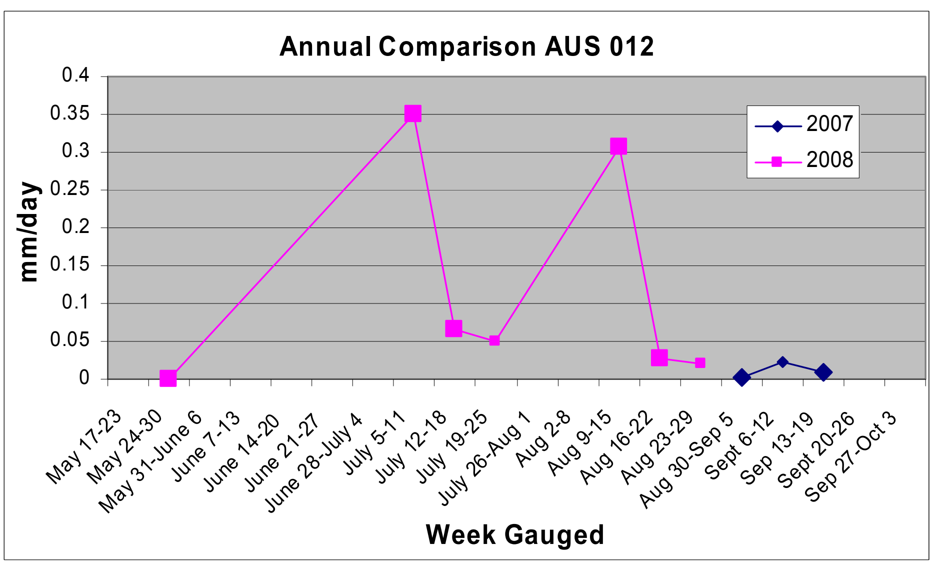

Annual Comparison AUS 007
mm/day
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

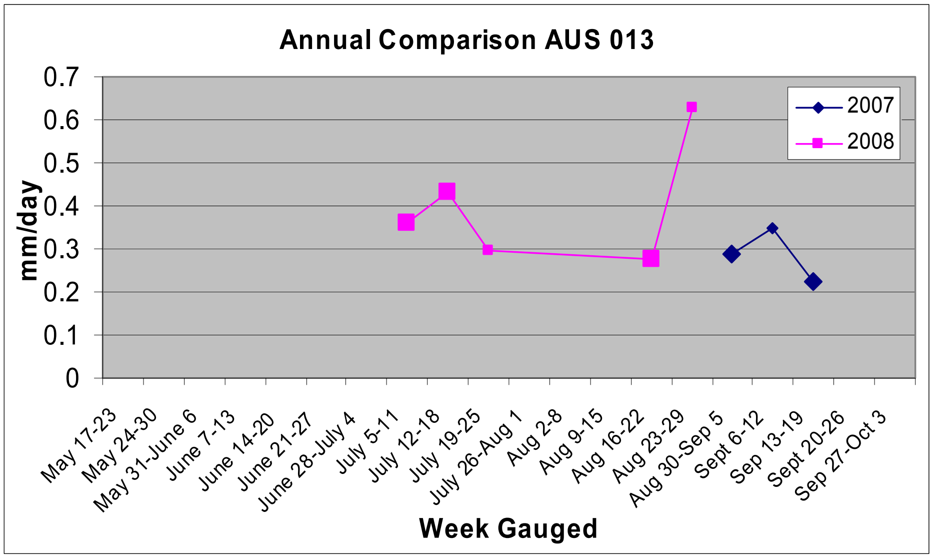

Annual Comparison AUS 008
mm/day
0.25
0.2
0.15
0.1
0.05
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged


Annual Comparison AUS 009
mm/day
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

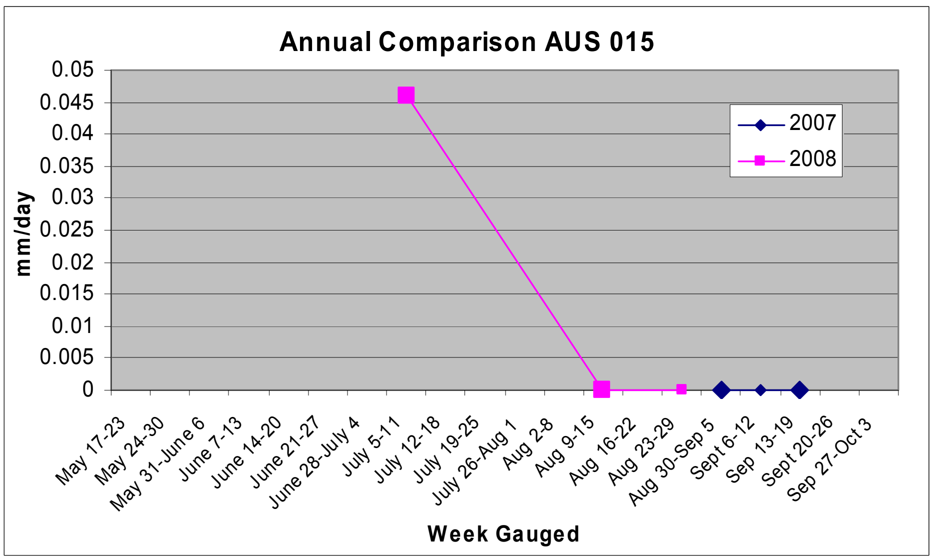

Annual Comparison AUS 010
mm/day
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

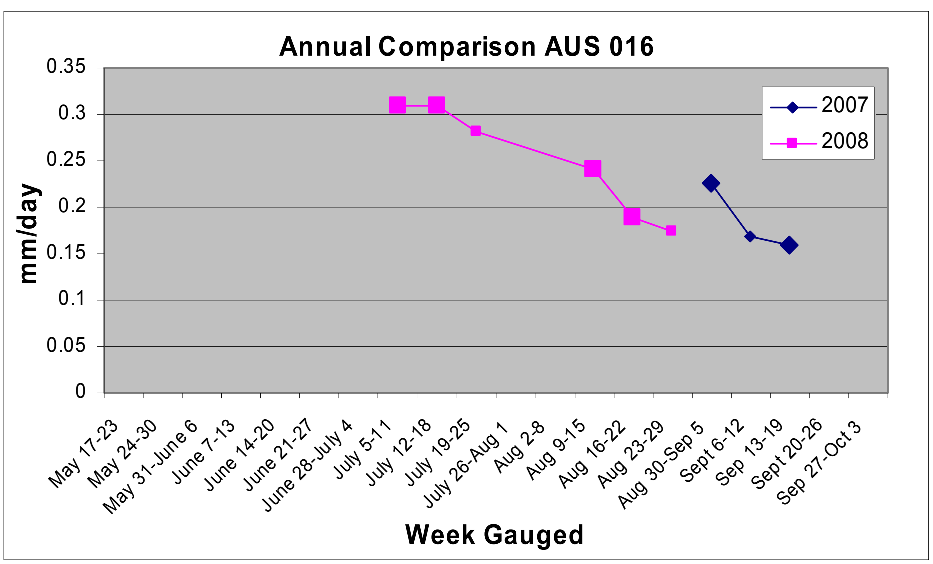

Annual Comparison AUS 011
mm/day
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

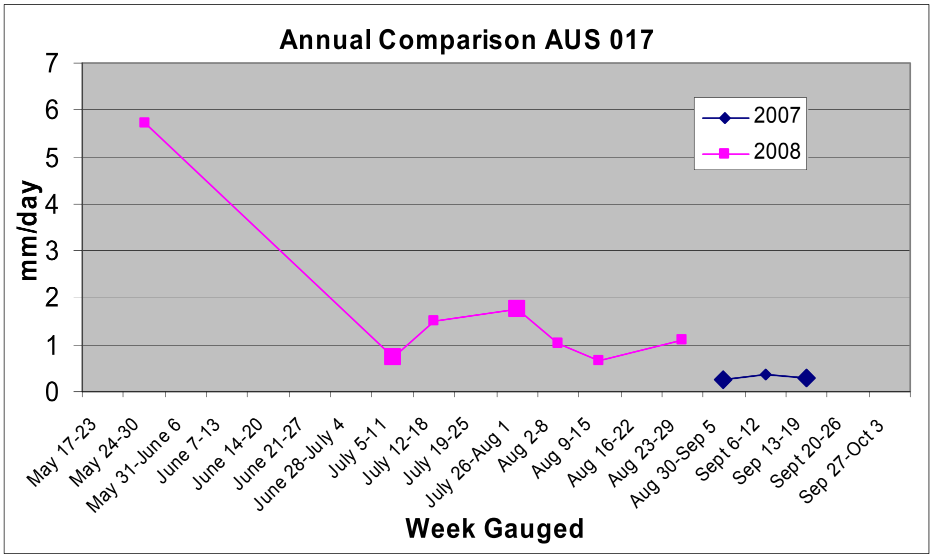

Annual Comparison AUS 012
mm/day
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

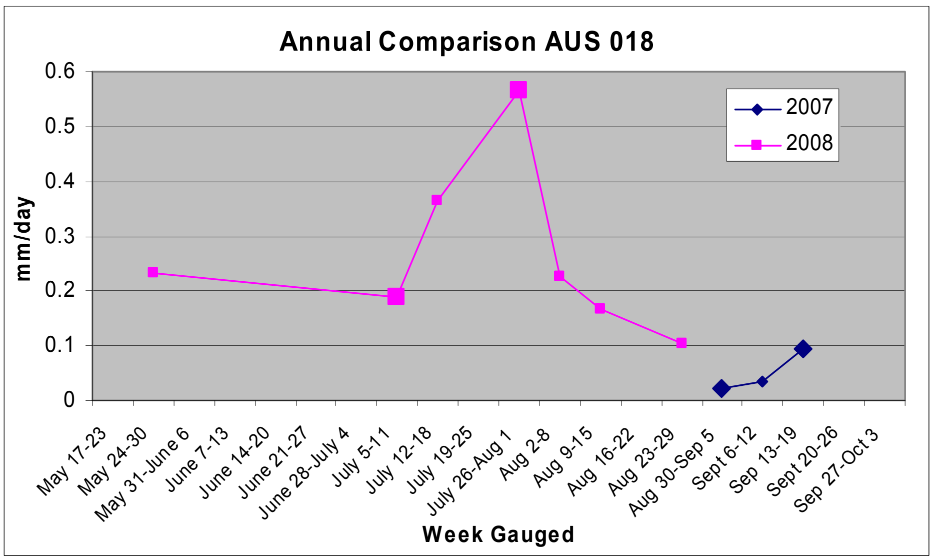


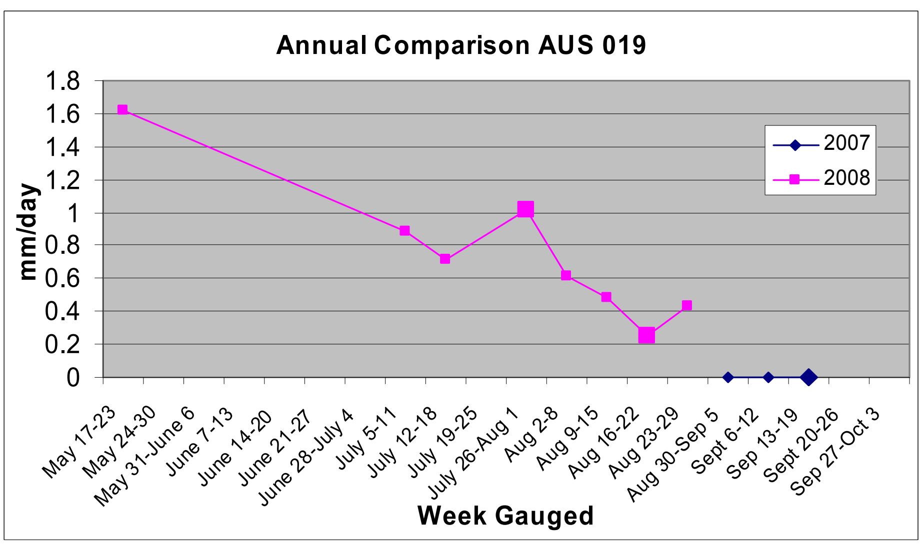
Note: No comparison for AUS 14 since it was taken at an incorrect location



