MUNICIPALITY OF JASPER

JASPER WASTEWATER MODEL

NOVEMBER 10, 2022

wsp

JASPER WASTEWATER MODEL

MUNICIPALITY OF JASPER

FINAL REPORT

PROJECT NO.: 221-07121-00
CLIENT REF:
DATE: NOVEMBER 10, 2022

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November 10, 2022

MUNICIPALITY OF JASPER
303 Pyramid Lake Road, Box 520
Jasper, AB T0E 1E0

Attention: Vidal Michaud, Utilities Manager, Operations Department

Subject: JASPER WASTEWATER MODEL
Client ref.:

Dear Mr. Michaud:

WSP is pleased to submit the draft report of the Jasper Wastewater Model study. Our team appreciates the opportunity to work with the Municipality of Jasper on this project. We would like to thank the Municipality's staff who assisted us through this journey, either in data provision or by way of input and feedback.

We are looking forward to supporting the Municipality of Jasper with new challenges in the future.

Sincerely,

10 Nov. 2022

Joshua Maxwell, M.Sc., P.Eng., PMP
Team Lead, Water Resources Engineering

Juan Upegui, M.Eng., P.Eng.
Water Resources Engineer

JM/JU
Encl. (1)

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REVISION 1				
November 4, 2022	Final Draft			
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REVISION 2				
November 10, 2022	Final Report			
Prepared by	Reviewed by	Approved By		
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The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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EXECUTIVE SUMMARY

The Municipality of Jasper (MOJ) retained WSP Canada Inc. (WSP) to develop a computer model of the wastewater collection system and assess the capacity of the existing system under existing and future population horizons. This is the first study that evaluates the wastewater collection system owned by the MOJ. The scope of work included reviewing background studies and datasets, developing a hydraulic model of the wastewater collection system including verification and calibration, implementing a temporary flow monitoring program, and assessing the capacity of the existing system under current and future conditions based on 10- and 25-year development and population horizons. This study did not assess the physical condition of the wastewater collection system.

The Jasper townsite (**Figure 1**) comprises 2.44 square kilometres (or 244 hectares) of land north of Highway 16 (Yellowhead Highway) and Highway 93 (Icefields Parkway). The major district zonings (**Figure 3**) in the townsite are Residential (32%), Railyard (30%), Institutional (14%), Open Space (12%) and Commercial (10%). According to the 2022 federal census, the population of the MOJ rural services area is 4,738 people with a private dwelling count of 1,675 units. The population in the townsite is 4,029 people and a private dwelling count of 1,585 units. The Jasper wastewater collection system also services the Whistlers and Wapiti campgrounds (Parks Canada) and resorts along Highway 93 (Icefields Parkway) and Highway 93A (Hazel Avenue). The Parks Canada campgrounds include a total of 1,144 sites (full hookup or unserviced), which operate yearly from May to October. The shadow population in the MOJ rural services area can be up to 474.

Proposed developments in the townsite include the Turret Street Apartments, Cabin Creek Apartments and Townhouses and the Jasper Connaught Development (**Figure 4**). These developments could increase the townsite population by up to 1,617 people. The 25-year potential development areas and population horizons were adopted from ISL Engineering and Land Services Ltd. (2022). The projected population in the townsite was 7,107 and 10,661 people for the 10- and 25-year horizons. Potential infill development areas (**Figure 4**) include the Old Town Jasper, Cabin Creek West, Snape's Hill Neighbourhood and Patricia Circle special management areas, as well as the area generally bounded by Willow Avenue and Miette Avenue in the southwest.

The MOJ's wastewater collection system (**Figure 5**) comprises a series of gravity sewers, force mains and lift stations that convey wastewater to the Jasper wastewater treatment plant (WWTP) in the north. The MOJ owns and operates 24.6 kilometres of gravity sewers ranging in pipe diameters between 200 and 600 millimetres and 378 manholes. Most sewers in the MOJ's system are 200 millimetres in pipe diameter, were constructed in the 1970s and consist of vitrified clay tile (VCT) pipe. More than half of the collection system is over 40 years old. There are two trunk sewers in the MOJ system: the Highway 16 Trunk Sewer and the Connaught Drive Trunk Sewer. The Highway 16 Trunk comprises 450/600-millimetre concrete pipe constructed in the 1970s and services the south end of the townsite including the Stan Wright Drive industrial area and the Parks Canada campgrounds. The Connaught Drive Trunk Sewer comprises 375/450-millimetre PVC pipe constructed early in the 2000s and services the north end of the townsite. There are two relief locations within the MOJ's wastewater collection system that allow the movement of flow from one trunk sewer subsystem to the other. One is located at Pyramid Avenue and Pyramid Lake Road/Bonhomme Street and the other is located on Connaught Drive and Bonhomme Street (**Figure 5**). The MOJ currently owns and operates three lift stations, all located in the southwest end of the townsite, including 966 metres of force mains. All MOJ-owned lift stations include two identical pumps with a lead/lag arrangement.

The perceived performance of the existing wastewater collection system was discussed with the MOJ staff. No capacity constraints have been observed. Most deficiencies were related to structural and operational aspects. Possible sources of infiltration were reported in the sewershed for flow gauge A22-129-01 (**Figure 10**) and the northwest end of the townsite.

A hydraulic model of the MOJ's wastewater collection system was developed in PCSWMM. The model network was primarily built based on existing GIS datasets provided by the MOJ and supplemented with record/as-built drawings and survey. The model provides a good representation of the hydraulic capacity of the system, however, two limitations should be understood:

- The model does not consider operational and maintenance aspects of the system such as accounting for the deposition of material, protrusions, or structural failures.
- The pump settings and performance data for the Parks Canada lift stations appeared to be outdated and should be validated.

WSP retained SFE Global Inc (SFE) to conduct short-term flow monitoring in the summer of 2022. The primary objective of this program was to collect data for use in calibrating and validating the hydraulic model. Flow gauges were installed at five locations in total (**Figure 10**) throughout the townsite and recorded data for one month. A rain gauge was also installed to identify wet weather conditions. Overall, the flow and rain gauge data were of good quality. Dry weather flow characteristics were inferred from the gauge data and current population values (estimated). Only three wet weather events were recorded (based on adopted criteria) during the monitoring program, all of which had return periods of less than 2 years. The future system loading was assigned assuming that the current wastewater generation rates would remain unchanged and would increase according to population increases. Wastewater flows from the Parks Canada campgrounds were accounted for in the hydraulic model and were based on past flow monitoring records provided by the MOJ. The hydraulic model was successfully calibrated under dry weather flow (DWF) conditions. Wet weather flow (WWF) calibration was not possible due to the lack of significant rainfall events during the flow monitoring program. Instead, the analysis under WWF conditions was conducted based on a constant rate of 0.28 L/s/ha, as recommended in the provincial guidelines.

A review of the WWTP inflow volumes indicated seasonality in the data, with higher volumes in the summer than in the winter. The Jasper Park Lodge (JPL) resort is a major contributor to the WWTP, comprising up to 20 percent of the total volumes. Influent rates to the WWTP indicated an average value of 97.0 L/s with peak rates as high as 260 L/s. The bi-monthly water billing records indicated an average consumption rate of 250 litres per capita per day, which is comparable to the values inferred from the flow monitoring program.

The MOJ's system was evaluated based on criteria compiled from provincial and other municipality standards. Under existing conditions (**Figure 19** to **Figure 21**), the model indicated that the wastewater sewer on the south leg of Stan Wright Drive would surcharge. More investigation is recommended at this sewer since it is downstream of the Parks Canada lift station, which uses outdated pump settings and performance data. The model also showed surcharging of a sewer on the lane west of Connaught Drive, south of Miette Avenue as it is installed with a reverse grade. No additional issues were observed during the WWF conditions based on assumed constant values of 0.28 and 0.5 L/s/ha.

Under the 25-year population horizon, the results for the DWF scenario are the same as under the existing conditions (deficiencies at the sewer on Stan Wright Drive and lane west of Connaught Drive). Additional sewers shown as surcharging in the WWF (0.5 L/s/ha) scenario included a sewer on Pyramid Avenue, east of Pyramid Lake Road and another on Patricia Street, south of Miette Avenue (**Figure 22** to **Figure 24**). Surcharging of these sewers should be verified with a model calibrated for WWF conditions.

Model improvement recommendations include:

- Confirm the pump start and stop settings for all MOJ lift stations.
- Confirm the pump flow-head curves and start and stop settings for the Parks Canada Lift Station (identifier HWY93A-HWY16 Stn.). Verify flow conditions at the sewer downstream by visually inspecting the manholes.
- Conduct a more comprehensive flow monitoring program, at a minimum, for a single season, spanning from approximately April to the end of October. A longer flow monitoring program has a higher chance of capturing a more significant rainfall event (higher return period) ultimately providing more data for wet weather flow characterization.
- Calibrate the model based on observed wet weather flow data that includes at least a 2-year rainfall event.
- Continue to verify the physical network by surveying wastewater collection infrastructure and reviewing CCTV video inspections to identify possible high-water marks within sewers. These water marks can be used for a qualitative assessment of the existing sewer loading and capacity.

Operational recommendations include:

- Inspecting the sewers and manholes within the flow gauge sewershed for A22-129-03 to confirm that there are no cross connections or other obvious significant sources of inflow or infiltration. Short-term flow monitoring results indicate that this flow gauge sewershed experiences high groundwater infiltration and RDII.
- Inspect all wastewater collection system manholes in the townsite to check for existing cross or weeping tile connections. These should be disconnected from the wastewater collection system if possible.
- Providing a smooth flow transition between the force mains and gravity sewers such that turbulence is minimized at the discharge manhole, which could lead to odour issues. The City of Edmonton Design and Construction Standards recommend that the force main enter the outlet manhole horizontally and at an invert elevation no more than 300 millimetres above the flow line of the receiving sewer. Discharge manholes should be inspected to ensure the structure has not deteriorated.
- Continue CCTV inspections of the existing system. Findings from the inspections can help identify inflow and infiltration sources and illegal cross-connections. Observing high water marks in the sewers can also be used to assess the existing system qualitatively.
- Continuing seasonal flow monitoring in the gravity sewer upstream of the Parks Canada lift station (identifier HWY93A-HWY16 Stn.).
- Continuing to monitor inflow rates and volumes from the JPL resort to assess impacts on the Jasper WWTP.
- Assess new development proposals (medium- and high-density only) using the wastewater hydraulic model developed in this study.

The MOJ may want to consider developing a wastewater system renewal program given that most of the system is over 40 years old.

1 BACKGROUND

1.1 INTRODUCTION

The Municipality of Jasper (MOJ) engaged WSP Canada Inc. (WSP) to develop a computer model of the wastewater collection system and assess the capacity of the existing system under existing and future population horizons. This is the first study that evaluates the wastewater collection system owned by the MOJ.

Jasper is a town embedded within the Rocky Mountains of Jasper National Park of Canada, a UNESCO World Heritage Site. The origins of Jasper as a community date back as early as 1907, and its role in the railway divisional point, shortly after Jasper National Park was created. Tourism is the primary industry in Jasper, drawing nearly two million visitors annually who visit the area for the beautiful natural environment and cultural heritage.

1.2 STUDY AREA

The MOJ is a specialized municipality in western Alberta that encompasses 751 square kilometres of land within the Canadian Rockies (key plan in **Figure 1**). The MOJ is surrounded by Improvement District No. 12 (Jasper National Park) on the north, east and south, and the British Columbia provincial border on the west. At the core of the MOJ boundary is the town of Jasper (**Figure 1**), which comprises 2.44 square kilometres (or 244 hectares) of land north of Highway 16 (Yellowhead Highway) and Highway 93 (Icefields Parkway).

Watercourses near the townsite include Cabin Creek at the southwest (a tributary of Miette River) and Cottonwood Creek at the north. The Athabasca River is a major watercourse located east of the townsite across Highway 16, at which major rivers such as the Miette, Maligne and Snaring discharge.

Figure 2 illustrates the ground topography in the townsite. The overall drainage direction within the townsite is towards the north/east, with existing ground elevations ranging between 1038.7 metres at the northeast and 1094.7 metres at the southwest end. The average ground elevation is 1061.4 metres, and the average ground slope is 8.7%.

1.2.1 EXISTING ZONING

The townsite includes a mix of zonings, including residential, industrial, commercial, and institutional (ICI) developments, as shown in **Figure 3**. **Table 1.1** provides a breakdown of the district zonings in the townsite.

Table 1.1 Townsite land use district zonings

DISTRICT ZONING	PERMITTED USES	AREA (ha)	COMPOSITION (%)
Residential	Residential developments ranging from one, two or multiple dwellings.	61.17	32
Commercial	Business uses, including tourist (hotels/hostels, or visitor centre), automobile service stations and storage services uses.	20.11	10
Open Space	Recreation and natural open space areas, including playing fields, parks and riparian areas.	22.41	12
Reserve	Lands set aside for potential future community use and development but not zoned for anything specific.	3.02	2
Institutional	Institutional, governmental, educational, and community service uses (including parking lots).	27.09	14
Railyard	CN Railways land in the townsite that is permitted only for railway purposes.	59.26	30
	TOTAL	**193.05**	**100**

The remaining area within the townsite boundary comprises areas without zoning and roadways (about 50.95 hectares).

1.2.2 CURRENT POPULATION

The MOJ rural services area has a current population of 4,738 people and a private dwelling count of 1,675 units (Statistics Canada, 2022). In comparison, the population estimate for the townsite (population centre) is less at 4,029 people and a private dwelling count of 1,585 units (Statistics Canada, 2022). The average household density in the rural services area and the townsite are 2.3 and 2.4 persons per household (Statistics Canada, 2022). Based on MOJ counts, there are 1,345 units for tourist accommodations available on the townsite.

The Jasper wastewater collection system also services various campgrounds and resorts along Highway 93 (Icefields Parkway) and Highway 93A (Hazel Avenue). The Whistlers and Wapiti campgrounds include 781 and 363 sites (full hookup or unserviced), which operate yearly from May to October.

The current shadow population in the MOJ rural services area can be up to 474. Shadow population is a term used to describe persons employed by an industrial or commercial establishment in a municipality for a minimum of 30 days within a municipal census year (Municipal Services Branch, 2013). For the shadow population to be reported, it must be greater than 1,000 persons or comprise at least 10% of the permanent population (Municipal Services Branch, 2013). Recent unit counts completed by the MOJ show that hotels in the townsite include about 179 units for staff accommodations. The latest shadow population count in the MOJ was reported to be 652 persons in 2013 (Municipal Services Branch, 2013).

1.2.3 FUTURE DEVELOPMENTS

Growth in the townsite for the foreseeable future is expected to occur within the current townsite boundary. **Figure 4** illustrates the areas where future developments are expected, including proposed and potential infill developments. Proposed developments include those with engineering plans or drawings submitted to the MOJ for review. **Table 1.2** provides more information about these proposed developments.

Table 1.2 Proposed developments

PROPOSED DEVELOPMENT	DEVELOPMENT AREA (ha)	PROPOSED ZONING	POPULATION ESTIMATES
Turret Street Apartments	0.61	R3b	177[2]
Cabin Creek Apartments and Townhouses	2.39[1]	R3b	220
Jasper Connaught Development	3.82	R3b	488 – 1,220
		TOTAL	**885 – 1,617**

Notes:

1 The Cabin Creek Apartments and Townhouses propose additional units in the parcels (existing buildings will remain in place).

2 The population estimate for the Turret Street Apartments was based on assumed infill densities.

The remaining future developments, or potential infill developments, were established in the Jasper Water Model study and adopted without modification (ISL Engineering and Land Services Ltd., 2022).

1.2.4 POPULATION HORIZONS

The MOJ's wastewater collection system was assessed under two future population horizons (permanent residents only) based on the growth projections in ISL Engineering and Land Services Ltd. (2022). The ISL study calculated low and high-population estimates for the 10- and 25-year population projections, but only the highest population estimates for each horizon were adopted in the current study. According to ISL Engineering and Land Services Ltd. (2022), the high estimates for population horizons are as follows:

— 10-year horizon (2032): 7,107 people.

— 25-year horizon (2047): 10,661 people.

1.3 SCOPE OF WORK

The primary objective of the current project was to develop a wastewater collection system model and identify capacity deficiencies in the system under existing and future conditions. The assessment was limited to MOJ-owned infrastructure, excluding private- and Parks Canada-owned infrastructure. This study did not assess the physical condition of the wastewater collection system. The scope of work for the project included:

— Reviewing background studies and datasets

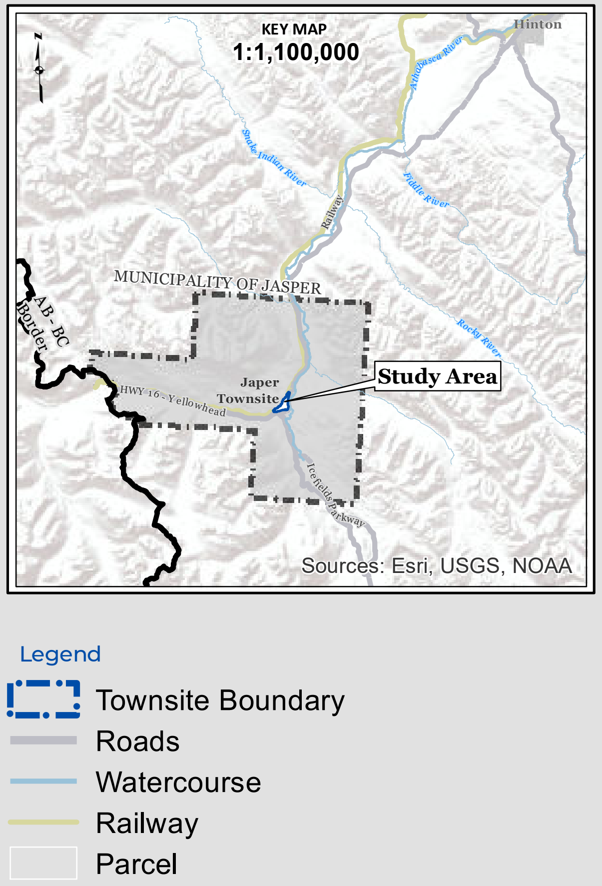
— Developing a hydraulic model, including verification and calibration

— Implementing a temporary flow monitoring program

— Assessing the capacity of the existing system under current and future conditions

— Developing a staged improvements program to support current and future conditions

— Prioritizing system improvement projects according to the 10- and 25-year development horizons



Jasper Wastewater Model

Figure 1: Study Area

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 100 200 400 600 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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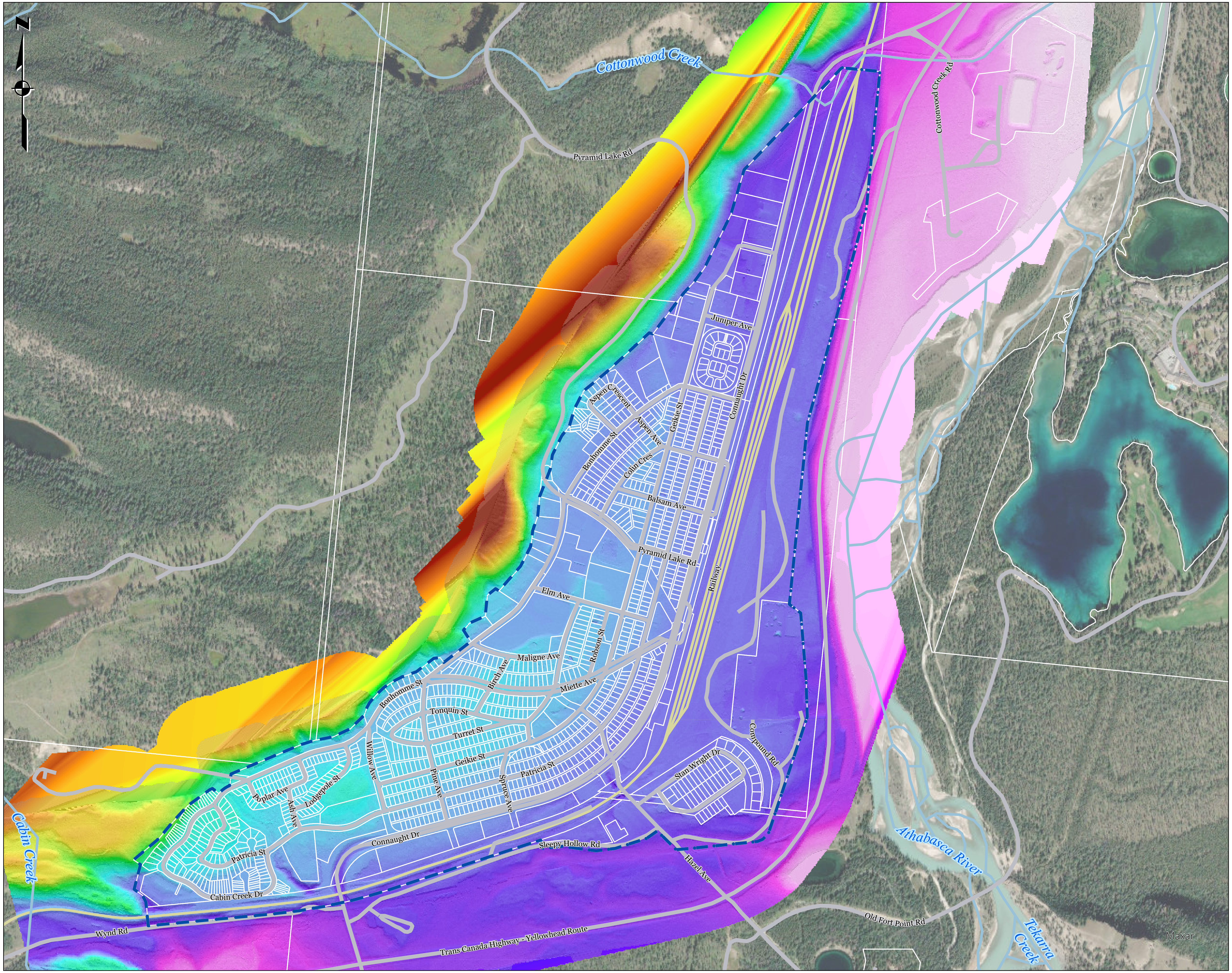
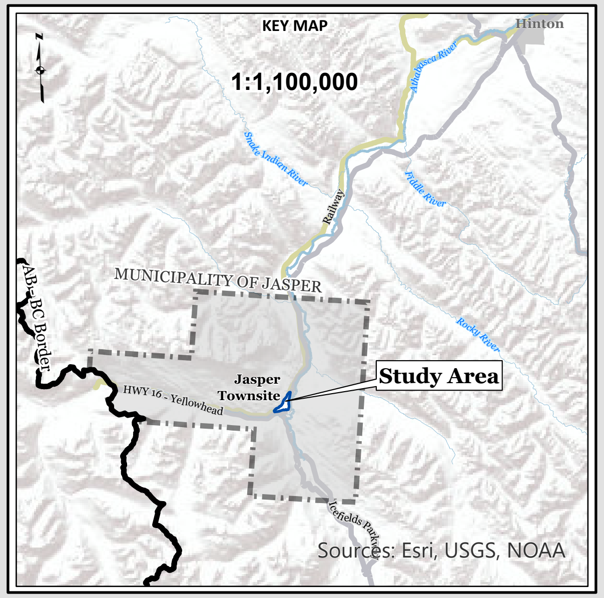
Report By: JU
Drawn by: LB
Reviewed By: JU

WSP Job #: 221-07121-00
Date: November 1, 2022
Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel

Ground Elevation (MASL)

1150

1020

Jasper Wastewater Model

Figure 2: Topography DEM

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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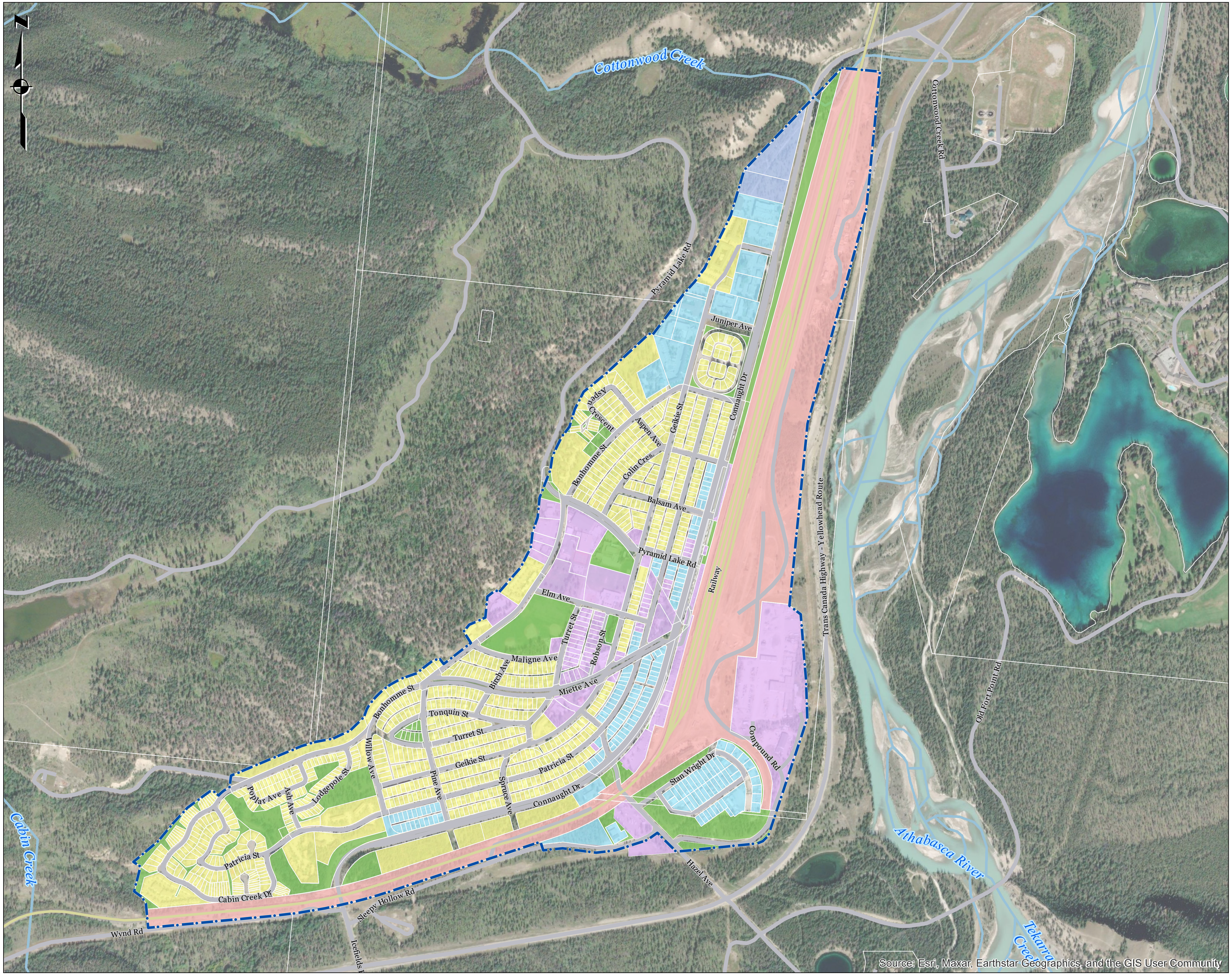
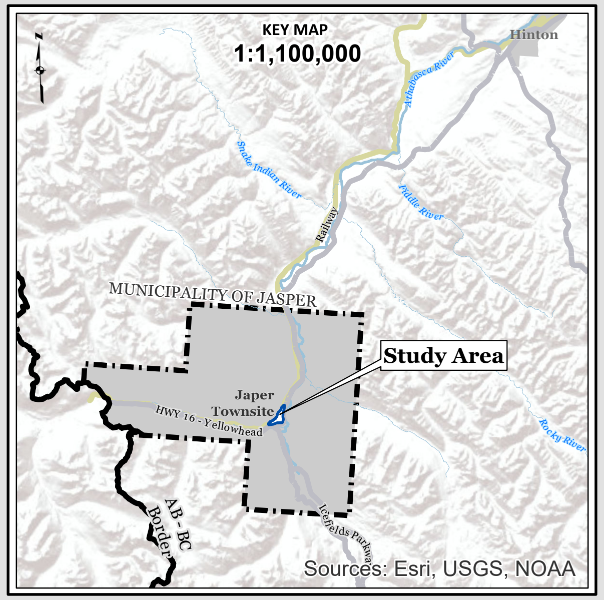
Drawn by: JC | Date: November 1, 2022
Reviewed By: JU | Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Residential District
- Commercial District
- Open Space District
- Institutional District
- Reserve District
- Railyard District

Jasper Wastewater Model

Figure 3: Existing Land Use

Municipality of Jasper Alberta, Canada

Scale: 1:12,000

0 100 200 400 600 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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Drawn by: LB
Reviewed By: JU

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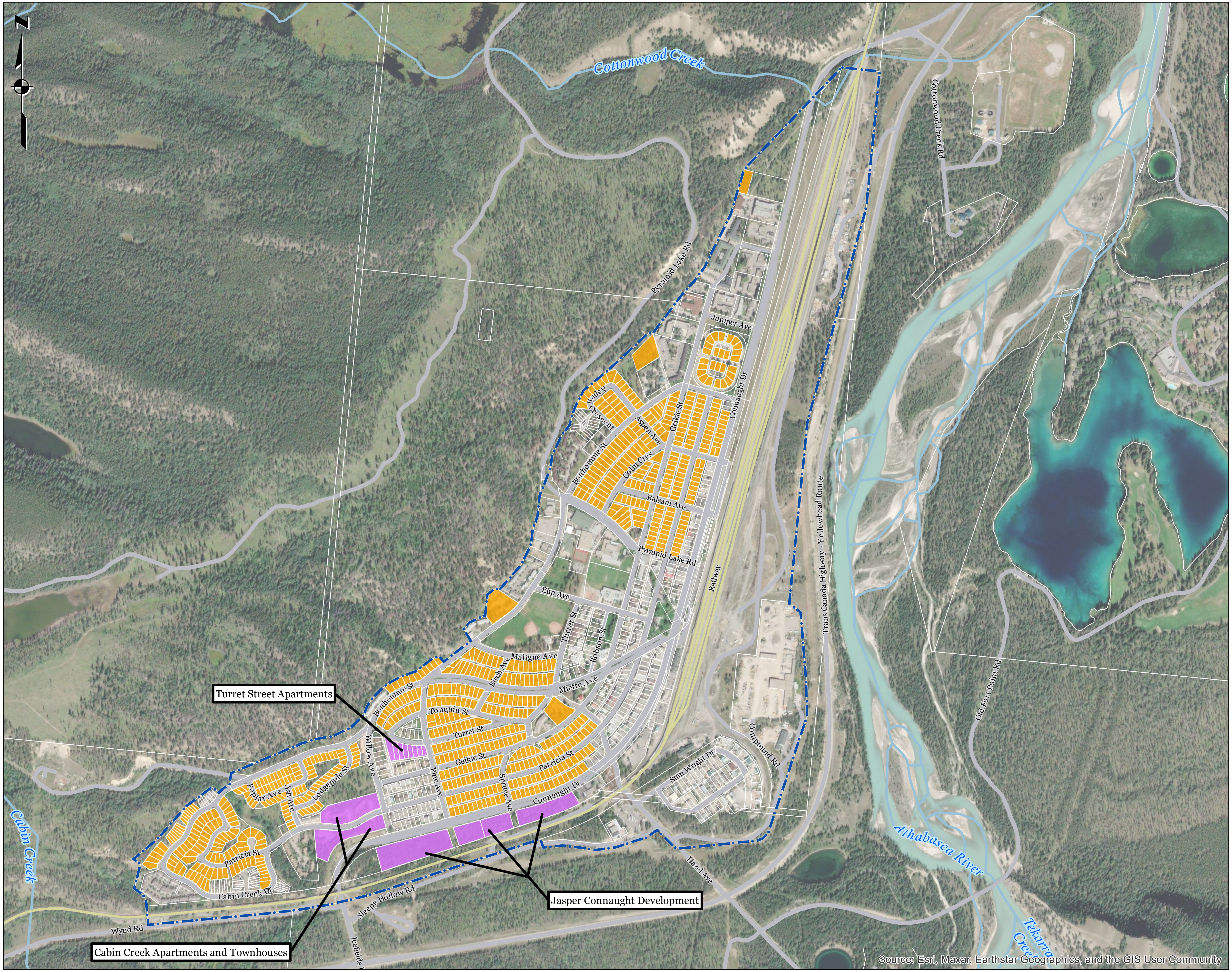
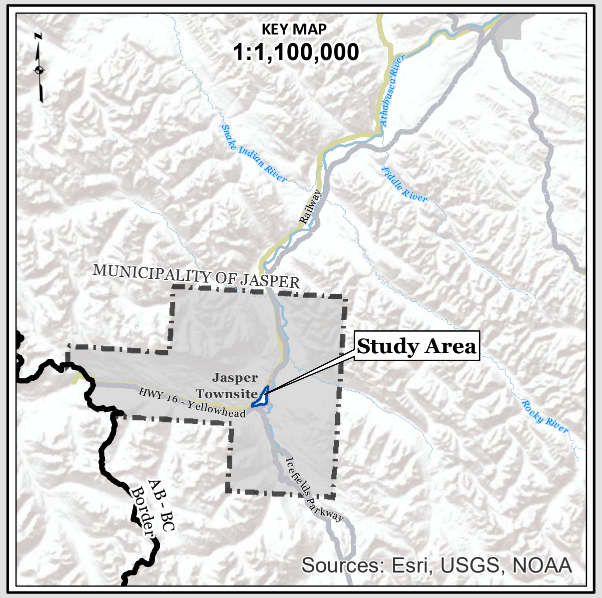
Office: Edmonton





Legend
- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Potential Infill Development
- Proposed Development

Jasper Wastewater Model

Figure 4: Future Developments
Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 100 200 400 600 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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Report By: JU
Drawn by: LB
Reviewed By: JU

WSP Job #: 221-07121-00
Date: November 2, 2022
Office: Edmonton

2 BACKGROUND REVIEW AND DATA COLLECTION

2.1.1 DATASETS AND DRAWINGS

Various datasets and drawings were provided by the MOJ for review. A brief description of the information relevant to the current study includes:

- GIS datasets:
  - Land use parcels and cadastral: polygons containing zoning and land description details for parcels.
  - Sanitary sewer services: lines containing the approximate location of sanitary sewer services.
  - Sanitary sewer mains: lines containing pipe segment identifiers, pipe materials, pipe diameters, installation year, invert elevations and owner information (MOJ, Parks Canada or private).
  - Sanitary sewer lift stations: points containing asset identifiers, a description field and owner information (MOJ, Parks Canada or private).
  - Sanitary sewer manholes: points containing manhole identifiers, invert and rim elevations, installation year and owner information (MOJ, Parks Canada or private).
  - Sanitary force mains: lines containing pipe segment identifiers, pipe materials, pipe diameters, installation year, invert elevations and owner information (MOJ, Parks Canada or private).
  - Townsite boundary.
  - LiDAR DEM: 0.1-metre grid data collected in 2015.
- Spreadsheets
  - Jasper building and hotel unit counts: contained unit count for apartment buildings, hotels and other residential unit counts.
  - Lift station pump volume records and run times for Sleepy Hollow, Patricia Place and Stone Mountain lift stations between January 1, 2021, and August 7, 2022 (daily).
- Wastewater flow data
  - Flow data downstream of the Whistler's and Wapiti Campgrounds (10-second intervals) for the period between June 3, 2021, and October 31, 2021 (10-second interval).
  - Flow data at the wastewater treatment plant influent channel (hourly) between January 1, 2017, and December 31, 2020.
  - Wastewater treatment plant influent volumes (daily) between January 1, 2018, and June 19, 2022.
- Water billing records (monthly) between January 1, 2021, and June 30, 2022.
- Record/as-built drawings
  - Inventory of Existing Utilities Jasper Townsite (Department of Public Works, 1968)
  - Jasper Townsite – Sanitary Sewage System Improvements – As Constructed (Stanley Associates Engineering, 1973)
  - Sewer and Water Improvements (1973) Jasper Townsite (Parks Canada Western Region, 1973)
  - Jasper Townsite Utilities Inventory (Parks Canada Western Region, 1975)
  - Jasper Utility Services (General Works Department Jasper National Park, 1975)
  - Cabin Creek West Subdivision – As Constructed (Walker, Newby & Associates Ltd., 1980)
  - Stone Mountain Village – Issued for Pricing Drawings (IBI Group, 1990)
  - Municipality of Jasper North End trunk Sewer and Water Record Drawings (Earth Tech, 2003)
  - Sleepy Hollow Lift Station and Other Works – Issued for As-Built (WSP Canada Inc., 2020)

- Connaught Offsite Services – Issued for Review (WSP Canada Inc., 2021)
- Cabin Creek Apartments – Overall Site Servicing – Option A (Al-Terra Engineering (Red Deer) Ltd., 2021)
- Cabin Creek Townhouses – Site Plan (Axiom Architecture Inc., 2021)
- Turret Street 52 Unit Apartment – Grading and Service Plan (RPK Architects Ltd., 2022)

2.1.2 PREVIOUS STUDIES

JASPER SEWER SYSTEM – INITIAL INFILTRATION ASSESSMENT (EARTH TECH CANADA INC., 2004)

The MOJ engaged Earth Tech to conduct an inflow and infiltration analysis of the Municipality's system as part of the project to upgrade the wastewater treatment plant (WWTP). At that time, the wastewater system was known to have direct inflows from the water distribution system ('water main bleeders') at some manholes. 'Water main bleeders' used to be provided near water mains with shallow bury depths to aid in circulating water and prevent freezing in the winter. The study involved analyzing flow monitoring data from the WWTP, JPL and the Whistler and Wapiti Campgrounds, completing night manhole inspections to assess inflows qualitatively, and collecting flow monitoring data at two key locations to quantify infiltration and inflows.

The list below summarizes the key findings from this study:

- The Sewer Sub-Section 12 system (area generally north of Pyramid Lake Road and west of Connaught Drive) was found to have 'watermain bleeders' at two manholes on Patricia Circle. Direct inflow was estimated in the order of 5 L/s.
- The Sewer Sub-Section 21/22 system (generally the storage and services area around Stan Wright Drive) was assumed to have low inflow and infiltration rates.
- The Sewer Sub-Section 28 system (generally around Connaught Drive between Miette Avenue and Pine Avenue) was found to have trickle inflow and infiltration.
- The Sewer Sub-Section 29 system (area generally southwest of Miette Avenue and south of Turret Street/east of Birch Avenue) was found to have significant and continuous inflow from a 'watermain bleeder' at one manhole.
- The Sewer Sub-Section 33/50 system (area generally west of Turret Street/Birch Avenue and south of Pyramid Lake Road) was found to have very little inflow and infiltration.
- A review of the WWTP influent data indicated that 'water main bleeders' may contribute between 9 to 15 L/s to the system. Contributions were significantly higher in the winter than in the spring and summer.
- No conclusions could be drawn from the JPL flow monitor data collected downstream of the lift station.
- A review of the Whistler and Wapiti Campground flow data indicated that the average flows were in the range of 1.0 L/s, with peak flows as high as 7.7 L/s. No significant inflow or infiltration is generated from the campgrounds.

The study identified 4-5 L/s of direct inflow due to 'water main bleeders' at Patricia Court and manhole 2476 (new identifier) from the west system. Direct inflow comprised 10-15% of the overall system capacity.

The MOJ confirmed that all watermain bleeders connected to the wastewater system had been decommissioned.

TACTICAL LEVEL ASSET MANAGEMENT STUDY (PHASE 2) – WATER DISTRIBUTION, WASTEWATER COLLECTION AND ROADWAYS (PILLAR SYSTEMS INC., 2017)

The MOJ engaged Pillar Systems Inc., to conduct a Tactical Level assessment and analysis of the Municipality's infrastructure assets. The study included a field-level assessment and lifecycle simulation of roadways, wastewater and water systems to maximize capital investments and ensure infrastructure sustainability. Specific to the wastewater system (manholes and sewers), Pillar Systems Inc. assessed the system as in good condition, with only about 2% of the sewers showing structural concerns. Primary concerns specific to the wastewater system were related to operations and maintenance items due to material buildup in the sewers and roots penetrating pipe joints. The wastewater system manholes were assessed to be in very good condition. Other deficiencies included about 50 wastewater service connections that could cause home sewer back-ups. Primary remediation measures related to operations and maintenance of the wastewater sewers ranged from root clearing and flushing to major works such as lining or replacement.