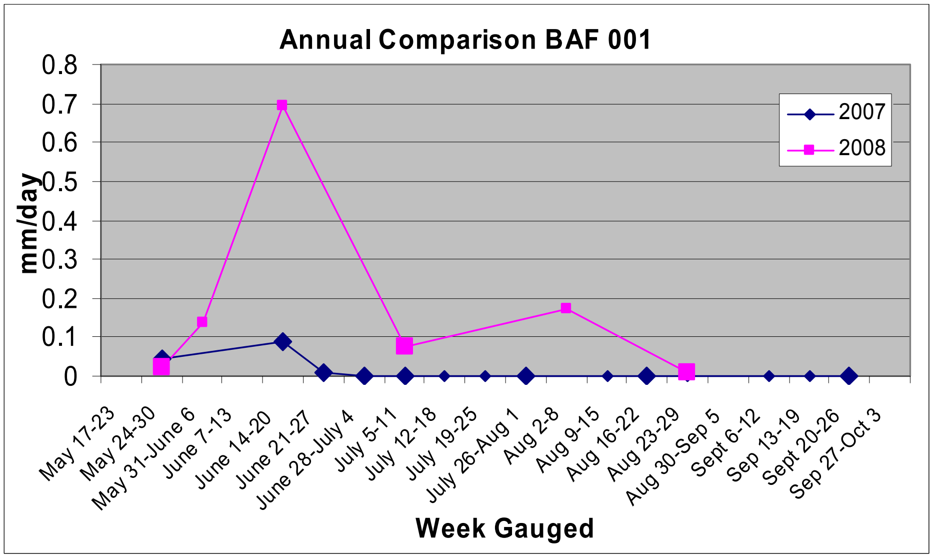


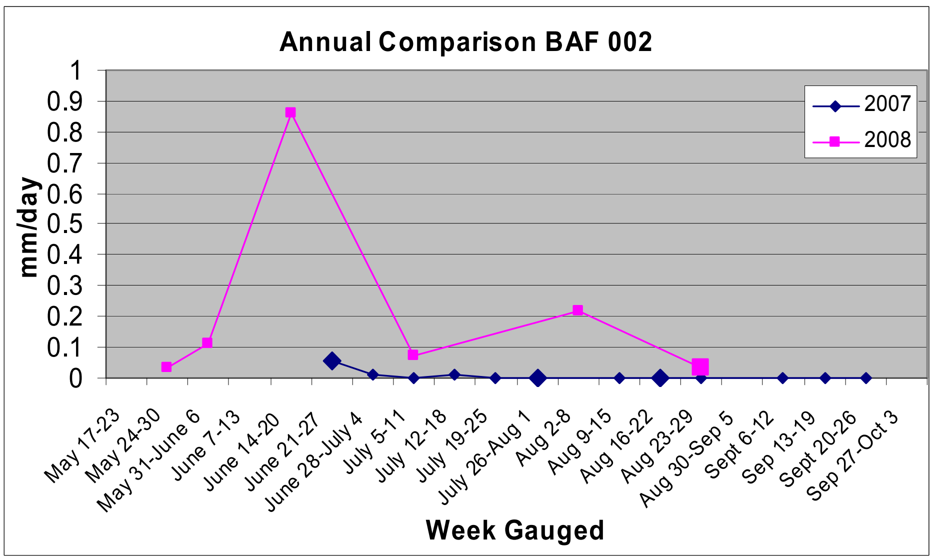


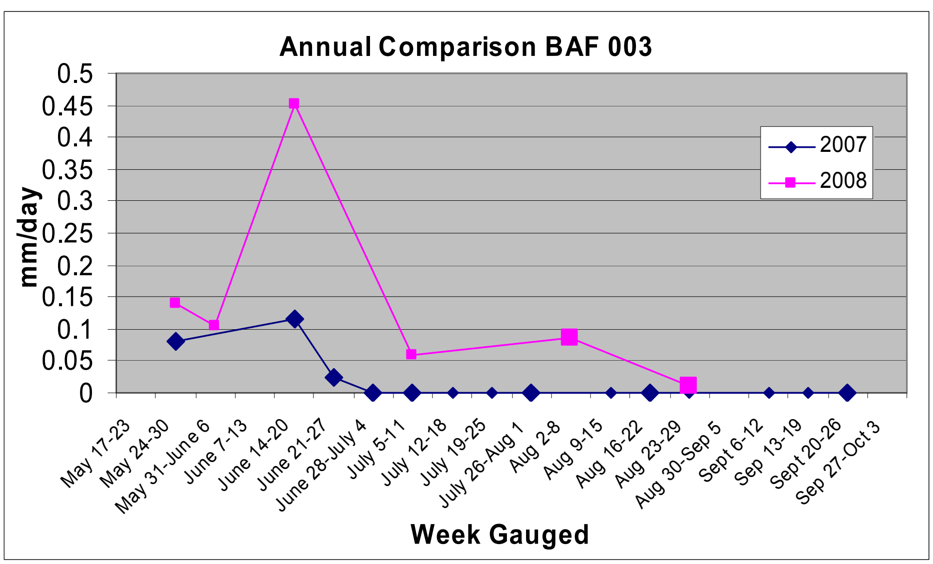


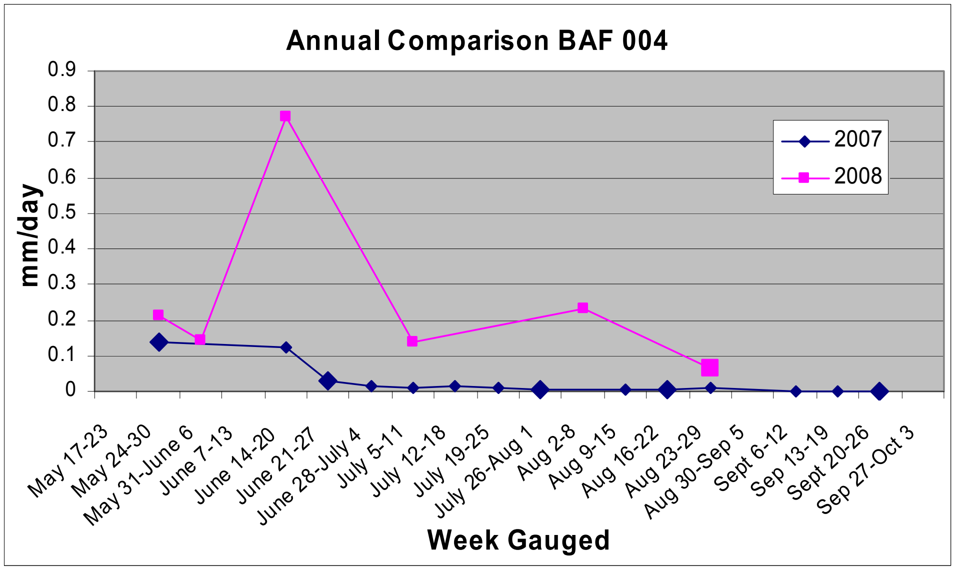


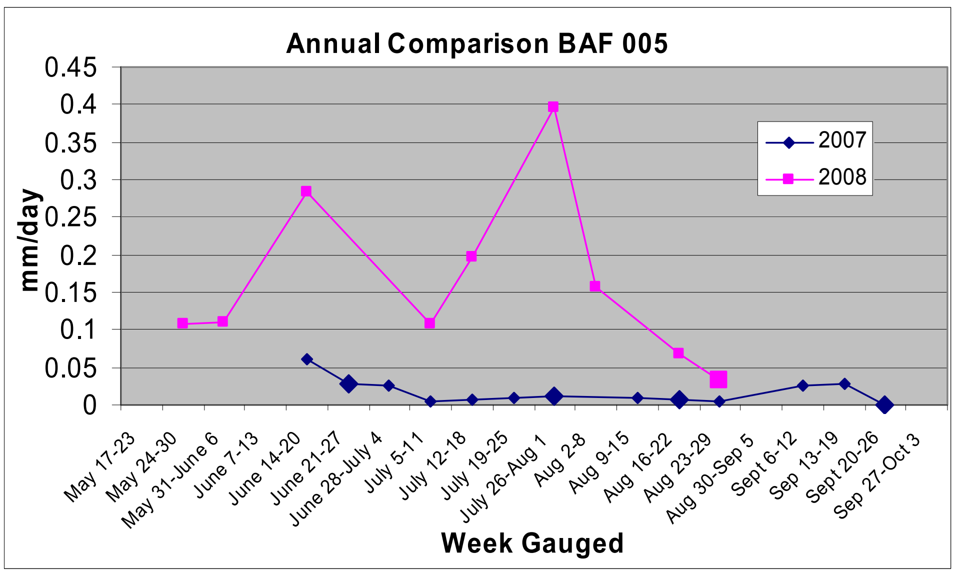
In 2007 site AUS-019 had a beaver dam just downstream of the monitoring location which resulted in no flow. However, in 2008 this monitoring site had flow for the entire duration of the study.


Annual Comparison BAF 001
mm/day
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged


Annual Comparison BAF 002
mm/day
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

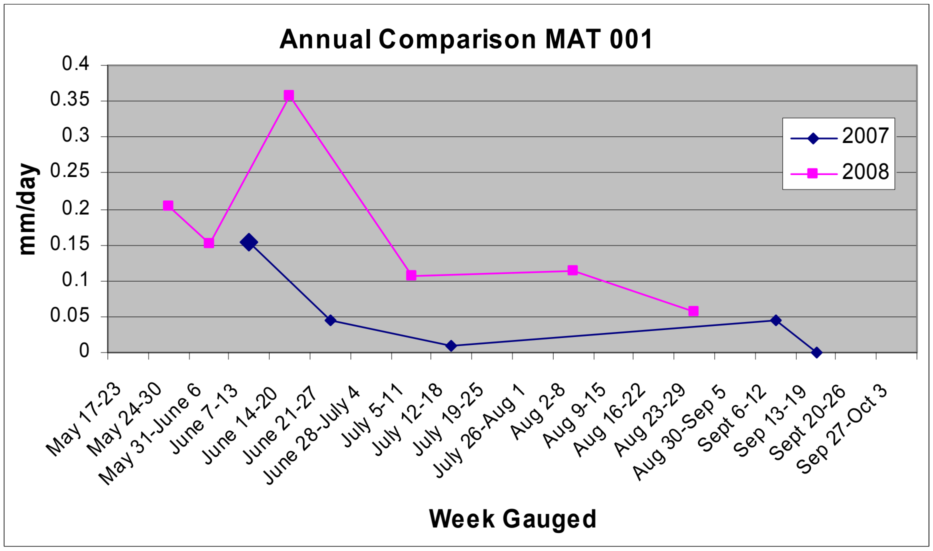

Annual Comparison BAF 003
mm/day
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

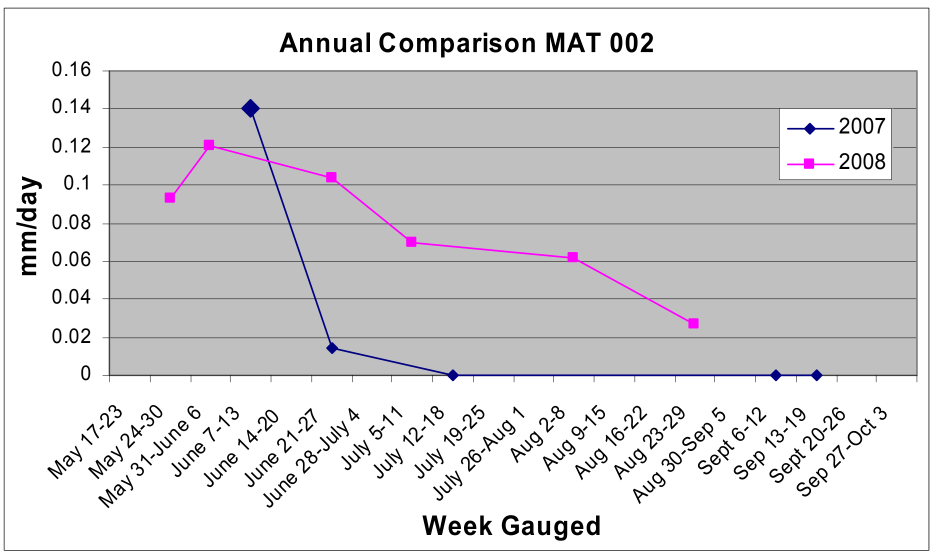


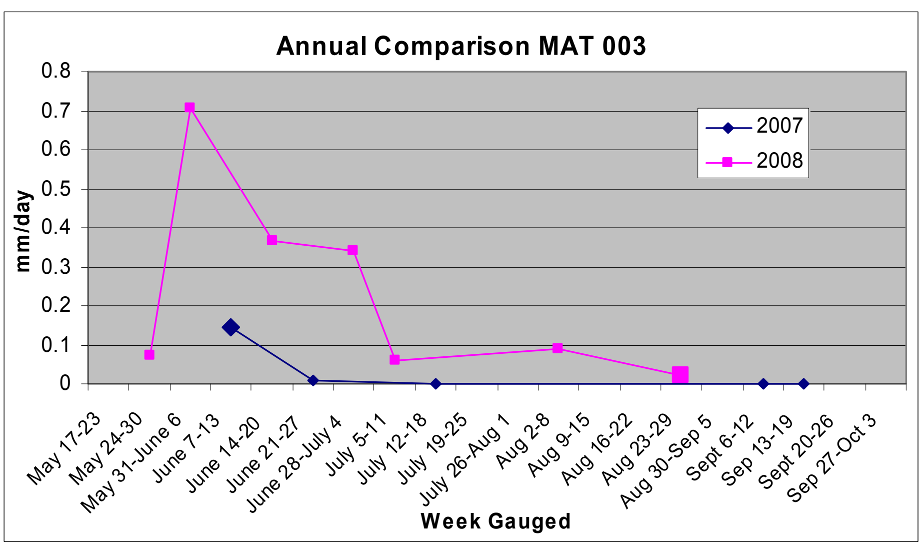


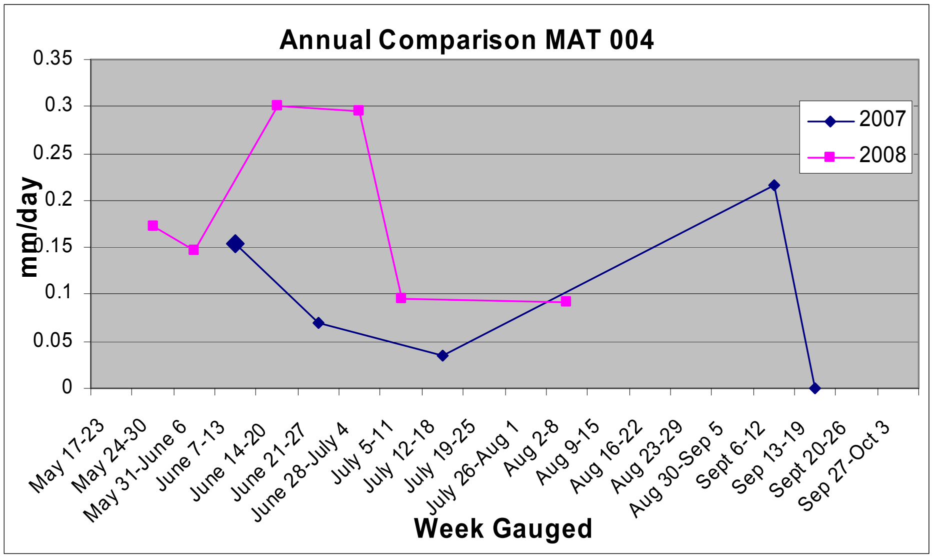
Note: In 2008, BAF 006 was measured at the incorrect location so no comparison is available.

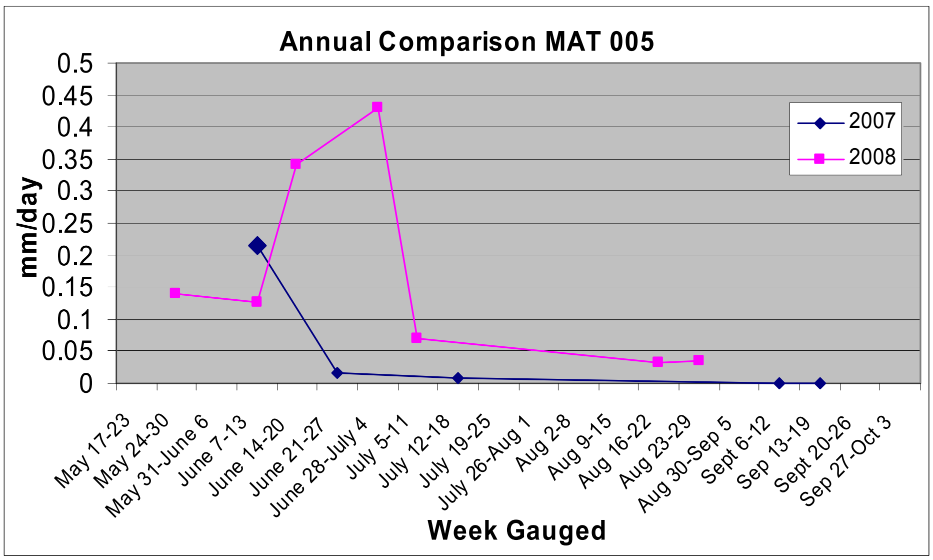
Maitland River Annual Comparison Graphs



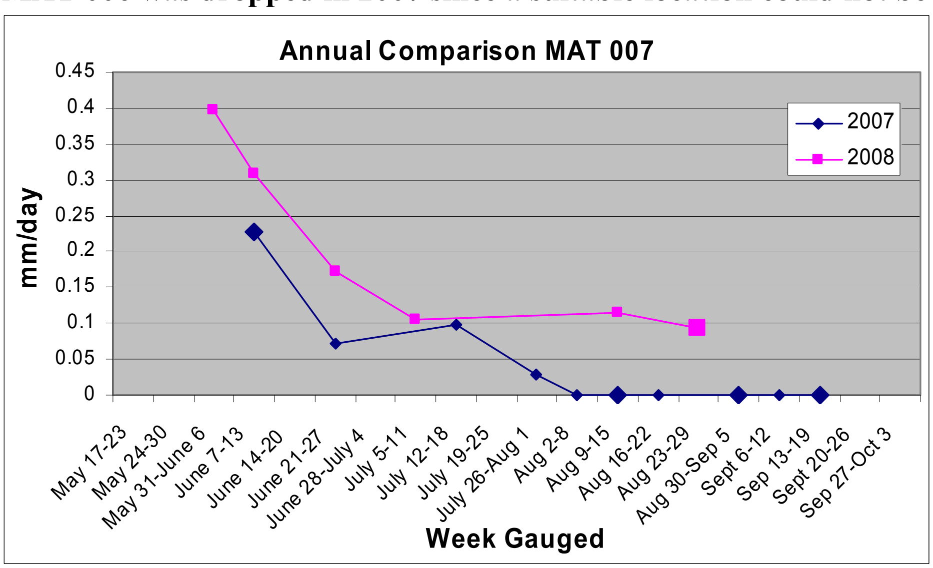


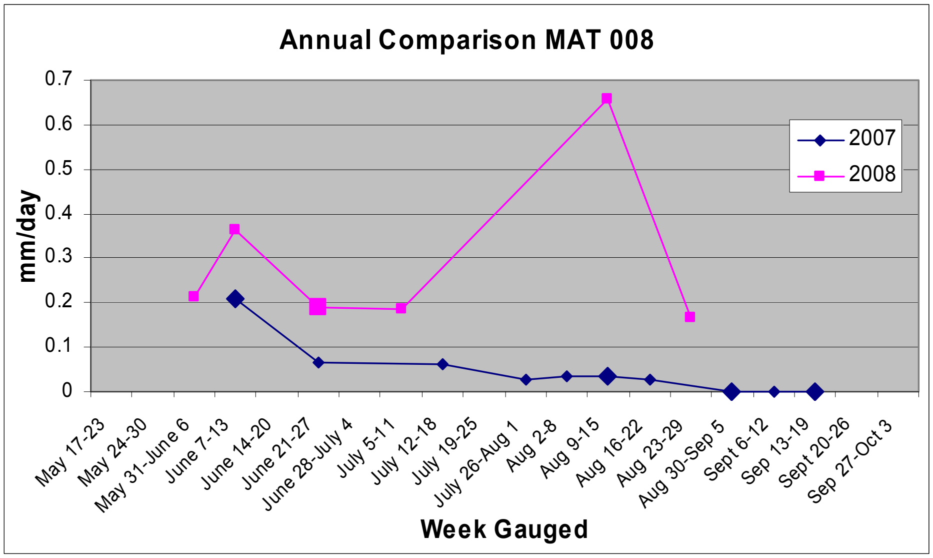


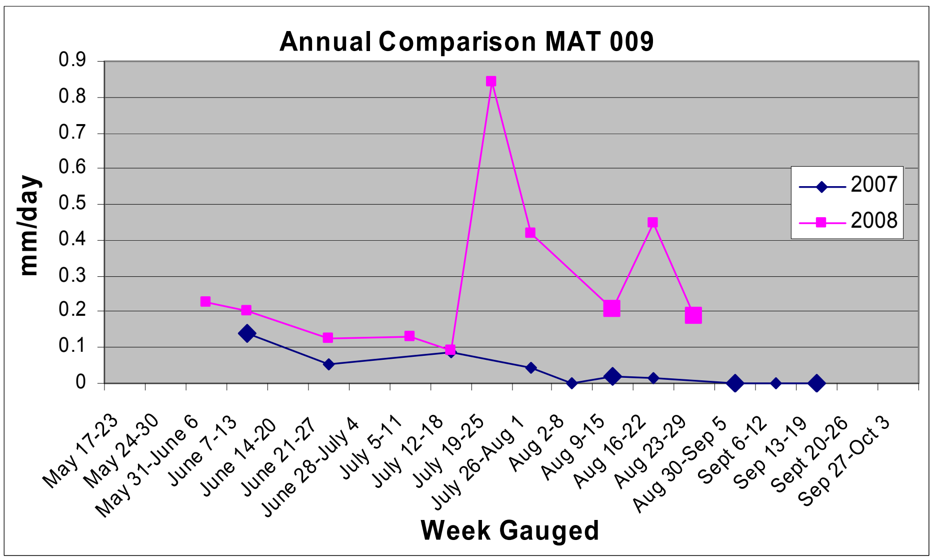


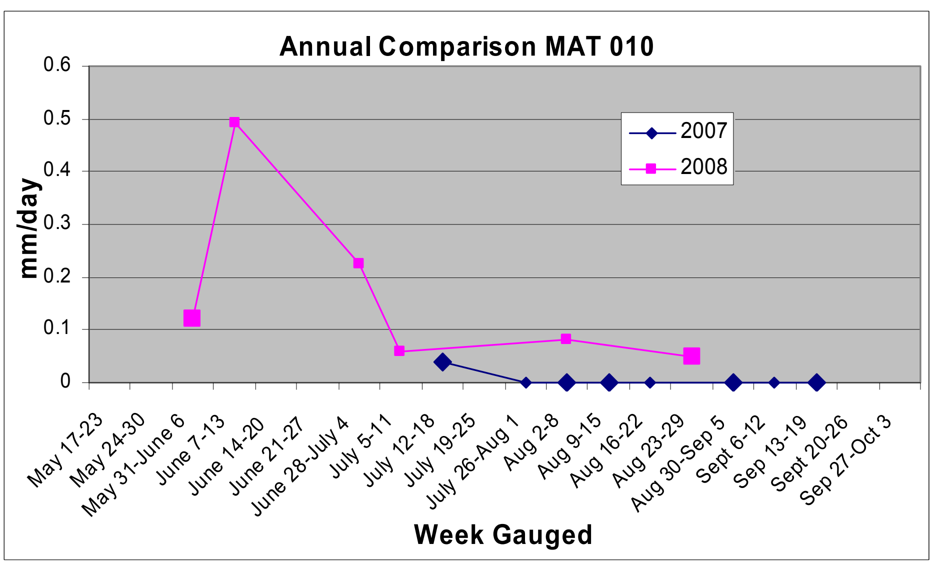


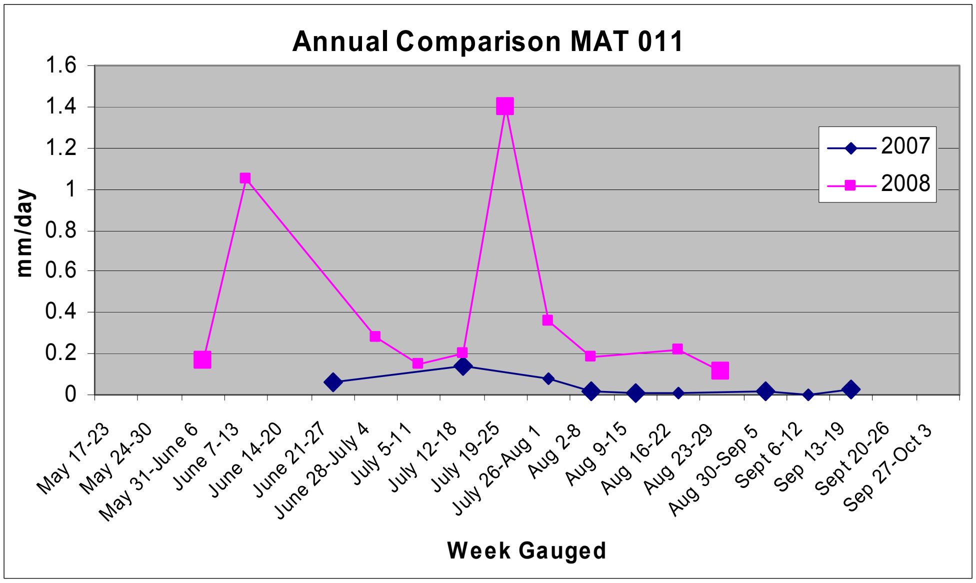
Note: MAT 006 was dropped in 2007 since a suitable location could not be found