CABIN CREEK DEVELOPMENT – EXISTING SANITARY FLOW (AL-TERRA ENGINEERING LTD., 2021)

A private developer engaged Al-Terra Engineering Ltd. to assess the capacity of the wastewater system near Patricia Street and Willow Avenue and determine if additional buildings in the lots (parcels CV-2 and CU-1) adjacent to Willow Avenue could be supported. The study included flow monitoring (two-week long) at a manhole on Patricia Street and Willow Avenue (manhole 3303) and a spreadsheet analysis of the 250-millimetre wastewater sewer on Patricia Street near the lots under existing and proposed conditions. Results from the flow monitoring indicated that peak flows in the existing sewer are about 17.4 L/s (about 51% full) with daily averages of 12.8 L/s. A spreadsheet analysis was conducted based on Edmonton sanitary flow generation parameters and population factors. The proposed additional buildings would increase the full flow utilization of the 250-millimetre sewer up to 55%.

PRELIMINARY SERVICING DESIGN REPORT FOR JASPER CONNAUGHT OFFSITE SERVICES – FEASIBILITY STUDY FOR PARCELS GA, GB & GC (AL-TERRA ENGINEERING LTD., 2021)

A private developer engaged Al-Terra Engineering Inc. to develop preliminary servicing concepts (sanitary sewer, stormwater and water distribution system) for the Jasper Connaught Offsite Services project to support proposed developments at parcels GA, GB and GC. The proposed developments are generally located between the CN Railway tracks and Connaught Drive, west of Hazel Avenue. The wastewater sewer servicing concept evaluated connections to the existing system at the 200-millimetre sewer on the lane north of Connaught Drive and the existing 200-millimetre stub near the Petro-Canada (upstream of the recently constructed Sleepy Hollow lift station). The recommended concept was to provide wastewater servicing for the proposed developments via the Sleepy Hollow Lift Station because it allowed a deeper sewer and had significant capacity available. The lift station service area currently includes only the Petro-Canada parcel and the public washrooms east of Hazel Avenue. The concept consisted of a new 200-millimetre wastewater sewer (565 metres) along the south end of Connaught Drive connected to an existing manhole west of the Petro-Canada building.

SEWER CAPACITY STUDY FOR PLANNED DEVELOPMENT AT 76 CONNAUGHT DRIVE – DRAFT (ALTA TECH ENVIRONMENTAL SERVICES INC., 2021)

The MOJ engaged Alta Tech Environmental Services Inc. to assess the capacity of the wastewater system in the north end of Jasper and determine if potential developments at parcels CH and CD (74 and 78 Connaught Drive) could be supported. The proposed developments consisted of an RCMP station and a new hotel. The study included a spreadsheet analysis of the Connaught Drive Trunk Sewer and its overall sewershed based on Edmonton sanitary flow generation parameters and population factors. The analysis showed that the proposed developments could be serviced via the existing local sewer on the west end of Connaught Drive or directly by the Connaught Drive Trunk Sewer. The wastewater sewer segment with the most flow utilization was 88% full (between manholes 1641 and 5967) along the Connaught Drive Trunk Sewer. The twinning of this sewer segment was recommended due to design flows being above the maximum recommended value of 86% according to Edmonton criteria and provincial standards and guidelines.

2.1.3 PLANNING DOCUMENTS

JASPER COMMUNITY SUSTAINABILITY PLAN (MUNICIPALITY OF JASPER AND PARKS CANADA, 2011)

The Jasper Community Sustainability Plan (the 'Plan') is the first long-term planning document that addresses the five pillars of community sustainability: economy, culture, society, environment and governance. The Plan was developed jointly by the MOJ and Parks Canada. The document describes the community's and Parks Canada vision for the future, sustainability principles and community goals, provides strategies and actions, details the land use plan, and describes tools for implementing the Plan. The Plan reported a current population (as of 2008) in the townsite of 3,969 (1,555 dwellings) with 776 people (396 dwellings) in the outlying areas. The total population in the MOJ service area was 4,745 (1,951 dwellings) in 2008, including an assumed shadow population value of 500 people (seasonal employees who are permanent residents in other communities). Projections in the Plan predicted a population between 4,899 and 5,222 by 2040 (number of dwellings between 2,016 and 2,149 units), but these values are now outdated. Growth needs were expected to be accommodated within the current townsite boundary.

Redevelopment and infill opportunities included the Community Core, Old Town Jasper, Snape's Hill Neighbourhood, Patricia Circle, Patricia Place and the Mountain Park Lodge area.

3 EXISTING WASTEWATER SYSTEM

3.1 OVERVIEW

The MOJ's wastewater collection system, including some private infrastructure, is shown in **Figure 5**. The MOJ's system comprises a series of gravity sewers, force mains and lift stations that convey wastewater to the Jasper wastewater treatment plant (WWTP) in the north. The wastewater system includes various lift stations and force mains (MOJ- and non-MOJ-owned, including private and Parks Canada infrastructure) and two trunk sewers. The townsite also includes one wastewater transfer station in the industrial area on Stan Wright Drive (manhole identifier 2958), which is generally underutilized as most recreational vehicle wastewater is discharged at the Parks Canada campgrounds (Wapiti and Whistlers).

3.2 WASTEWATER TREATMENT PLANT

The MOJ operates a Level IV WWTP located east of Highway 16 (Yellowhead Highway) along Cottonwood Creek Road. The service area of the WWTP includes the townsite, Parks Canada campgrounds and private resorts located along Highway 93 (Icefields Parkway) and Highway 93A north of the Wapiti Campground, as well as the Jasper Park Lodge (JPL) and Pine Bungalows resort areas. Wastewater from the townsite is conveyed to the WWTP via two trunk sewers, while wastewater from the Pine Bungalows and JPL resorts is conveyed via a 200-millimetre force main. The trunk sewers and force main join into a single gravity sewer south of the WWTP. The MOJ operates two flow gauges upstream of the WWTP (**Figure 5**) that are used to track the total influent ('WWTP flow meter') and the influent from the JPL only ('JPL flow meter').

3.3 WASTEWATER SYSTEM CHARACTERISTICS

The MOJ owns and operates a wastewater collection system that includes approximately 24.6 kilometres of gravity sewers ranging in pipe diameters between 200 and 600 millimetres and 378 manholes (**Figure 5**). Most wastewater sewers are 200 millimetres in pipe diameter. A cast iron pipe with a unique size (355-millimetre diameter) is located under the railway tracks. **Table 3.1** summarizes the pipe diameters in the MOJ's wastewater collection system.

Table 3.1 Wastewater sewer composition by pipe diameter

DIAMETER (mm)	LENGTH (m)	PERCENTAGE OF TOTAL SYSTEM (%)
200	12,170	49.5
250	2,838	11.5
300	2,050	8.3
355	131	<1
375	1,097	4.5
450	3,154	12.8
600	933	3.8
Unknown	2,215	9.0
Total	24,588	100

Most gravity sewers in the MOJ's system were constructed in the 1970s and consist of vitrified clay tile (VCT) pipe. More than half of the wastewater collection system comprises pipes that are over 40 years old. **Figure 6** and

Figure 7 illustrate the construction periods and pipe materials of the wastewater collection system. The lengths and composition of the wastewater collection system by construction decade and pipe material are provided in **Table 3.2** and **Table 3.3**, respectively.

Table 3.2 Wastewater sewer construction periods

CONSTRUCTION DECADE	LENGTH (m)	PERCENTAGE OF TOTAL SYSTEM (%)
1950-1969	3,430	13.9
1970-1979	12,524	50.9
1980-1989	1,385	5.6
1990-1999	468	1.9
2000-2009	4,775	19.4
2010-present	27	<1
Unknown	1,980	8.1
Total	24,588	100

Table 3.3 Wastewater sewer composition by pipe material

PIPE MATERIAL	LENGTH (m)	PERCENTAGE OF TOTAL SYSTEM (%)
Asbestos cement (AC)	315	1.3
Cast iron	140	<1
Concrete	6,427	26.1
Polyvinyl chloride (PVC)	5,574	22.7
Vitrified clay tile (VCT)	11,359	46.2
Unknown	774	3.1
Total	24,588	100

3.4 TRUNK SEWERS

The MOJ wastewater collection system includes two trunk sewers along Highway 16 and Connaught Drive. In this study, the trunk sewers will be referred to as the Highway 16 Trunk Sewer and the Connaught Drive Trunk Sewer. Major infrastructure and their corresponding sewersheds are shown in **Figure 8**. The Highway 16 Trunk Sewer comprises 450/600-millimetre concrete pipe constructed early in the 1970s. This trunk sewer generally services the south end of the townsite (south of Pyramid Avenue), including the Stan Wright Drive industrial area and the Parks Canada campgrounds. The Highway 16 Trunk Sewer conveys wastewater from all MOJ and Parks Canada lift stations. The Connaught Drive Trunk Sewer comprises 375/450-millimetre PVC pipe constructed early in the 2000s. This trunk sewer generally services the north end of the townsite (north of Pyramid Avenue and west of Connaught Drive).

3.4.1 RELIEF LOCATIONS

There are two relief (flow-split) locations in the MOJ's wastewater collection system between the trunk sewer subsystems (**Figure 5**). At these manholes, flows can move from one subsystem to the other if surcharging occurs. The first relief location is at Pyramid Avenue and Pyramid Lake Road/Bonhomme Street (manhole identifier 463), with normal flow being directed to the southeast along Pyramid Avenue toward the Highway 16 Trunk Sewer. The second relief location is southeast of Connaught Drive and Bonhomme Street (manhole identifier 4683), with normal flow being directed to the northeast toward the Connaught Drive Trunk Sewer. **Table 3.4** provides more information about these relief locations.

Table 3.4 Wastewater relief location characteristics

LOCATION (MANHOLE ID)	OUTGOING PIPE DIA. (mm)	OUTGOING INVERT ELEV. (m)	OVERFLOW PIPE DIA. (mm)	OVERFLOW INVERT ELEV. (m)
463	250	1058.787	250	1059.168
4683	375	1053.007	375/355	1053.317

3.5 LIFT STATIONS AND FORCE MAINS

The MOJ currently owns and operates three lift stations, all located in the southwest end of the townsite, including 966 metres of force mains (excluding those servicing the Pine Bungalows and JPL resorts, which are privately owned). **Table 3.5** presents **i**nformation about the MOJ- and Parks Canada-owned lift stations. Data in the table was compiled from the record/as-built drawings and GIS datasets. All lift stations include two identical pumps with a lead/lag arrangement. The service areas for the MOJ-owned lift stations are shown in **Figure 8**.

Table 3.5 Lift station and force main characteristics

LIFT STATION	ASSET ID	OWNER	NO. OF PUMPS	LIFT STATION CAPACITY – FIRM (L/s)	FORCE MAIN DIAMETER (mm)	FORCE MAIN LENGTH (m)	FORCE MAIN MATERIAL
Stone Mountain	LS7	MOJ	2 x 6.3 hp	7.8	150	483.4	Ductile/cast iron
Patricia Place	LS6	MOJ	2 x 2.4 hp	6.1	100	105.3	Cast iron
Sleepy Hollow	LS8	MOJ	2 x 4 hp	11.5	100	377.3	HDPE/PVC
HWY93A-HWY16	Lift station No.2	Parks Canada	2 x 18 hp	29.4	150	377.4	Cast iron
Miette River	Lift station No.1	Parks Canada	2 x 18 hp	27.8	150	325.3	PE

In discussions with the MOJ, it was reported that Parks Canada lift stations had the pumps and generators replaced recently. The Parks Canada lift station pumps were assumed to have been replaced by a modern equivalent of the originals for model purposes.

3.6 PERFORMANCE REVIEW WORKSHOP

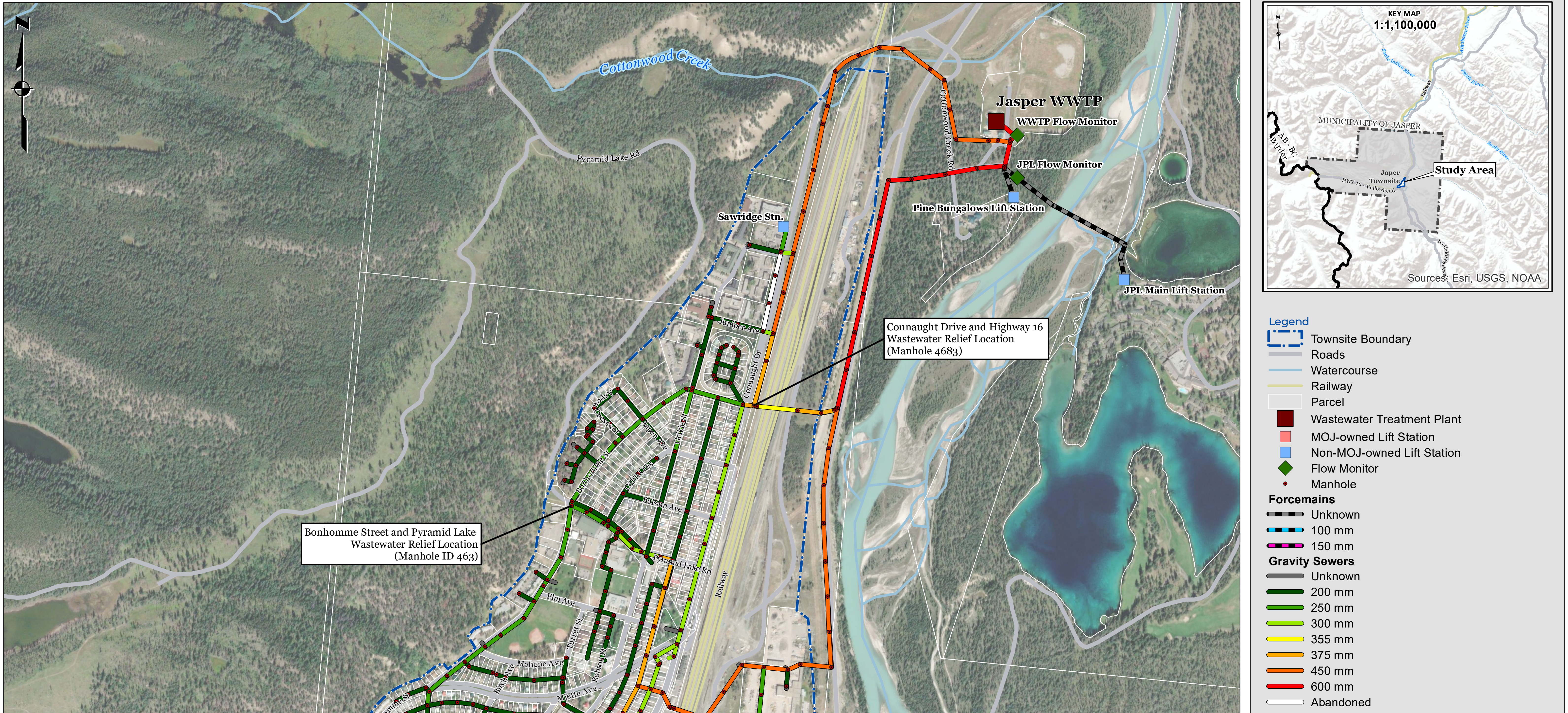
The WSP team met with MOJ staff on June 28, 2022, to review the performance of the existing wastewater collection system. The overall function of the system, known issues and maintenance practices were discussed. In general, the wastewater collection system was reported to be sized appropriately as there have not been any basement floodings or manhole overflows reported during any weather conditions (dry or wet). Similarly, all MOJ-owned lift stations were reported to be performing as expected and without issues. The lift stations are being upgraded to a new standard adopted by the MOJ.

Deficiencies in the existing system were mostly related to structural and operational aspects. The MOJ reported that some pipe failures have been found in the system and have been repaired as needed. Infiltration sources to the wastewater system were reported to be primarily from watermain breaks (past construction practices installed watermains and wastewater sewers in a common trench, with the watermains placed above sewers) and possible weeping tile connections to the wastewater collection system. Roof leaders were confirmed to be connected either to the storm sewer system or discharge to the surface.

Infiltration has been observed in the wastewater collection system during CCTV inspections in wet weather. The MOJ reported that the sewershed for flow gauge A22-129-01 (refer to **Figure 10** for flow gauge location and sewershed) and the northwest end of the townsite experiences significant inflow and infiltration during wet weather. The suspected source of wet weather flows entering the system is from manholes located in sags and cracked manhole structures and pipes.

Recurring blockages were also reported, primarily near the lodging area of town (north end). The MOJ has received odour complaints regarding the Stone Mountain and Patricia Place lift stations and force main discharge points. Both lift stations discharge at the same manhole (approximately at Ash Avenue and Patricia Street).

The MOJ owns CCTV equipment and aims to inspect the entire system. Previous CCTV inspection work has also been completed. The MOJ conducts regular preventative hydro-jetting or power flushing of the wastewater sewers every month or two. The entire wastewater collection system was reported to be cleaned approximately every five years.



Jasper
Wastewater Model

Figure 5: Wastewater Collection System - Pipe Diameters

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

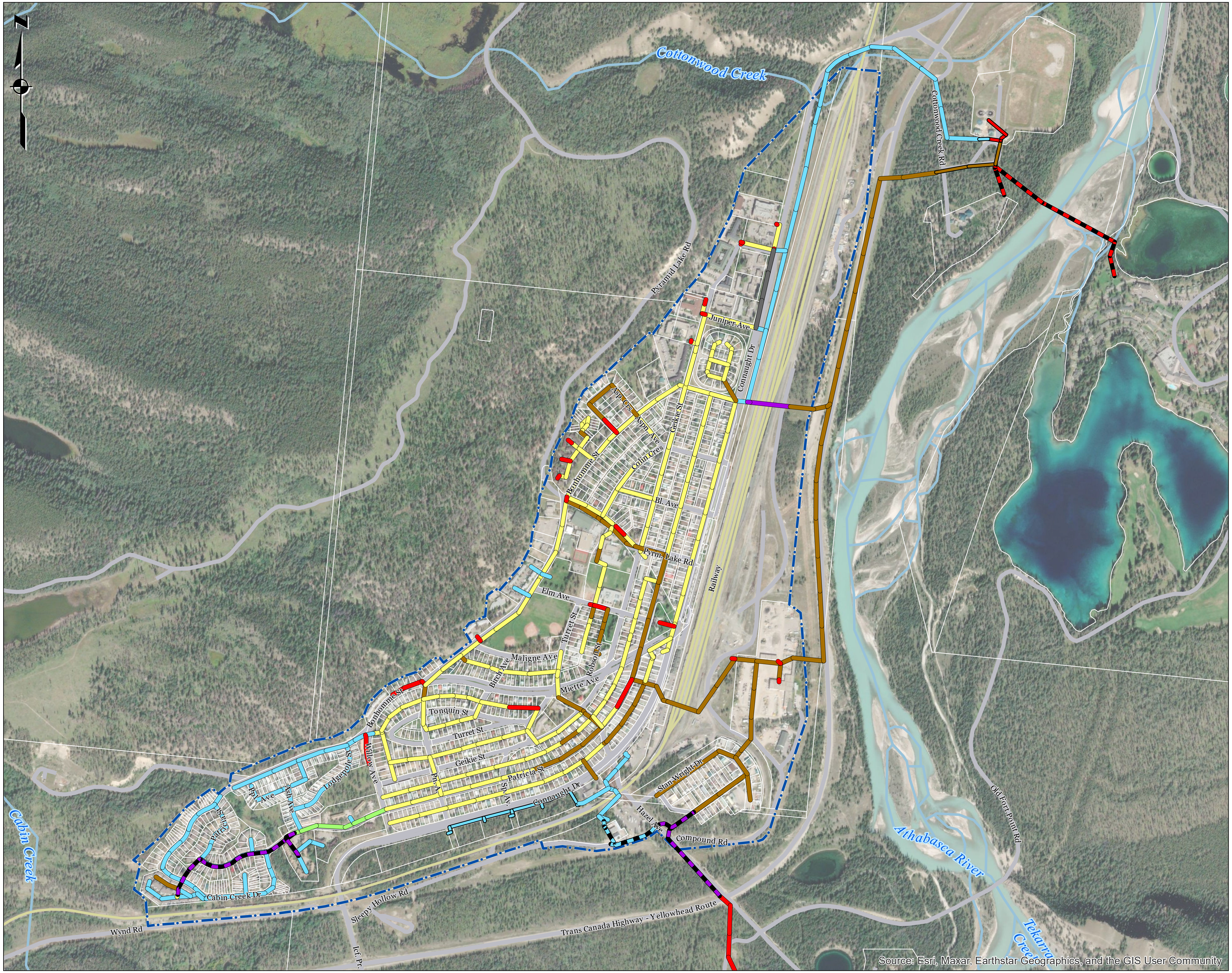
0 100 200 400 600 800 Metres

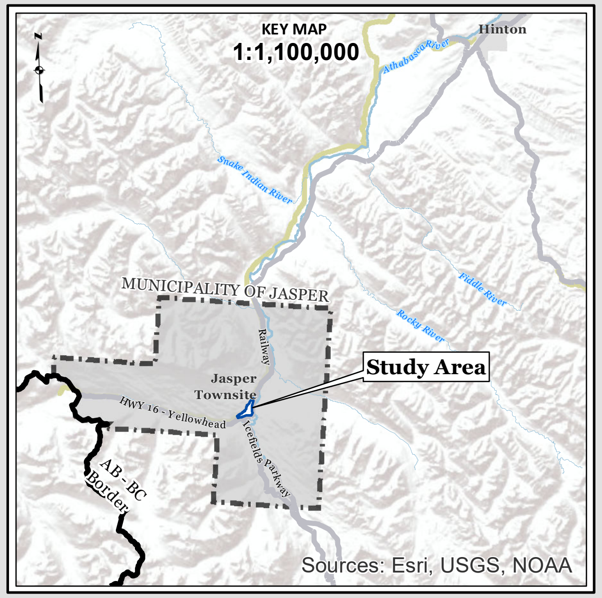
Universal Transverse Mercator (Zone 11)
North American Datum (1983)

wsp

Report By: JU
Drawn by: LB
Reviewed By: JU

WSP Job #: 221-07121-00
Date: November 1, 2022
Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel

Forcemains

- Cast Iron
- PVC
- Unknown

Gravity Sewers

- Asbestos Cement
- Concrete
- Vitrified Clay Tile
- Cast Iron
- PVC
- Unknown
- Abandoned

Note: Pipe materials as shown are based on the MOJ raw GIS datasets and may be represented differently in the model (updated based on record/as-built drawings)

Jasper Wastewater Model

Figure 6: Wastewater Collection System - Pipe Material

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 100 200 400 600 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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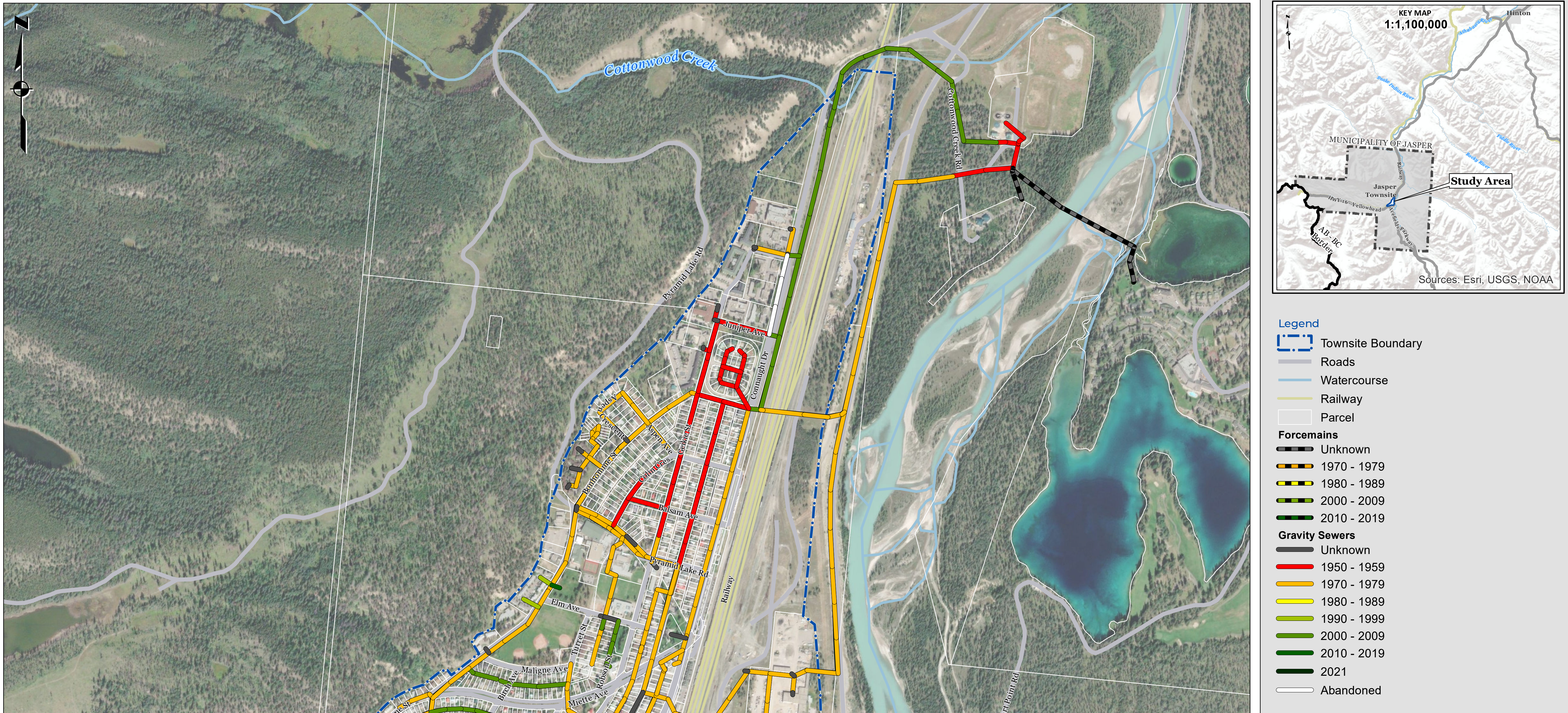
	Drawn by: LB	Date: November 1, 2022
	Reviewed By: JU	Office: Edmonton



Jasper Wastewater Model

Figure 7: Wastewater Collection System - Construction Period

Municipality of Jasper

Alberta, Canada

Scale: 1:12,000

0 100 200 400 600 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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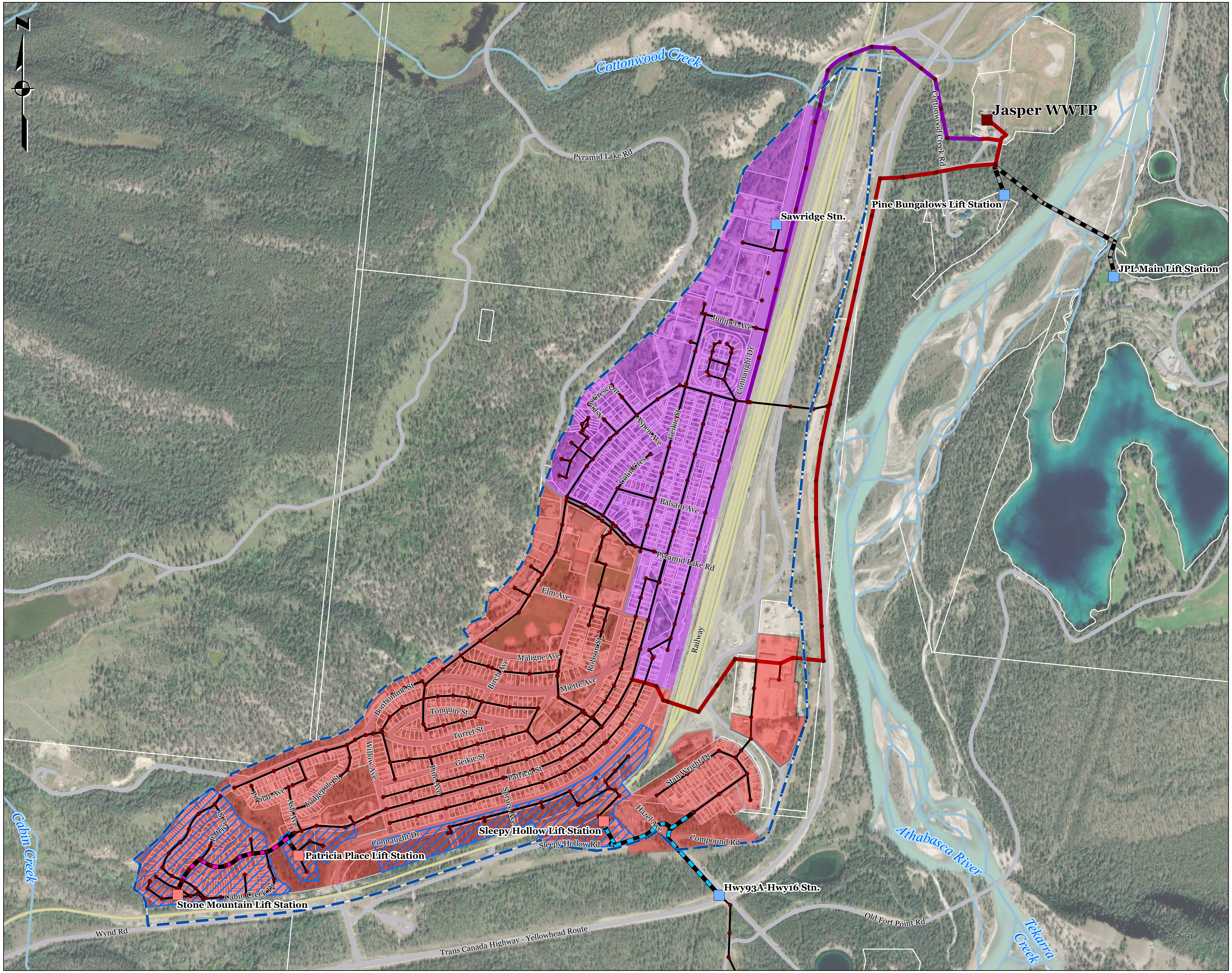
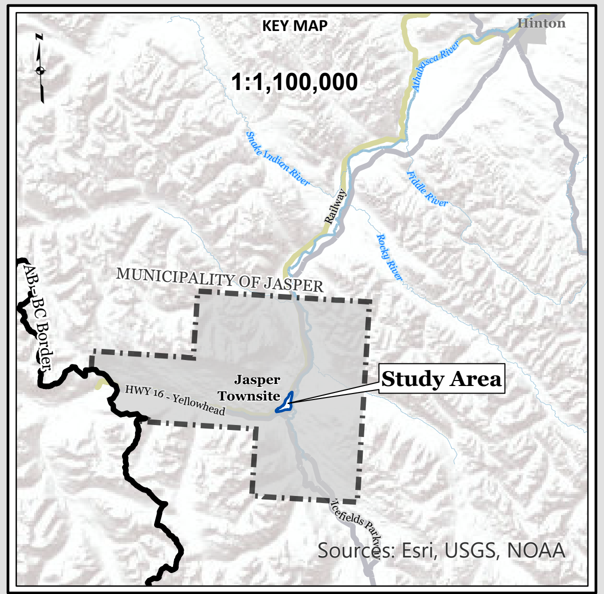
Date: November 1, 2022
Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Manhole
- Gravity Sewers
- Connaught Drive Trunk Sewer
- Highway 16 Trunk Sewer
- Connaught Drive Trunk Sewer Sewershed
- Highway 16 Trunk Sewer Sewershed
- Lift Station Sewershed

Forcemains

- 100 mm
- 150 mm
- Unknown

Jasper Wastewater Model

Figure 8: Major Wastewater Infrastructure Sewersheds

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

wsp

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Drawn by: JC
Reviewed By: JU
WSP Job #: 221-07121-00
Date: November 2, 2022
Office: Edmonton

4 HYDRAULIC MODEL

4.1 MODEL DEVELOPMENT

4.1.1 SELECTED SOFTWARE

The hydraulic model representing the MOJ's wastewater collection system was developed in PCSWMM. PCSWMM is a GIS-based version of the United States Environmental Protection Agency Storm Water Management Model (US EPA SWMM or SWMM). SWMM is a dynamic rainfall-runoff computer program that simulates single event or continuous rainfall time-series runoff quantity and quality. The program simulates runoff from the model sub-catchments and routes the runoff through the hydraulic network (pipes, channels, storage or treatment elements, pumps and regulators) during the simulation period. SWMM is widely used for the planning, analyzing and designing of stormwater, combined, and wastewater sewer systems in urban and non-urban areas.

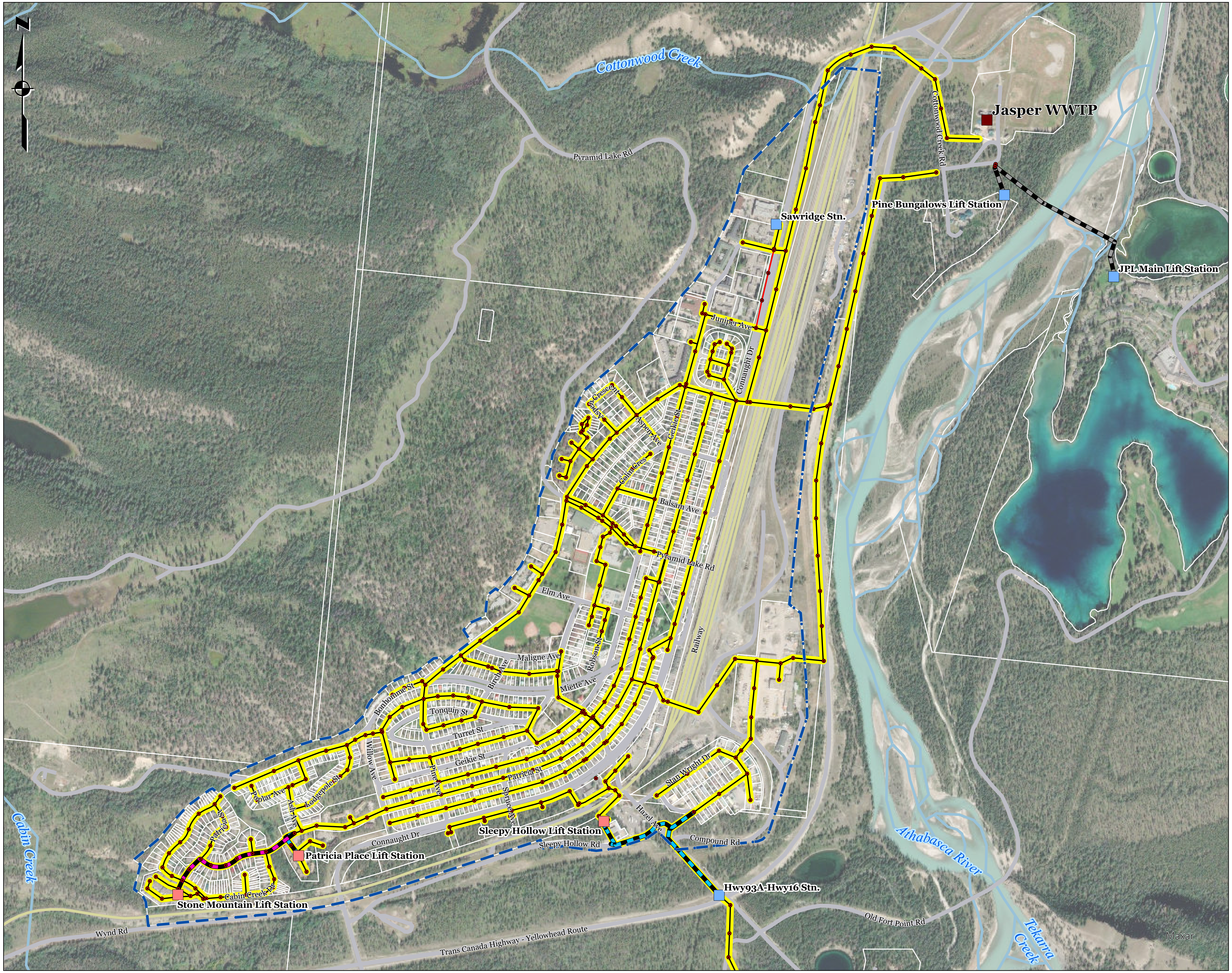
4.1.2 MODEL ASSUMPTIONS

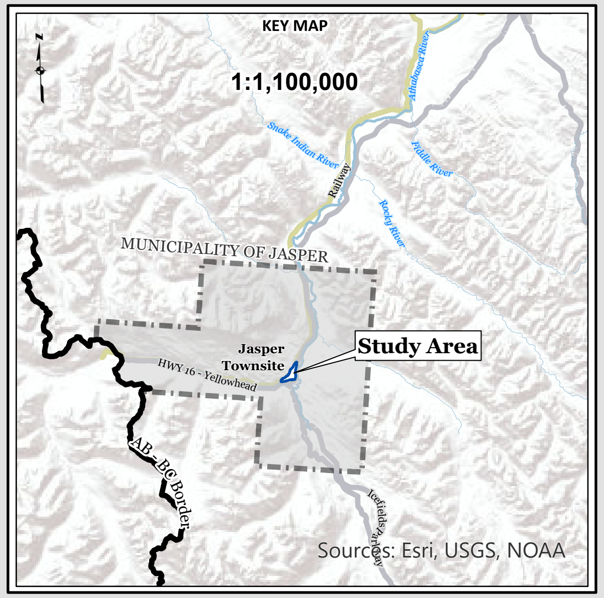
A computer model is a simplified physical system representation with some limitations. Most of these are related to structural and operational items such as:

1. The full cross-sectional area of the pipe is assumed to be available. This means that the model does not consider obstructions in the pipe (due to settlement, protrusions or material buildup, etc.) or structural failures.
2. Reliable pump flow-head data for the Parks Canada lift stations were unavailable. Furthermore, start and stop settings for both Parks Canada lift stations were inferred from as-built/record drawings. Flows from these lift stations may be conservative.

4.1.3 PHYSICAL NETWORK

The model network is shown in **Figure 9**. The physical wastewater collection network in the model was primarily created by importing the sanitary sewer mains, lift stations, manholes and force mains GIS datasets (shapefiles). The datasets contained data gaps (invert and rim elevations and pipe diameters) which were filled mainly by extracting information from record/as-built drawings and verified by surveying select infrastructure. The accuracy of record/as-built drawings was reasonable (within 10 centimetres compared to surveyed elevations). The model network was reviewed with the MOJ and corrected as required. Input from the MOJ consisted primarily of clarifying conflicting information in record/as-built drawings regarding pipe diameter information and existing relief locations in the system. The physical network included the townsite and Parks Canada system (two lift stations and gravity sewers along Highway 19 and Highway 93A) that services the Wapiti and Whistlers campgrounds. The force main and pump stations servicing the Pine Bungalows and JPL resorts were not included in the model as these discharge almost directly to the WWTP. **Table 4.1** summarizes the various model elements that represent the MOJ's system.





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Manhole
- Abandoned Sewers
- Gravity Sewers (MOJ Dataset)
- Gravity Sewers (Model Network)

Forcemains (MOJ Dataset and Model Network)

- 100 mm
- 150 mm
- Unknown (Not Included in Model Network)

Jasper Wastewater Model

Figure 9: Model Network

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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Drawn by: JC
Reviewed By: JU
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Table 4.1 Summary of model elements

MODEL ELEMENT	USED TO REPRESENT	ITEM COUNT
Junction	Manhole/plug Force main joint/material transition	367 (MOJ-owned) 21 (Parks Canada-owned) 2
Conduit	Gravity sewer Force main	378 (MOJ-owned) 19 (Parks Canada-owned) 3 (MOJ-owned) 2 (Parks Canada-owned)
Pump	Pumps	6 (MOJ-owned) 4 (Parks Canada-owned)
Storage unit	Wet well	5
Outfall	Jasper WWTP	2

Manhole and pipe identifiers were adopted from the MOJ GIS datasets if available. Manholes without MOJ identifiers were named using values in the 10,000 series range (for example, 10001, 10002, etc.). Similarly, pipes without an identifier were assigned a name with a prefix of 'C' (for example, C5, C30, etc.). Lift stations were also named in the model according to available MOJ identifiers.