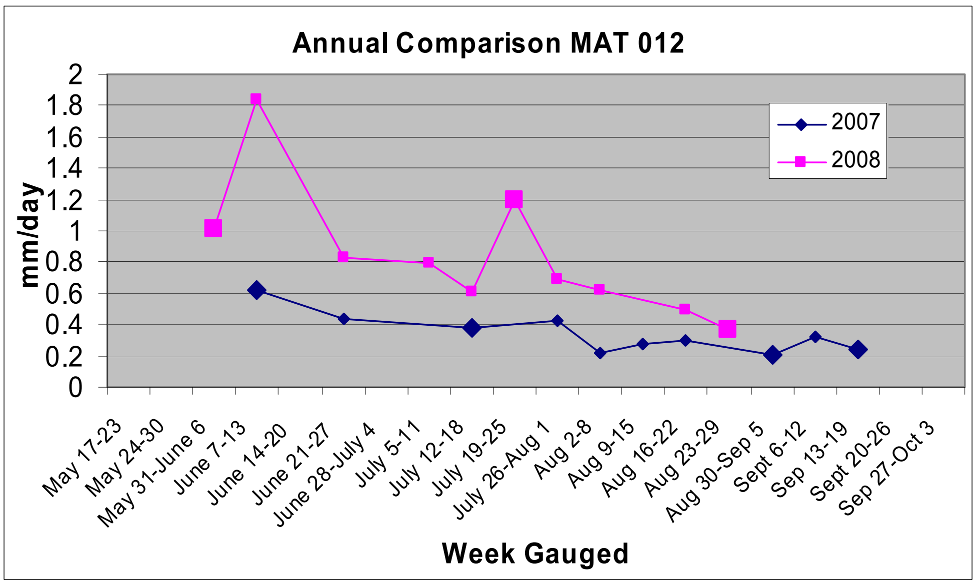


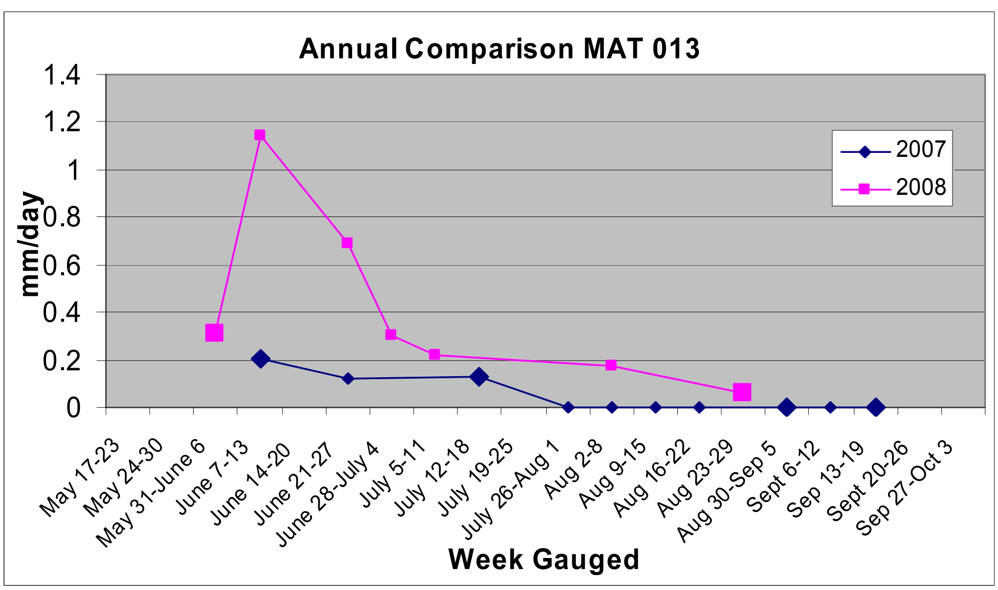

Annual Comparison MAT 008
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mm/day
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

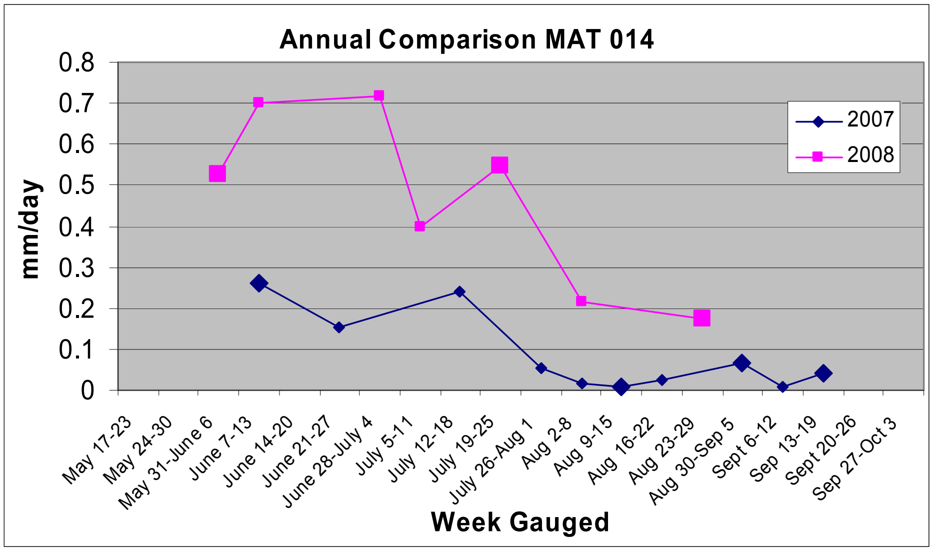

Annual Comparison MAT 009
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mm/day
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

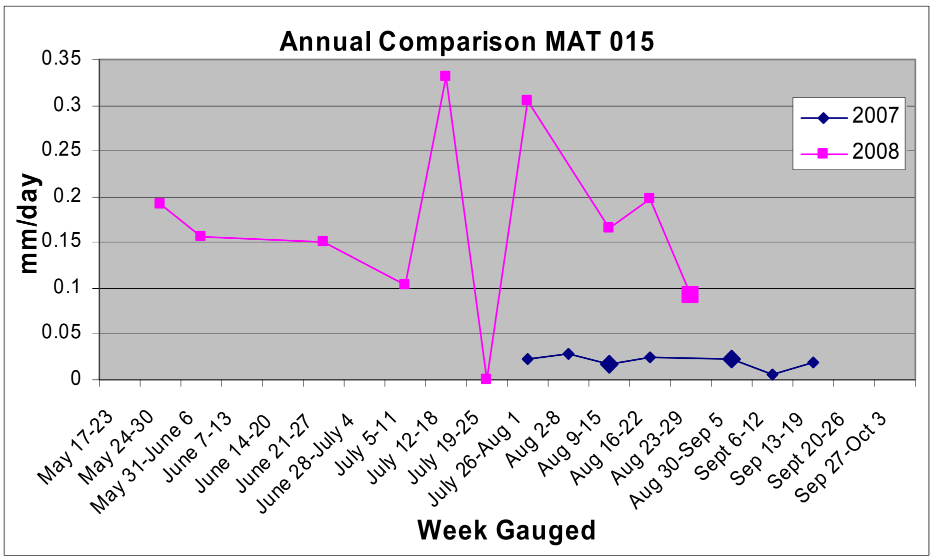

Annual Comparison MAT 010
0.6
0.5
0.4
0.3
0.2
0.1
0
mm/day
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

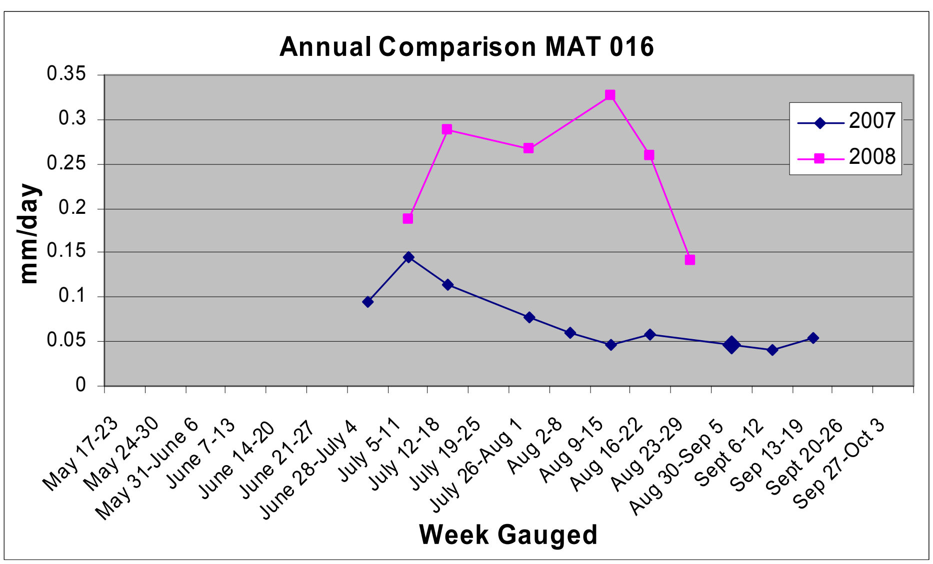

Annual Comparison MAT 011
mm/day
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged


Annual Comparison MAT 012
mm/day
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

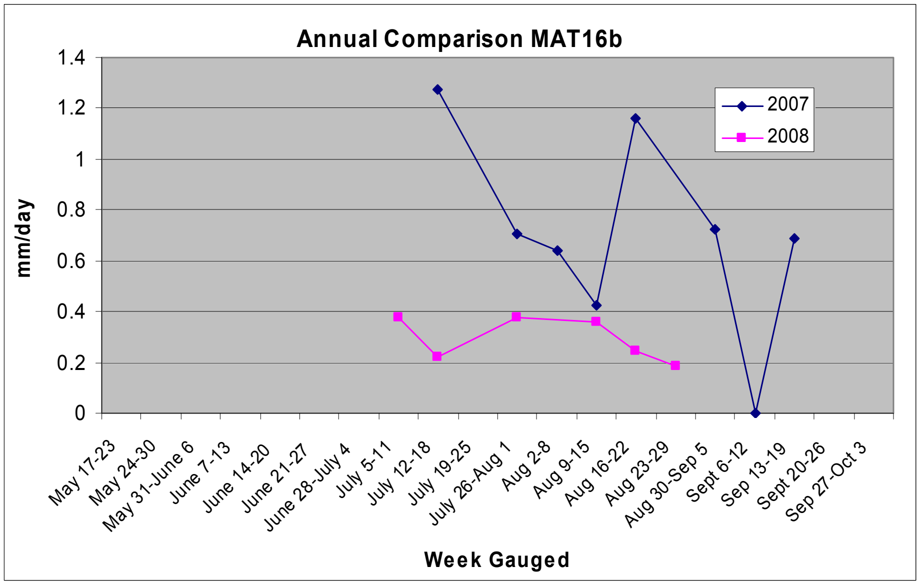

Annual Comparison MAT 013
mm/day
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged



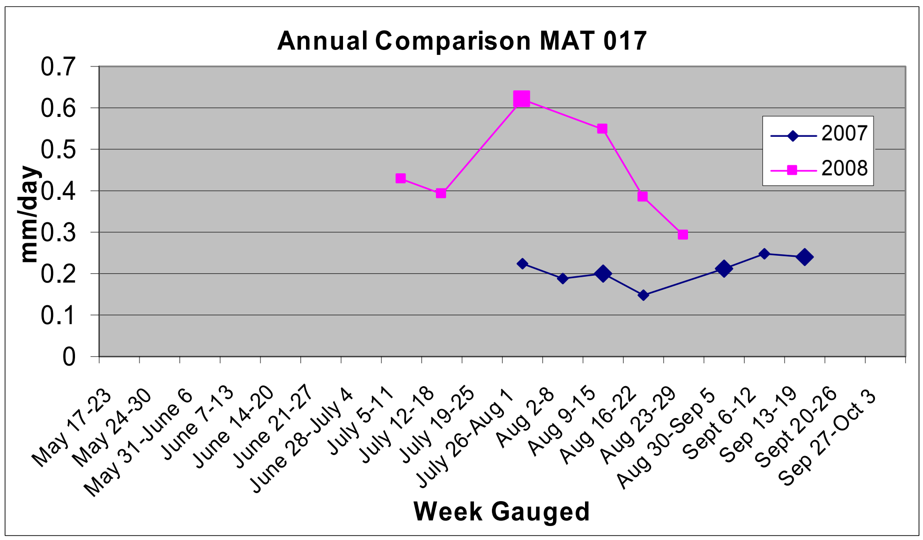


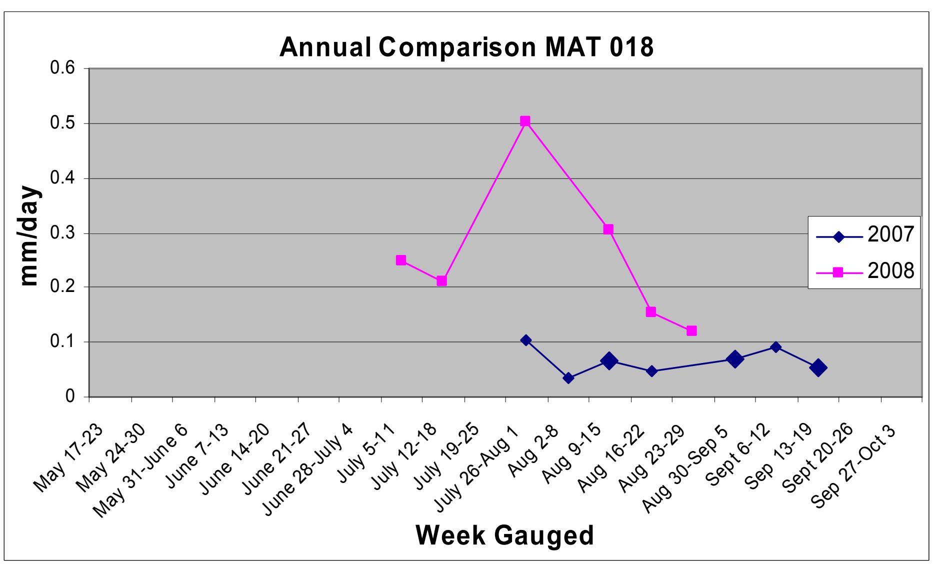


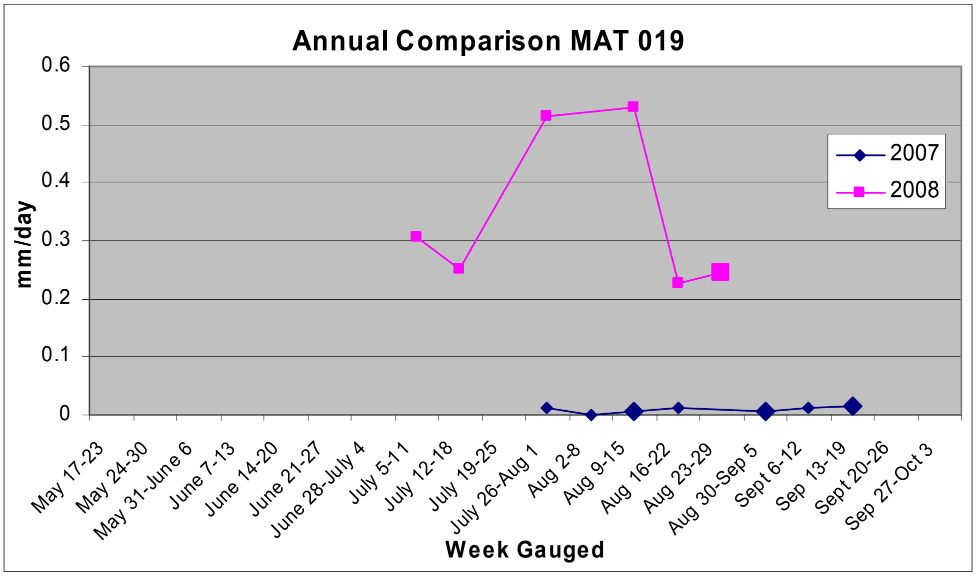
Note: The 2008 value was calculated by adding Wingham B with MAT 016b