Missing manhole rim elevations were extracted from the LiDAR DEM and supplemented with survey data as available. A universal Manning's roughness coefficient of 0.013 was adopted for all gravity sewers regardless of material (generally representative of VCT, PVC and concrete pipe roughness). The roughness coefficient for the force mains was based on the pipe material and age based on literature values and are provided in **Table 4.2**. Minor loss coefficients were implemented at all conduits. The force mains included an entry loss coefficient that included the combined effect of fittings and appurtenances within the lift station (elbows, valves, etc.).

Table 4.2 Force main Hazen-Williams coefficients

PIPE MATERIAL	YEAR OF CONSTRUCTION	HAZEN-WILLIAMS COEFFICIENT
Cast iron	1980	80
Ductile iron	1990	140
HDPE/PE	2018	140
PVC	2011	150

Record/as-built drawings were unavailable for some sewer services, for which grades were assumed to be zero percent. These sewers are located along Swift Crescent, Brewster Crescent and similar places, which are not along the main network.

Lift station data was compiled from record/as-built drawings and equipment manufacturer data. Wet well geometry for the lift stations was developed based on the record/as-built drawings. All wet wells at MOJ-owned lift stations consisted of a 1.8-metre diameter structure. Pump flow-head data was extracted from curves provided by Xylem based on the pump model and serial numbers. If available, pump start and stop elevations were obtained from record/as-built drawings. Pump start and stop elevations for the Stone Mountain Lift Station were provided by the MOJ. Flow-head curves for the pumps are provided in **Appendix A** for reference.

Two outfall nodes were implemented at the downstream end of both inlet trunk sewers to the WWTP. Outfalls act as downstream boundary conditions. A normal flow depth boundary condition was assumed at both outfall nodes since water level data at either the trunk sewers or the influent sewer to the WWTP was unavailable. The normal flow assumption is appropriate as the wastewater network upstream of the trunk sewers is at a much higher elevation (about a 20-metre differential in elevations).

4.2 FLOW MONITORING

SFE Global Inc. (SFE) was retained to conduct short-term flow monitoring in the summer of 2022. The objective of the program was to collect flow data at key locations in the wastewater collection system for calibrating and validating the computer model. SFE installed four (4) flow gauges (identifiers A22-129-01 to 04) and one (1) tipping bucket rain gauge on June 28, 2022 (**Figure 10**). The flow gauges were removed after one month (end of July 2022), and at the same time, an additional flow gauge (identifier A22-129-05) was installed at another location until August 25, 2022. In total, flow gauges were installed at five different locations throughout the wastewater collection system. The flow monitoring report prepared by SFE is included in **Appendix B**.

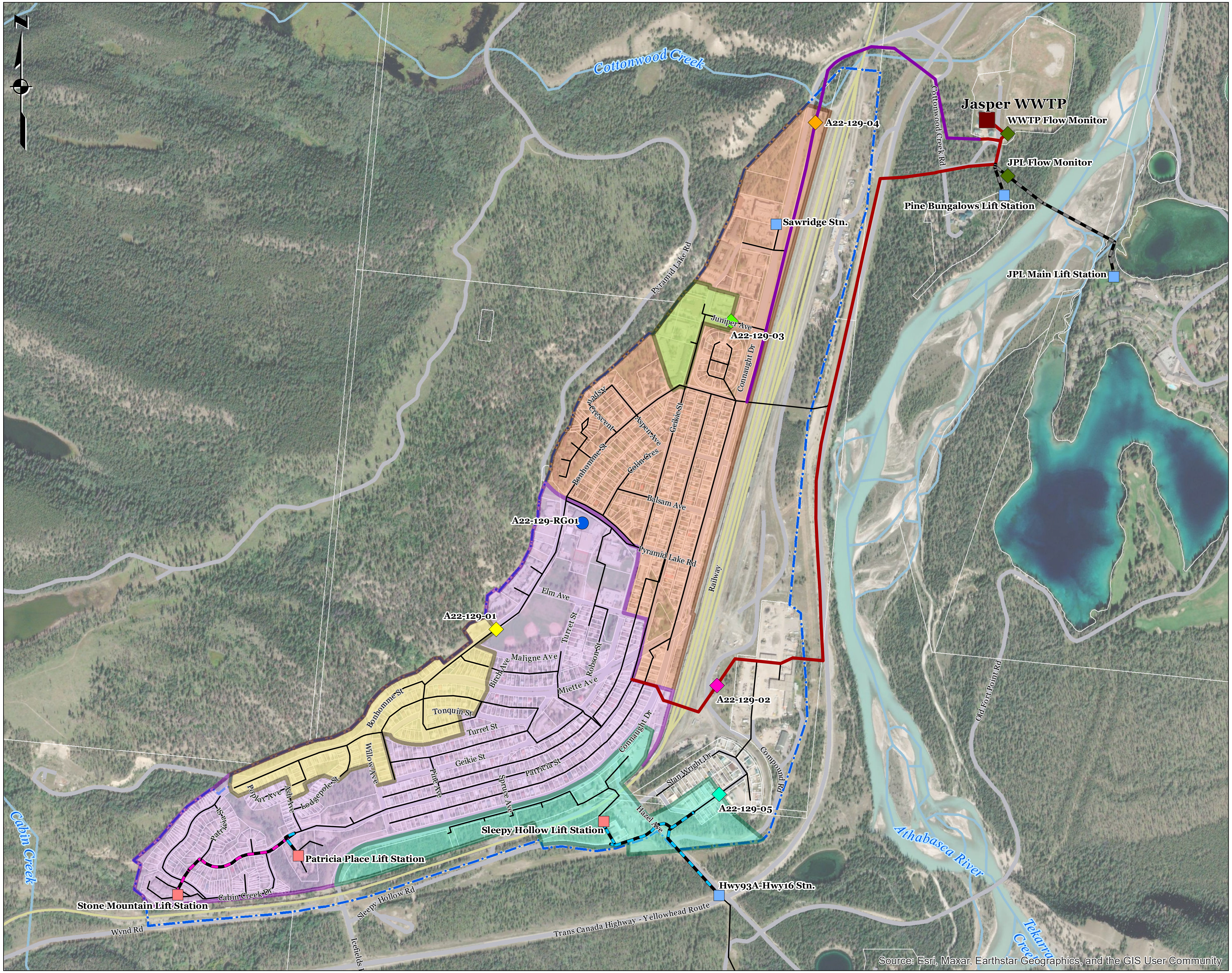
4.2.1 FLOW MONITOR AND RAIN GAUGE LOCATIONS

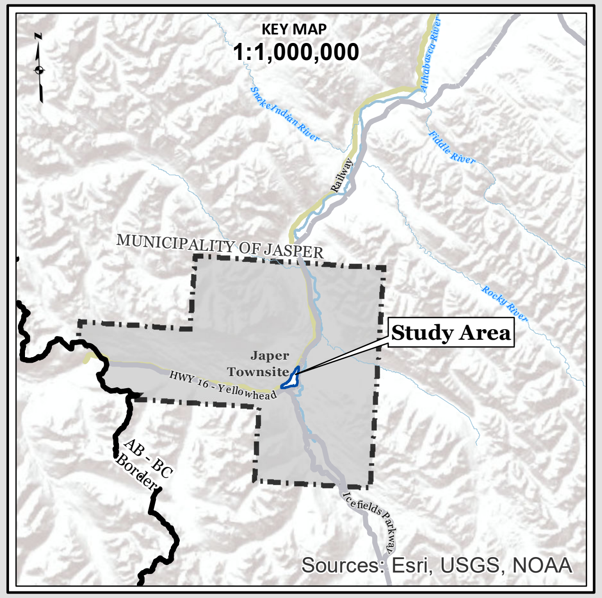
The location of the flow and rain gauges is shown in **Figure 10**. Flow gauges were sited based on sewershed and system characteristics such as land uses and pipe materials. The rain gauge was located near the core area of the townsite on the rooftop of the Jasper Fitness & Aquatic Centre. **Table 4.3** summarizes flow and rain gauge characteristics. Custom compound weirs were required at low flow or small diameter pipes. The reported accuracy of the weirs and area velocity metres is within 5 percent.

Table 4.3 Flow and rain gauge information

GAUGE ID	PERIOD START	PERIOD END	TYPE	PIPE DIAMETER (mm)	LOCATION
A22-129-01	June 27, 2022	July 26, 2022	Custom compound weir	250	Pyramid Lake Road, northeast of Maligne Avenue
A22-129-02	June 27, 2022	July 26, 2022	Area velocity metre	450	West of Jasper National Park Maintenance Facility
A22-129-03	June 27, 2022	July 26, 2022	Custom compound weir	200	Juniper Street and Tonquin Inn access
A22-129-04	June 27, 2022	July 26, 2022	Area velocity metre	450	North end of Jasper, near Connaught Drive
A22-129-05	July 26, 2022	August 26, 2022	Custom compound weir	200	Near 17 Stan Wright Drive
A22-129-RG01	June 27, 2022	August 26, 2022	Tipping bucket	not applicable	305 Bonhomme Street

Data provided by SFE included accumulated rainfall and rainfall intensity for the rain gauge. Flow gauges that used a weir only recorded flow depth, while an area velocity metre recorded flow velocity and depth. Flow is estimated based on the weir equation or the pipe area-velocity relationship in both instances. All data was provided in five (5) minute time steps.





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Gravity Sewers
- Connaught Drive Trunk Sewer
- Highway 16 Trunk Sewer

Forcemains
- 100 mm
- 150 mm
- Unknown
- Rain Gauge
- Flow Monitor

Flow Monitors	Catchments
A22-129-01	A22-129-01
A22-129-02	A22-129-02
A22-129-03	A22-129-03
A22-129-04	A22-129-04
A22-129-05	A22-129-05

Jasper Wastewater Model

Figure 10: Rain Gauge and Flow Monitor Locations

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 100 200 400 600 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

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Drawn by: LB
Reviewed By: JU

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Date: November 2, 2022
Office: Edmonton

4.2.2 FLOW AND RAIN GAUGE DATA ANALYSIS

Time series plots of depth, flow and velocity (if available) were reviewed, along with the rainfall for each flow gauge. The time series plots for all flow gauges, including the rainfall, are provided in **Appendix C**. The data were reviewed for quality and completeness so that gaps, inconsistent or abnormal data could be excluded from the analysis. In general, the process consisted of the following steps:

— Plotting the flow and rain data series to identify data gaps or suspect data and check the consistency of readings between the parameters recorded (flow depth and velocity, for example).

— Complete a scattergraph analysis for the flow monitoring period.

— Conducting a flow balance analysis (only applicable for gauges downstream of others).

— Identifying relationships between rainfall and flow in the wastewater system.

Depending on the issues observed, the record may be filled with a zero value, corrected or discarded for subsequent analyses. Overall, the data quality at all flow gauges was good. The data was not modified, and gap filling was limited to adding zero values where timesteps were inconsistent. The depth, flow and velocity (as applicable) time series for flow gauges A22-129-01, A22-129-03, A22-129-04 and A22-129-05 indicate overall good data quality. Data from flow gauge A22-129-02 showed suspect flow depth and velocity data early in the record (morning of June 28, 2022) and sensor 'drifting' in the morning of July 20, 2022, and onwards. Flow gauge A22-129-05 is downstream of the Sleepy Hollow and Parks Canada lift stations and therefore shows highly variable measurements, reflecting the start and stop pumping cycles.

Scattergraphs were generated by plotting depth and velocity measurements from the applicable flow gauges (only A22-129-02 and A22-129-04 recorded velocity measurements). These are provided in **Appendix C**. The scattergraphs also include depth and velocity relationships for selected Manning's roughness coefficients (0.013 and 0.020 in this study) and the iso-Froude line (Froude number equal to one). A significant difference between the theoretical depth-velocity curves could indicate incorrect physical data of the sewer (i.e., slopes, diameter) or possible increased pipe roughness or backwater effects. A summary of the scattergraph review is provided in **Table 4.4**.

Table 4.4 Summary of scattergraph review

GAUGE ID	FLOW REGIME	SIGNS OF SURCHARGE	OTHER OBSERVATIONS
A22-129-02	Subcritical	None	Suspect data shows supercritical flow early in the record (morning of June 28, 2022)
A22-129-04	Sub and supercritical	None	None

The scattergraph analysis showed no signs of surcharging, identified by recorded depths greater than the pipe diameter. As described previously, there are some suspect data early in the record for flow gauge A22-129-02. Differences in the theoretical depth-velocity curves versus those observed could be explained due to errors in the physical pipe data.

The flow balance analysis consisted of subtracting the flow values at the upstream gauge from the downstream gauge. If flow balance is achieved (i.e., the upstream flow gauge values are lower than those downstream), the difference can be used to estimate the flows in the local sewershed. Flow gauges A22-129-02 and A22-129-04 are downstream of gauges A22-129-01 and A22-129-03, respectively. Flow balance figures for the downstream gauges are provided in **Appendix C**. A review of the results indicates that flow balance is achieved; therefore, the difference in flow values was used to estimate local sewershed flows.

4.2.3 DRY WEATHER FLOW ANALYSIS

The three major components of flow in a wastewater collection system include base wastewater flow (BWF), groundwater infiltration (GWI) and rainfall-derived inflow and infiltration (RDII). Dry weather flow (DWF) analysis establishes the base wastewater flow (BWF) and groundwater infiltration (GWI) components for each gauged sewershed (i.e., DWF = BWF + GWI).

Dry weather days were selected based on the rainfall data by choosing a 24-hour period (from 0:00 to 24:00) where at least the preceding 72 hours have less than 1 millimetre of rainfall. Dry days were grouped according to weekdays or weekends. Individual dry days were then plotted for each day group on a chart covering 24 hours to identify an average DWF pattern and rule out outliers. Typically, dry days with missing data or visible outliers are discarded from the analysis. However, due to the very short duration of the flow monitoring program, no days were excluded. Furthermore, the diurnal patterns entered in the model were averaged on an hourly basis (more on this below). Next, GWI was determined using the Stevens-Schutzbach method (1998), which relates the BWF and minimum daily DWF to calculate the base infiltration. BWF is then calculated by subtracting the GWI flow from the DWF pattern.

The dry weather flow characteristics for each flow gauge are summarized in **Table 4.5**, except for gauge A22-129-05, which could not be analyzed due to the highly-variable nature of the data reflecting start and stop pump cycles. The BWF value and corresponding wastewater generation rate per capita (litres per capita per day or L/c/day) include residential, ICI and groundwater infiltration based on an estimated total population (and population equivalents for ICI areas).

Table 4.5 Dry weather flow characteristics

GAUGE ID	SEWERSHED AREA (ha)	RESIDENTIAL POPULATION[1]	ICI POPULATION EQUIVALENT[3]	BWF (L/s)	BWF (L/c/day)	GWI (L/s)	UNIT GWI (L/s/ha)
A22-129-01	15.03	873	--	2.92	289	1.38	0.092
A22-129-02[2]	90.77	3,182	1,077	18.00	489	4.57	0.060
A22-129-03	4.54	--	1,251	4.92	340	1.54	0.346
A22-129-04[2]	60.13	1,864	2,973	10.76	499	2.12	0.038

Notes:

1 Estimated based on City of Edmonton population generation factors and equivalent district zoning.
2 These flow gauges are downstream of others; therefore, the results are for the local sewershed between the upstream and downstream gauges.
3 ICI population equivalents were based on an assumed 25-person per hectare value.

The unit GWI values in the sewershed for flow gauge A22-129-03 are very high in comparison to other areas in the townsite. Wastewater sewers and manholes in this sewershed should be inspected to confirm that there are no cross connections or other obvious significant sources of inflow or infiltration.

The dry weather flow analysis figures in **Appendix C** illustrate weekday and weekend diurnal patterns (5-minute intervals) along with the trace data. Observed peaking factors of the high-resolution diurnal pattern shows peaking factors of about 1.5 except for gauge A22-129-03, which displays peaking factors as high as 2.0. The high-resolution diurnal patterns were averaged based on every hour of the day to allow data entry into PCSWMM. The final hourly diurnal patterns used in the model for the weekdays and weekends are shown in **Figure 11** and **Figure 12**.

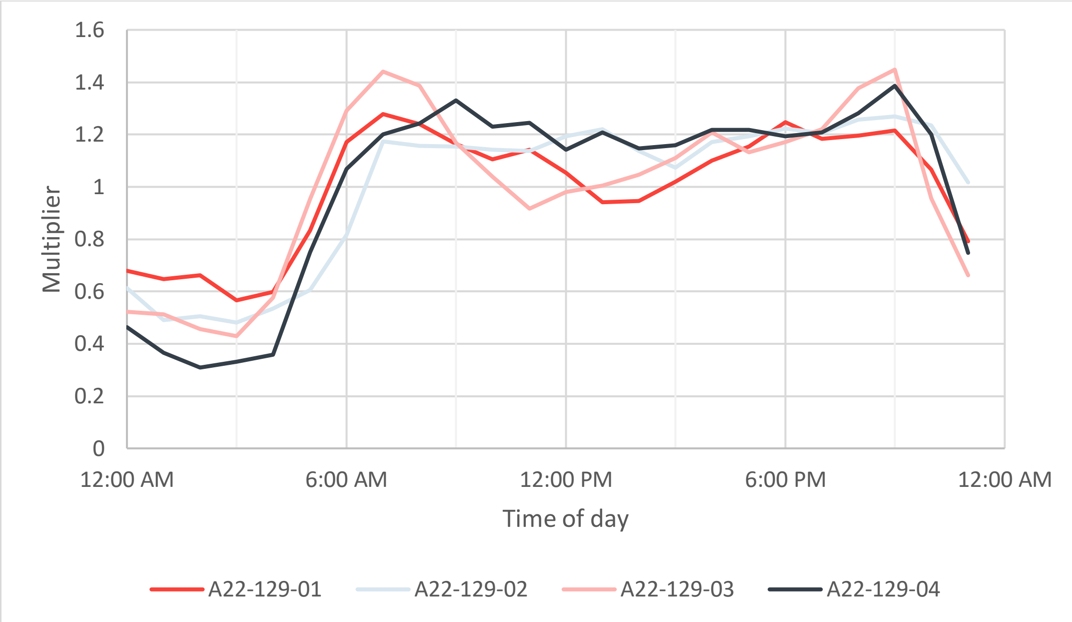


Figure 11 **Weekday diurnal patterns at each flow gauge sewershed**

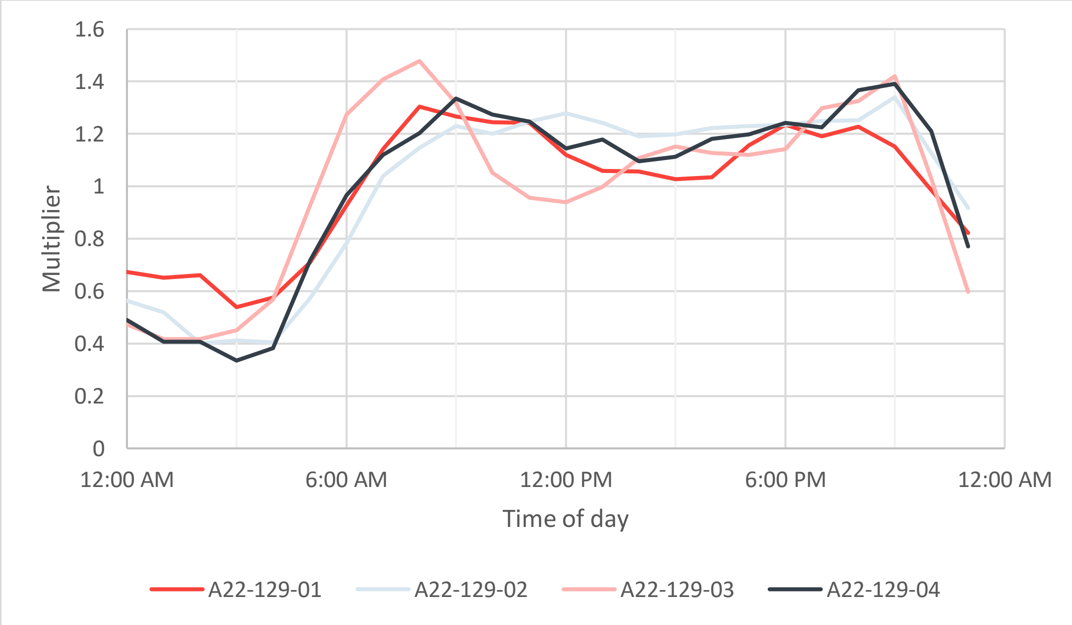


Figure 12 **Weekend diurnal patterns at each flow gauge sewershed**

As shown in the previous figures, the weekday and weekend diurnal patterns are very similar. Possible explanations for this include the effect of hourly averaging and tourism in the townsite, which may lead to somewhat consistent wastewater generation patterns throughout the week regardless of the day.

4.2.4 WET WEATHER FLOW ANALYSIS

Wet weather flow (WWF) comprises both the DWF and the rainfall-derived inflow and infiltration (RDII) flow that enters the wastewater collection system during rainfall events. WWF analysis consists of estimating RDII when the system is under influence of rainfall events and is calculated by subtracting the DWF.

Individual rainfall events were selected from the rain gauge record based on a cumulative depth of at least 3 millimetres. An interevent time of 12 hours was adopted to separate the storm events. **Table 4.6** summarizes the characteristics of rainfall events that met the adopted criteria for the monitoring period between the end of June to the end of July 2022.

Table 4.6 Summary of selected storm events

START	END	DURATION (hr)	TOTAL RAINFALL (mm)	PEAK 5-MINUTE INTENSITY (mm/hr)	RETURN PERIOD (yr)
2022-06-28 14:20:00	2022-06-29 15:35:00	25.25	6.00	6.0	<2 years
2022-07-04 14:45:00	2022-07-05 06:45:00	16.00	10.25	9.0	<2 years
2022-07-08 14:35:00	2022-07-09 00:40:00	10.09	3.75	6.0	<2 years

The selected WWF rainfall events were then compared with the intensity-duration-frequency (IDF) curves for the Jasper Weather Station (WS), which has the longest record (31 years between 1963 and 1994) in the area. The Jasper WS has since been replaced with the Jasper Warden WS; however, the latter has a record of only 12 years long. **Figure 13** illustrates the intensity of the selected rainfall events and duration compared to the Jasper WS IDF curves, which shows that the observed rainfall events have a return period much less than the 2-year event.

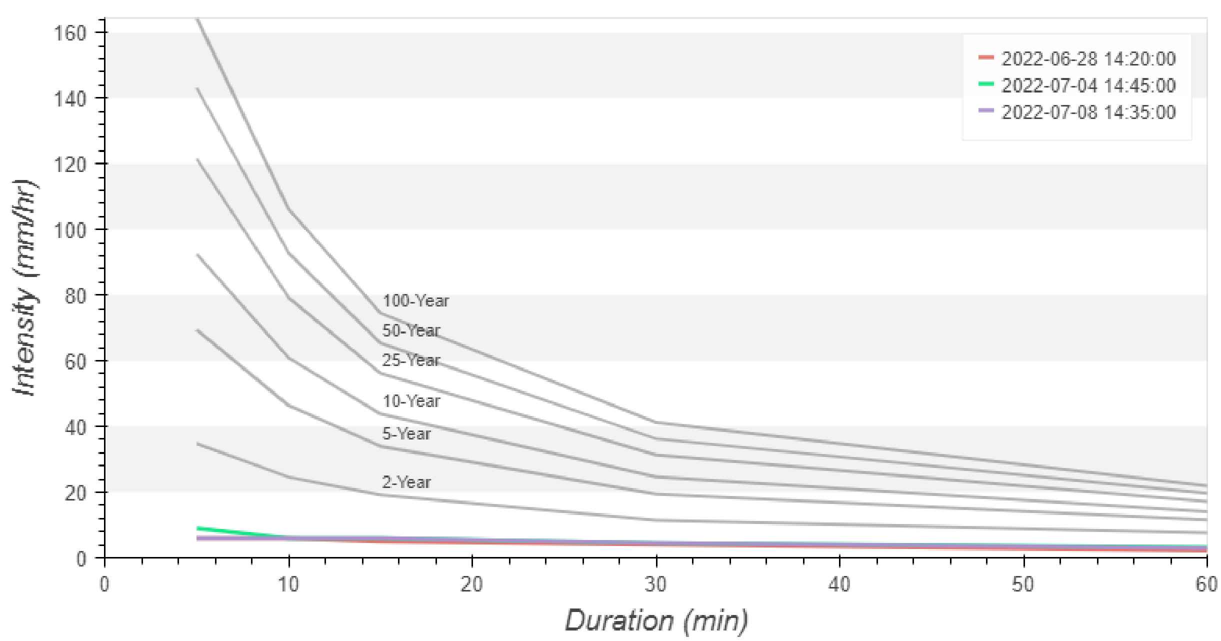


Figure 13 Rainfall events selected for WWF analysis

Appendix C also includes charts illustrating the estimate of RDII flow contributions for each flow gauge sewershed. The analysis revealed that all gauged sewersheds (excluding A22-129-05) have some RDII flow contributions even during the small rainfall events observed during the flow monitoring period. Wet weather flow analysis was not conducted on the data for flow gauge A22-129-05 as it was affected by the upstream pump cycles. **Table 4.7** provides a summary of the RDII flows for the selected rainfall events.

Table 4.7 Summary of selected storm events

GAUGE ID	SEWERSHED AREA (ha)	PEAK RDII (L/s)			PEAK UNIT RDII (L/s/ha)		
		2022-06-28	2022-07-04	2022-07-08	2022-06-28	2022-07-04	2022-07-08
A22-129-01	15.03	2.553	2.520	1.340	0.170	0.168	0.089
A22-129-02	90.77	12.666	11.560	8.540	0.167	0.153	0.113
A22-129-03	4.54	8.254	8.378	5.699	1.818	1.845	1.255
A22-129-04	60.13	7.174	6.655	3.694	0.129	0.120	0.066

For context, the provincial guidelines outline that the allowance for extraneous (or general inflow and infiltration) for all land uses is 0.28 litres per second per hectare (L/s/ha) (Alberta Environment and Sustainable Resource Development, 2013). As calculated in the previous table, the sewershed for flow gauge A22-129-03 displays peak unit RDII rates much higher than the provincial allowance for RDII even during the relatively small rainfall events (i.e., < 2-year event) observed during the flow monitoring period. Further field investigation is recommended in this sewershed to confirm that there are no cross connections or other obvious significant sources of inflow or infiltration. Other flow gauge sewersheds show peak unit RDII values less than outlined in provincial standards, although these values are calculated for events with a return period much less than a 2-year event.

4.3 MODEL LOADING

The main flow components in a wastewater sewer include the following:

— Dry weather flow (DWF): BWF (residential and ICI wastewater) and GWI, which is the flow that enters the wastewater sewers and manholes through cracks in the structures.
— Wet weather flow (WWF): rainfall-derived inflow and infiltration that enters the wastewater collection system.

DWF was loaded in the model based on estimated population values within sub-sewersheds, and WWF was added to the model as a fixed amount based on the gross contributing sewershed. WWF was added only at sub-sewersheds that included a population estimate (i.e., parks and parking lots were assumed to not generate WWF contributions).

4.3.1 DRY WEATHER FLOW LOADING

Wastewater loads were added to the model at selected nodes based on the estimated population within each sub-sewershed. Population values were initially estimated by using the average density according to Statistics Canada (2022); however, the total number of permanent residents was too low. Ultimately, the residential population values were estimated based on Edmonton factors (EPCOR, 2021a) by determining equivalent zoning districts between the communities. The total population count for the existing conditions was 5,030 people, which allowed a buffer of up 1,000 persons to account for the shadow population and tourists. ICI area population equivalents were calculated based on an assumed 25 people per hectare value. The loading approach consisted of the following steps:

1. Delineating the sub-sewersheds according to assumed building service connections.
2. Estimating the total population (residential and ICI equivalents) within each sub-sewershed.
3. Calculating average dry weather flow contributions from each sub-sewershed based on the wastewater generation rates (including GWI) derived from flow monitoring data (**Table 4.5**).

The process adopted for loading the wastewater model is depicted in **Figure 14**.

Figure 14 Illustration of wastewater model loading

All model nodes that had inflows (wastewater loadings) were assigned weekday and weekend diurnal patterns developed from the flow monitoring program. Patterns were assigned according to the location of each sub-sewershed within the applicable flow gauge sewershed. Entirely residential areas, such as the Stone Mountain and Patricia Place lift station sewersheds, were assigned a pattern based on flow gauge identifier A22-129-01 (also a residential sewershed). **Table 4.8** summarizes the average dry weather flow generation rates adopted in the model for the various service areas in the townsite. These rates were based on flow monitoring data (refer to **Section 4.2.3**) although were adjusted to achieve a closer match between the observed and simulated flows at the flow gauges in the model. The average rates in the table below were calculated based on the current total service area population (residential and ICI population equivalents).

Table 4.8 Average dry weather flow for model loading

FLOW GAUGE ID/SERVICE AREA	AVERAGE WASTEWATER GENERATION RATE (L/c/day)
A22-129-01	300
Stone Mountain LS (within A22-129-02 sewershed)	300
Patricia Place LS (within A22-129-02 sewershed)	300
A22-129-02	550
A22-129-03	360
A22-129-04	270
Unmonitored area	300

4.3.2 FUTURE SYSTEM LOADING

The wastewater loading of the system under future population horizons followed the same approach as the existing conditions. The population values were increased within all sub-sewersheds that contained proposed development parcels or potential infill developments (refer to **Figure 4**) and average flows in the model were recalculated accordingly. The high population estimate values from the proposed developments were adopted (refer to **Table 1.2**). The rest of the future population was distributed evenly throughout the potential infill development areas. The total future residential population was 10,622 people for the 25-year horizon. The average wastewater generation rates from the existing conditions were maintained.

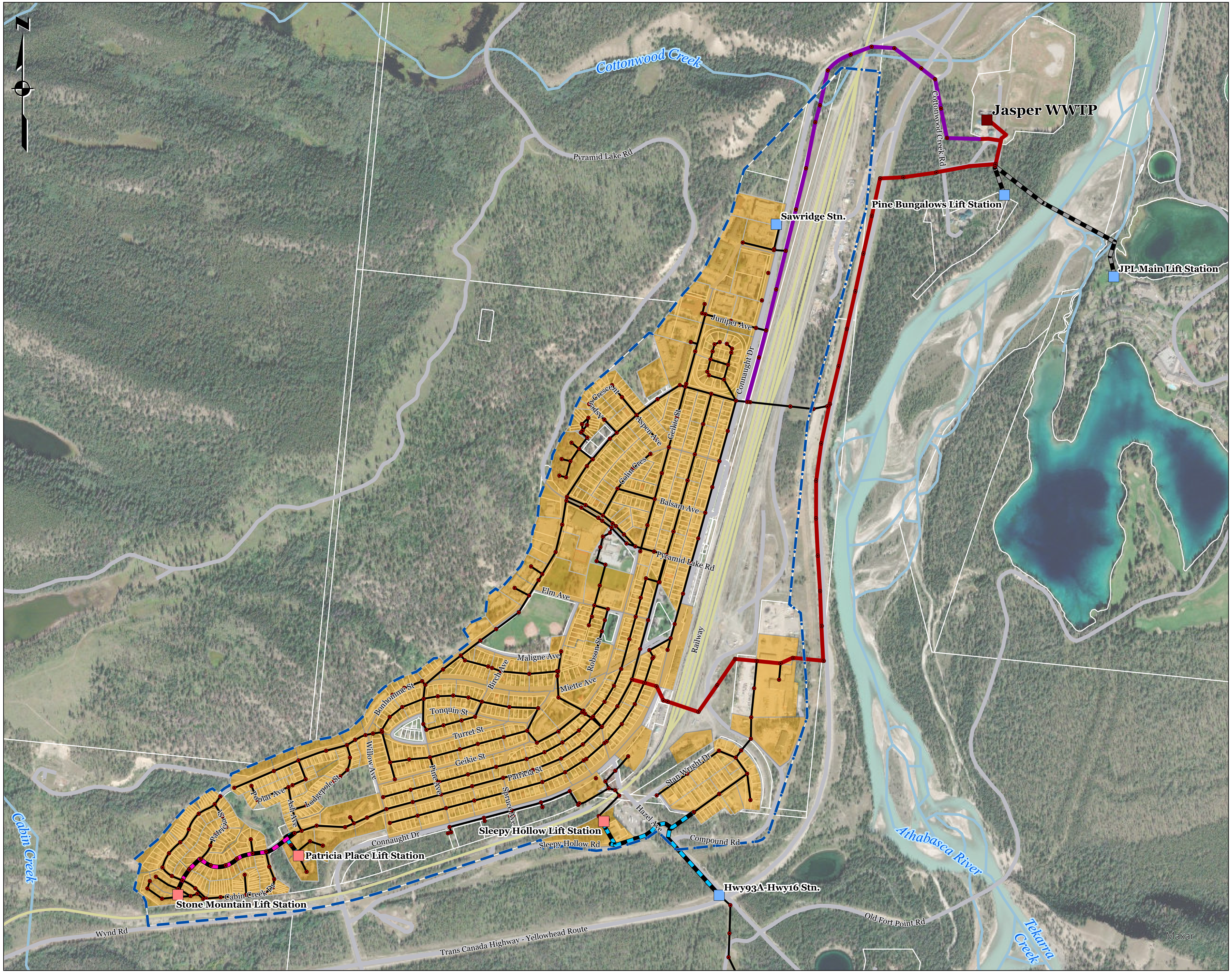
4.3.3 WHISTLERS AND WAPITI CAMPGROUNDS

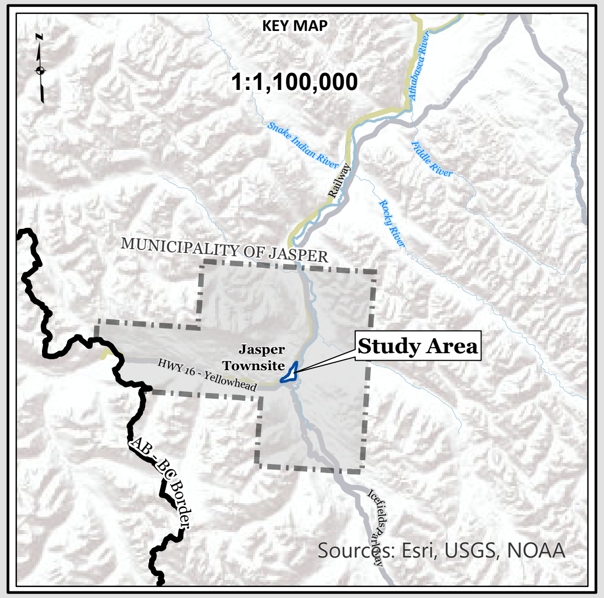
As described previously, the Whistlers and Wapiti campgrounds are serviced by the MOJ's wastewater collection system. The MOJ provided wastewater flow records from the Whistlers and Wapiti campgrounds for the camping season in 2021. The flow gauge was located at a manhole on the gravity sewer owned by Parks Canada, where Highway 93 (Icefields Parkway) branches into Highway 93A. The record included ten-second data from June 6 to October 31, 2021. The week of July 25-31 (Monday to Sunday) had the highest wastewater volumes generated from the campgrounds and was used to establish a conservative estimate of the average flow and diurnal patterns. The rainfall records for the Jasper Warden WS, located approximately 7 kilometres northeast of the townsite core, showed virtually no rainfall during the selected period (a total rainfall of 0.8 millimetres for the week). The average wastewater flow for the chosen period was 3.71 L/s, with hourly averaged peaking factors ranging between 0.35 and 1.99 for weekdays, and 0.12 and 2.29 for weekends.

4.3.4 WET WEATHER FLOW LOADING

Wet weather flow model calibration is preferred to be based on a single rainfall event large enough to cause surface ponding and runoff or an extended period with significant rain (United States Environmental Protection Agency, 2014). Since the observed rainfall events did not meet these criteria, calibration of the model under WWF was not completed. Furthermore, WWF simulations generally are conducted based on 25-year design storms, which would require major extrapolation of the observed data during the flow monitoring period. Instead, WWF was considered in the model by adding contributions based on the gross area of the sewershed.

The value adopted in this study followed provincial guidelines and applied 0.28 L/s/ha to account for RDII in the model (Alberta Environment and Sustainable Resource Development, 2013). Provincial standards and guidelines recommend that this value is applied irrespective of land use classification to account for inflows at manholes not located in sags and for infiltration flow to pipes and manholes. An additional inflow allowance (0.4 L/s/manhole) could have also been added at wastewater system manholes within roadway sags, although this was not implemented since less than five (5) percent of the MOJ's system manholes are within depressions in the townsite. **Figure 15** illustrates the sewersheds used to determine the WWF model loadings under the existing conditions. In the future population development horizon, the parcels that are currently undeveloped but will be developed were added to calculate WWF contributions. A conservative WWF contribution of 0.5 L/s/ha was also used to test the system under worst-case inflow and infiltration conditions.





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Manhole
- Gravity Sewers
- Connaught Drive Trunk Sewer
- Highway 16 Trunk Sewer
- WWF Sewershed

Forcemains

- 100 mm
- 150 mm
- Unknown

Jasper Wastewater Model

Figure 15: Wet Weather Flow Sewersheds

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

Report By: JU | WSP Job #: 221-07121-00
Drawn by: JC | Date: November 2, 2022
Reviewed By: JU | Office: Edmonton

4.4 MODEL CALIBRATION RESULTS

4.4.1 DRY WEATHER FLOW CALIBRATION

Due to the short duration of the flow monitoring program, it was impossible to isolate a continuous period of seven (7) days that included weekdays and weekends and met the dry weather day criteria (days with preceding 72 hours that have less than 1 millimetre of rainfall). Two weeks of the record periods offered the best alternative for DWF calibration and validation: the week of July 11-17 and July 18-25. A total of seven weekdays from these two weeks were selected to develop the weekday average DWF and diurnal patterns for each flow gauge sewershed. Weekend average DWF and patterns were developed based on four selected weekend days. DWF model validation consisted of a qualitative approach that compares the simulated profile against the minimum and maximum data bounds for the selected dry days and the overall shape of the hydrograph (Urban Drainage Group, 2017). **Figure 16** compares the simulated and observed hydrographs at the flow gauges for the week of July 11-18.