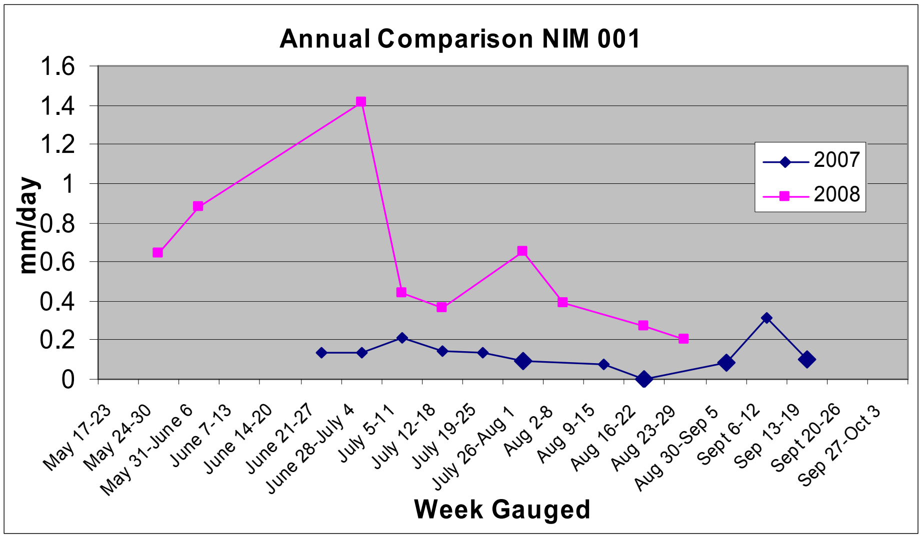
Note: The 2007 MAT 016b value was calculated by subtracting MAT016 from Wingham B

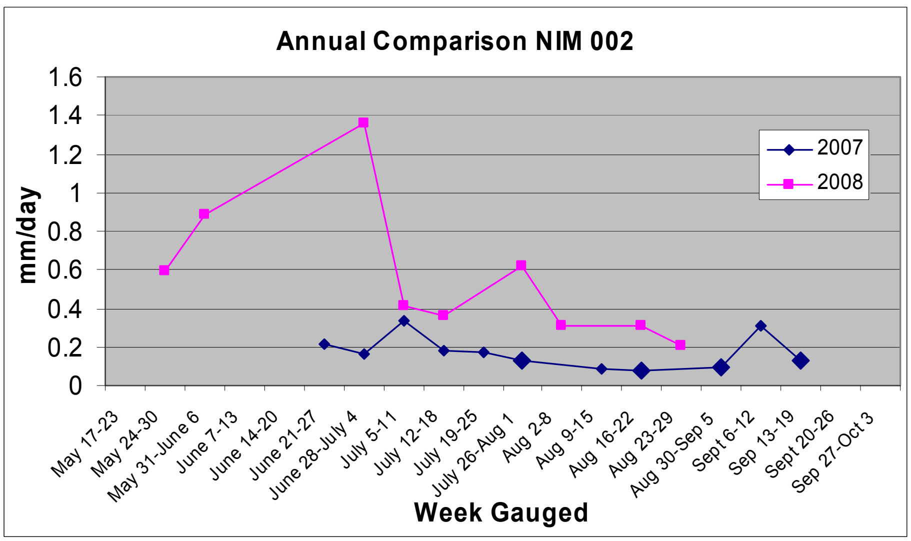


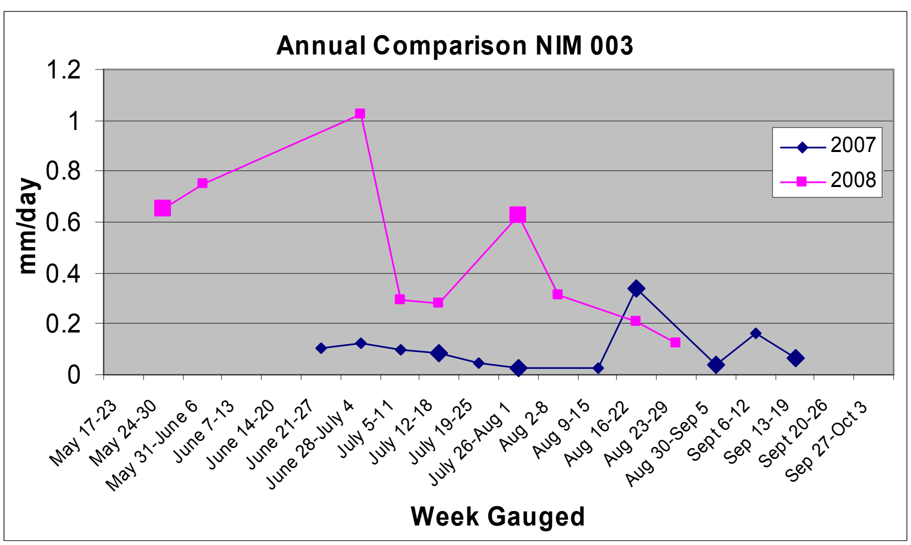



Annual Comparison MAT 019
mm/day
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

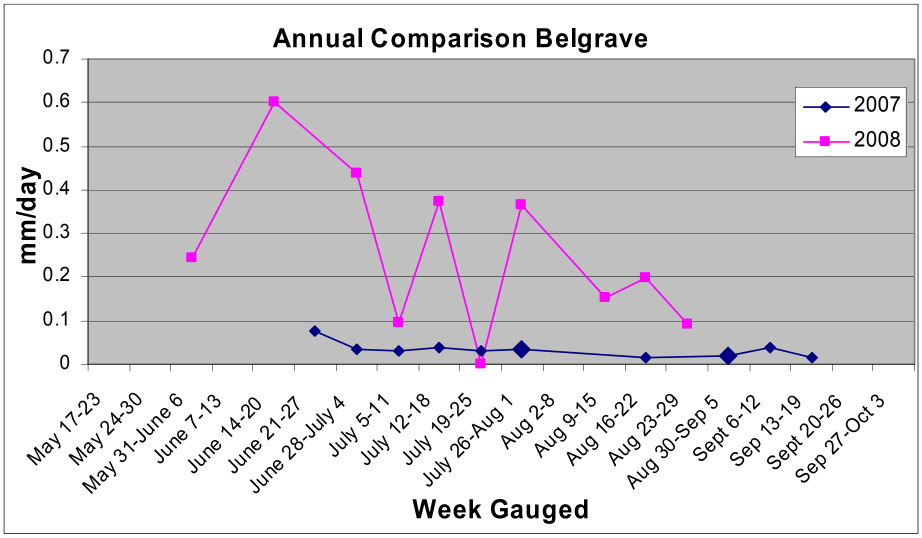
Nine Mile River Annual Comparison Graphs

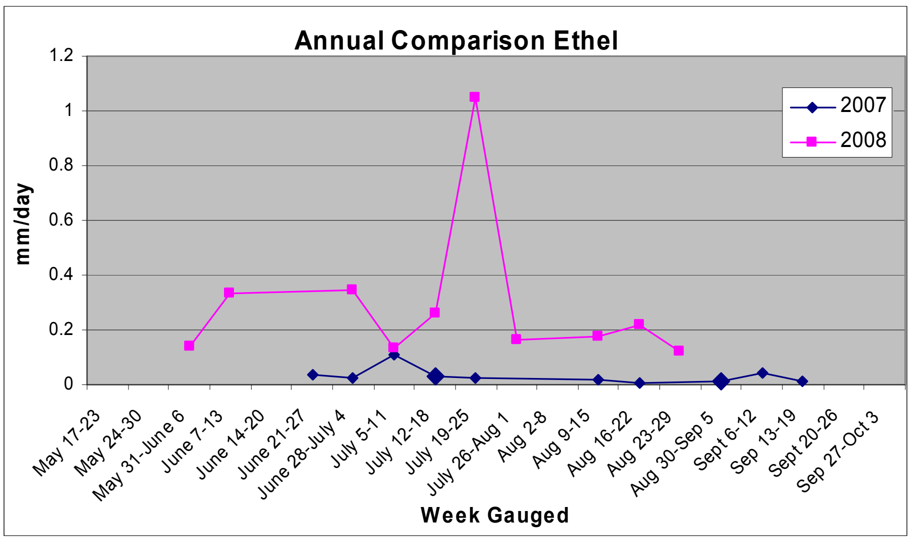


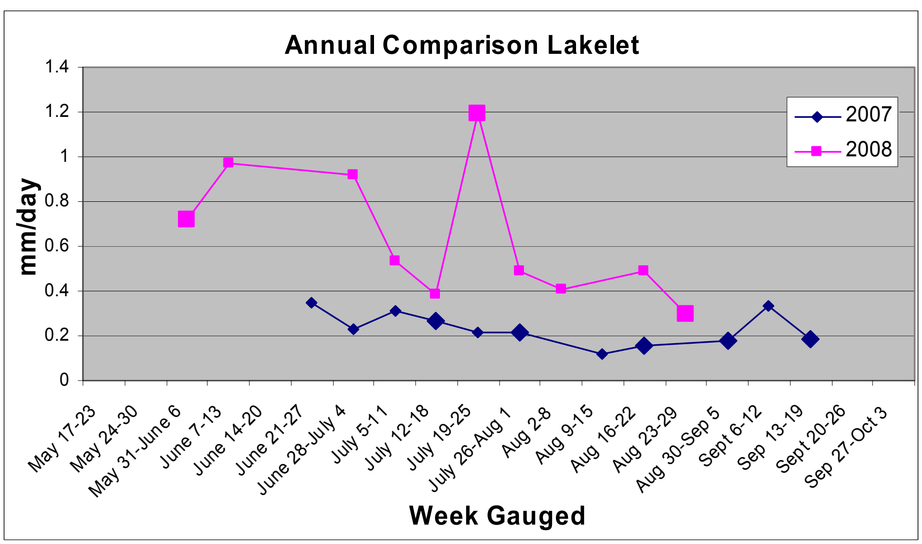


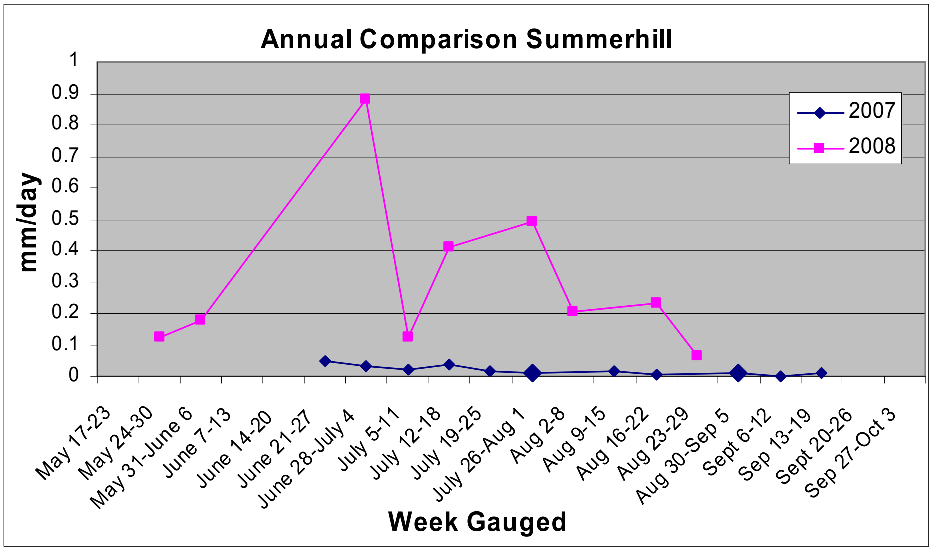


QA/QC Annual Comparison Graphs

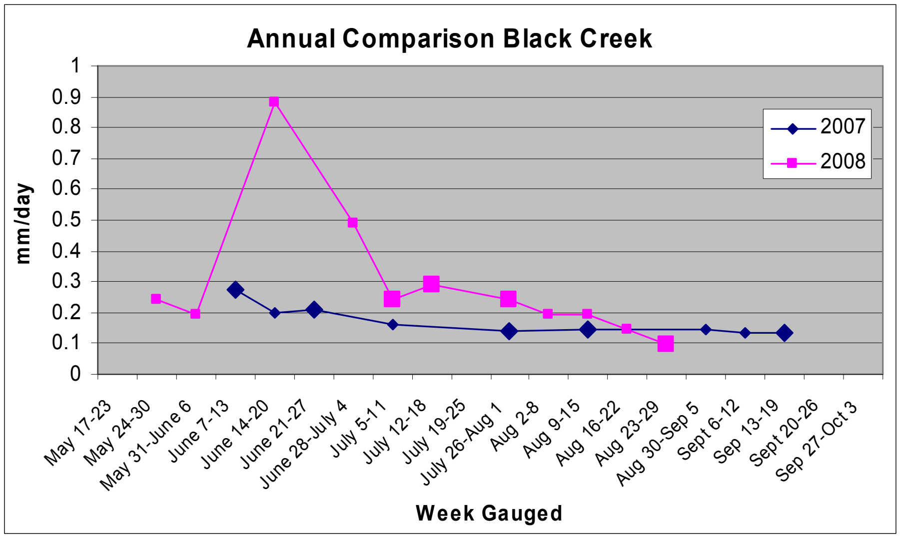


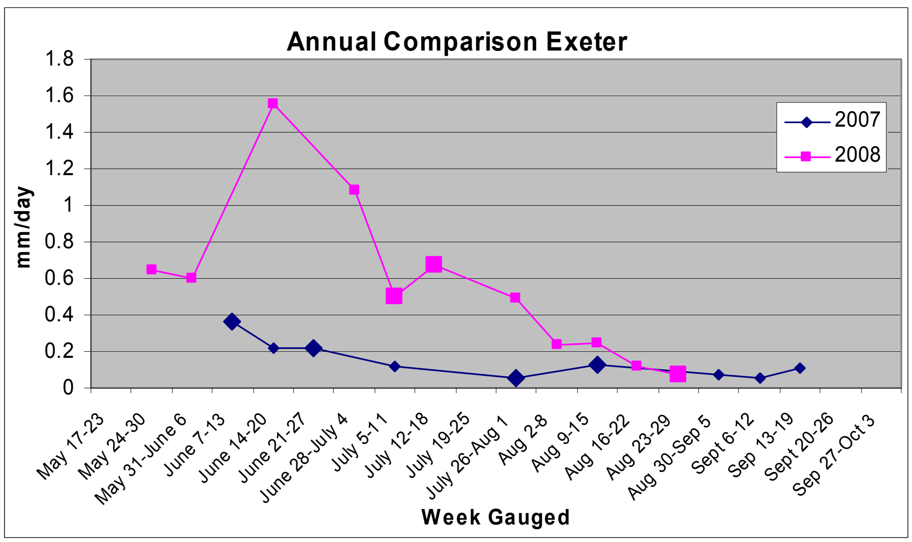


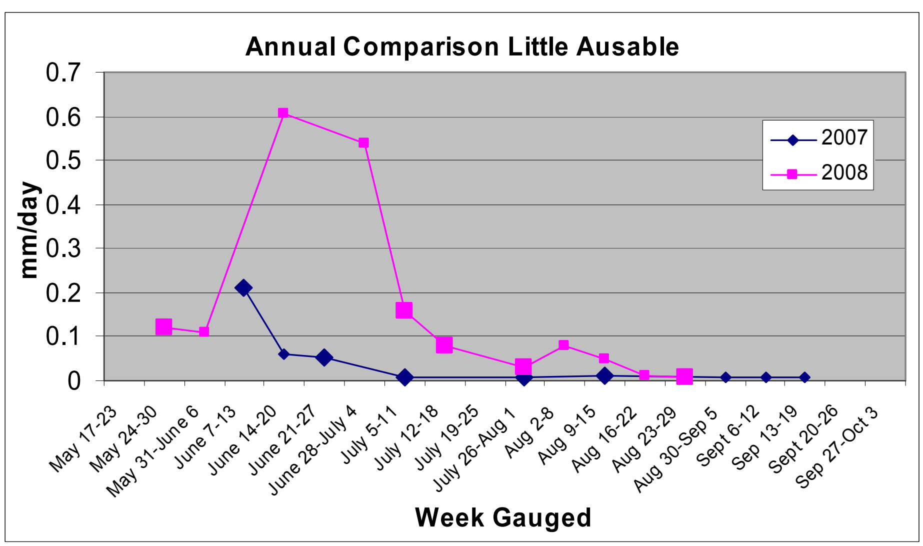


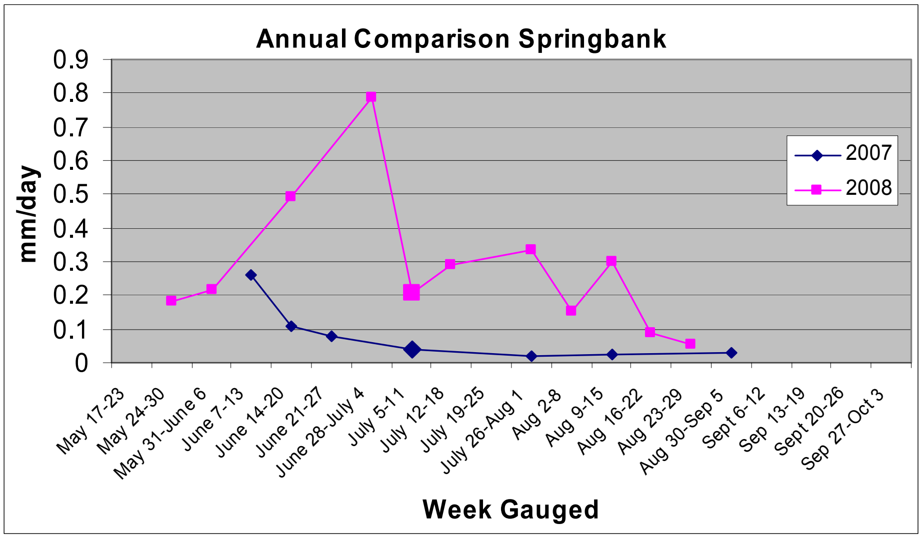

Annual Comparison Summerhill
mm/day
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

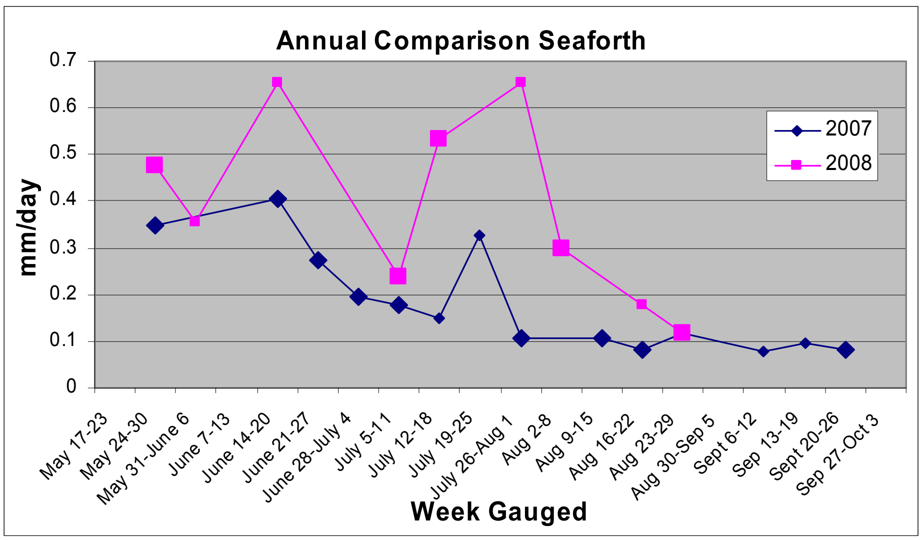
Permanent Gauge Annual Comparison Graphs