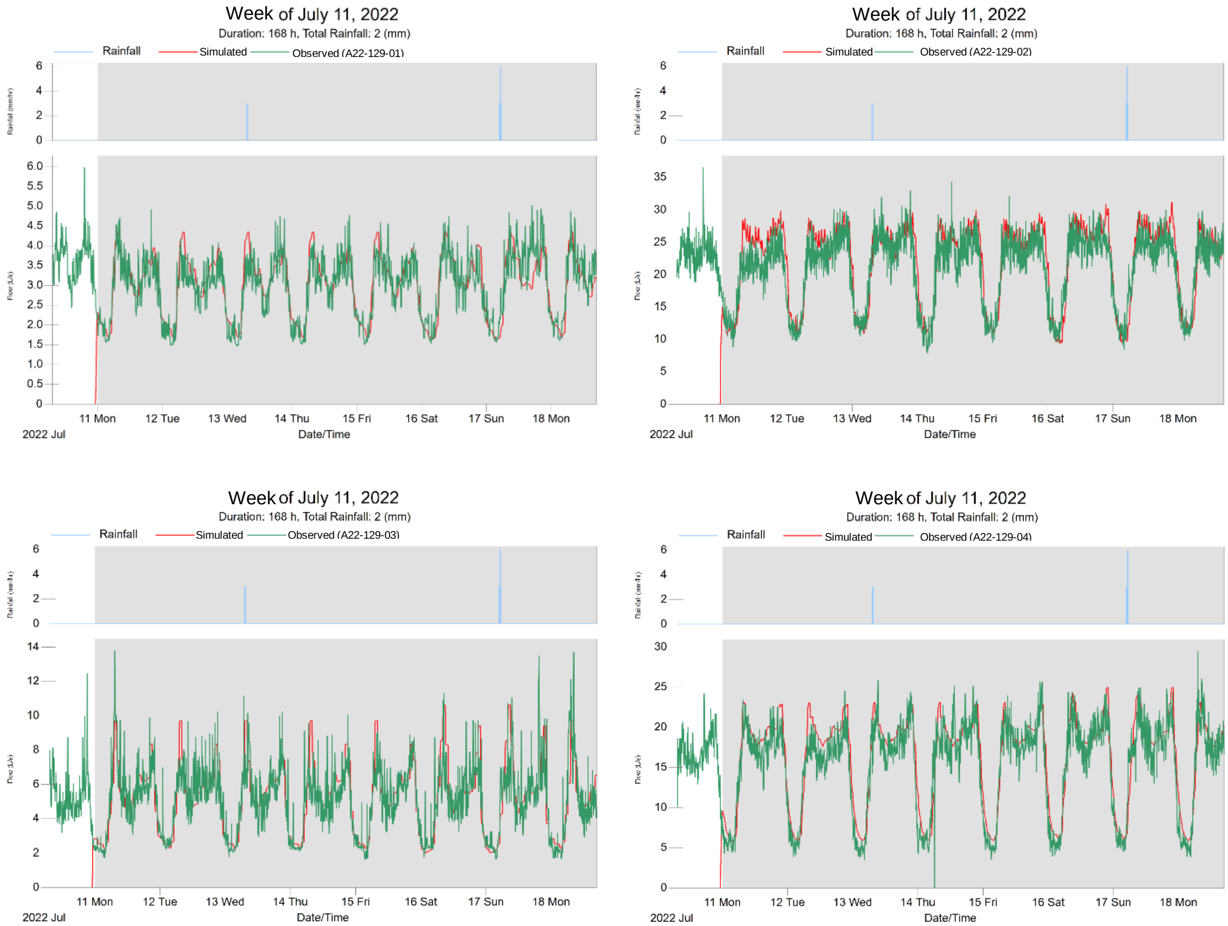


Figure 16 **DWF calibration results**

Generally, the flow peaks and hydrograph shapes visually compare well to the observed data. Charts providing a more quantitative analysis of the model are provided in **Appendix D**. Overall, the flow predicted by the model was within the minimum and maximum data bounds and the Nash-Sutcliffe Efficiency Coefficient (NSEC) ranged between 0.546 and 0.822, indicating the model has predictive skill (i.e., NSEC greater than 0.5).

4.4.2 WET WEATHER FLOW CALIBRATION

As described previously, the observed rainfall data was unsuitable for WWF model calibration.

5 EXISTING SYSTEM ASSESSMENT

5.1 OVERVIEW

The following section of the report assesses the existing wastewater collection system based on adopted evaluation criteria. This section also briefly analyzes wastewater system data and water consumption records which show the impact due to COVID-19 provincial restrictions and its impact on tourism locally.

5.2 WWTP AND WATER BILLING DATA REVIEW

5.2.1 WWTP DAILY INFLUENT VOLUMES

The MOJ provided a dataset containing the calculated wastewater volumes from the townsite and JPL measured at the WWTP flow meter and the JPL flow meter. The record contained daily wastewater volumes collected between January 1, 2018, and June 6, 2022, and is illustrated in **Figure 17**. Townsite influent volume values were calculated from the difference in volume readings between the WWTP flow meter and the JPL flow meter.

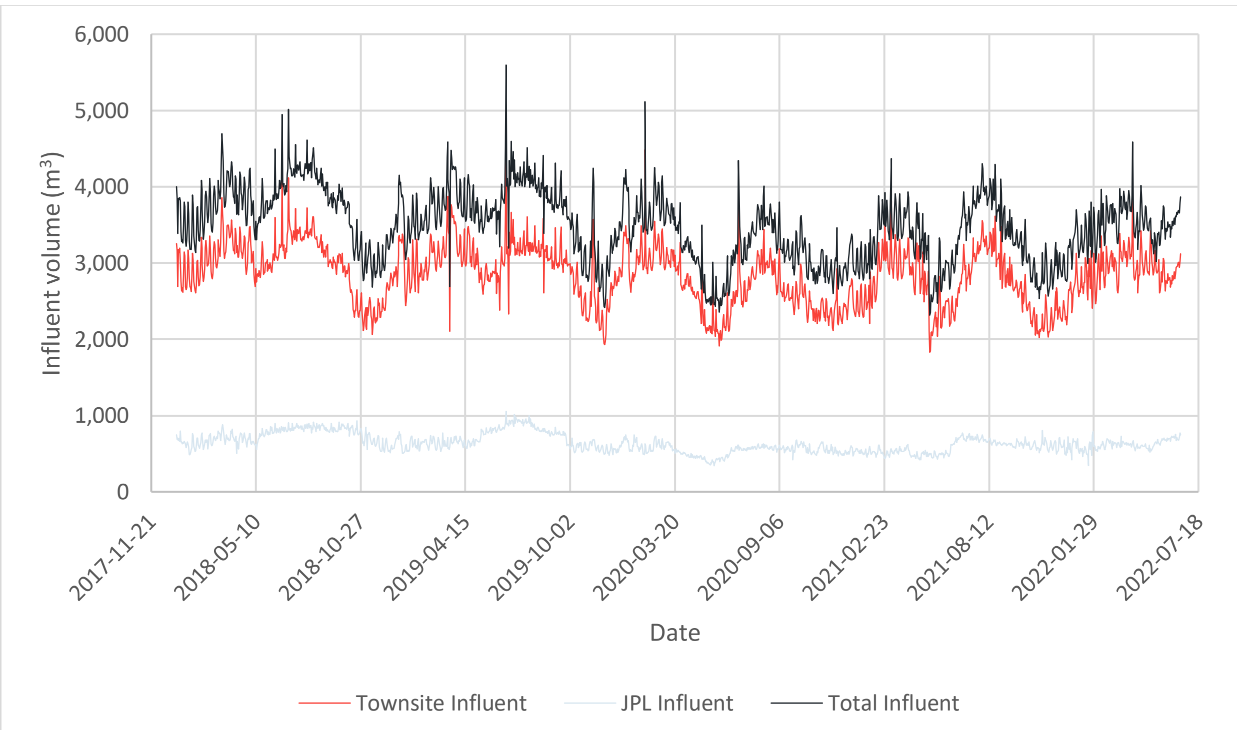


Figure 17 WWTP daily influent volumes (2018-2022)

Data analysis indicated that the average daily total influent to the WWTP is 3,475 cubic metres, with peaks as high as 5,600 cubic metres. The data shows seasonality in wastewater flows to the WWTP, with higher volumes in the summer than in the winter. The higher peaks in the summer are likely a result of increased tourism and RDII flows. The data further indicates that the influent volumes from 2018 and 2019 were greater than in recent years, likely due to COVID-19 restrictions. Peaks from earlier years are in the range of 4,500 cubic metres, while more recently, the peaks are in the low 4,200 cubic metre range. Approximately 80 percent of the total influent is from the townsite, while the JPL resort contributed the remaining 20 percent.

5.2.2 WWTP INFLUENT RATES

The MOJ also provided influent flow records from the WWTP flow meter containing data between January 1, 2017, and January 1, 2021. As described previously, the WWTP flow meter considers the overall area serviced by the WWTP, including the JPL force main. The record contained hourly influent rates to the WWTP and is illustrated in **Figure 18**.

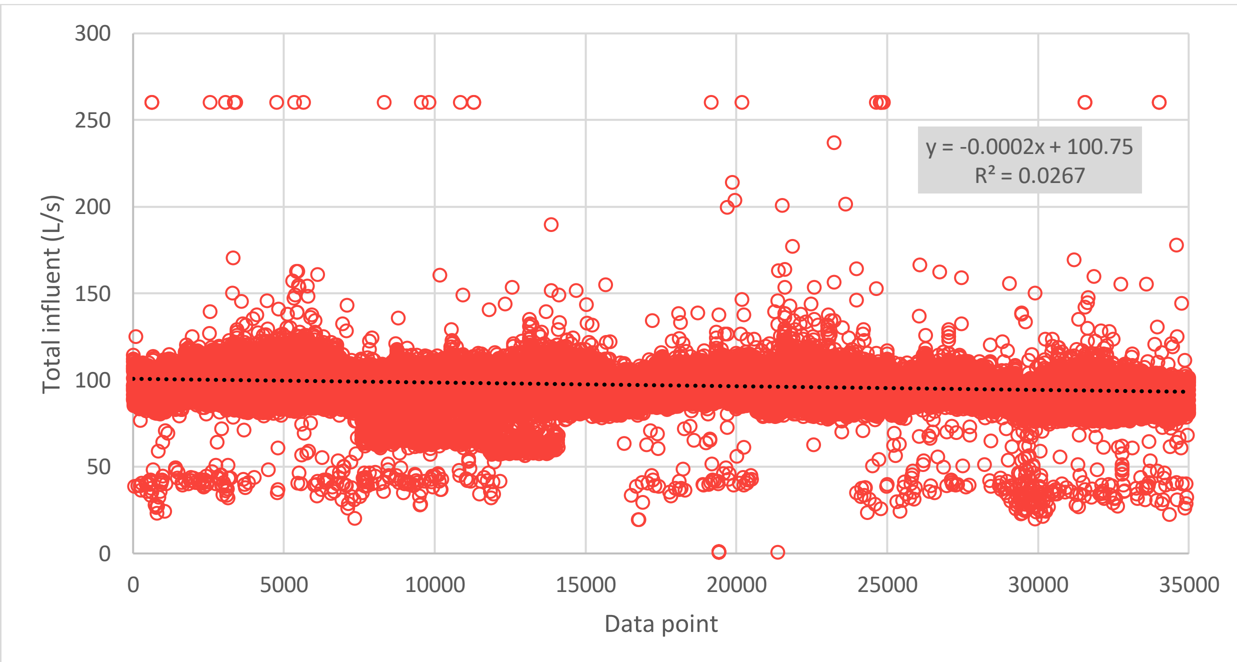


Figure 18 WWTP influent rates (2017-2020)

The daily average influent rate to the WWTP was calculated as 97.0 L/s with peak rates as high as 260 L/s. The trendline indicates a mildly decreasing pattern, likely due to decreased inflows during COVID-19 provincial restrictions.

5.2.3 AVERAGE WATER CONSUMPTION

The MOJ provided bi-monthly water consumption records between January 1, 2021, and June 30, 2022 (18 months). The records contained consumption totals, averages and unit count for residential, commercial in-town and commercial out-of-town users. Average residential consumption rates for residential users were estimated based on a population density of 2.3 persons per unit for the MOJ rural services area (Statistics Canada, 2022). Records indicated that there are between 1,175 and 1,206 residential units and 176 and 180 commercial units in town. **Table 5.1** summarizes the residential average water consumption rates for the entire town and the residential to commercial water consumption ratio.

Table 5.1 Average water consumption rates

PERIOD	RESIDENTIAL CONSUMPTION RATE (L/c/day)	COMMERCIAL TO RESIDENTIAL WATER CONSUMPTION RATIO
January 1 to February 28, 2021	275	1.48
March 1 to April 30, 2021	308	1.34
May 1 to June 30, 2021	257	1.94
July 1 to August 31, 2021	292	2.28
September 1 to October 31, 2021	204	2.41
November 1 to December 31, 2021	178	1.84
January 1 to February 28, 2022	265	1.67
March 1 to April 30, 2022	276	1.78
May 1 to June 30, 2022	205	2.44

Data analysis indicated that the average residential water consumption rates were about 250 litres per capita per day (L/c/day), with minimum and maximum values of 178 and 308 L/c/day. The residential water consumption rate is comparable to the wastewater generation rates inferred from the flow gauge data, which is about 300 litres per capita per day for flow gauge A22-129-01. Excess flows could be a result of infiltration into the wastewater collection system. The data also showed that commercial water consumption in the town is sometimes more than double what residential areas use.

5.3 EVALUATION CRITERIA

The MOJ currently does not have engineering design standards or guidelines. In discussions with the MOJ, it was reported that new developments are generally required to design or analyze infrastructure using the latest version of the City of Edmonton Design and Construction Standards. The evaluation criteria for the MOJ's wastewater collection system were based on provincial standards and guidelines and the City of Edmonton Design and Construction Standards. **Table 5.2** summarizes the adopted level of service criteria used to assess the existing wastewater collection system.

Table 5.2 Level of service criteria

COMPONENT	CRITERIA	HYDRAULIC INDICATOR
Gravity sewer	Design flow/depth: - Less than 86% full flow (or 80% full flow depth) Design velocities: - Minimum of 0.6 m/s - Maximum of 3.0 m/s	Asset is deficient if: - Q/Qfull > 0.86 - V < 0.6 m/s or - V > 3.0 m/s
Force main	Design velocities: - Minimum of 0.6 m/s - Maximum of 3.5 m/s The optimal velocity range is between 0.9 and 1.5 m/s	Asset is deficient if: - V < 0.6 m/s or - V > 3.5 m/s
Lift station	Minimum pump units: - two identical and interchangeable pumps	Asset is deficient if: - number of pump units < 2

Minimum design velocities are specified to achieve self-cleansing and resuspension of material (i.e., prevent settlement of solids), although this criterion is generally applied for new developments. While a significant portion of the MOJ's wastewater collection system exhibits velocities below the desired minimum (0.6 m/s), no concerns were reported by the MOJ that can be attributed to low flow velocities. If the settlement of material inside the wastewater collection pipes becomes a concern in the future, the model developed in this study may be used to identify potentially problematic sewers.

Maximum design velocities are generally set to ensure that the gravity sewer or force main is stable (prevents joint displacement), as well as mitigating turbulence (leads to odour issues) and erosion (of the pipe).

5.4 EXISTING CONDITIONS

The existing wastewater collection system was assessed under DWF and WWF conditions based on the current population. The goal of this scenario was to identify any existing capacity issues in the current system.

Model results are presented in **Figure 19** for DWF conditions and **Figure 20** and **Figure 21** for the WWF conditions based on a 0.28 and 0.5 L/s/ha inflow and infiltration allowance. Model results indicate that the existing system generally performs to the required level of service under DWF and WWF (0.28 and 0.5 L/s/ha) conditions. All MOJ force mains also displayed flow velocities greater than 0.6 m/s, and all lift stations have identical and interchangeable pumps. Several MOJ sewers have flow velocities less than 0.6 m/s under WWF scenarios due to the small flow contributions throughout the system. However, both trunk sewers maintain velocities greater than the minimum velocity threshold even under DWF conditions.

Under DWF conditions, the model shows a segment of wastewater sewer on the south leg of Stan Wright Drive as surcharging and flooding. Although more investigation is recommended to verify the model results at this sewer since it is downstream of the Parks Canada Lift Station (identifier HWY93A-HWY16), which uses assumed pump flow-head curves and start and stop settings. The model shows surcharging of this sewer in all current and future conditions scenarios. A review of the data for flow gauge A22-129-05 (**Appendix C**) shows a few instances of observed depths at this sewer greater than 200 millimetres, which may confirm there is some surcharging (the GIS datasets show the sewer downstream of the Parks Canada force main as a 200-millimetre pipe). The Parks Canada Lift Station settings and physical pipe data (i.e., diameter) should be verified and updated in the model.

The DWF model results also show an additional sewer surcharging due to its reverse grade. The segment includes a 300-millimetre sewer on the lane west of Connaught Drive, south of Miette Avenue. The MOJ confirmed that this sewer has a reverse grade and requires regular flushing. This sewer is also shown as surcharging under all other scenarios due to the installation grade.

Results are the same for the WWF scenario based on the 0.28 L/s/ha inflow and infiltration allowance.

The relief locations in all existing scenarios remained unused.

5.5 FUTURE CONDITIONS

5.5.1 25-YEAR POPULATION HORIZON

As described previously, growth in the townsite is expected to be accommodated within its current municipal boundary. No additional infrastructure was envisioned to be required to service areas as the existing network has good coverage of the entire townsite. The future populations were also assessed under DWF and WWF (0.28 and 0.5 L/s/ha) conditions. The goal of this scenario was to identify any capacity issues in the current system that need to be addressed such that future developments can be accommodated.

Model results are presented in **Figure 22** for DWF conditions and **Figure 23** and **Figure 24** for the WWF conditions based on a 0.28 and 0.5 L/s/ha inflow and infiltration allowance. Model results indicate that the existing system generally performs to the required level of service under DWF and WWF (0.28 and 0.5 L/s/ha) conditions. All MOJ force mains also displayed flow velocities greater than 0.6 m/s.

Under DWF conditions and all future conditions scenarios, the model shows a segment of wastewater sewer on the south leg of Stan Wright Drive as surcharging and flooding. Confirmation of the Parks Canada pump data and settings is recommended. The model results for the WWF scenario based on the 0.28 L/s/ha inflow and infiltration allowance are the same as in DWF future conditions.

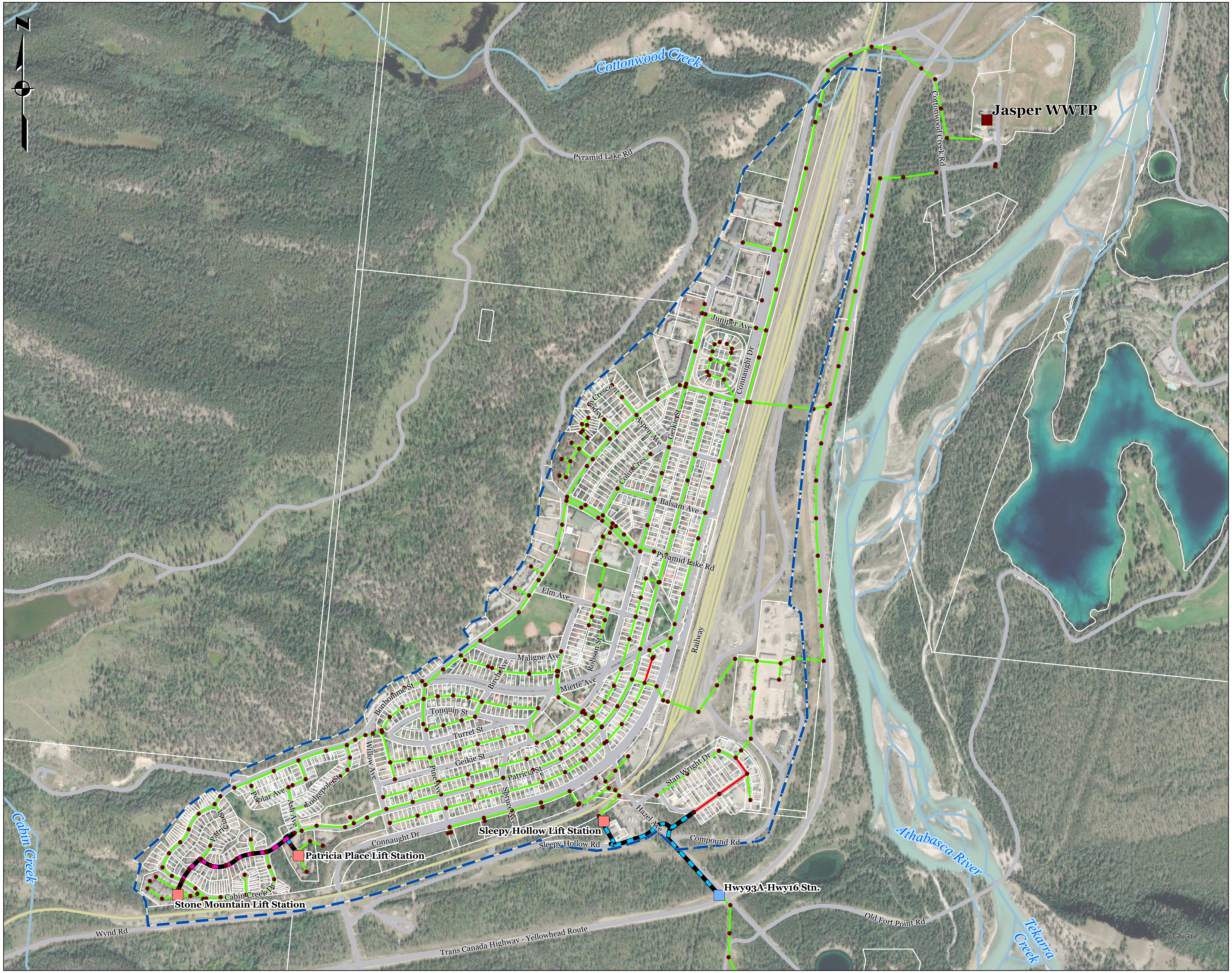
The model shows the following additional sewers as surcharging in the WWF scenario with a 0.5 L/s/ha inflow and infiltration allowance:

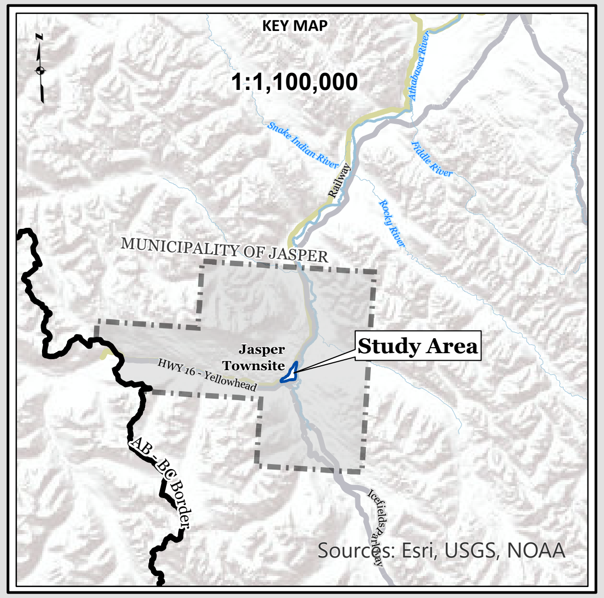
— a 250-millimetre sewer on Pyramid Avenue, east of Pyramid Lake Road, and,
— a 375-millimetre sewer on Patricia Street, south of Miette Avenue.

The previously mentioned sewer segments should be verified with a model calibrated under appropriate WWF conditions. The assumption of 0.5 L/s/ha inflow and infiltration allowance is conservative and may not represent actual values in the MOJ's system.

The model also shows a 200-millimetre wastewater sewer service as surcharging at Pyramid Lake Road, south of Elm Avenue. This sewer segment is surcharging due to an assumed zero percent grade. Implementation of actual inverts at this service is expected to resolve the simulated surcharge in the model.

The relief locations in all future scenarios remained unused as in the existing conditions.





Jasper Wastewater Model

Figure 19: Model Results - Existing Conditions - DWF

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

Report By: JU | WSP Job #: 221-07121-00
Drawn by: JC | Date: November 1, 2022
Reviewed By: JU | Office: Edmonton

Jasper Wastewater Model

Figure 20: Model Results - Existing Conditions - WWF (0.28 L/s/ha)

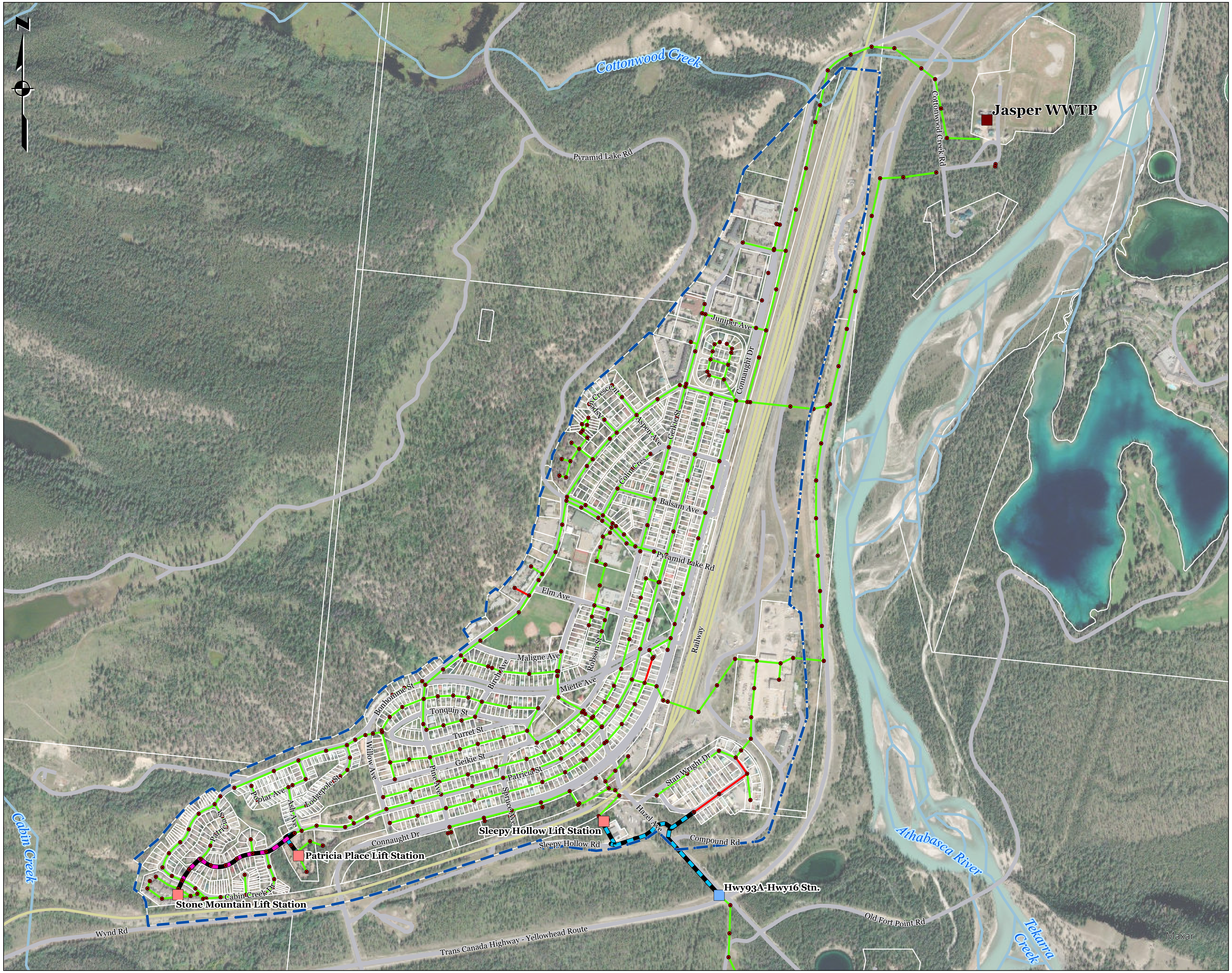
Municipality of Jasper
Alberta, Canada

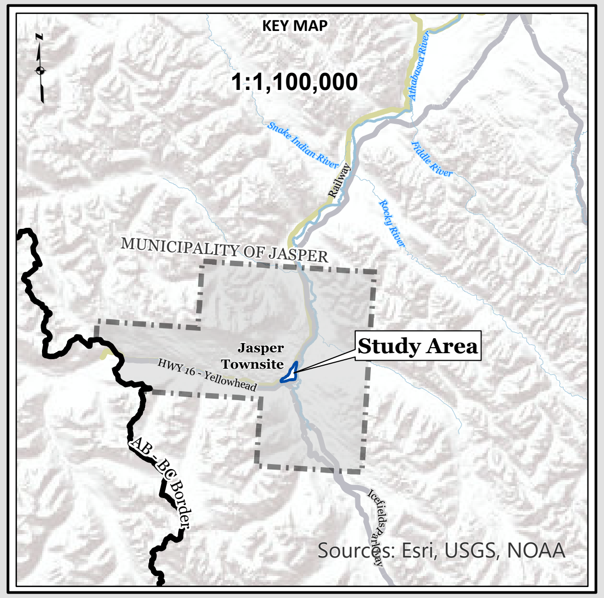
Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

Report By: JU	WSP Job #: 221-07121-00
Drawn by: JC	Date: November 1, 2022
Reviewed By: JU	Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Manhole

Forcemains

- 100 mm
- 150 mm
- Unknown

Gravity Sewers

- Q/Qfull > 0.86
- Q/Qfull < 0.86

Jasper Wastewater Model

Figure 21: Model Results - Existing Conditions - WWF (0.5 L/s/ha)

Municipality of Jasper
Alberta, Canada

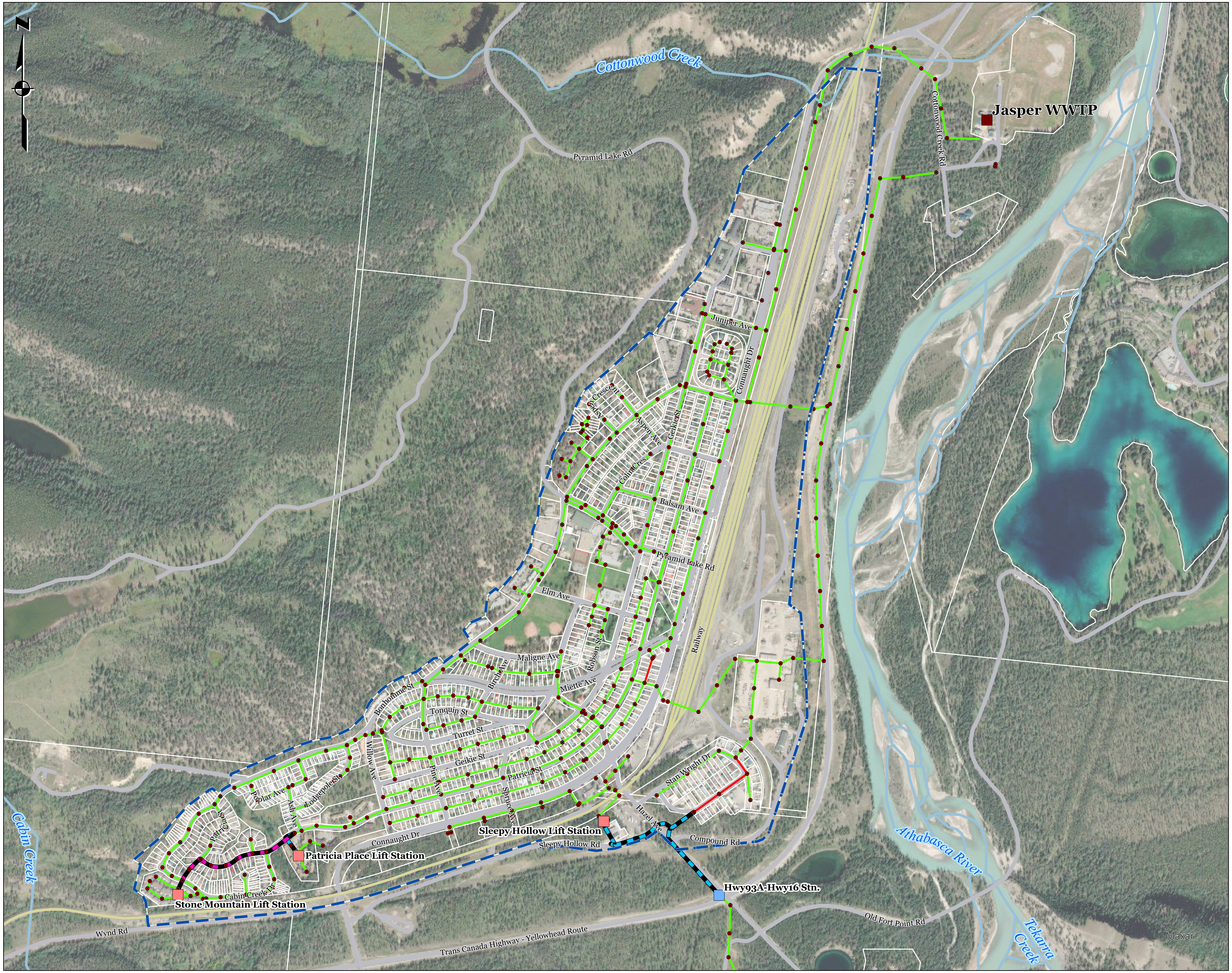
Scale: 1:12,000

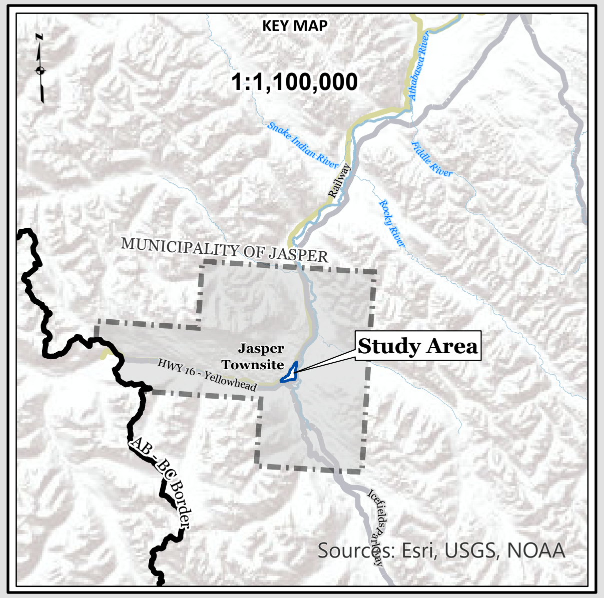
0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

wsp

Report By: JU
Drawn by: JC
Reviewed By: JU
WSP Job #: 221-07121-00
Date: November 1, 2022
Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Manhole

Forcemains

- 100 mm
- 150 mm
- Unknown

Gravity Sewers

- Q/Qfull > 0.86
- Q/Qfull < 0.86

Jasper Wastewater Model

Figure 22: Model Results - 25-year Population Horizon - DWF

Municipality of Jasper
Alberta, Canada

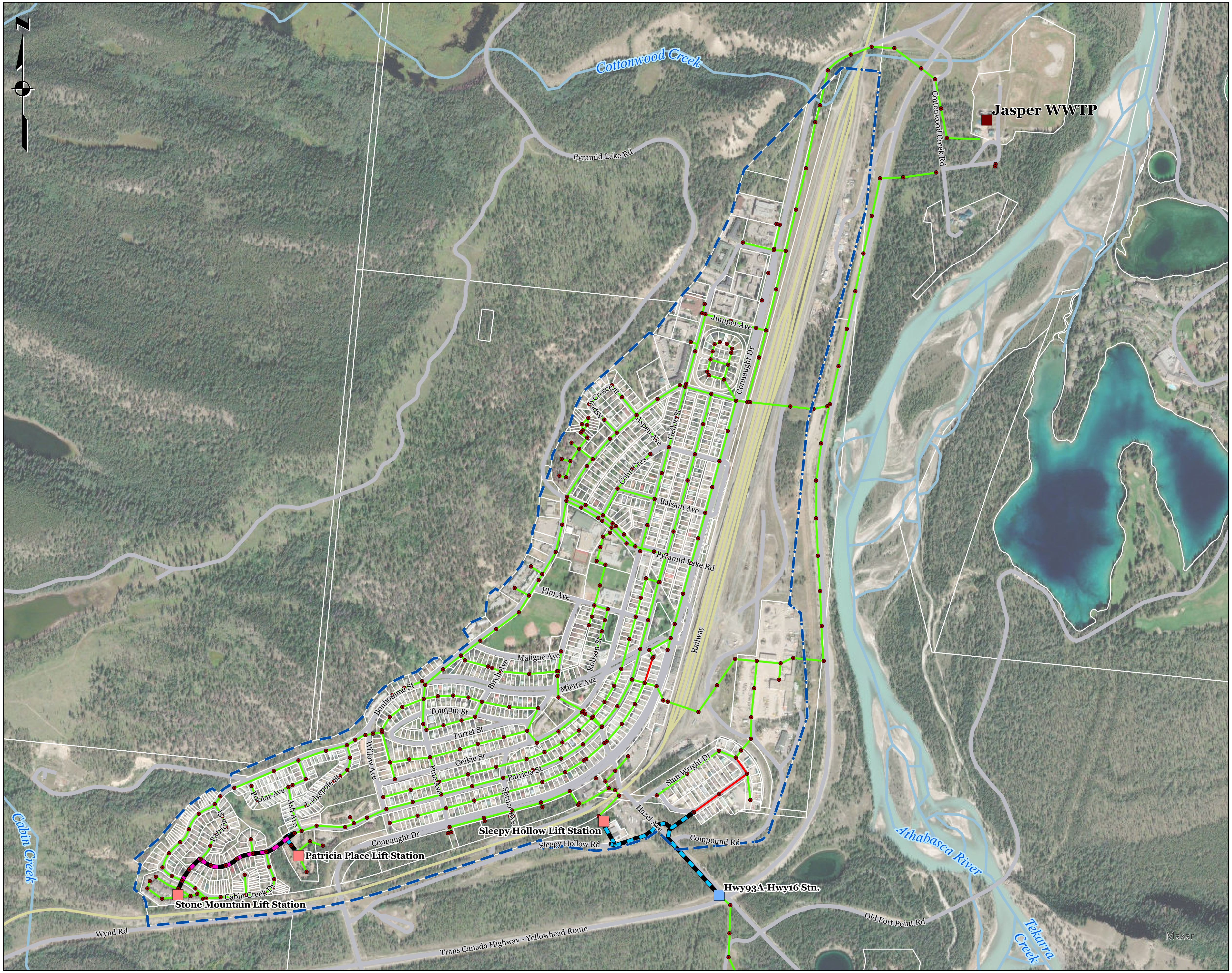
Scale: 1:12,000

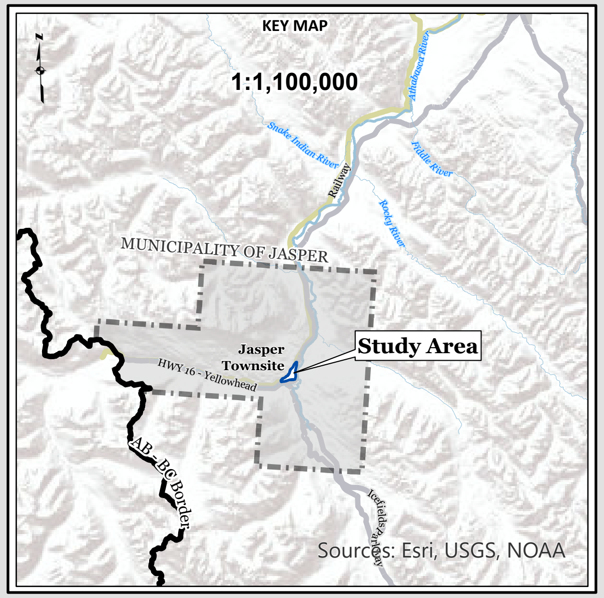
0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

Report By: JU
Drawn by: JC
Reviewed By: JU

WSP Job #: 221-07121-00
Date: November 1, 2022
Office: Edmonton





Legend

- Townsite Boundary
- Roads
- Watercourse
- Railway
- Parcel
- Wastewater Treatment Plant
- MOJ-owned Lift Station
- Non-MOJ-owned Lift Station
- Manhole

Forcemains

- 100 mm
- 150 mm
- Unknown

Gravity Sewers

- Q/Qfull > 0.86
- Q/Qfull < 0.86

Jasper Wastewater Model

Figure 23: Model Results - 25-year Population Horizon - WWF (0.28 L/s/ha)

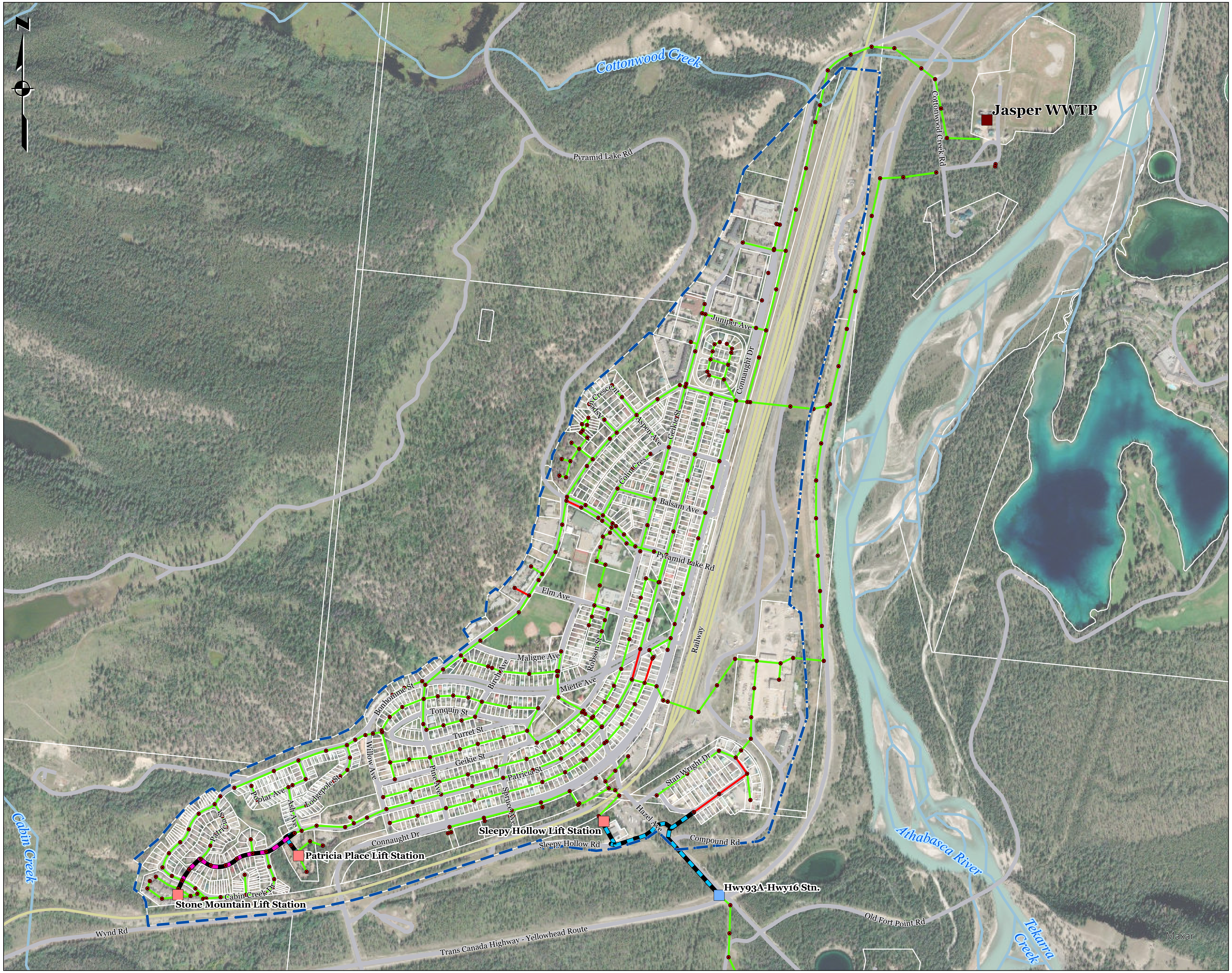
Municipality of Jasper
Alberta, Canada

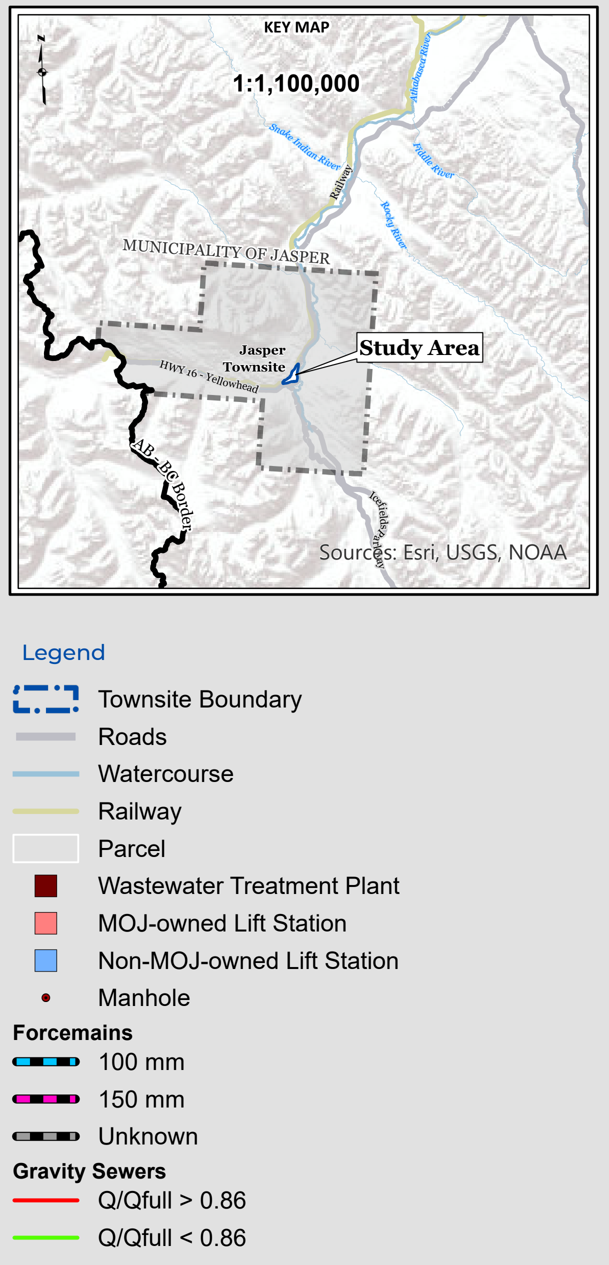
Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

Report By: JU	WSP Job #: 221-07121-00
Drawn by: JC	Date: November 1, 2022
Reviewed By: JU	Office: Edmonton





Jasper Wastewater Model

Figure 24: Model Results - 25-year Population Horizon - WWF (0.5 L/s/ha)

Municipality of Jasper
Alberta, Canada

Scale: 1:12,000

0 80 160 320 480 640 800 Metres

Universal Transverse Mercator (Zone 11)
North American Datum (1983)

WSP

Report By: JU | WSP Job #: 221-07121-00
Drawn by: JC | Date: November 1, 2022
Reviewed By: JU | Office: Edmonton

6 WASTEWATER SYSTEM IMPROVEMENTS

6.1 OVERVIEW

This section provides a list of capital projects for the MOJ to resolve capacity issues in the existing wastewater collection system under existing and future conditions. Improvement projects have been assigned a unique identifier for easy reference.

6.2 EXISTING CONDITIONS

Model results indicated that the existing system generally performs to the required level of service under DWF and WWF (0.28 and 0.5 L/s/ha) conditions. A single improvement is proposed under the existing conditions.

IMPROVEMENT GS-01

Replacement of 80 metres of 300-millimetre sewer on the lane west of Connaught Drive, south of Miette Avenue (shown in **Figure 19** to **Figure 24**). This sewer segment is in a developed area and other existing utilities.

6.3 FUTURE CONDITIONS

6.3.1 25-YEAR POPULATION HORIZON

As described previously, the model showed some additional sewers as surcharging in the WWF scenario with a 0.5 L/s/ha inflow and infiltration allowance: a 250-millimetre sewer on Pyramid Avenue, east of Pyramid Lake Road, and a 375-millimetre sewer on Patricia Street, south of Miette Avenue. These issues are recommended to be confirmed with a model calibrated to WWF conditions.

6.4 PROJECT SUMMARY AND COSTS

Table 6.1 Improvement projects – summary**Table 6.1** provides a cost breakdown of the improvement project. The estimated construction costs include an allowance for engineering (20%) and contingency (30%) but exclude GST. Unit rates include trenching and backfilling, supply and installation of the pipe and surface restoration activities based on projected 2022-2023 construction costs. The unit rates also include an allowance for manholes.

Table 6.1 Improvement projects – summary

PROJECT	DESCRIPTION	UNIT RATE ($/lm)	CONSTRUCTION COST ($)	ENGINEERING AND CONTINGENCY (50%)	PROJECT TOTAL ($)[1]
GS-01	Replace 80 m of 300 mm sewer (4-5 m deep)	$1,200	$96,000	$48,000	$144,000

Notes:

1 Values rounded up to the nearest thousand.

7 SUMMARY AND RECOMMENDATIONS

The Jasper Wastewater Model study assessed the conveyance capacity of the MOJ's wastewater collection system under existing and future conditions. This study did not assess the physical condition of the wastewater collection system. A computer model representing the MOJ's wastewater collection system was developed based on existing GIS datasets and supplemented with record/as-built drawings and survey data. The model was calibrated based on dry weather flow data from a short-term (1-month) flow monitoring program during the summer of 2022. Wet weather flow calibration of the model was not completed as all observed rainfall events displayed return periods less than the 2-year event. Calibration under wet weather conditions is preferred to be completed based on a minimum 2-year event (large enough to cause surface ponding and runoff) or an extended period with significant rain. Wet weather inflow and infiltration allowances were considered based on the provincial recommendations of 0.28 L/s/ha. A higher allowance of 0.5 L/s/ha was also evaluated to test the system.

Existing WWTP data were reviewed and analyzed, as well as water consumption records for recent years. The MOJ's wastewater collection system was evaluated based on design criteria outlined in provincial standards and guidelines and the City of Edmonton Design and Construction Standards (EPCOR, 2021a). Model results indicated that the existing system generally performs to the required level of service except for a 300-millimetre sewer on the lane west of Connaught Drive, south of Miette Avenue, currently installed with a reverse grade. This sewer should be replaced with one that allows positive drainage. While some additional deficiencies were identified under future conditions, these should be confirmed with a model that is calibrated to account for actual wet weather flows.

Model improvement recommendations include:

- Confirm the pump start and stop settings for all MOJ lift stations.
- Confirm the pump flow-head curves and start and stop settings for the Parks Canada Lift Station (identifier HWY93A-HWY16 Stn.). Verify flow conditions at the sewer downstream by visually inspecting the manholes.
- Conduct a more comprehensive flow monitoring program, at a minimum, for a single season, spanning from approximately April to the end of October. A longer flow monitoring program has a higher chance of capturing a more significant rainfall event (higher return period) ultimately providing more data for wet weather flow characterization.
- Calibrate the model based on observed wet weather flow data that includes at least a 2-year rainfall event.
- Continue to verify the physical network by surveying wastewater collection infrastructure and reviewing CCTV video inspections to identify possible high-water marks within sewers. These water marks can be used for a qualitative assessment of the existing sewer loading and capacity.

Operational recommendations include:

- Inspecting the sewers and manholes within the sewershed for flow gauge A22-129-03 to confirm that there are no cross connections or other obvious significant sources of inflow or infiltration. Short-term flow monitoring results indicate that this flow gauge sewershed experiences high groundwater infiltration and RDII.
- Inspect all wastewater collection system manholes in the townsite to check for existing cross or weeping tile connections. These should be disconnected from the wastewater collection system if possible.
- Providing a smooth flow transition between the force mains and gravity sewers such that turbulence is minimized at the discharge manhole, which could lead to odour issues. The City of Edmonton Design and Construction Standards recommend that the force main enter the outlet manhole horizontally and at an invert elevation no more than 300 millimetres above the flow line of the receiving sewer. Discharge manholes should be inspected to ensure the structure has not deteriorated.
- Continue CCTV inspections of the existing system. Findings from the inspections can help identify inflow and infiltration sources and illegal cross-connections. Observing high water marks in the sewers can also be used to assess the existing system qualitatively.
- Continuing seasonal flow monitoring in the gravity sewer upstream of the Parks Canada lift station (identifier HWY93A-HWY16 Stn.).
- Continuing to monitor inflow rates and volumes from the JPL resort to assess impacts on the Jasper WWTP.

— Assess new development proposals (medium- and high-density only) using the wastewater hydraulic model developed in this study.

The MOJ may want to consider developing a wastewater system renewal program given that most of the system is over 40 years old.

8 REFERENCES

Alberta Environment and Sustainable Resource Development. (2013). *Part 4 Wastewater Systems Guidelines for Design, Operating and Monitoring of a Total of 5 Parts.* Edmonton: Alberta Government.

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APPENDIX

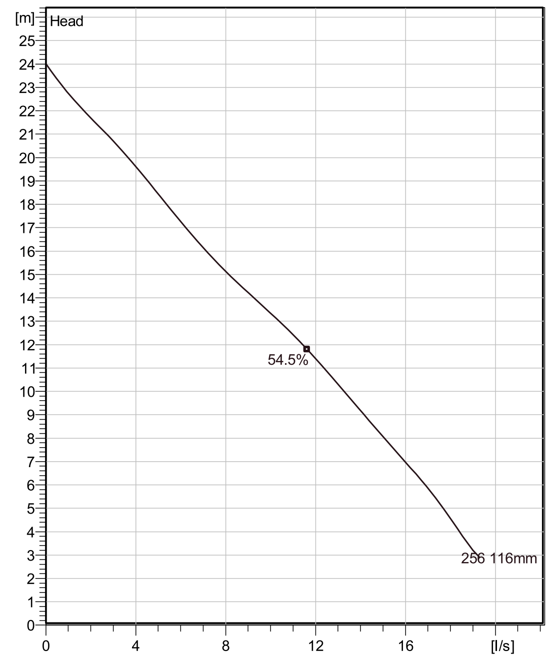
A PUMP CURVES

NP 3085 SH 3~ Adaptive 256

Patented self cleaning semi-open channel impeller, ideal for pumping in waste water applications. Modular based design with high adaptation grade.

Technical specification

Curves according to: Water, pure Water, pure [100%],39.2 °F,62.42 lb/ft³,1.6891E-5 ft²/s



Curve: ISO 9906

Configuration

Motor number
N3085.070 15-09-2AL-W 4hp

Installation type
P - Semi permanent, Wet

Impeller diameter
116 mm

Discharge diameter
3 inch

Pump information

Impeller diameter
116 mm

Discharge diameter
3 inch

Inlet diameter
80 mm

Maximum operating speed
3415 rpm

Number of blades
2

Max. fluid temperature
40 °C

Materials

Impeller
Hard-Iron ™

Stator housing material
Grey cast iron

Project		**Created by**	Mercy Onweni		
Block		**Created on**	8/8/2022	**Last update**	8/8/2022

NP 3085 SH 3~ Adaptive 256

Technical specification

Motor - General

Motor number N3085.070 15-09-2AL-W 4hp	**Phases** 3~	**Rated speed** 3415 rpm	**Rated power** 4 hp
ATEX approved CSA	**Number of poles** 2	**Rated current** 11 A	**Stator variant** 27
Frequency 60 Hz	**Rated voltage** 208 V	**Insulation class** H	**Type of Duty** S1
Version code 070			

Motor - Technical

Power factor - 1/1 Load 0.93	**Motor efficiency - 1/1 Load** 80.5 %	**Total moment of inertia** 0.152 lb ft²	**Starts per hour max.** 30
Power factor - 3/4 Load 0.91	**Motor efficiency - 3/4 Load** 82.5 %	**Starting current, direct starting** 65 A	
Power factor - 1/2 Load 0.86	**Motor efficiency - 1/2 Load** 82.3 %	**Starting current, star-delta** 21.7 A	

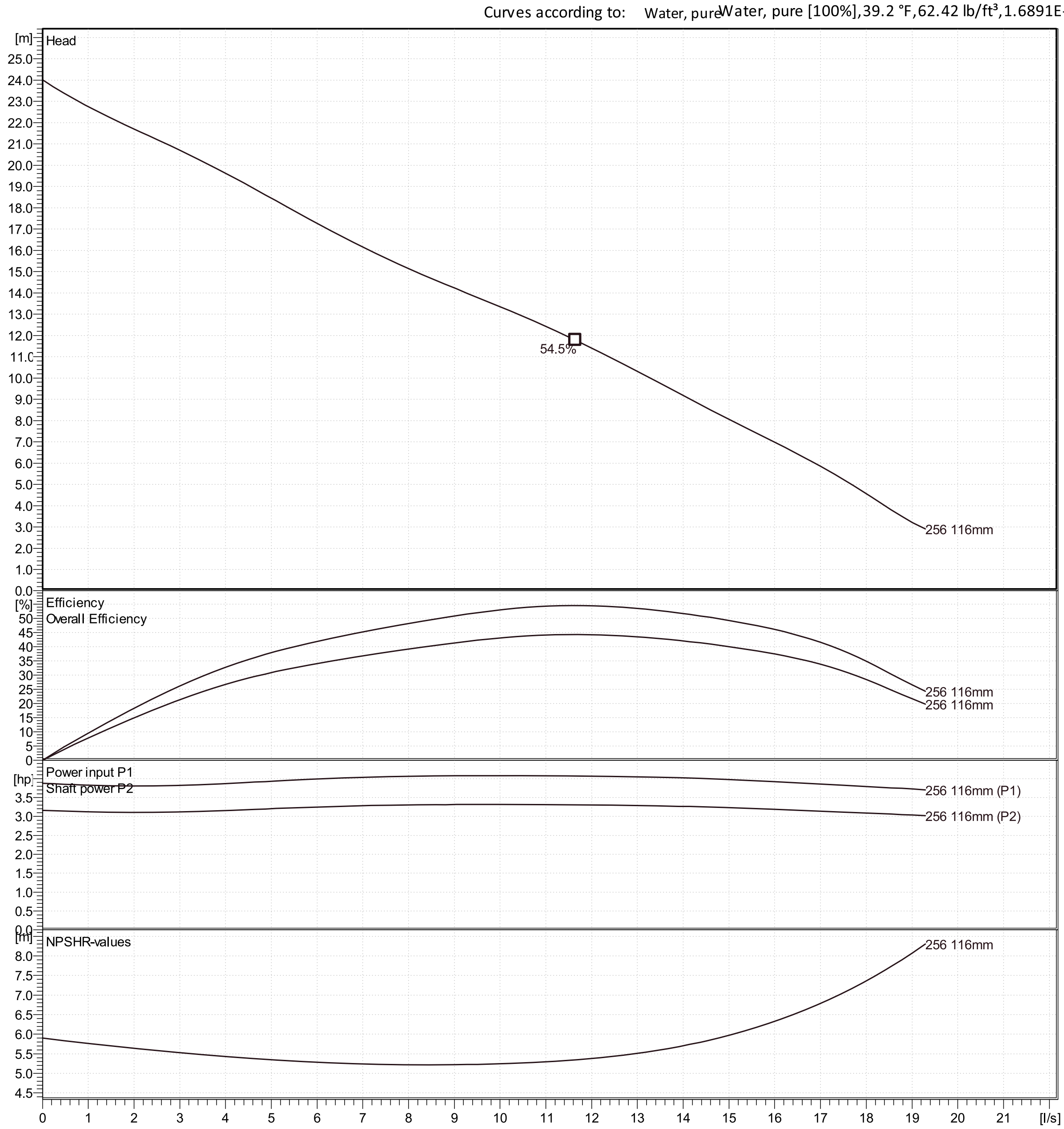
NP 3085 SH 3~ Adaptive 256

Performance curve

Duty point

Flow **Head**

Curves according to: Water, pure Water, pure [100%],39.2 °F,62.42 lb/ft³,1.6891E-5 ft²/s



Curve: ISO 9906

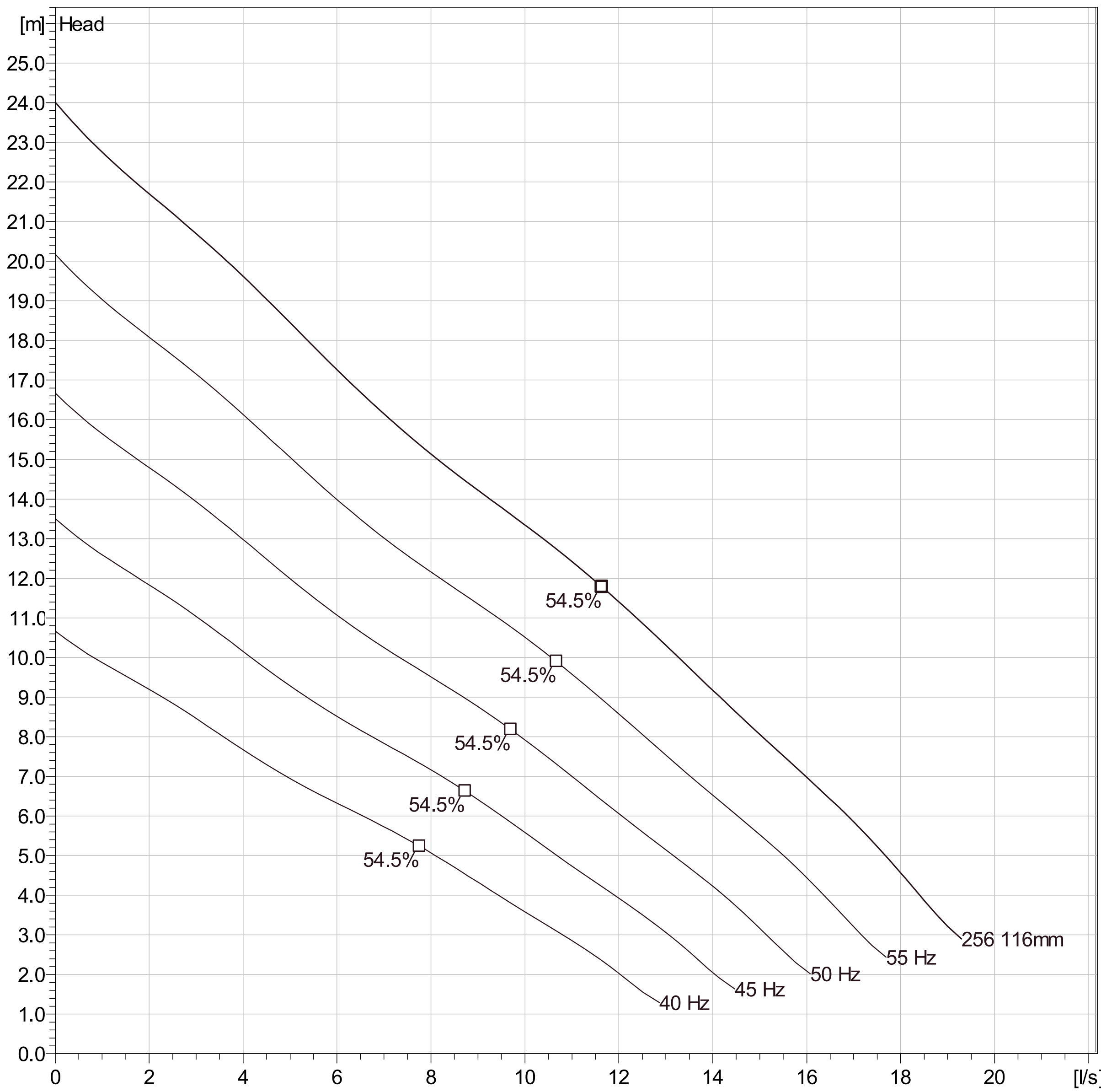
Mercy Onweni

Created on 8/8/2022 **Last update** 8/8/2022

NP 3085 SH 3~ Adaptive 256

Duty Analysis

Curves according to: Water, pure [100%] ; 39.2°F; 62.42lb/ft³; 1.6891E-5ft²/s



Operating characteristics

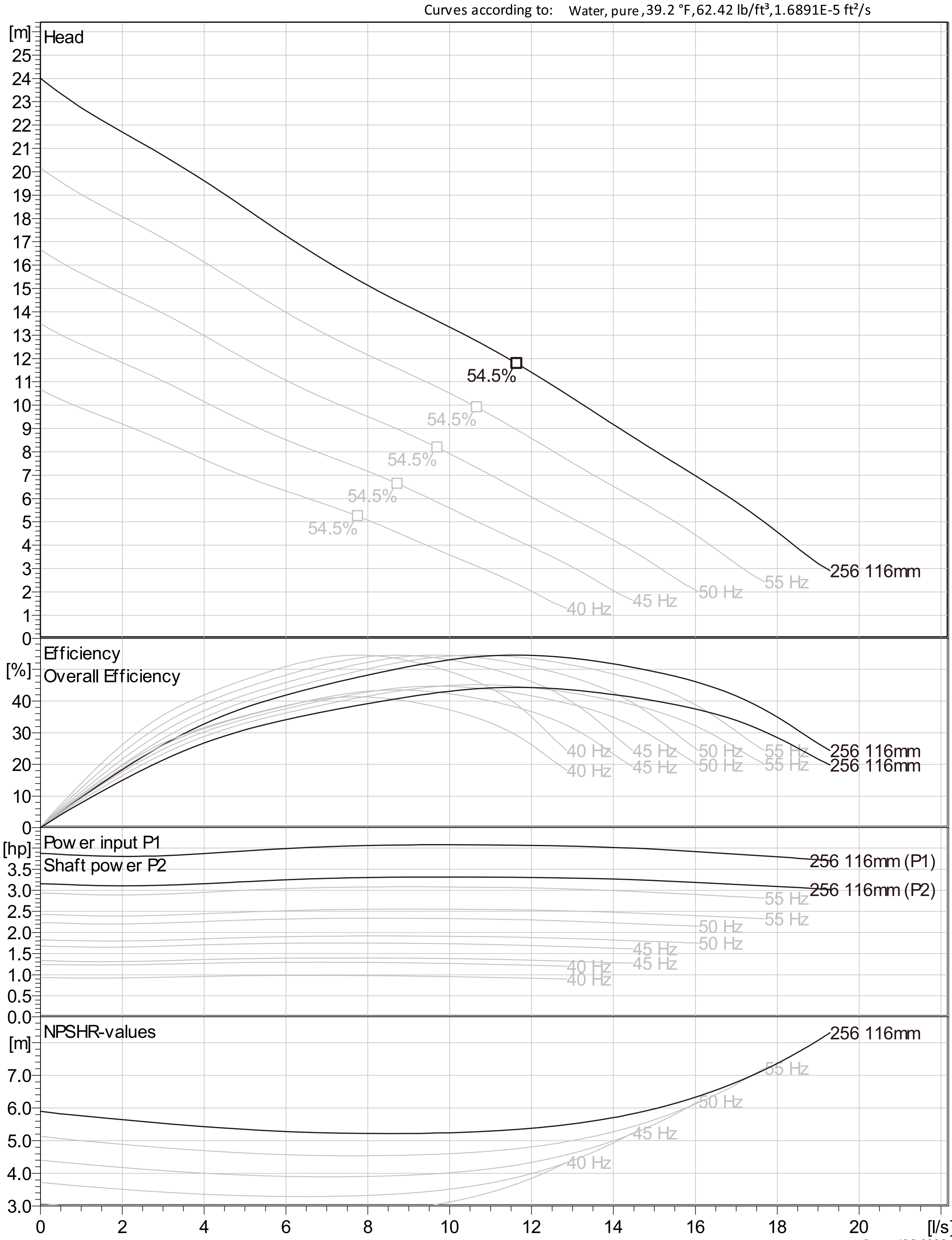
Pumps / Systems	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Spec. Energy	NPSHre
	l/s	m	hp	l/s	m	hp		kWh/US MG	m

Project	**Created by**	Mercy Onweni	
Block	**Created on**	8/8/2022	**Last update** 8/8/2022

NP 3085 SH 3~ Adaptive 256

VFD Curve

Curves according to: Water, pure ,39.2 °F,62.42 lb/ft³,1.6891E-5 ft²/s



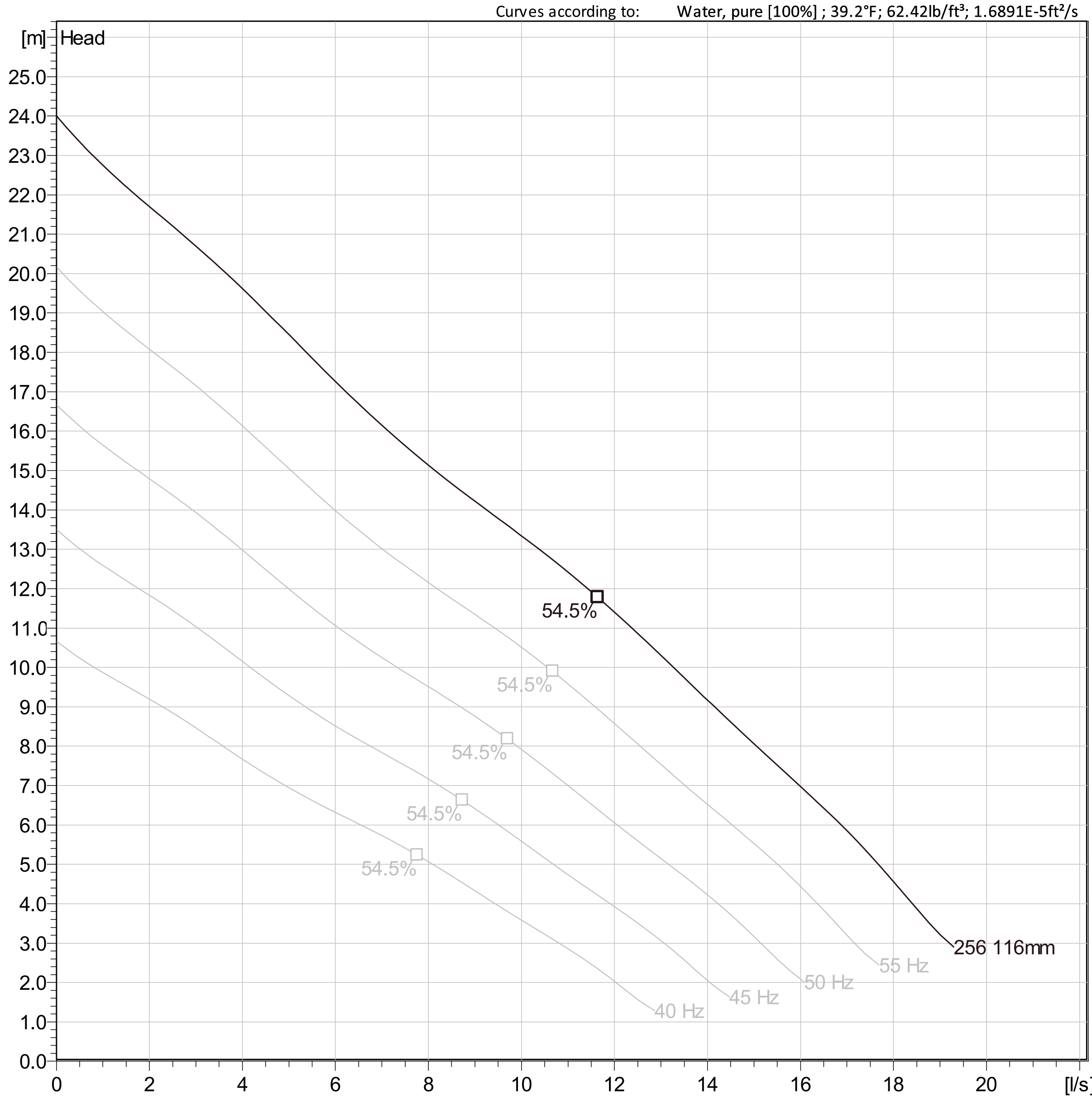
Curve: ISO 9906

Project	**Created by**	Mercy Onweni		
Block	**Created on**	8/8/2022	**Last update**	8/8/2022

NP 3085 SH 3~ Adaptive 256

VFD Analysis

Curves according to: Water, pure [100%] ; 39.2°F; 62.42lb/ft³; 1.6891E-5ft²/s



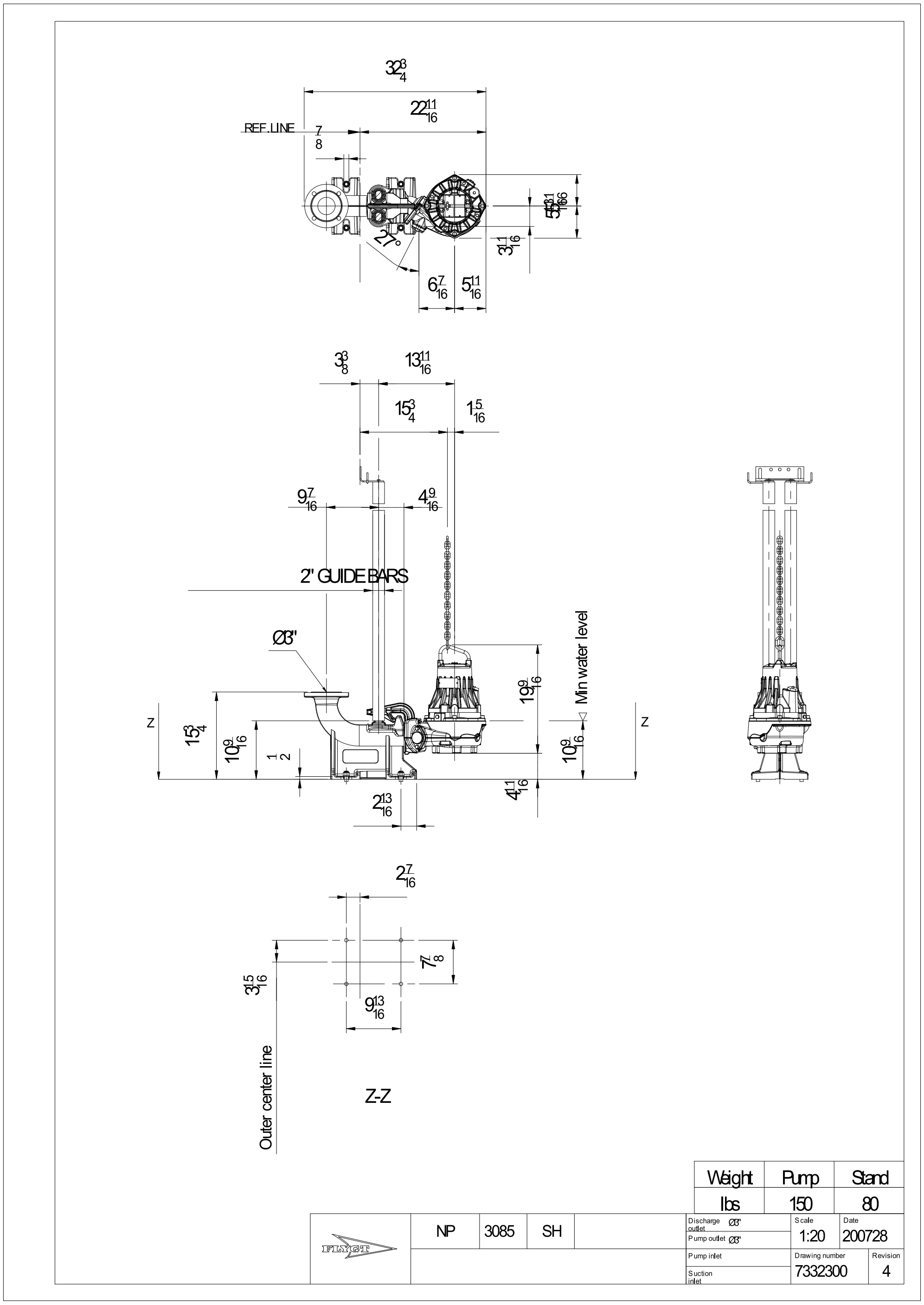
Operating Characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific energy	NPSHre
		l/s	m	hp	l/s	m	hp		kWh/US MG	m

Project		**Created by**	Mercy Onweni	
Block		**Created on**	8/8/2022	**Last update** 8/8/2022

NP 3085 SH 3~ Adaptive 256

Dimensional drawing



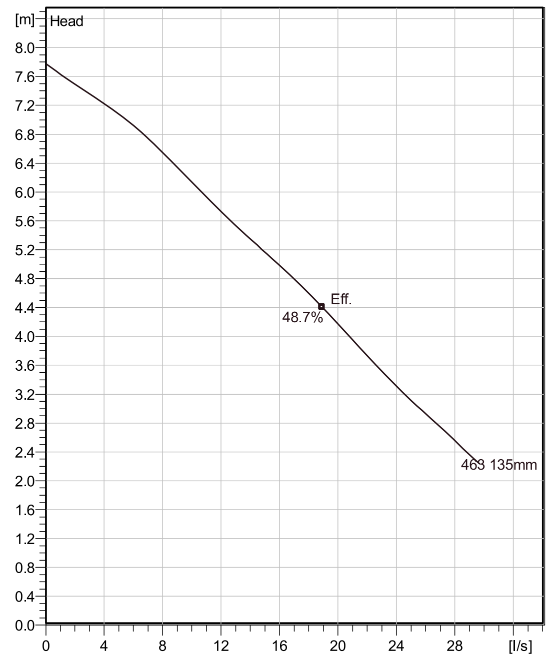
Project		**Created by**	Mercy Onweni
Block		**Created on**	8/8/2022
		Last update	8/8/2022

NP 3085 MT 1~ 463

FLYGT
a xylem brand

Technical specification

Curves according to: Water, pure Water, pure [100%],39.2 °F,62.43 lb/ft³,1.6889E-5 ft²/s



Curve: ISO 9906

Configuration

Motor number
N3085.183 15-10-4AL-W
2.4hp

Installation type
P - Semi permanent, Wet

Impeller diameter
135 mm

Discharge diameter
3 inch

Pump information

Impeller diameter
135 mm

Discharge diameter
3 inch

Inlet diameter
80 mm

Maximum operating speed
1710 rpm

Number of blades
2

Max. fluid temperature
40 °C

Materials

Impeller
Grey cast iron

Stator housing material
Grey cast iron

Project	**Created by**	Mercy Onweni		
Block	**Created on**	8/12/2022	**Last update**	8/12/2022

NP 3085 MT 1~ 463

Technical specification

Motor - General

Motor number N3085.183 15-10-4AL-W 2.4hp	**Phases** 1~	**Rated speed** 1710 rpm	**Rated power** 2.4 hp
ATEX approved No	**Number of poles** 4	**Rated current** 10 A	**Stator variant** 12
Frequency 60 Hz	**Rated voltage** 230 V	**Insulation class** H	**Type of Duty**
Version code 183			

Motor - Technical

Power factor - 1/1 Load 0.94	**Motor efficiency - 1/1 Load** 80.5 %	**Total moment of inertia** 0.434 lb ft²	**Starts per hour max.** 0
Power factor - 3/4 Load 0.96	**Motor efficiency - 3/4 Load** 82.0 %	**Starting current, direct starting** 47 A	
Power factor - 1/2 Load 0.95	**Motor efficiency - 1/2 Load** 79.5 %	**Starting current, star-delta** 15.7 A	