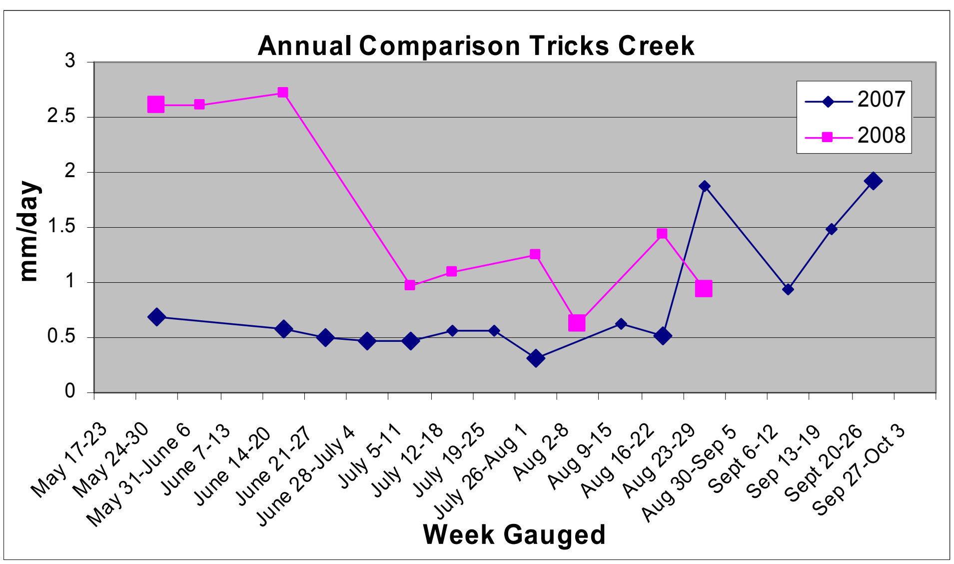


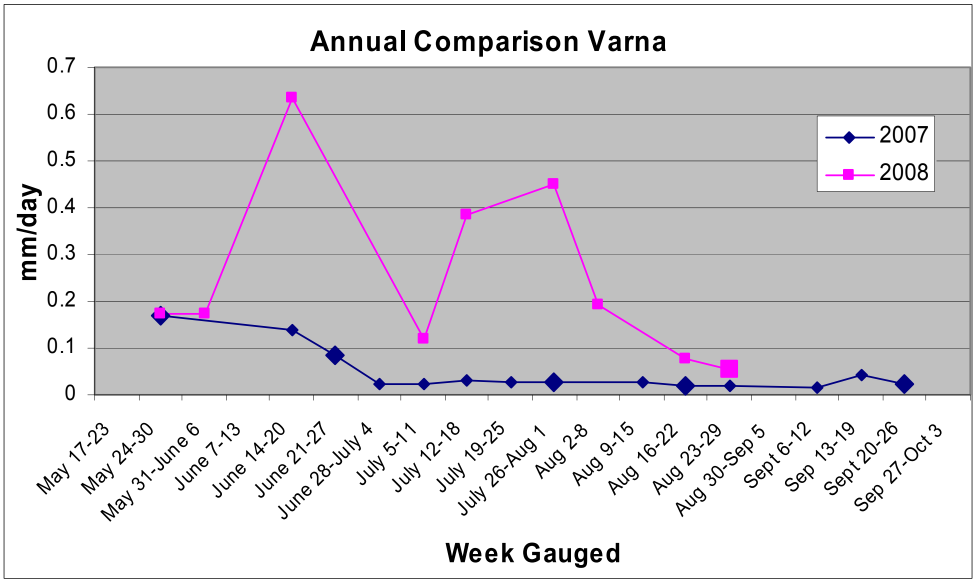


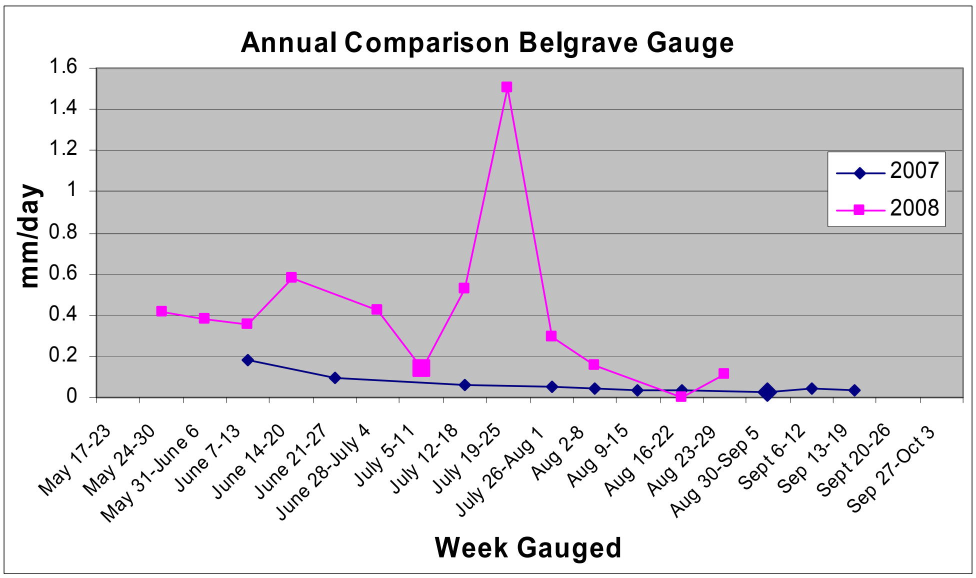


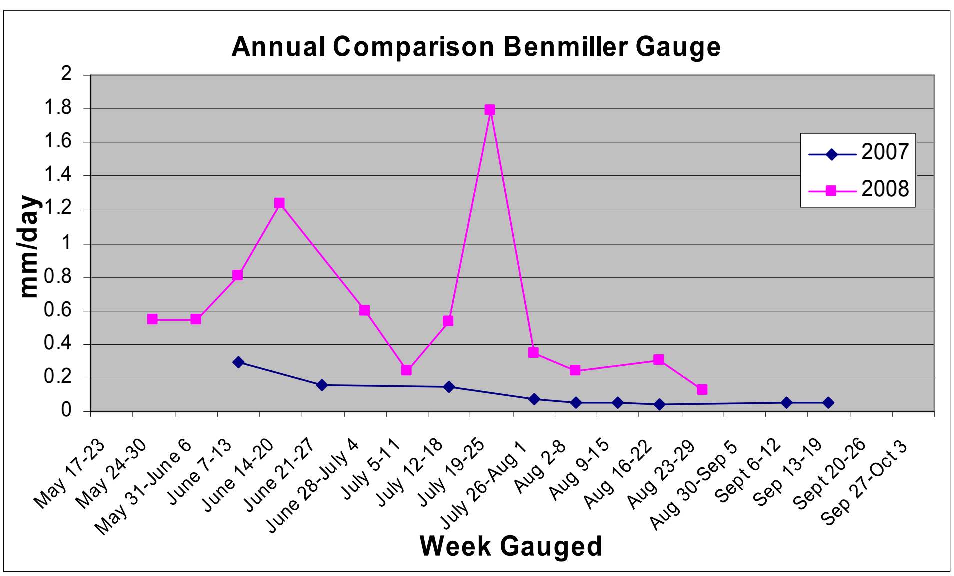


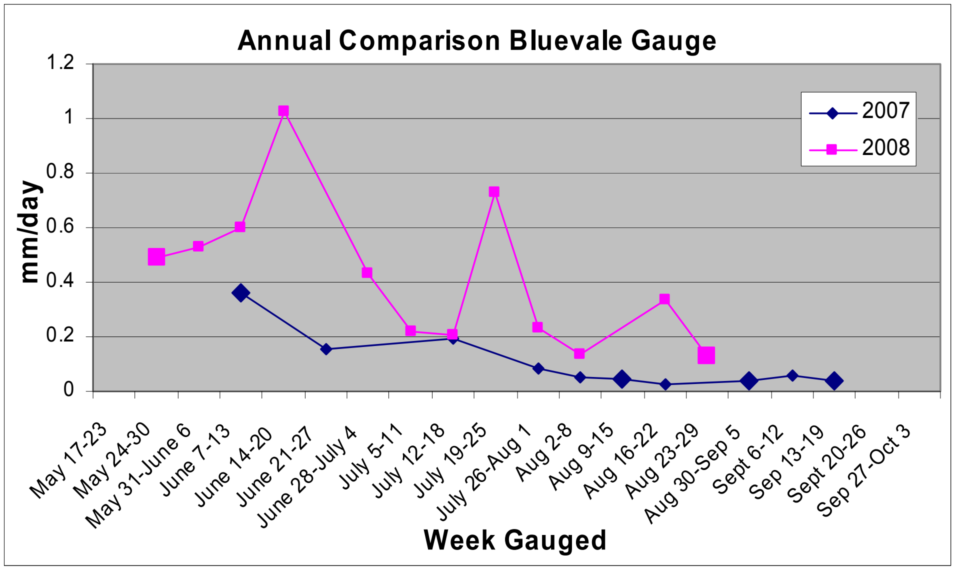
Note: Values from the Seaforth STP have not be obtained for 2008

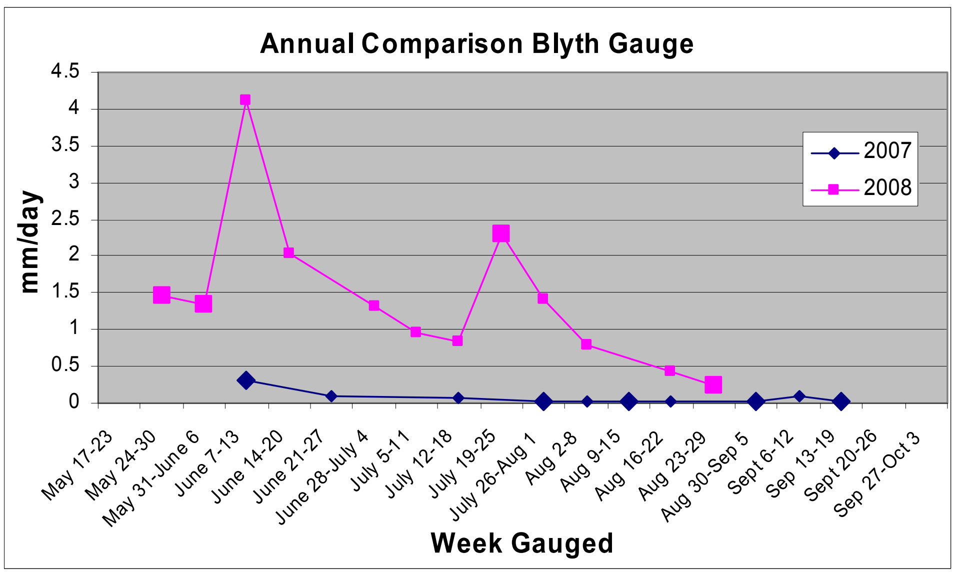



Annual Comparison Varna
mm/day
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

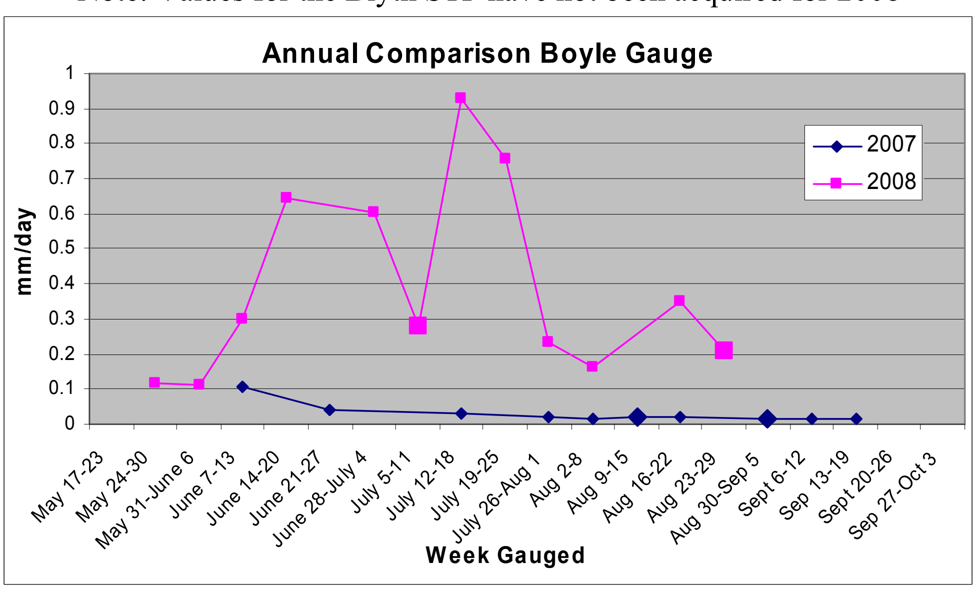

Annual Comparison Belgrave Gauge
mm/day
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

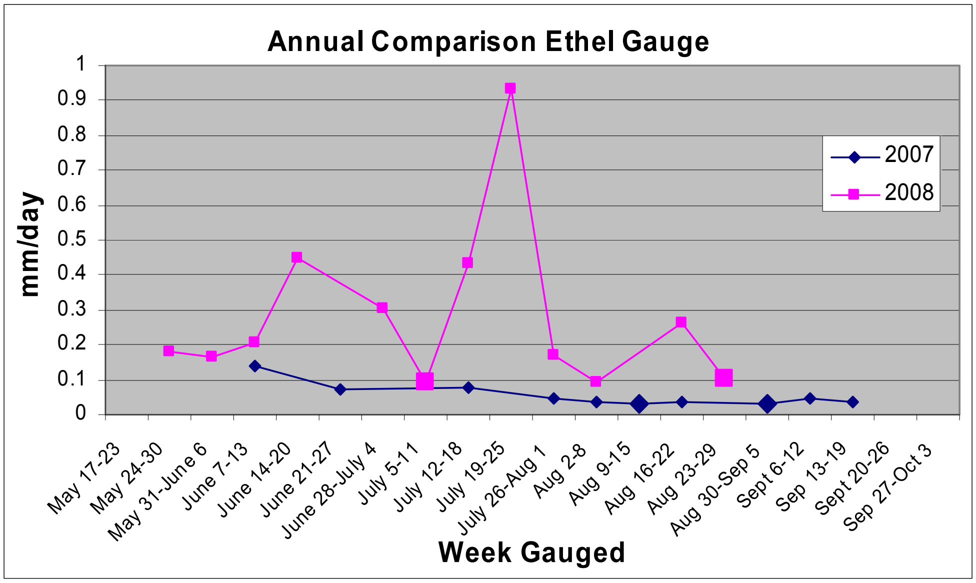

Annual Comparison Benmiller Gauge
mm/day
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

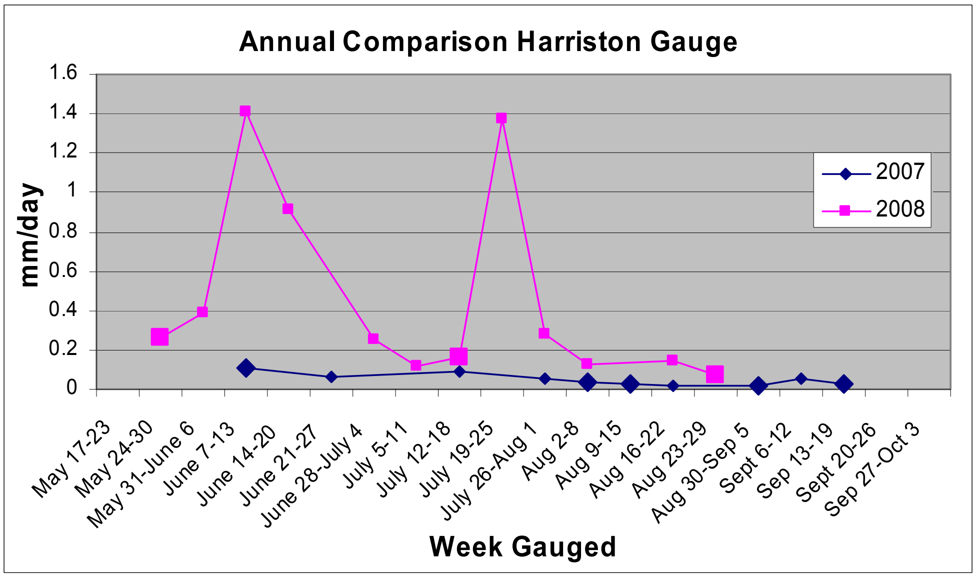


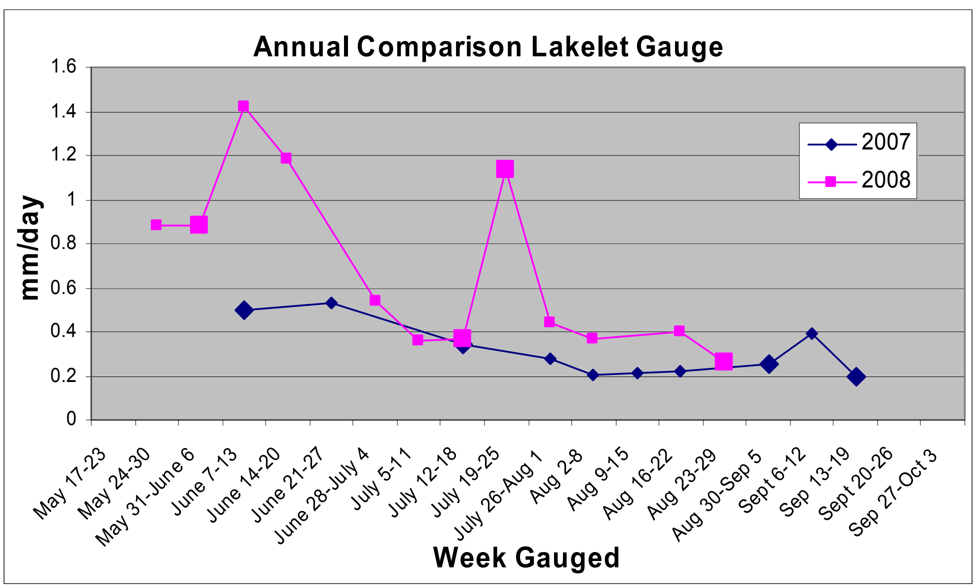


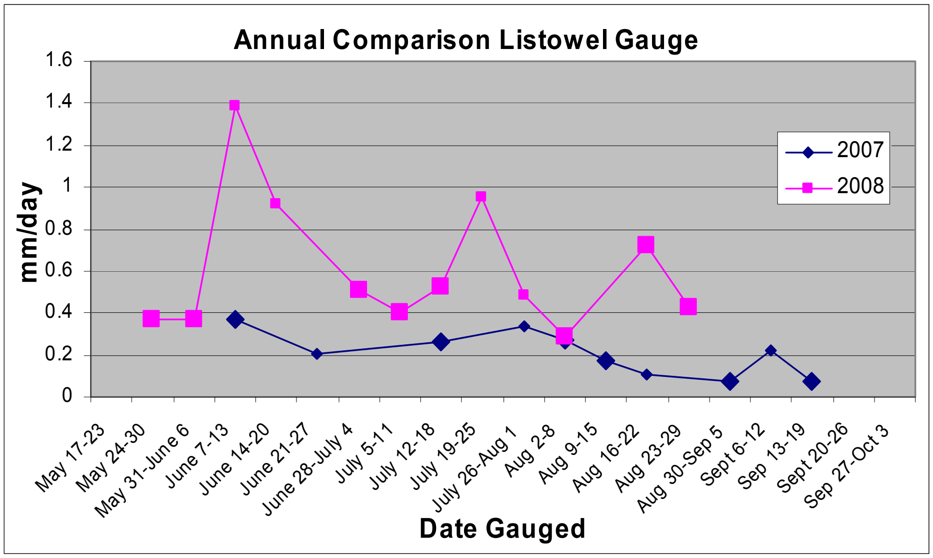
Note: Values for the Blyth STP have not been acquired for 2008