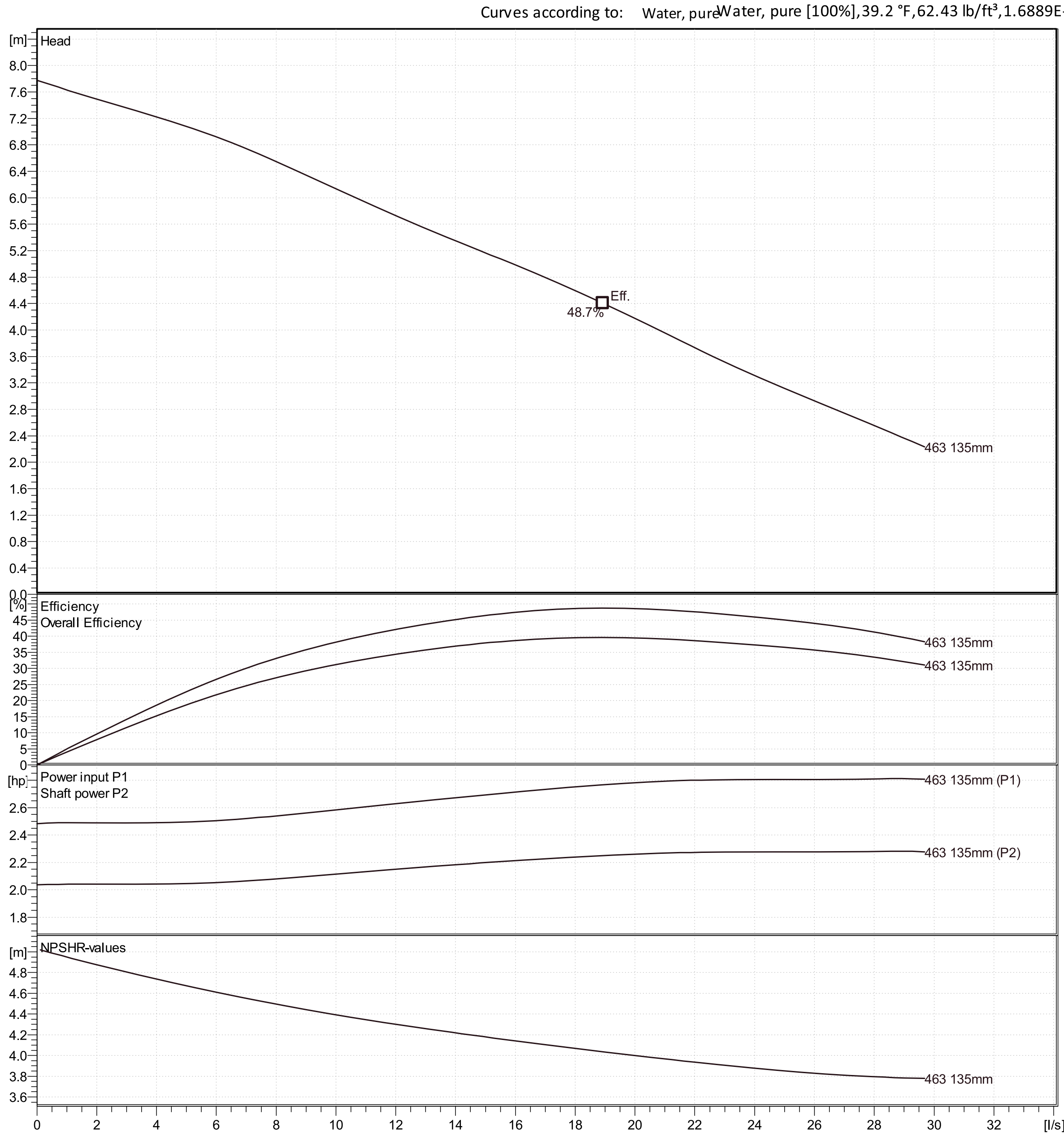
NP 3085 MT 1~ 463

Performance curve

Duty point

Flow	Head

Curves according to: Water, pure Water, pure [100%],39.2 °F,62.43 lb/ft³,1.6889E-5 ft²/s



Curve: ISO 9906

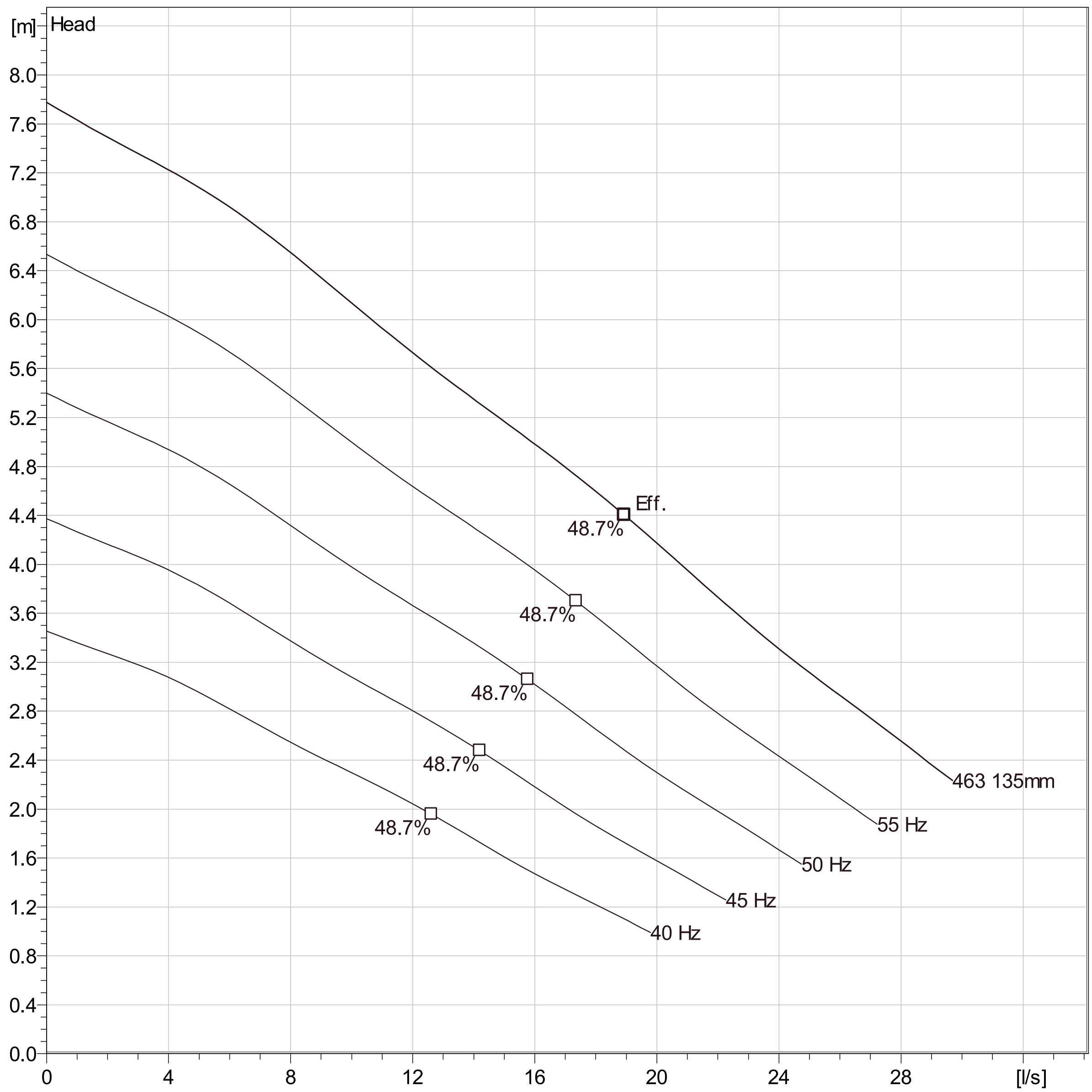
Mercy Onweni

Created on 8/12/2022 **Last update** 8/12/2022

NP 3085 MT 1~ 463

Duty Analysis

Curves according to: Water, pure [100%] ; 39.2°F; 62.43lb/ft³; 1.6889E-5ft²/s



Operating characteristics

Pumps / Systems	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Spec. Energy	NPSHre
	l/s	m	hp	l/s	m	hp		kWh/US MG	m

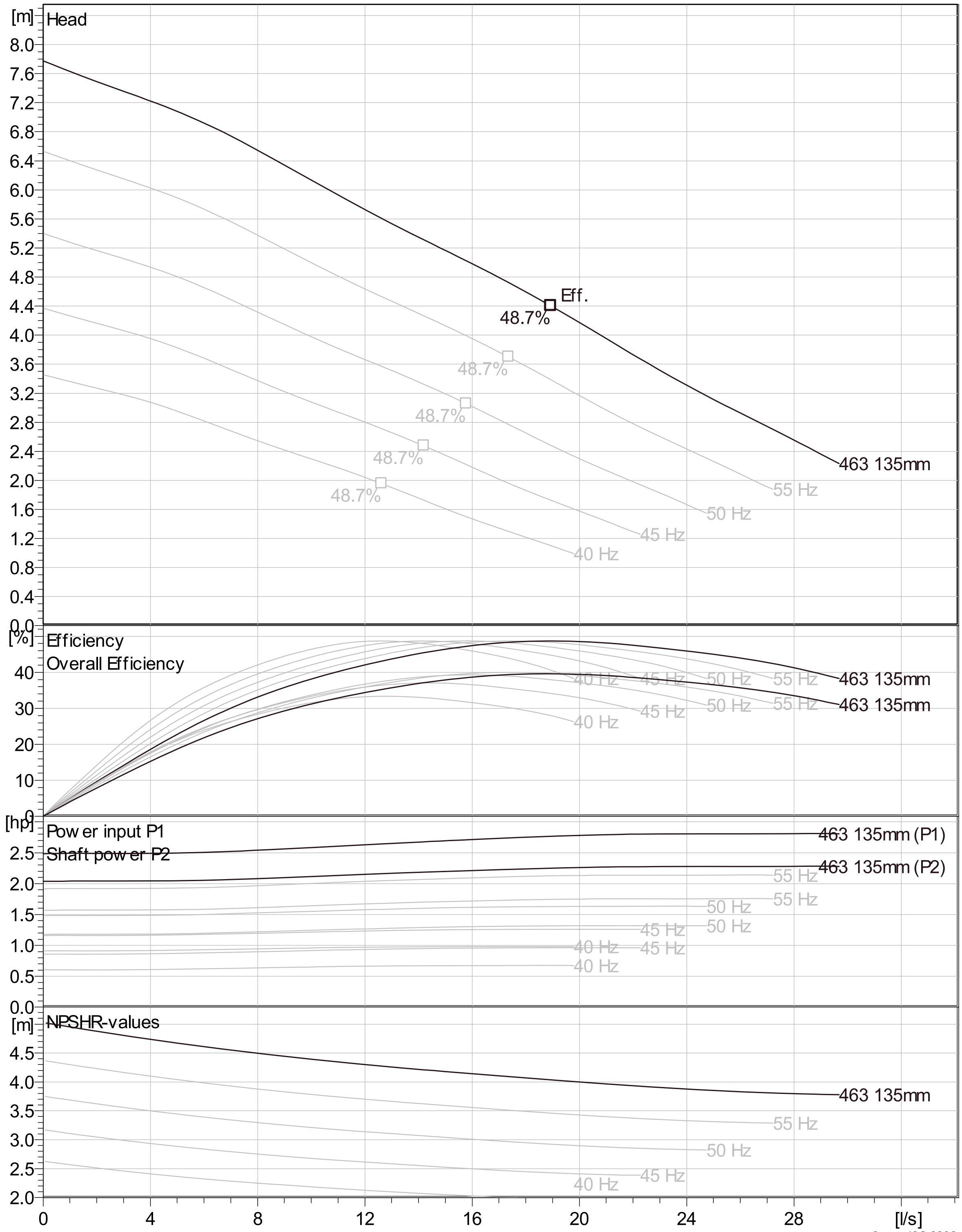
Project	**Created by**	Mercy Onweni		
Block	**Created on**	8/12/2022	**Last update**	8/12/2022

NP 3085 MT 1~ 463

VFD Curve

FLYGT a xylem brand

Curves according to: Water, pure, 39.2 °F, 62.43 lb/ft³, 1.6889E-5 ft²/s



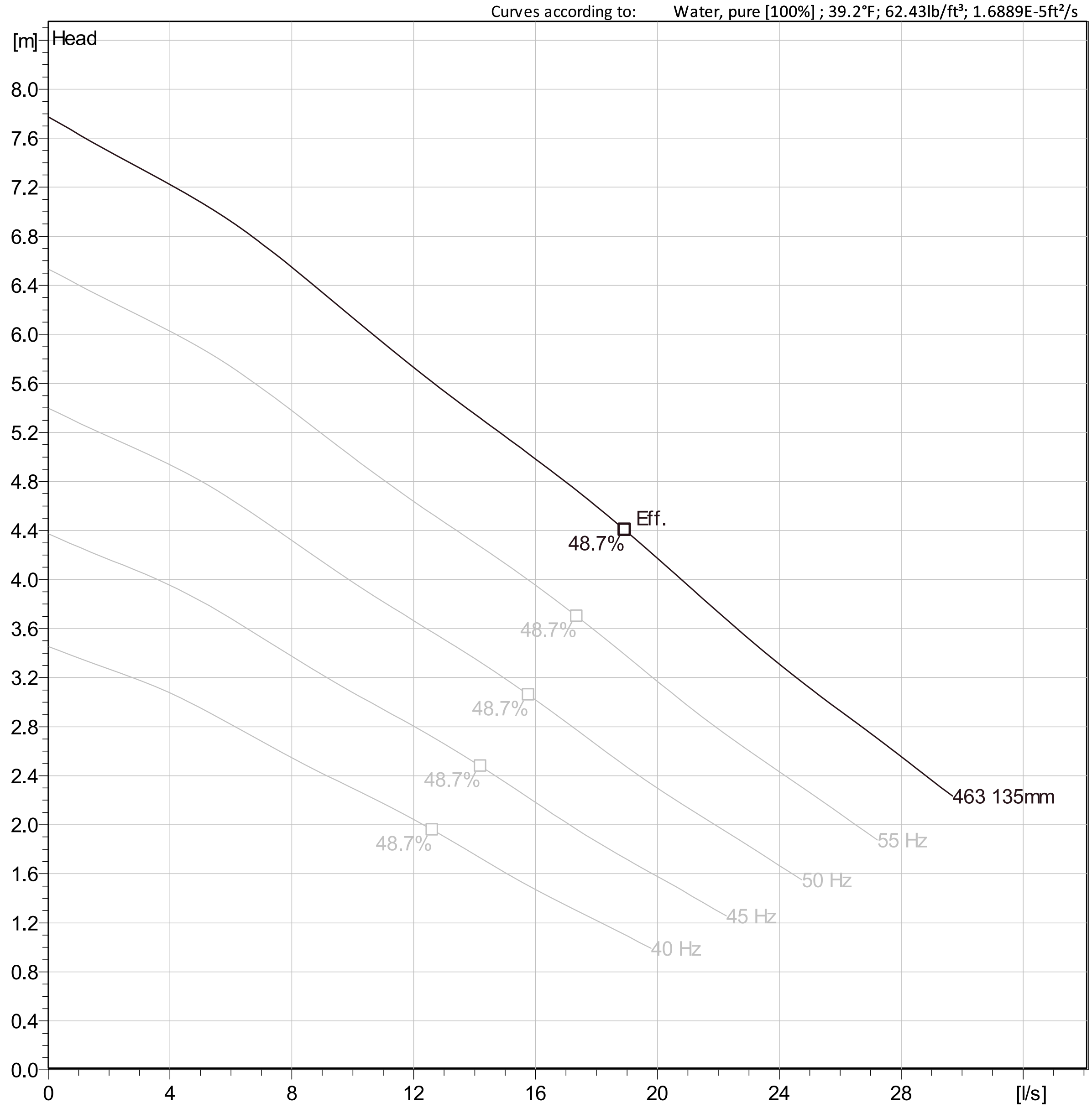
Curve: ISO 9906

Project		**Created by**	Mercy Onweni
Block		**Created on**	8/12/2022 **Last update** 8/12/2022

NP 3085 MT 1~ 463

VFD Analysis

Curves according to: Water, pure [100%] ; 39.2°F; 62.43lb/ft³; 1.6889E-5ft²/s



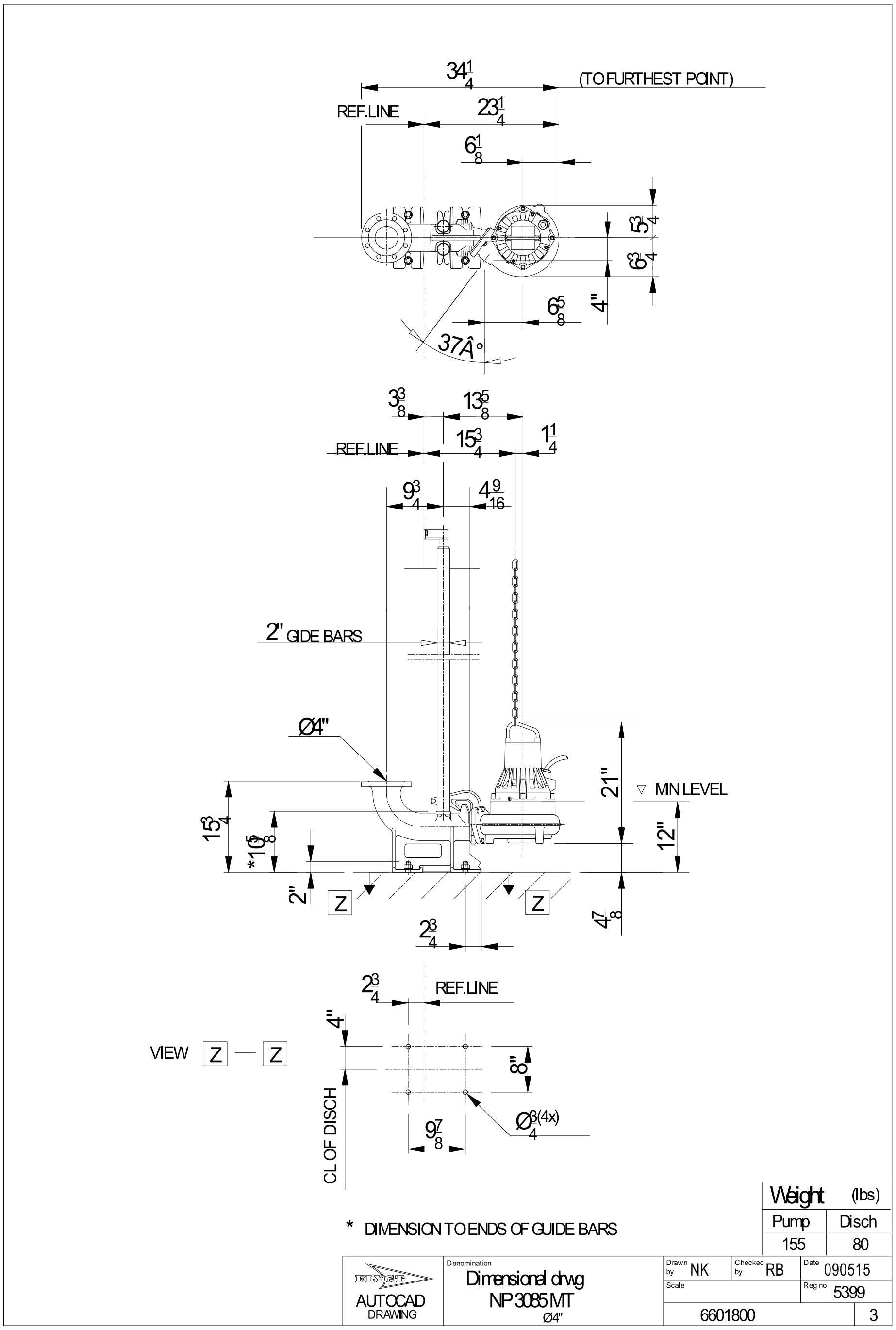
Operating Characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific energy	NPSHre
		l/s	m	hp	l/s	m	hp		kWh/US MG	m

Project		Created by	Mercy Onweni	
Block		Created on	8/12/2022	Last update 8/12/2022

NP 3085 MT 1~ 463

Dimensional drawing



Weight	(lbs)
Pump	Disch
155	80

Project		**Created by**	Mercy Onweni
Block		**Created on**	8/12/2022 **Last update** 8/12/2022

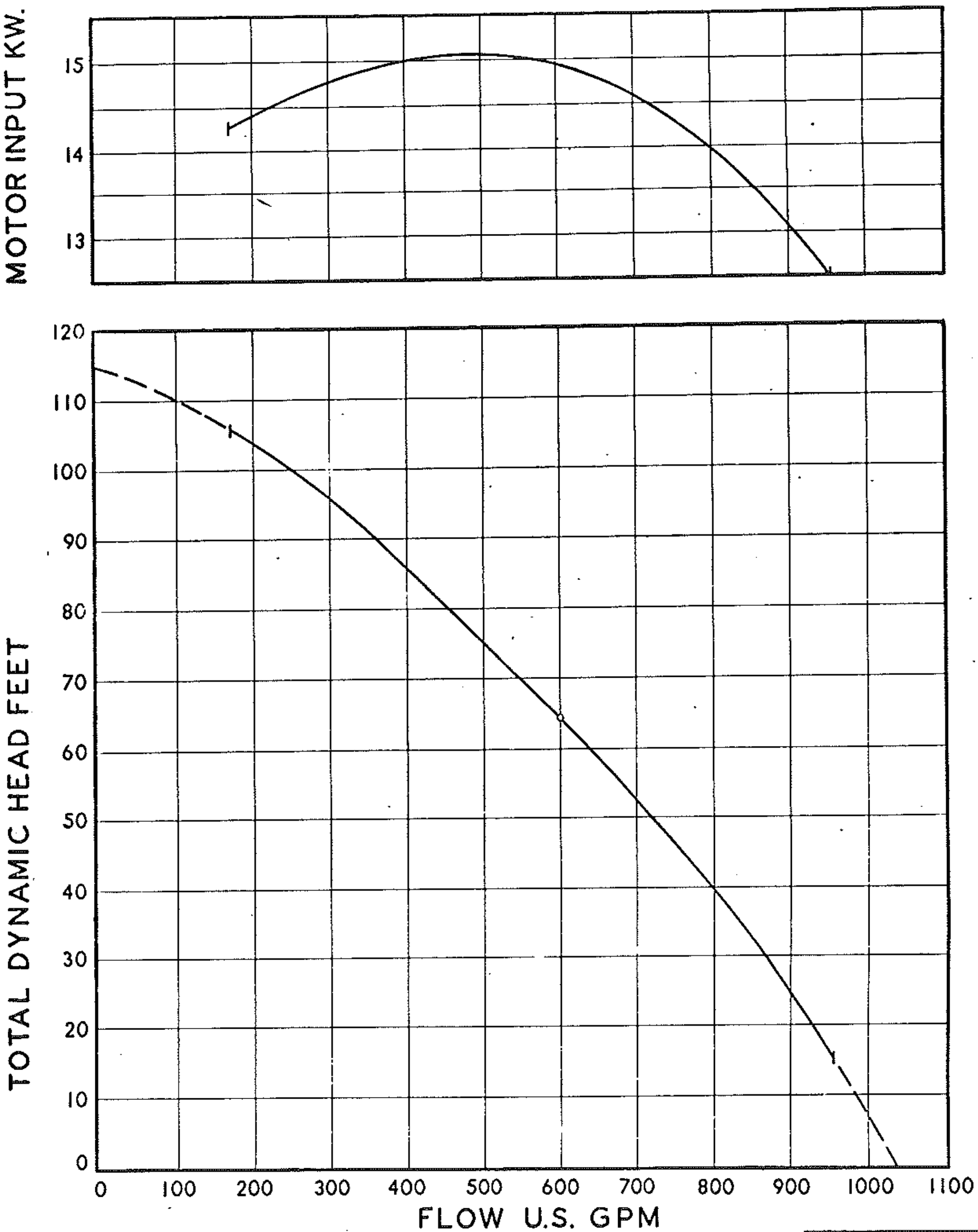
FLYGT

FLYGT CORPORATION ITT

6"H.H. CP-3151

IMPELLER 151-480

MOTOR RATED HP. 18
AT 1700 RPM
3Ø:208, 220/440, 550V.



REV.		
MADE FROM		
DRAWN	E.K.K.	72-07-17
APPV'D	N. Nagy	72-08-01

PERFORMANCE CURVES ARE BASED ON TESTS WITH CLEAR WATER AT AMBIENT TEMPERATURE

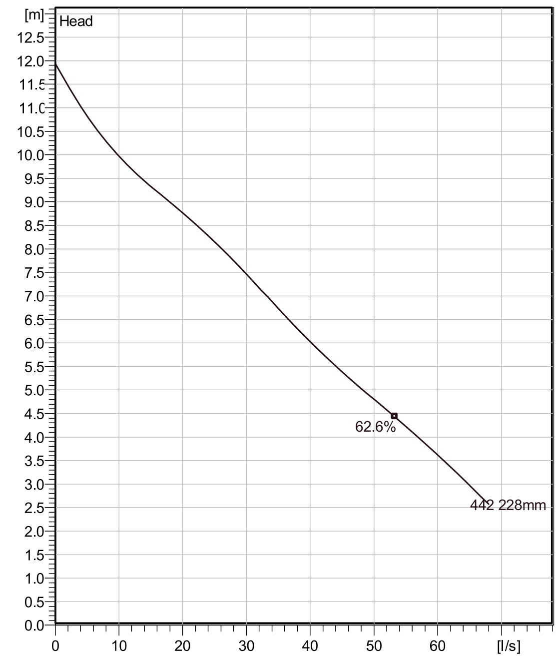
DRAWING NUMBER

00C0 804

CP 3127 LT 3~ 442

Technical specification

Curves according to: Water, pure Water, pure [100%],4 °C,1000 kg/m³,1.569 mm²/s



Curve: ISO 9906

Configuration

Motor number
C3127.180 21-10-4AL-W 4.7KW

Installation type
P - Semi permanent, Wet

Impeller diameter
228 mm

Discharge diameter
150 mm

Pump information

Impeller diameter
228 mm

Discharge diameter
150 mm

Inlet diameter
150 mm

Maximum operating speed
1450 rpm

Number of blades
1

Throughlet diameter
76 mm

Max. fluid temperature
40 °C

Materials

Impeller
Grey cast iron

Stator housing material
Grey cast iron

Project	**Created by**	Mercy Onweni		
Block	**Created on**	8/8/2022	**Last update**	8/8/2022

CP 3127 LT 3~ 442

Technical specification

Motor - General

Motor number C3127.180 21-10-4AL-W 4.7KW	**Phases** 3~	**Rated speed** 1450 rpm	**Rated power** 6.3 hp
ATEX approved No	**Number of poles** 4	**Rated current** 5.6 A	**Stator variant** 3
Frequency 50 Hz	**Rated voltage** 690 V	**Insulation class** H	**Type of Duty**
Version code 180			

Motor - Technical

Power factor - 1/1 Load 0.85	**Motor efficiency - 1/1 Load** 83.0 %	**Total moment of inertia** 0.075 kg m²	**Starts per hour max.** 0
Power factor - 3/4 Load 0.80	**Motor efficiency - 3/4 Load** 83.5 %	**Starting current, direct starting** 34 A	
Power factor - 1/2 Load 0.71	**Motor efficiency - 1/2 Load** 82.0 %	**Starting current, star-delta** 11.3 A	

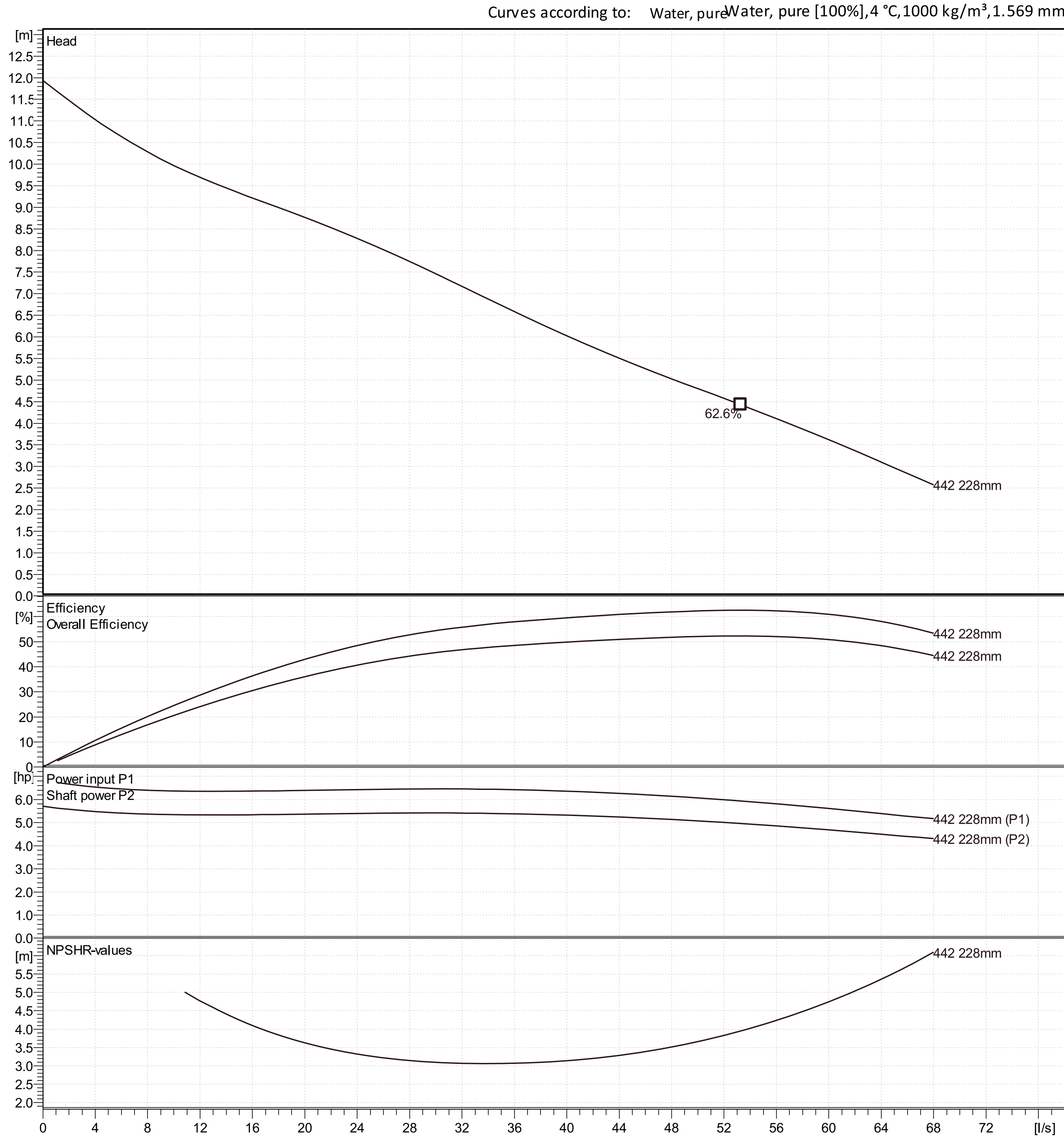
CP 3127 LT 3~ 442

Performance curve

Duty point

Flow **Head**

Curves according to: Water, pure Water, pure [100%],4 °C,1000 kg/m³,1.569 mm²/s



Curve: ISO 9906

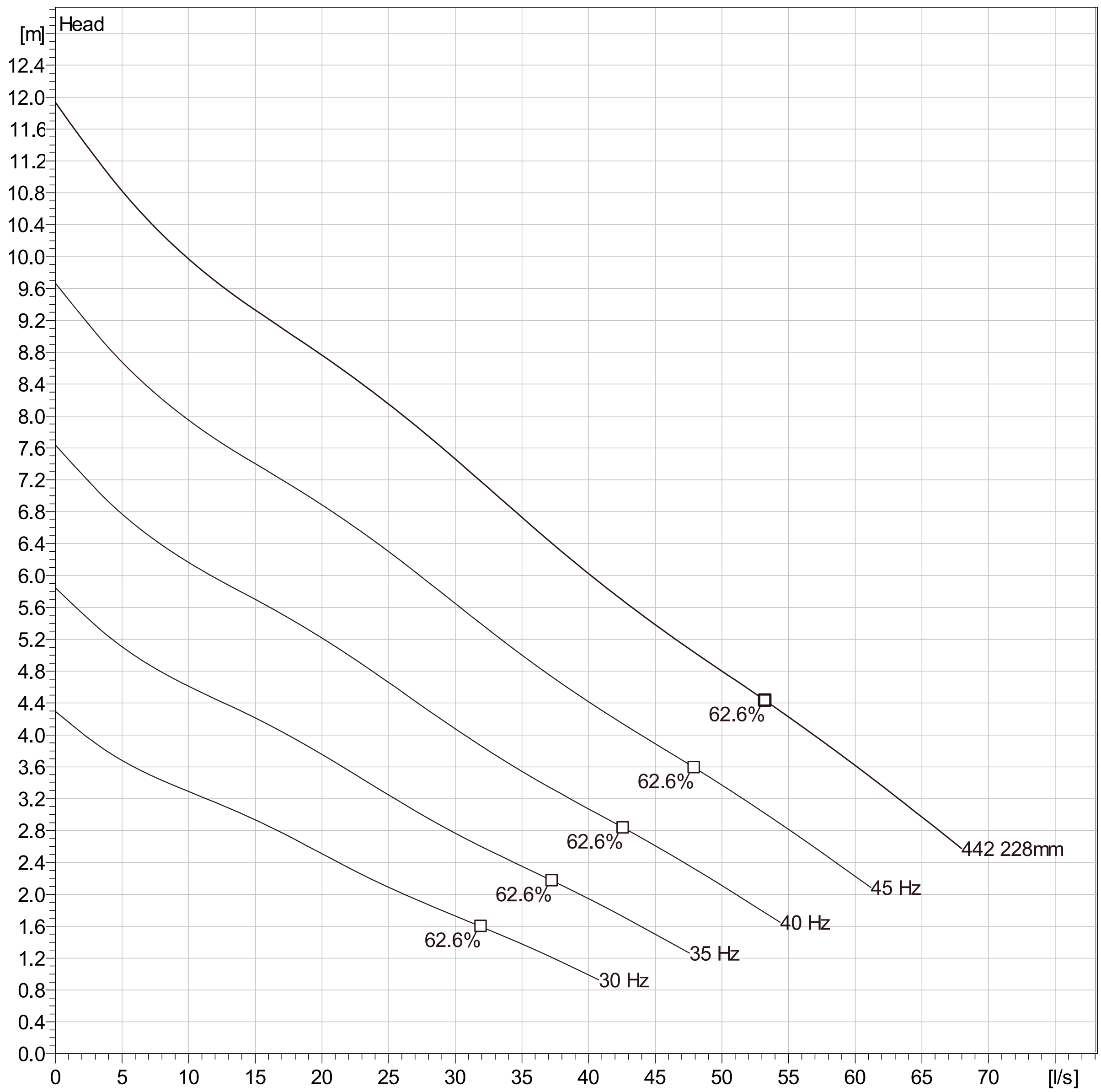
Mercy Onweni

Created on 8/8/2022 **Last update** 8/8/2022

CP 3127 LT 3~ 442

Duty Analysis

Curves according to: Water, pure [100%] ; 4°C; 1000kg/m³; 1.569mm²/s



Operating characteristics

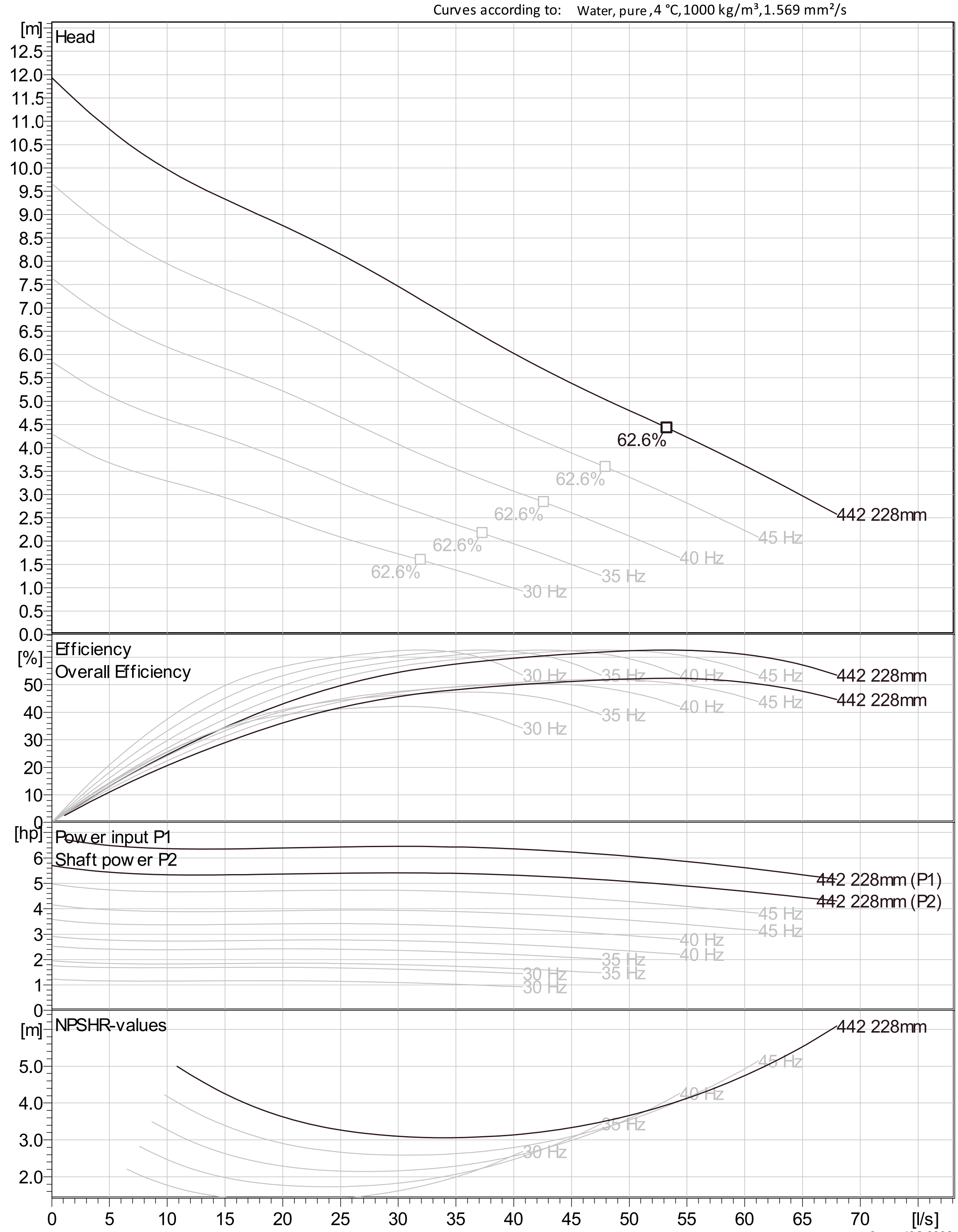
Pumps / Systems	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Spec. Energy	NPSHre
	l/s	m	hp	l/s	m	hp		kWh/m³	m

Project	**Created by**	Mercy Onweni	
Block	**Created on**	8/8/2022	**Last update** 8/8/2022

CP 3127 LT 3~ 442

VFD Curve

Curves according to: Water, pure, 4 °C, 1000 kg/m³, 1.569 mm²/s



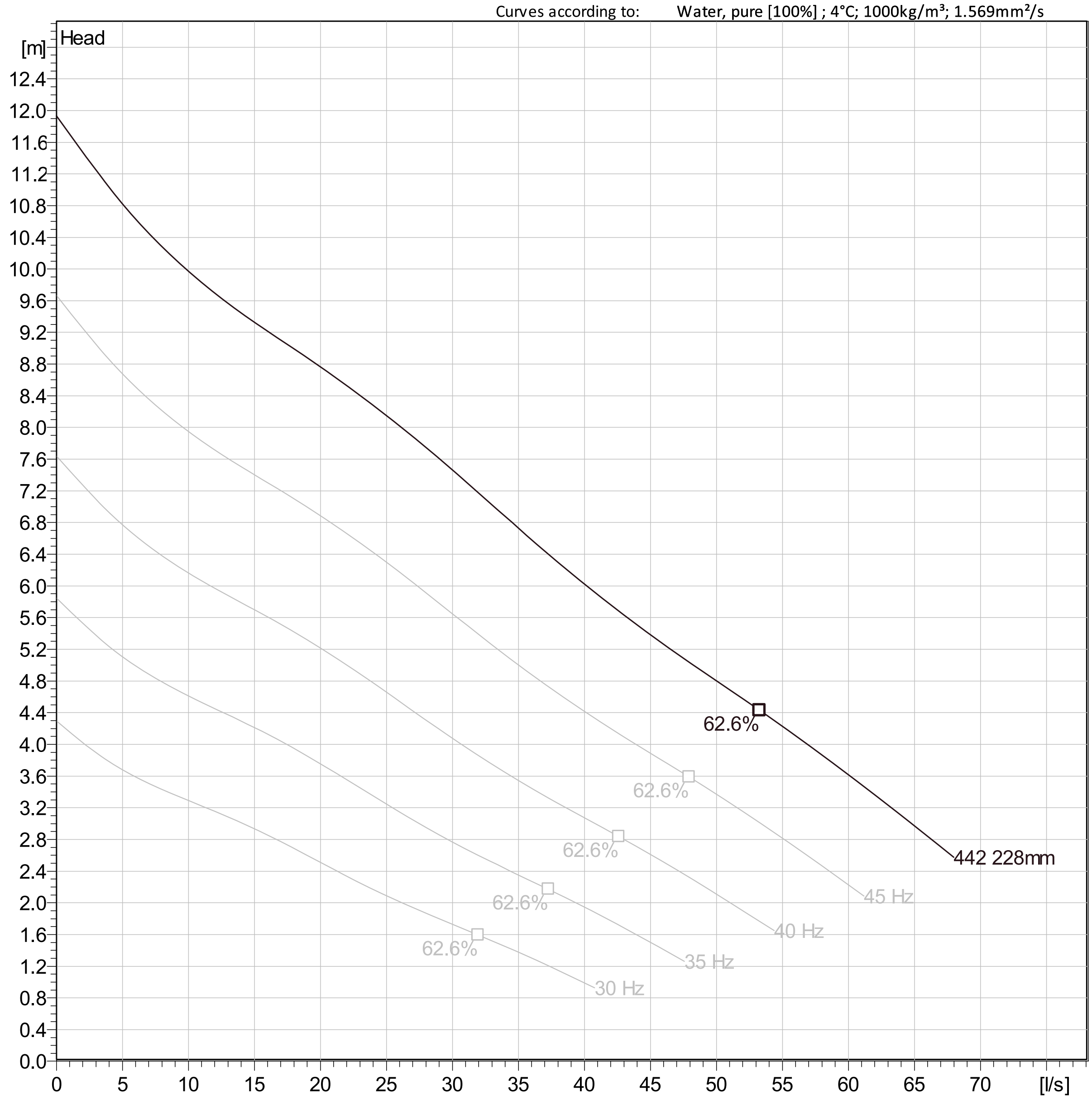
Curve: ISO 9906

Project		**Created by**	Mercy Onweni		
Block		**Created on**	8/8/2022	**Last update**	8/8/2022

CP 3127 LT 3~ 442

VFD Analysis

Curves according to: Water, pure [100%] ; 4°C; 1000kg/m³; 1.569mm²/s



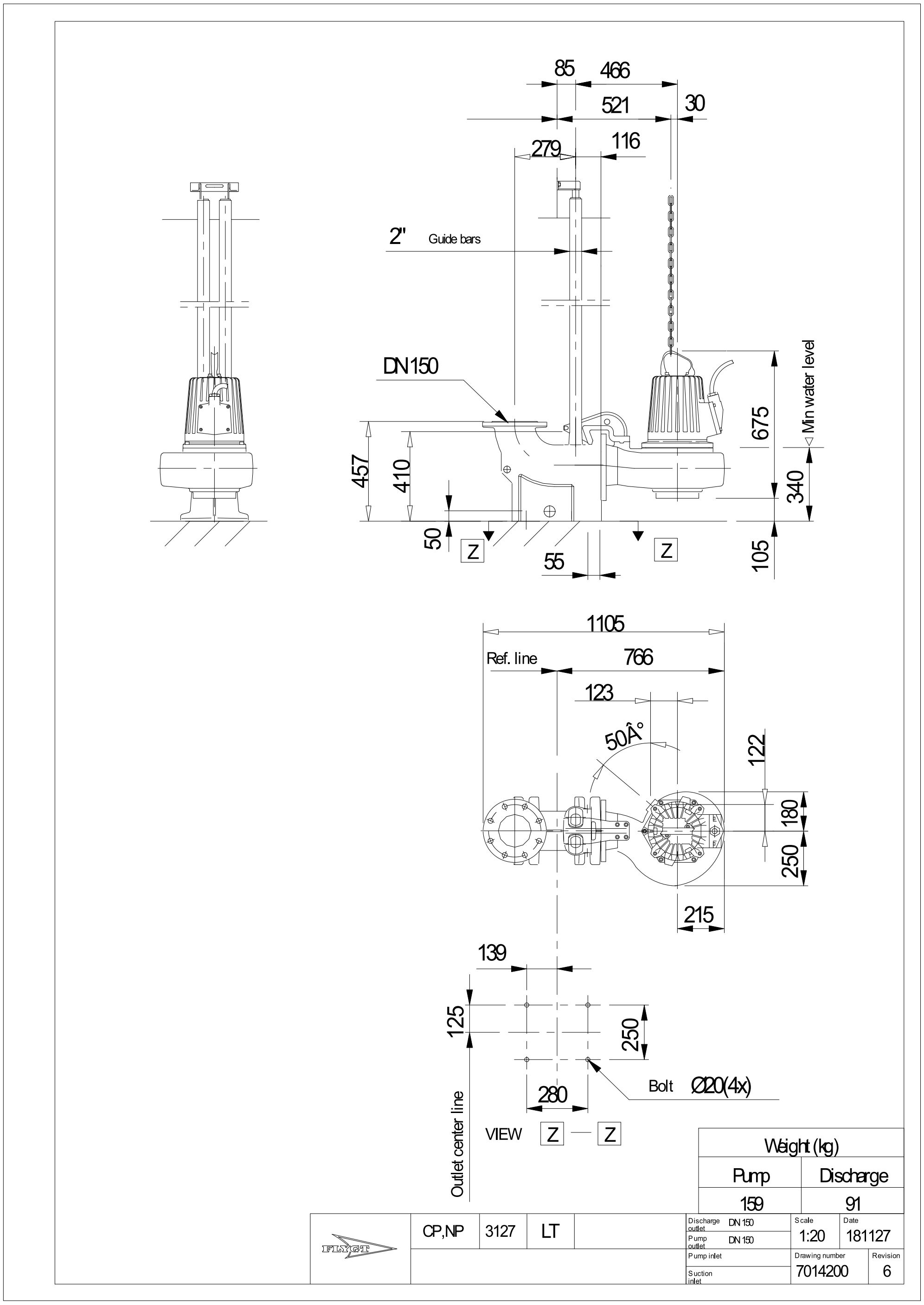
Operating Characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific energy	NPSHre
		l/s	m	hp	l/s	m	hp		kWh/m³	m

Project		**Created by**	Mercy Onweni	
Block		**Created on**	8/8/2022	**Last update** 8/8/2022

CP 3127 LT 3~ 442

Dimensional drawing



Project		**Created by**	Mercy Onweni
Block		**Created on**	8/8/2022 **Last update** 8/8/2022

APPENDIX

B FLOW MONITORING REPORT

Final Report for

WSP Canada Inc.

Attn: Joshua Maxwell, M.Sc., P.Eng., PMP

Jasper, Alberta

2022 Sanitary Sewer Flow Monitoring

Prepared and submitted by:

SFE Global

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Edmonton, Alberta T5S 1N3

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Ph (604) 856-2220 *Fx* (604) 856-3003

September 2, 2022

Joshua Maxwell, M.Sc., P.Eng., PMP
Team Lead, Water Resources, Municipal Engineering, Infrastructure

WSP Canada Inc.
10909 Jasper Ave
Edmonton, Alberta
T5J 3L9

FINAL REPORT:
2022 Jasper Sanitary Sewer Flow Monitoring

Dear Joshua,

Please find enclosed SFE's Final Report for the above-mentioned project. If you have any questions, or concerns, please do not hesitate to contact us at your earliest convenience.

Thank you for having SFE conduct this work on your behalf. We are appreciative of the opportunity to work with you and your team on this project. We look forward to working together again soon.

Sincerely,
SFE Global

Nick Schellenberg
Director of Operations
(780) 461-0171
nick@sfeglobal.com
www.sfeglobal.com

1. Introduction

This report provides details of the sanitary sewer flow monitoring project conducted in Jasper Alberta. SFE Global was retained by WSP under the direction of Joshua Maxwell, M.Sc., P.Eng., PMP. Nick Schellenberg represented SFE Global as Project Manager during this project.

As requested, SFE installed four (4) sanitary sewer flow monitors and one (1) tipping bucket rain gauge on June 28th, 2022. After one month of flow monitoring SFE Global removed the four (4) sanitary flow monitors and installed one (1) additional sanitary monitor until August 25th, 2022.

2. Flow Monitoring Stations

Prior to installing flow monitoring stations, SFE performs detailed site assessments of each potential site to determine the acceptability of SFE's Custom Compound Weir. Factors such as pipe size, channel condition, site location, site access, and flow hydraulics were all considered and documented while performing site assessments.

SFE installed the flow monitoring station in accordance with the approved site assessment documentation. The meters were calibrated and set to log data at 5-minute intervals.

3. QA/QC and Safety Statement

SFE confirms that all flow monitoring stations were installed according to SFE's QA/QC methodology and protocol, and standard industry practice. All flow monitoring equipment and weir material has been removed from the site locations. Note, all data is raw and was not altered or corrected before submission. Velocity or level dropouts occur from debris, rags, and sensor interruption from sewer flows. SFE verified all reading were within manufacturer accuracy.

SFE has a comprehensive Company Safety Manual and can be reviewed upon request.

Confined space entry procedures and general site/traffic safety was adhered to during site installation and site maintenance. SFE utilizes an approved rescue system, a 2800 CFM air induction device and four-gas air quality monitors. All of our staff members are thoroughly trained and certified in confined space entry procedures. Certificates are available upon request.

A thorough traffic control plan was established and used by SFE Global crews where required.

4. Appendices

Appendix #1 Includes Flow Graphs, Summary Reports and Maintenance Records
Appendix #2 Includes Custom Compound Weirs – Technical Information
Appendix #3 Includes Area Velocity Flow Metering – Technical Information

Appendix 1

Flow Graphs
Summary Reports
Maintenance Records

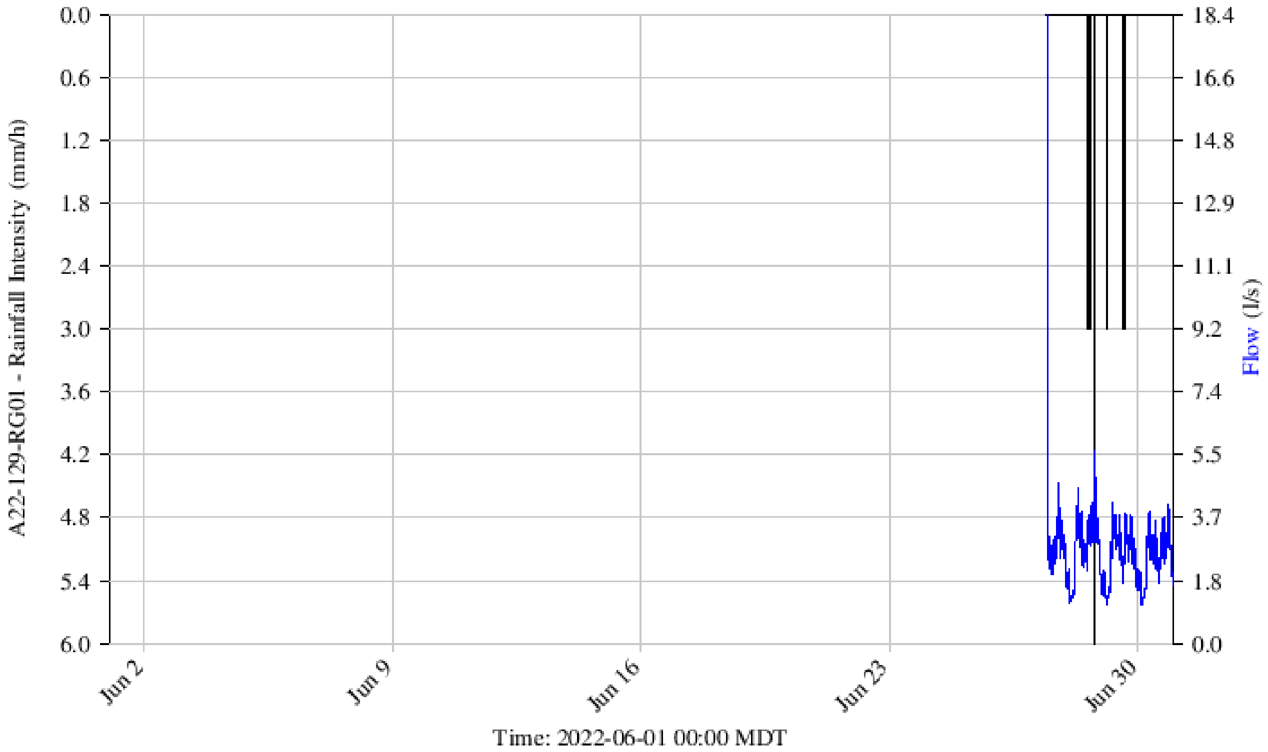
Monthly Report

A22-129 - WSP Jasper TFM

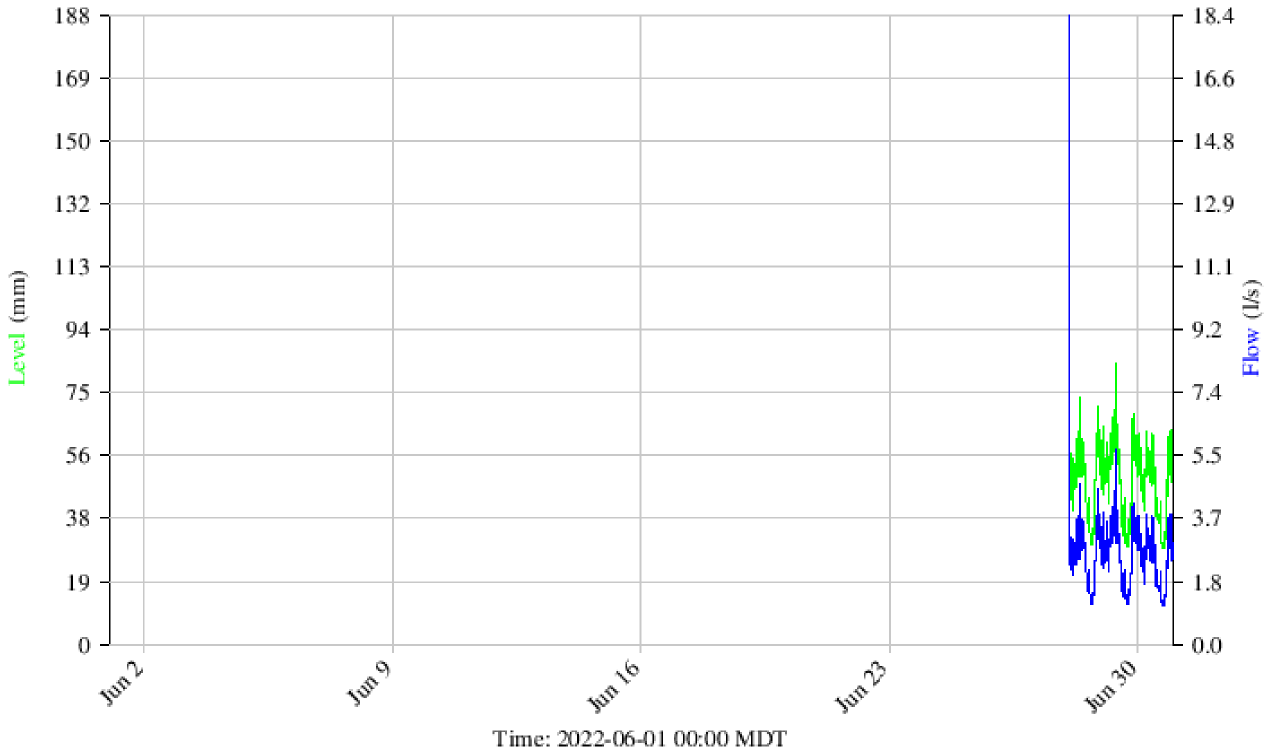
June 2022

A22-129-01

A22-129-01 – Flow with rain intensity



A22-129-01 – Level with velocity and flow

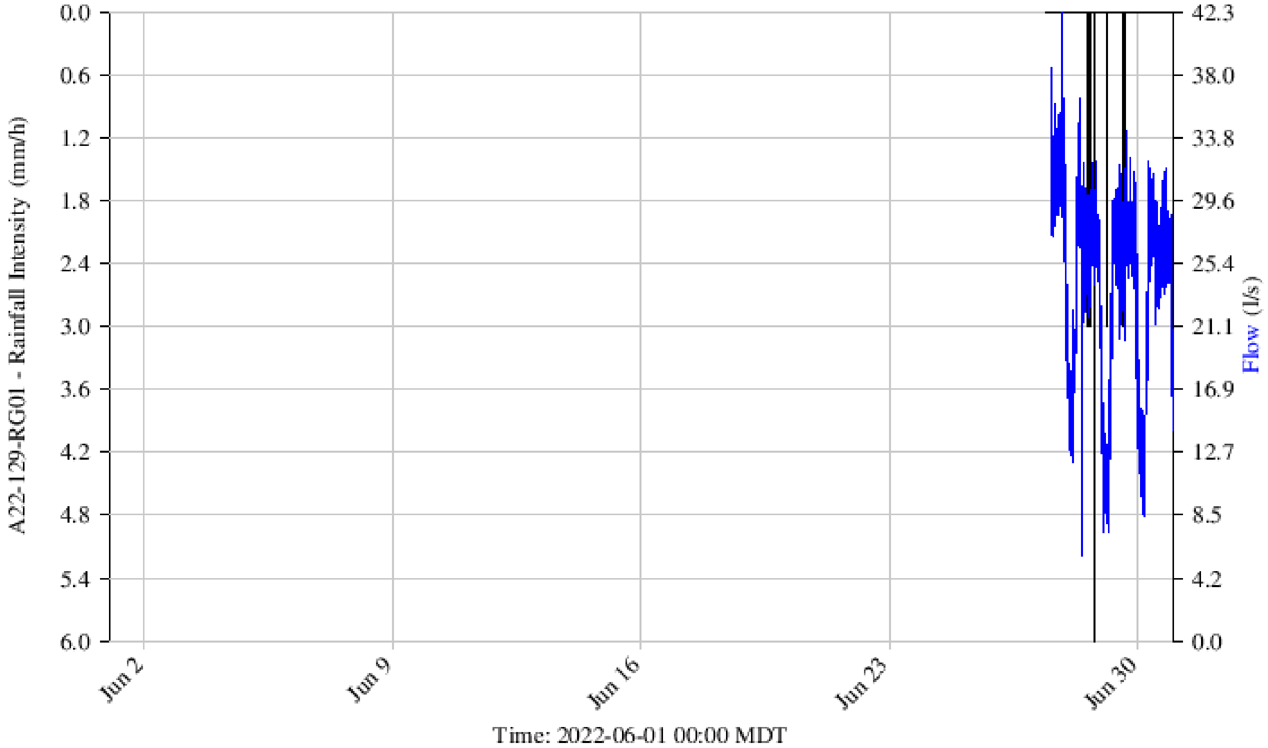


A22-129-01 – Summary report

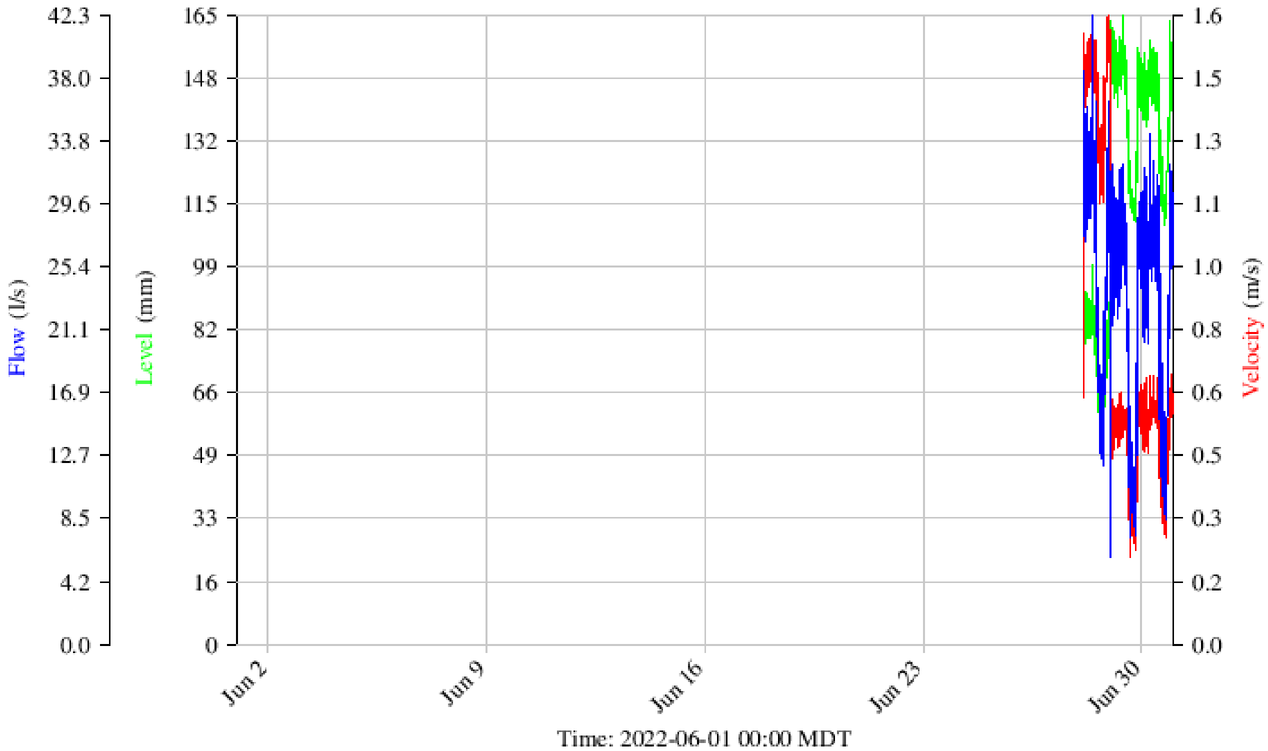
	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	n/a	n/a	n/a	n/a	n/a
2	n/a	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a	n/a
6	n/a	n/a	n/a	n/a	n/a
7	n/a	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a	n/a
9	n/a	n/a	n/a	n/a	n/a
10	n/a	n/a	n/a	n/a	n/a
11	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	n/a	n/a	n/a
17	n/a	n/a	n/a	n/a	n/a
18	n/a	n/a	n/a	n/a	n/a
19	n/a	n/a	n/a	n/a	n/a
20	n/a	n/a	n/a	n/a	n/a
21	n/a	n/a	n/a	n/a	n/a
22	n/a	n/a	n/a	n/a	n/a
23	n/a	n/a	n/a	n/a	n/a
24	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	n/a	n/a	n/a
26	n/a	n/a	n/a	n/a	n/a
27	2.01	3.24	18.44	279.94	0.00
28	1.20	2.77	5.69	239.14	3.75
29	1.16	2.53	4.14	218.40	2.25
30	1.14	2.49	4.10	214.73	0.00
Mean	**1.44**	**2.63**	**6.96**	**227.37**	**1.20**
Minimum	**1.14**	**2.14**	**2.42**	**184.66**	**0.00**
Maximum	**2.01**	**3.24**	**18.44**	**279.94**	**3.75**
Total	**n/a**	**n/a**	**n/a**	**1,136.86**	**6.00**

A22-129-02

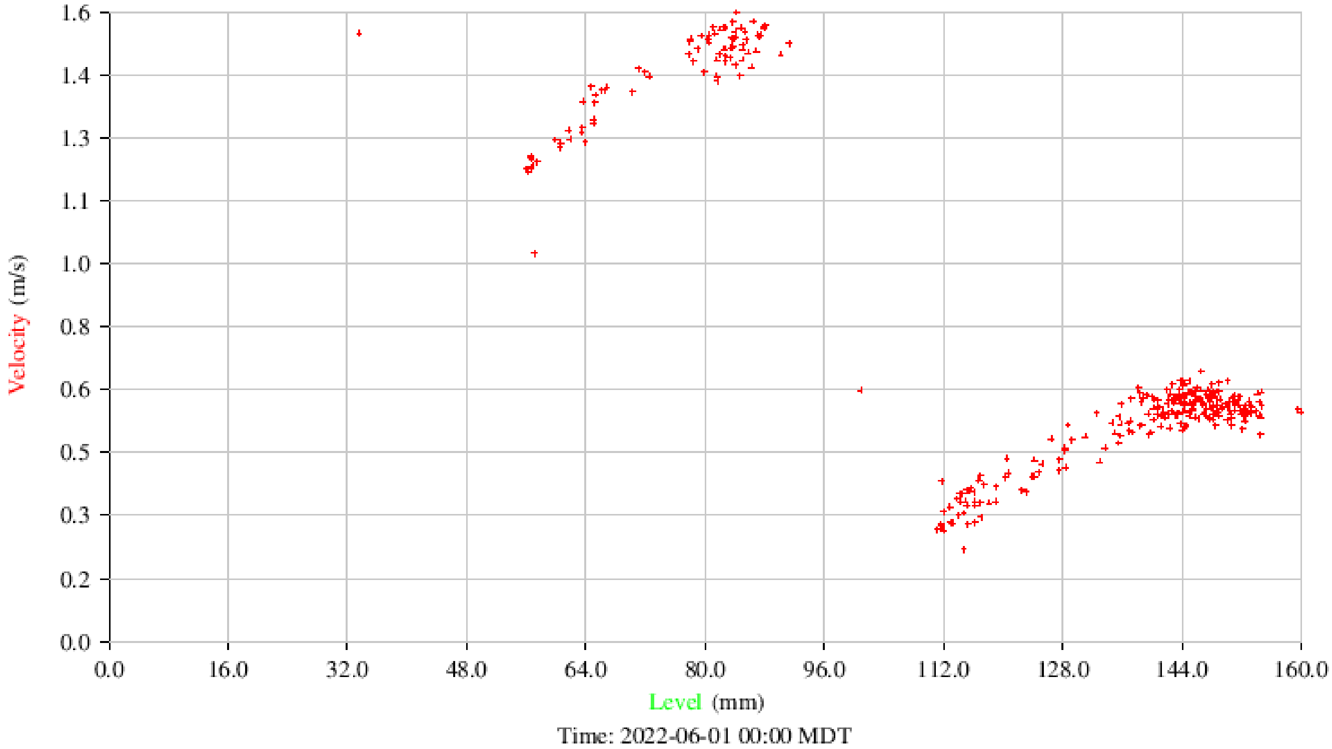
A22-129-02 – Flow with rain intensity



A22-129-02 – Level with velocity and flow



A22-129-02 – Level vs. velocity scatter plot

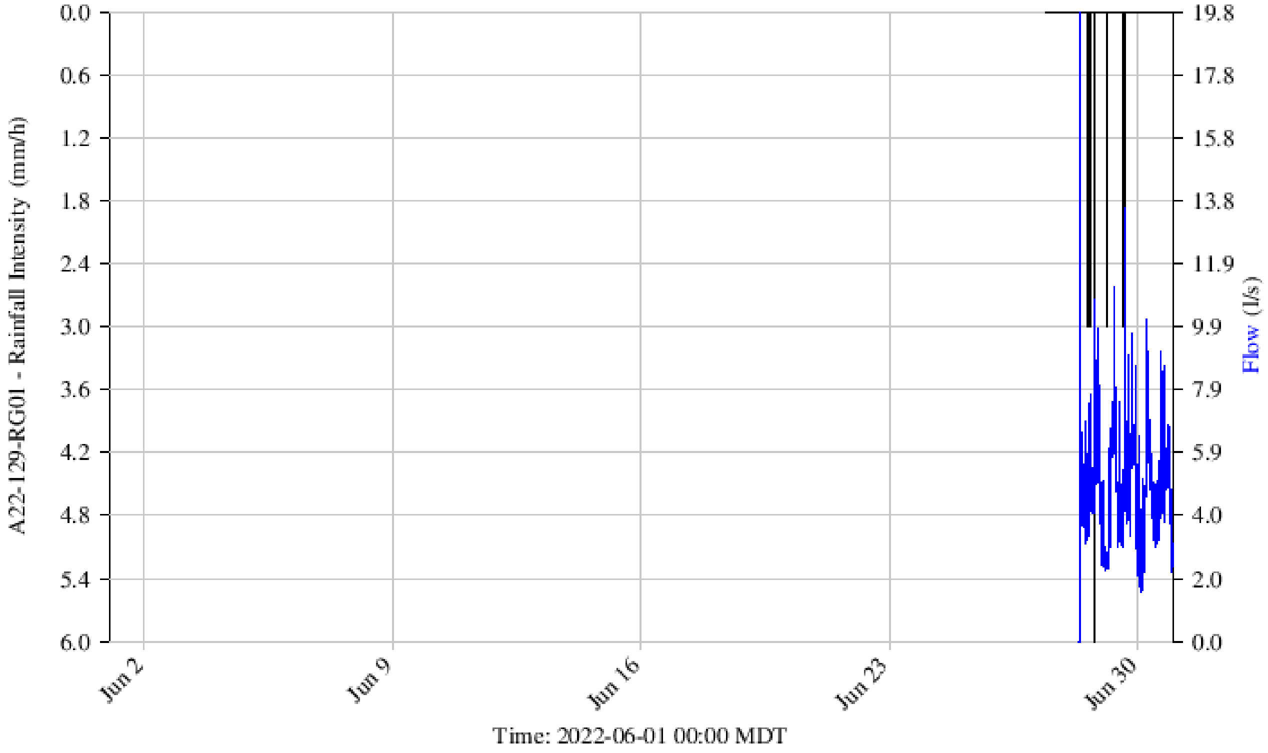


A22-129-02 – Summary report

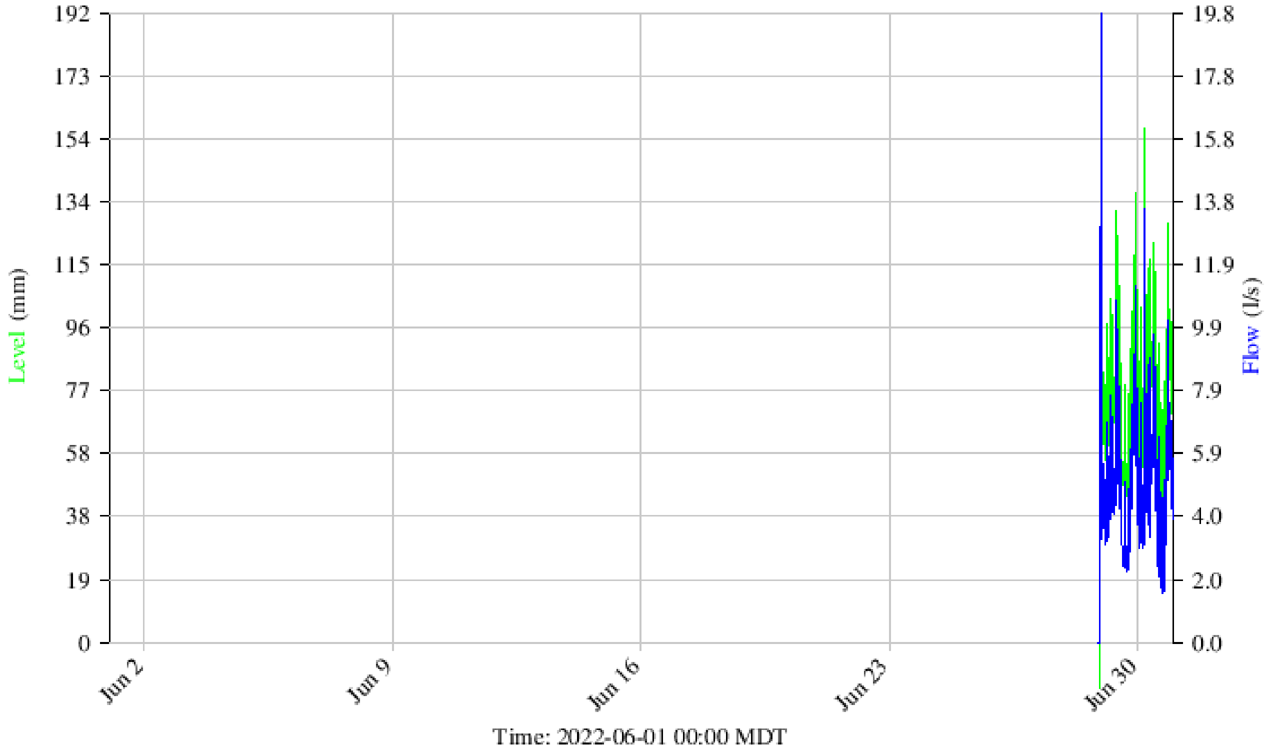
	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	n/a	n/a	n/a	n/a	n/a
2	n/a	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a	n/a
6	n/a	n/a	n/a	n/a	n/a
7	n/a	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a	n/a
9	n/a	n/a	n/a	n/a	n/a
10	n/a	n/a	n/a	n/a	n/a
11	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	n/a	n/a	n/a
17	n/a	n/a	n/a	n/a	n/a
18	n/a	n/a	n/a	n/a	n/a
19	n/a	n/a	n/a	n/a	n/a
20	n/a	n/a	n/a	n/a	n/a
21	n/a	n/a	n/a	n/a	n/a
22	n/a	n/a	n/a	n/a	n/a
23	n/a	n/a	n/a	n/a	n/a
24	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	n/a	n/a	n/a
26	n/a	n/a	n/a	n/a	n/a
27	25.50	31.19	42.26	2,694.57	0.00
28	5.79	24.08	36.52	2,080.71	3.75
29	7.21	22.55	34.33	1,948.58	2.25
30	8.33	22.98	32.30	1,985.80	0.00
Mean	**12.19**	**23.98**	**33.81**	**2,071.73**	**1.20**
Minimum	**5.79**	**19.09**	**23.63**	**1,648.97**	**0.00**
Maximum	**25.50**	**31.19**	**42.26**	**2,694.57**	**3.75**
Total	**n/a**	**n/a**	**n/a**	**10,358.63**	**6.00**

A22-129-03

A22-129-03 – Flow with rain intensity



A22-129-03 – Level with flow

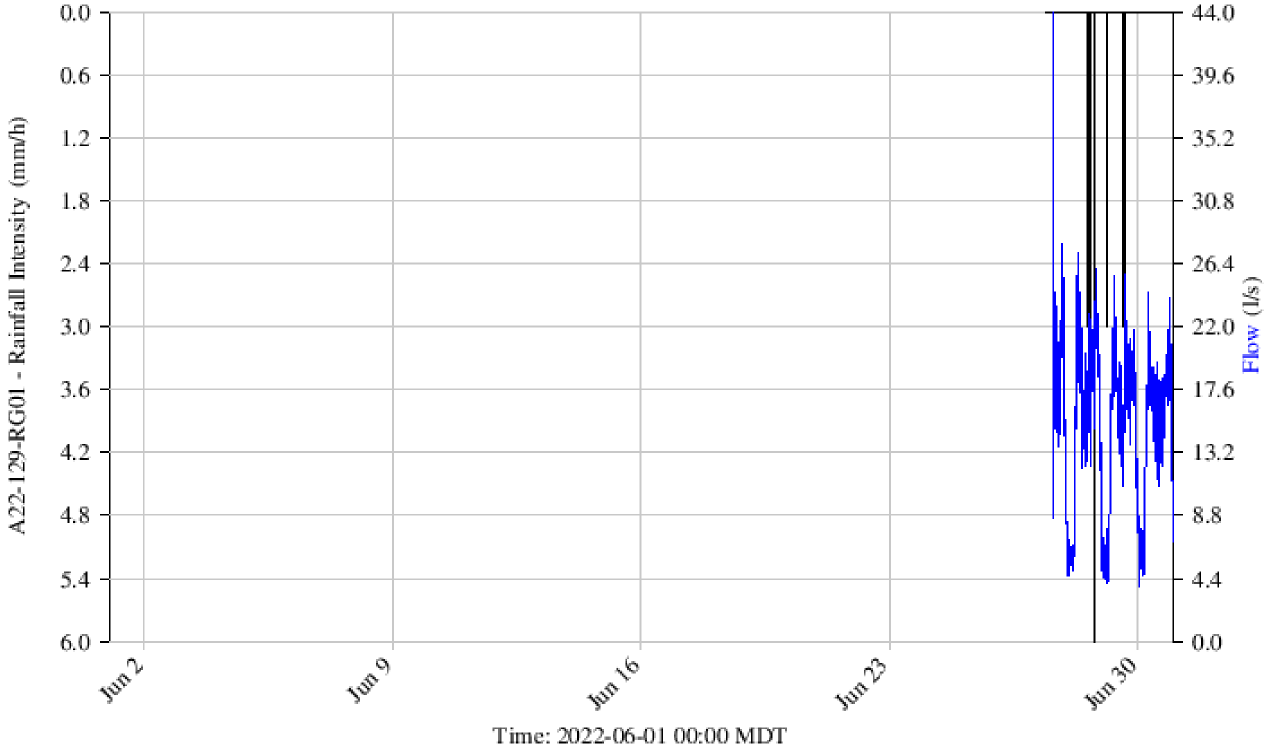


A22-129-03 – Summary report

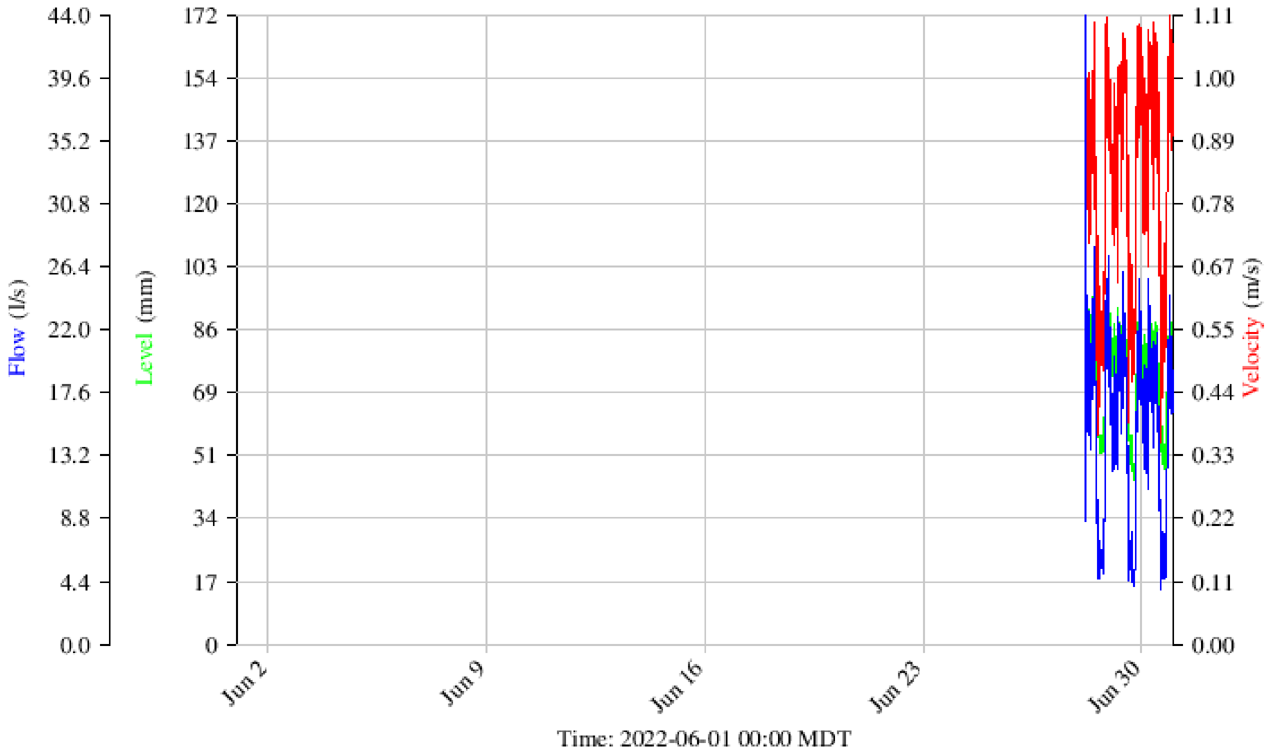
Day	Min (l/s)	Avg (l/s)	Max (l/s)	Volume (m3)	Rainfall (mm)
1	n/a	n/a	n/a	n/a	0.00
2	n/a	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a	n/a
6	n/a	n/a	n/a	n/a	n/a
7	n/a	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a	n/a
9	n/a	n/a	n/a	n/a	n/a
10	n/a	n/a	n/a	n/a	n/a
11	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	n/a	n/a	n/a
17	n/a	n/a	n/a	n/a	n/a
18	n/a	n/a	n/a	n/a	n/a
19	n/a	n/a	n/a	n/a	n/a
20	n/a	n/a	n/a	n/a	n/a
21	n/a	n/a	n/a	n/a	n/a
22	n/a	n/a	n/a	n/a	n/a
23	n/a	n/a	n/a	n/a	n/a
24	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	n/a	n/a	n/a
26	n/a	n/a	n/a	n/a	n/a
27	n/a	n/a	n/a	n/a	0.00
28	0.00	4.98	19.76	430.16	3.75
29	2.22	4.73	13.62	408.61	2.25
30	1.53	4.40	10.14	380.45	0.00
Mean	**1.48**	**4.22**	**11.78**	**364.35**	**1.20**
Minimum	**0.00**	**2.76**	**3.60**	**238.18**	**0.00**
Maximum	**2.22**	**4.98**	**19.76**	**430.16**	**3.75**
Total	**n/a**	**n/a**	**n/a**	**1,457.40**	**6.00**