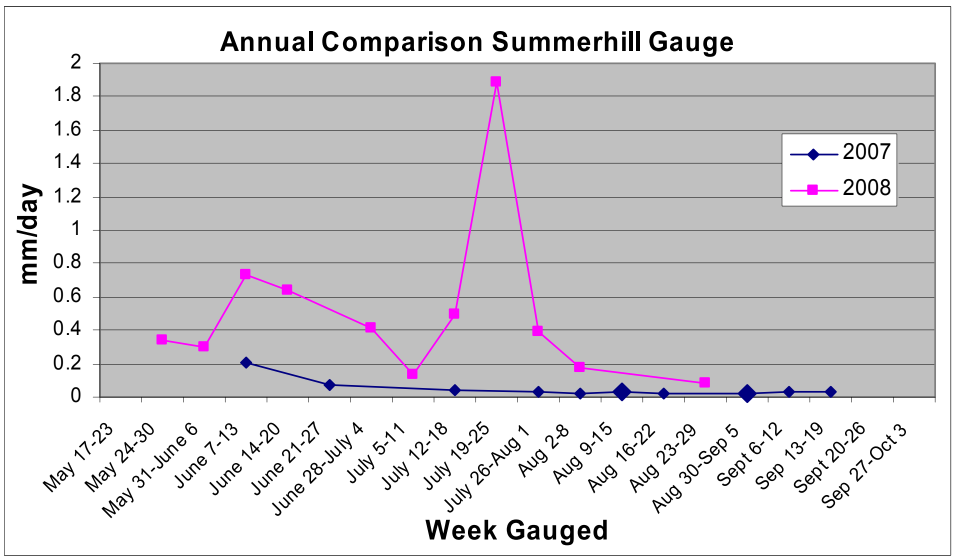

Annual Comparison Ethel Gauge
mm/day
Week Gauged
2007
2008
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3

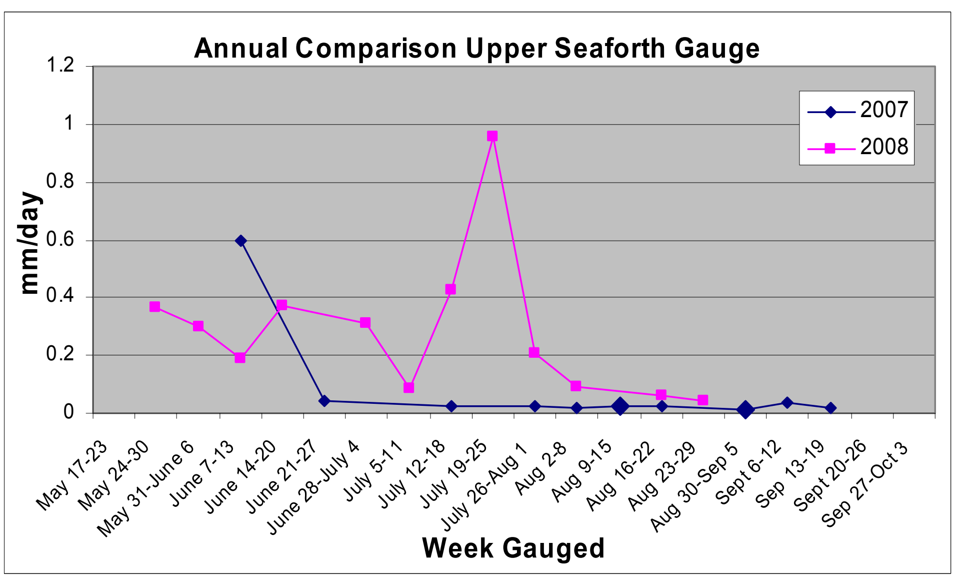

Annual Comparison Harriston Gauge
mm/day
Week Gauged
2007
2008
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3

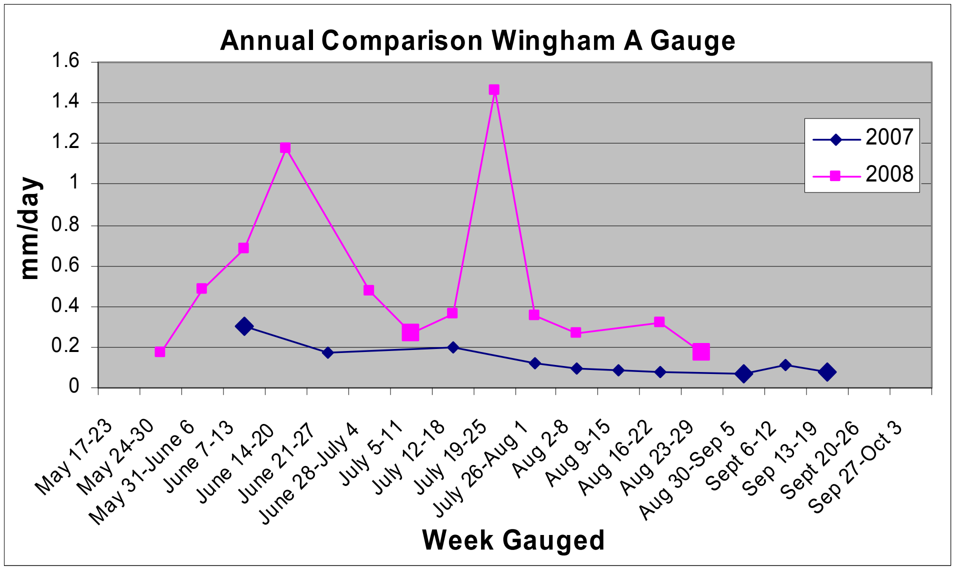

Annual Comparison Lakelet Gauge
mm/day
Week Gauged
2007
2008
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3

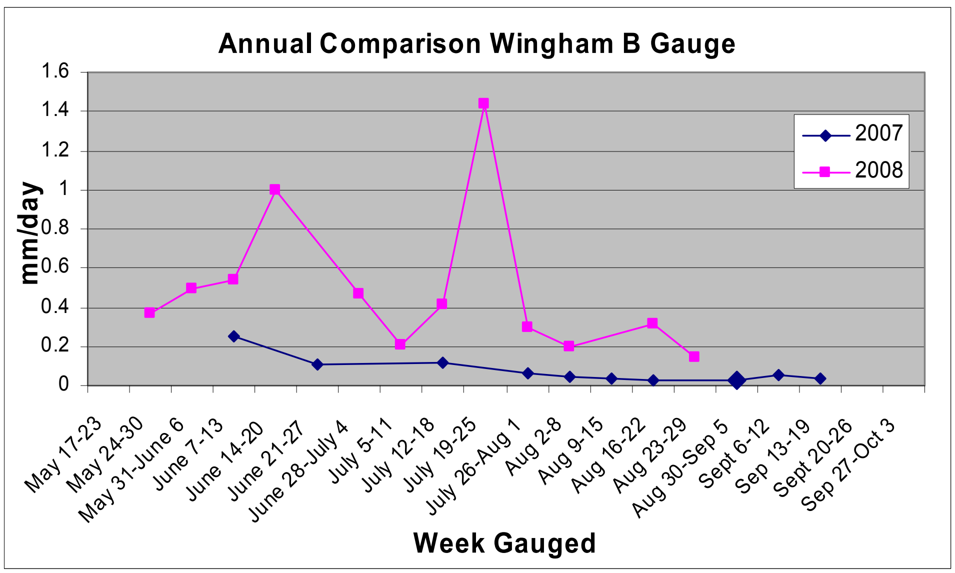


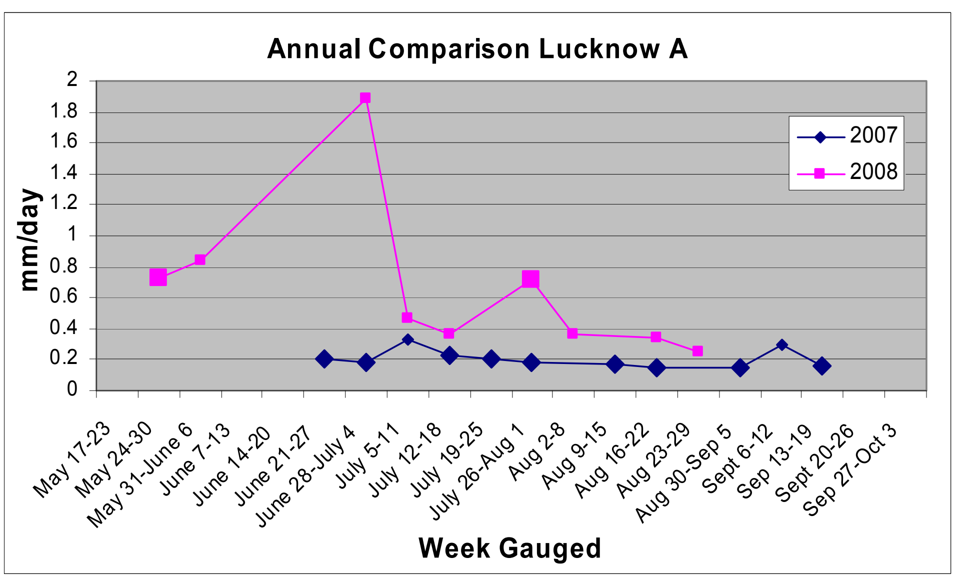
Note: Values for Listowel STP have not been acquired for 2008

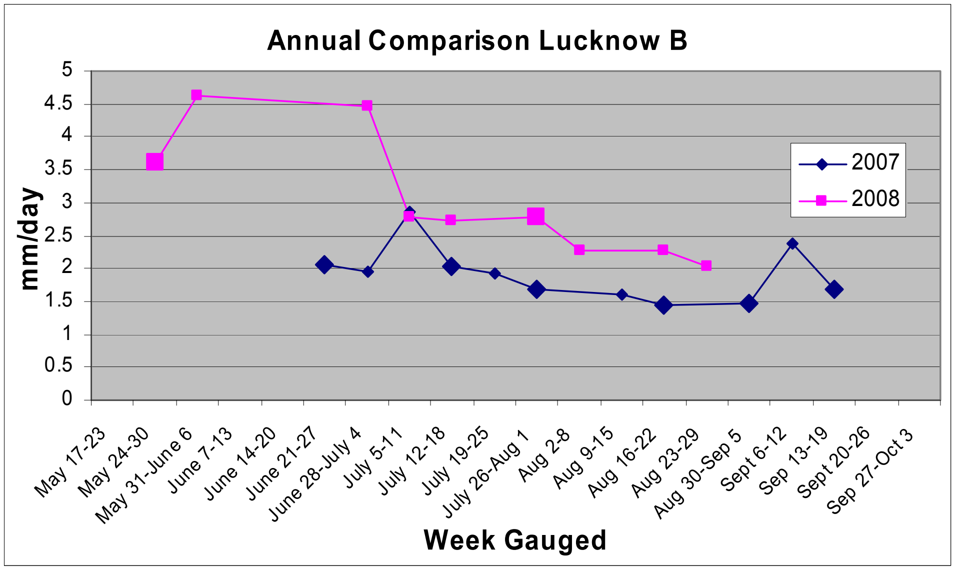





Annual Comparison Wingham A Gauge
mm/day
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged


Annual Comparison Wingham B Gauge
mm/day
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged


Annual Comparison Lucknow A
mm/day
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged


Annual Comparison Lucknow B
mm/day
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
2007
2008
May 17-23
May 24-30
May 31-June 6
June 7-13
June 14-20
June 21-27
June 28-July 4
July 5-11
July 12-18
July 19-25
July 26-Aug 1
Aug 2-8
Aug 9-15
Aug 16-22
Aug 23-29
Aug 30-Sep 5
Sept 6-12
Sep 13-19
Sept 20-26
Sep 27-Oct 3
Week Gauged

Appendix E: Electronic Data

2008 Electronic Data List:

- Route Flow Data (Ausable, Bayfield, Maitland, and Nine Mile (ABMV))
- Flow Charts (ABMV)
- Air Photos (ABMV)
- Baseflow Data
    - Literature Review Documents
    - Site Photos
    - Catchment Areas
    - Site Data Sheets
    - Stage Measuring Data Sheets
    - GPS Locations
    - QA/QC Info.
    - Location Legend
    - Data Summary Tables
    - Precipitation Data
    - Baseflow Maps
    - Copy of Baseflow Document