A22-129-04

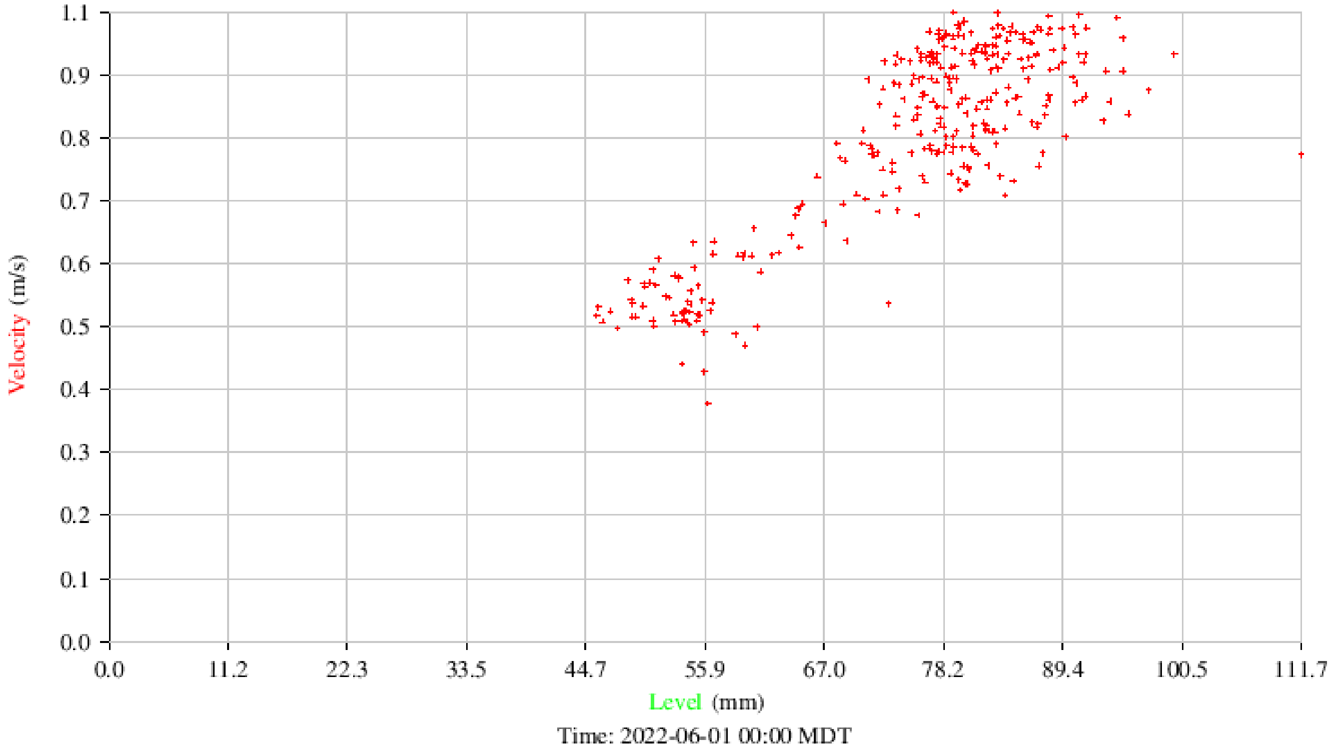
A22-129-04 – Flow with rain intensity



A22-129-04 – Level with velocity and flow



A22-129-04 – Level vs. velocity scatter plot



A22-129-04 – Summary report

	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	n/a	n/a	n/a	n/a	n/a
2	n/a	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a	n/a
6	n/a	n/a	n/a	n/a	n/a
7	n/a	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a	n/a
9	n/a	n/a	n/a	n/a	n/a
10	n/a	n/a	n/a	n/a	n/a
11	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	n/a	n/a	n/a
17	n/a	n/a	n/a	n/a	n/a
18	n/a	n/a	n/a	n/a	n/a
19	n/a	n/a	n/a	n/a	n/a
20	n/a	n/a	n/a	n/a	n/a
21	n/a	n/a	n/a	n/a	n/a
22	n/a	n/a	n/a	n/a	n/a
23	n/a	n/a	n/a	n/a	n/a
24	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	n/a	n/a	n/a
26	n/a	n/a	n/a	n/a	n/a
27	8.51	19.24	43.96	1,662.56	0.00
28	4.54	15.74	27.21	1,359.64	3.75
29	4.06	14.70	25.62	1,269.91	2.25
30	3.76	14.47	24.41	1,250.14	0.00
Mean	**5.55**	**15.42**	**28.19**	**1,331.99**	**1.20**
Minimum	**3.76**	**12.94**	**19.74**	**1,117.71**	**0.00**
Maximum	**8.51**	**19.24**	**43.96**	**1,662.56**	**3.75**
Total	**n/a**	**n/a**	**n/a**	**6,659.95**	**6.00**

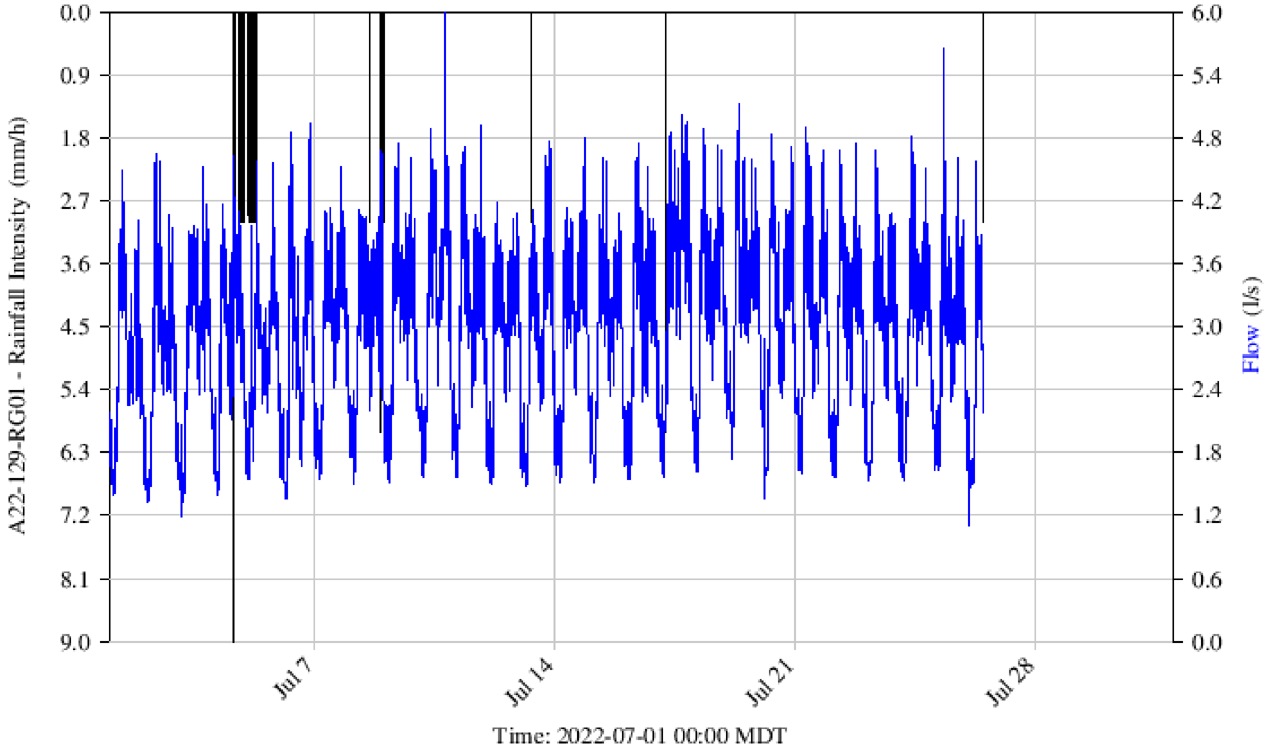
Monthly Report

A22-129 - WSP Jasper TFM

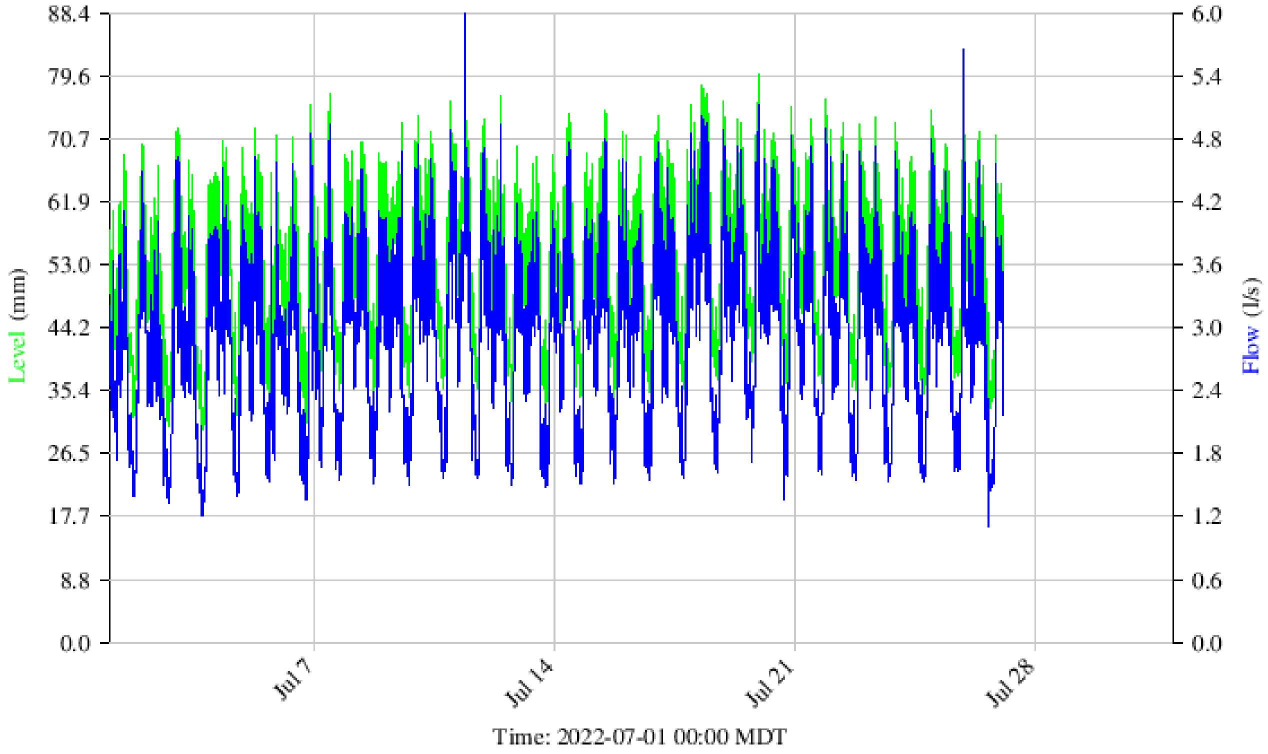
July 2022

A22-129-01

A22-129-01 – Flow with rain intensity



A22-129-01 – Level with velocity and flow

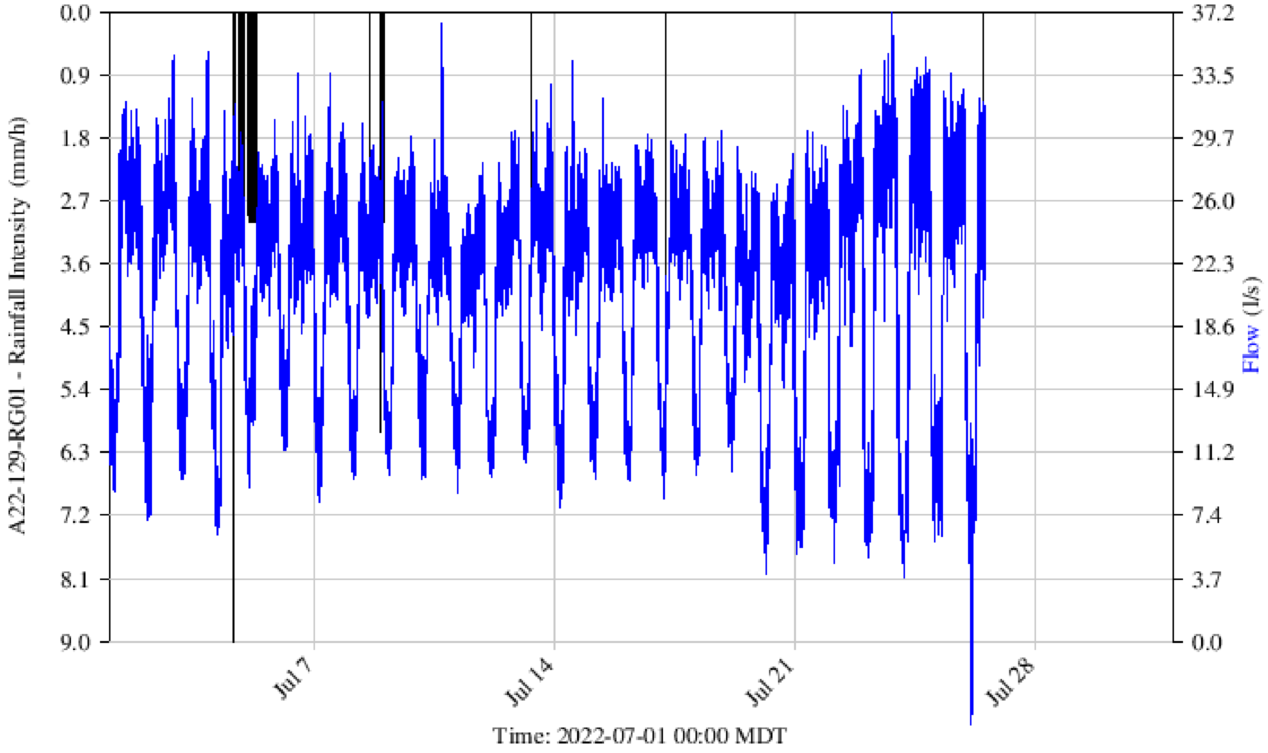


A22-129-01 – Summary report

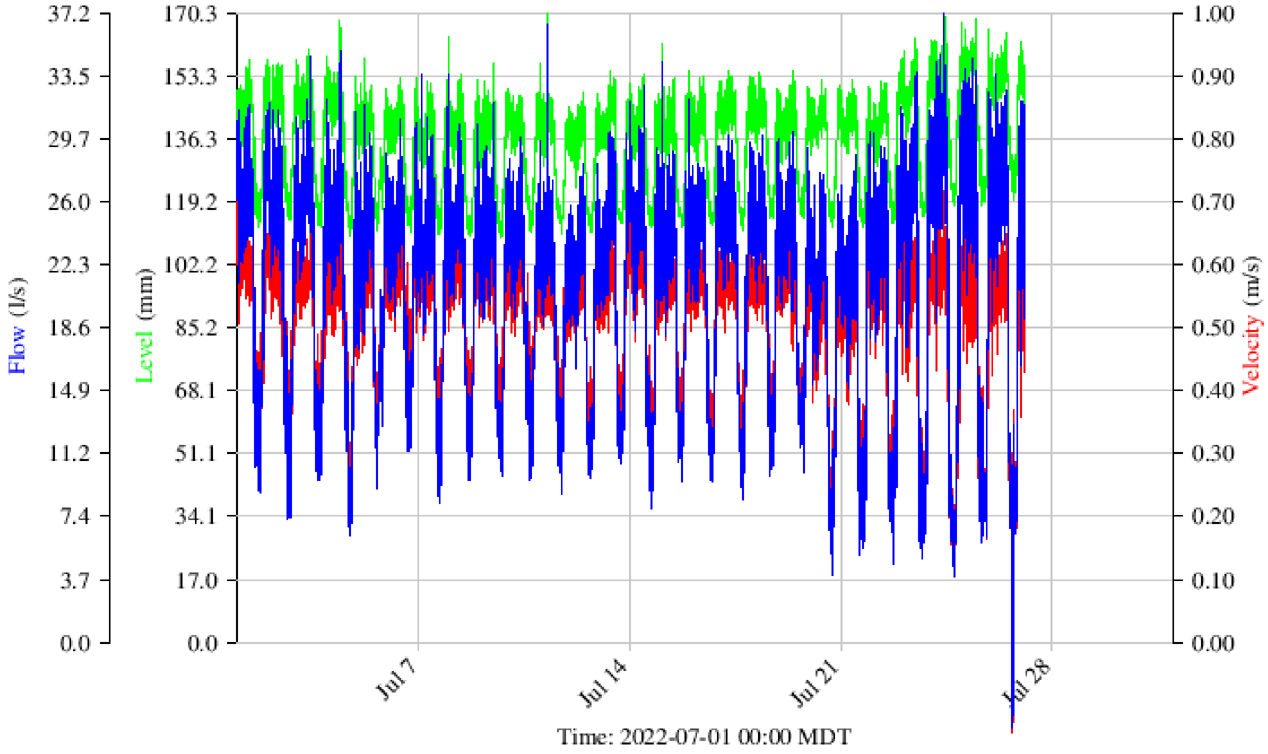
	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	1.38	2.66	4.48	230.04	0.00
2	1.32	2.67	4.63	230.30	0.00
3	1.19	2.76	4.51	238.52	0.00
4	1.39	2.79	4.63	241.25	5.00
5	1.53	2.76	4.56	238.07	5.25
6	1.35	2.72	4.93	234.67	0.00
7	1.55	2.96	4.51	255.43	0.00
8	1.50	2.97	4.67	256.40	3.50
9	1.50	3.02	4.74	261.17	0.25
10	1.56	3.14	5.98	271.12	0.00
11	1.55	3.00	4.92	258.89	0.00
12	1.48	2.83	4.18	244.29	0.00
13	1.47	2.87	4.75	247.62	0.50
14	1.50	2.95	4.79	254.57	0.00
15	1.50	2.95	4.60	254.80	0.00
16	1.53	2.95	4.74	255.31	0.00
17	1.55	3.24	5.02	279.83	1.50
18	1.61	3.14	4.87	271.15	0.00
19	1.72	3.24	5.11	280.12	0.00
20	1.35	3.08	4.81	266.27	0.00
21	1.59	3.05	4.89	263.23	0.00
22	1.55	2.97	4.73	256.36	0.00
23	1.53	2.87	4.67	247.82	0.00
24	1.52	2.94	4.79	253.97	0.00
25	1.62	2.84	5.63	245.68	0.00
26	1.10	2.41	4.56	208.50	0.25
27	n/a	n/a	n/a	n/a	0.00
28	n/a	n/a	n/a	n/a	0.00
29	n/a	n/a	n/a	n/a	0.00
30	n/a	n/a	n/a	n/a	0.00
31	n/a	n/a	n/a	n/a	0.00
Mean	**1.48**	**2.91**	**4.80**	**251.75**	**0.52**
Minimum	**1.10**	**2.41**	**4.18**	**208.50**	**0.00**
Maximum	**1.72**	**3.24**	**5.98**	**280.12**	**5.25**
Total	**n/a**	**n/a**	**n/a**	**6,545.39**	**16.25**

A22-129-02

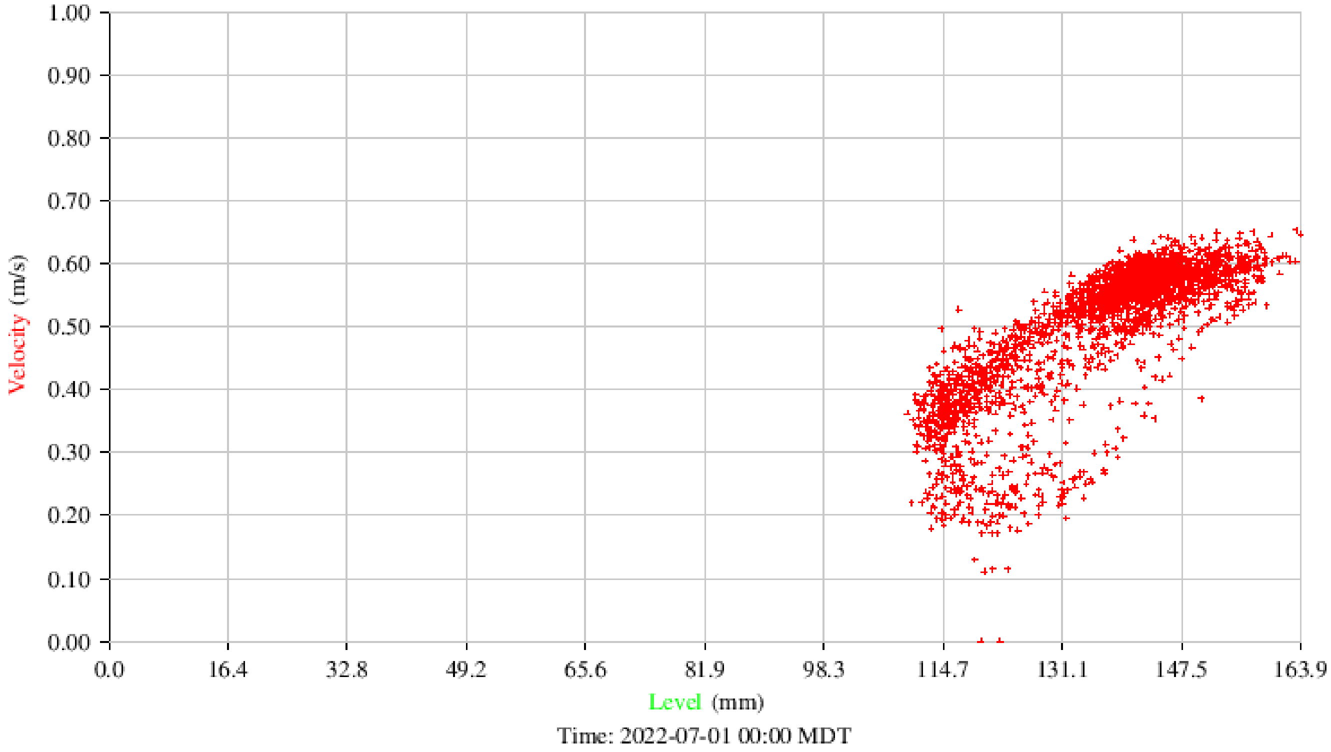
A22-129-02 – Flow with rain intensity



A22-129-02 – Level with velocity and flow



A22-129-02 – Level vs. velocity scatter plot

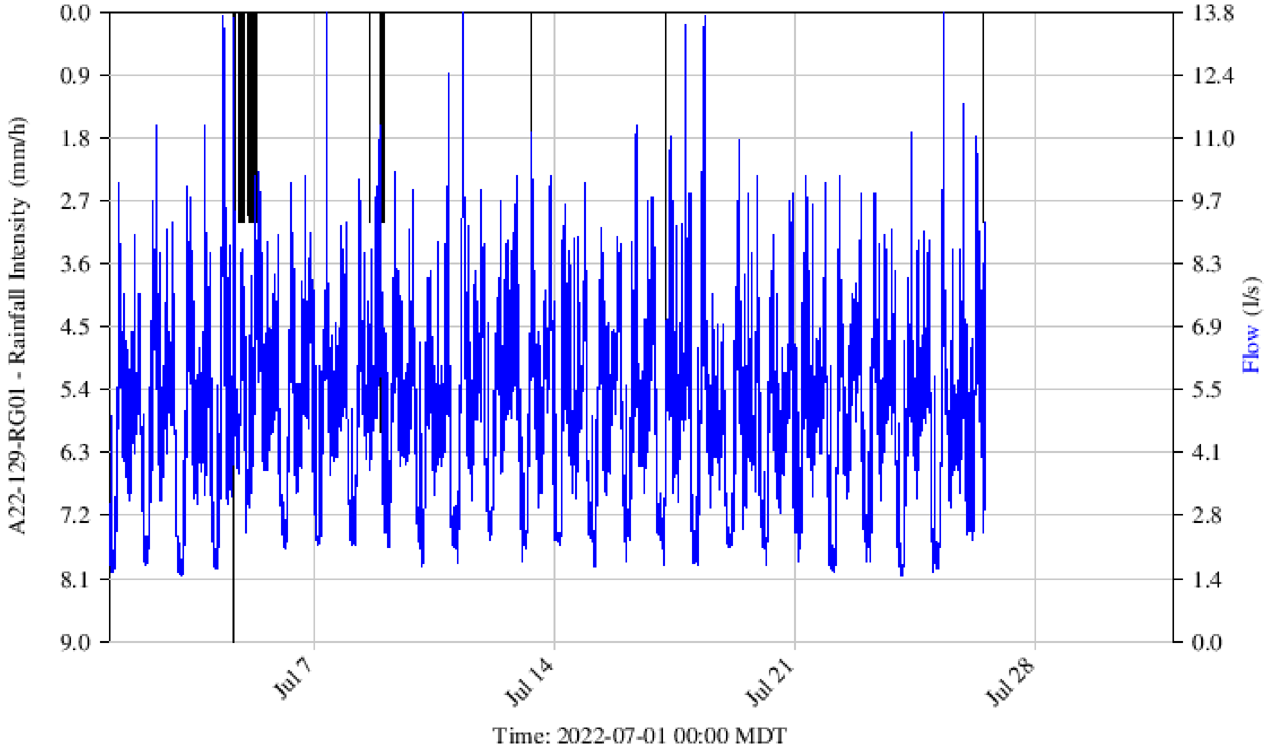


A22-129-02 – Summary report

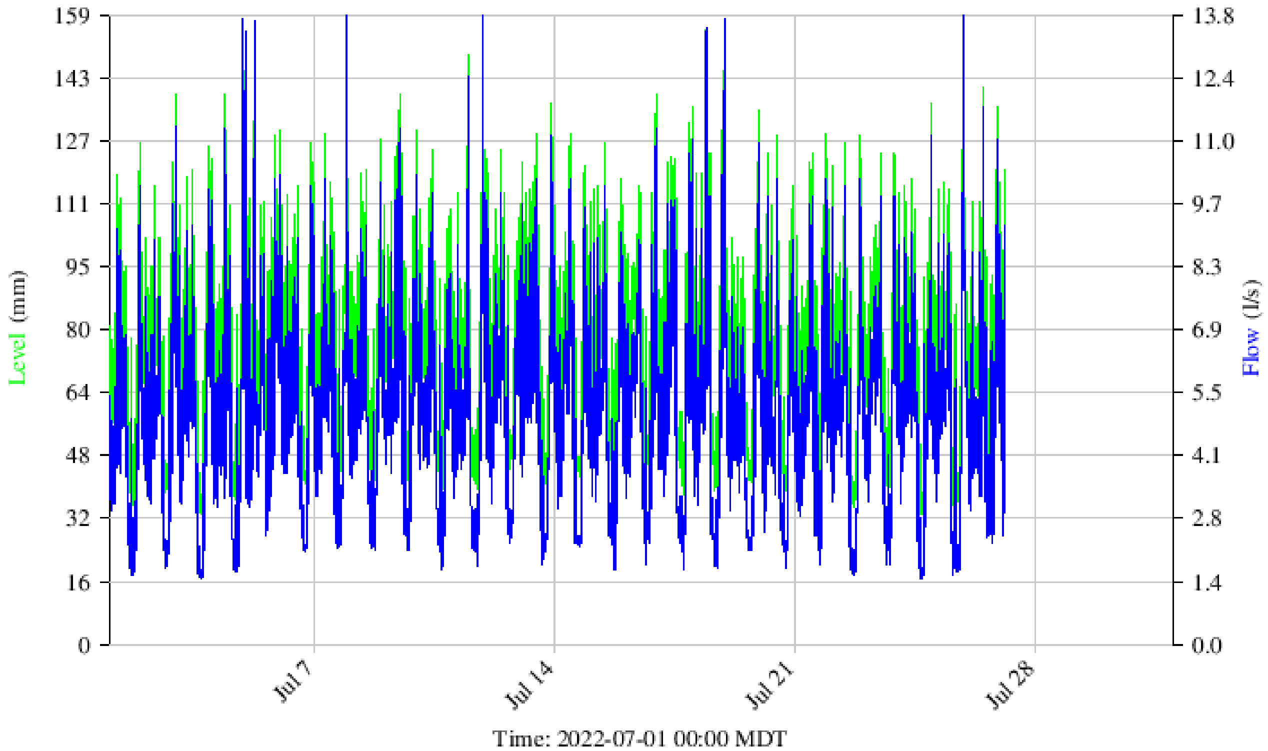
Day	Min (l/s)	Avg (l/s)	Max (l/s)	Volume (m3)	Rainfall (mm)
1	8.82	22.23	31.87	1,921.07	0.00
2	7.20	21.72	34.68	1,876.63	0.00
3	9.58	21.59	34.90	1,865.25	0.00
4	6.34	20.04	31.76	1,731.46	5.00
5	9.05	21.33	30.88	1,842.51	5.25
6	11.28	21.57	33.60	1,864.07	0.00
7	8.24	20.95	33.57	1,810.15	0.00
8	9.57	20.90	31.91	1,805.81	3.50
9	9.76	20.73	29.90	1,790.65	0.25
10	9.56	20.35	36.55	1,758.62	0.00
11	8.78	19.59	28.31	1,692.30	0.00
12	9.73	20.60	30.21	1,779.64	0.00
13	10.52	21.79	32.96	1,882.89	0.50
14	7.86	20.38	34.38	1,760.67	0.00
15	9.51	20.86	32.12	1,802.28	0.00
16	9.45	21.34	30.01	1,843.94	0.00
17	8.41	21.06	29.99	1,819.57	1.50
18	9.82	21.16	30.22	1,828.25	0.00
19	9.98	19.97	29.25	1,725.28	0.00
20	3.97	18.32	28.82	1,582.95	0.00
21	5.18	19.54	30.23	1,688.37	0.00
22	4.60	21.23	33.76	1,834.70	0.00
23	4.93	22.52	37.18	1,945.82	0.00
24	3.81	21.21	34.49	1,832.77	0.00
25	5.85	21.87	33.57	1,889.80	0.00
26	-4.99	15.94	32.07	1,377.58	0.25
27	n/a	n/a	n/a	n/a	0.00
28	n/a	n/a	n/a	n/a	0.00
29	n/a	n/a	n/a	n/a	0.00
30	n/a	n/a	n/a	n/a	0.00
31	n/a	n/a	n/a	n/a	0.00
Mean	**7.57**	**20.72**	**32.20**	**1,790.50**	**0.52**
Minimum	**-4.99**	**15.94**	**28.31**	**1,377.58**	**0.00**
Maximum	**11.28**	**22.52**	**37.18**	**1,945.82**	**5.25**
Total	**n/a**	**n/a**	**n/a**	**46,553.06**	**16.25**

A22-129-03

A22-129-03 – Flow with rain intensity



A22-129-03 – Level with flow

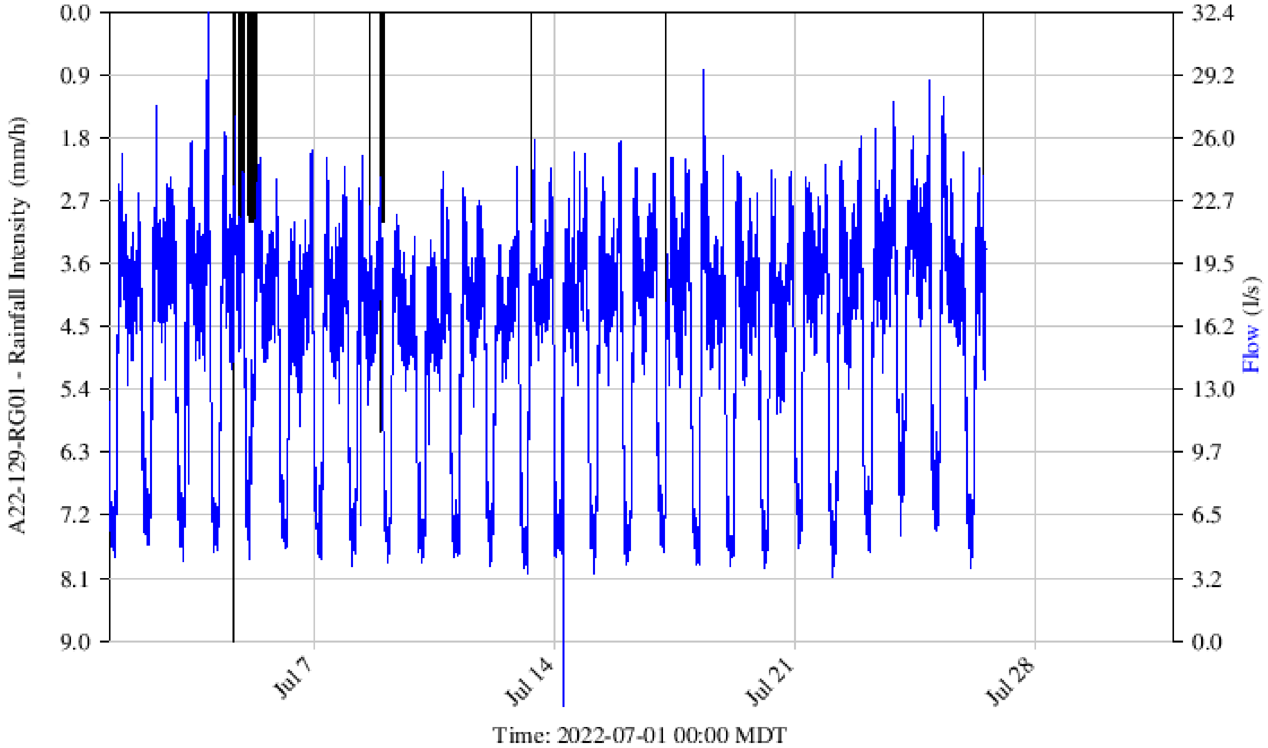


A22-129-03 – Summary report

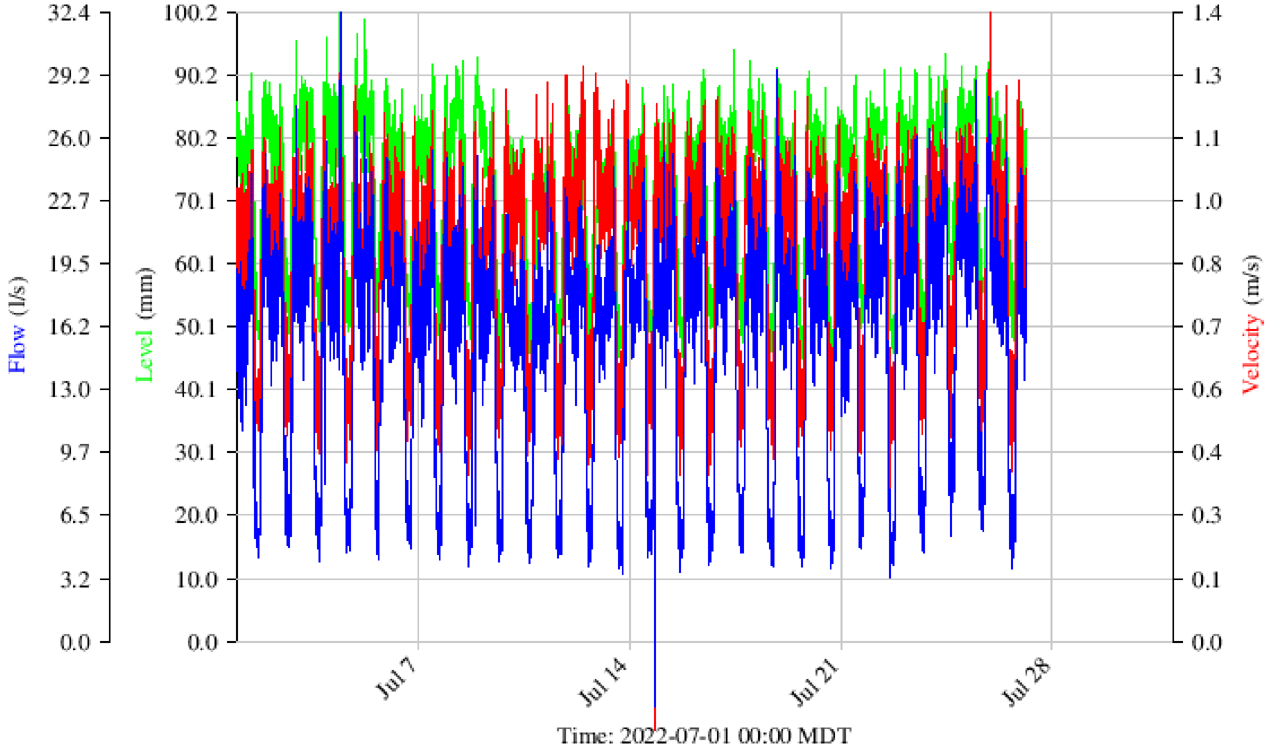
	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	1.52	4.55	10.06	392.98	0.00
2	1.67	4.84	11.33	417.97	0.00
3	1.44	4.52	11.33	390.63	0.00
4	1.59	5.10	13.70	440.75	5.00
5	2.38	5.54	10.30	478.35	5.25
6	2.03	5.00	10.22	432.34	0.00
7	2.09	4.98	13.79	430.51	0.00
8	2.08	5.06	11.33	437.39	3.50
9	2.04	4.95	10.30	427.86	0.25
10	1.65	4.71	12.46	407.32	0.00
11	1.71	5.24	13.79	452.79	0.00
12	2.21	5.22	10.22	451.05	0.00
13	1.74	5.04	11.17	435.57	0.50
14	2.13	4.85	10.06	419.44	0.00
15	1.62	5.00	9.05	431.84	0.00
16	1.74	5.02	11.33	434.08	0.00
17	1.65	5.13	13.53	443.20	1.50
18	1.66	4.74	13.70	409.77	0.00
19	2.05	4.64	11.01	400.99	0.00
20	1.69	4.60	9.83	397.15	0.00
21	1.74	4.94	10.22	426.69	0.00
22	1.50	4.83	10.22	417.16	0.00
23	1.72	4.96	9.83	428.21	0.00
24	1.43	4.69	11.17	405.44	0.00
25	1.52	4.57	13.79	394.56	0.00
26	2.21	4.64	11.09	400.58	0.25
27	n/a	n/a	n/a	n/a	0.00
28	n/a	n/a	n/a	n/a	0.00
29	n/a	n/a	n/a	n/a	0.00
30	n/a	n/a	n/a	n/a	0.00
31	n/a	n/a	n/a	n/a	0.00
Mean	**1.80**	**4.90**	**11.34**	**423.25**	**0.52**
Minimum	**1.43**	**4.52**	**9.05**	**390.63**	**0.00**
Maximum	**2.38**	**5.54**	**13.79**	**478.35**	**5.25**
Total	**n/a**	**n/a**	**n/a**	**11,004.59**	**16.25**

A22-129-04

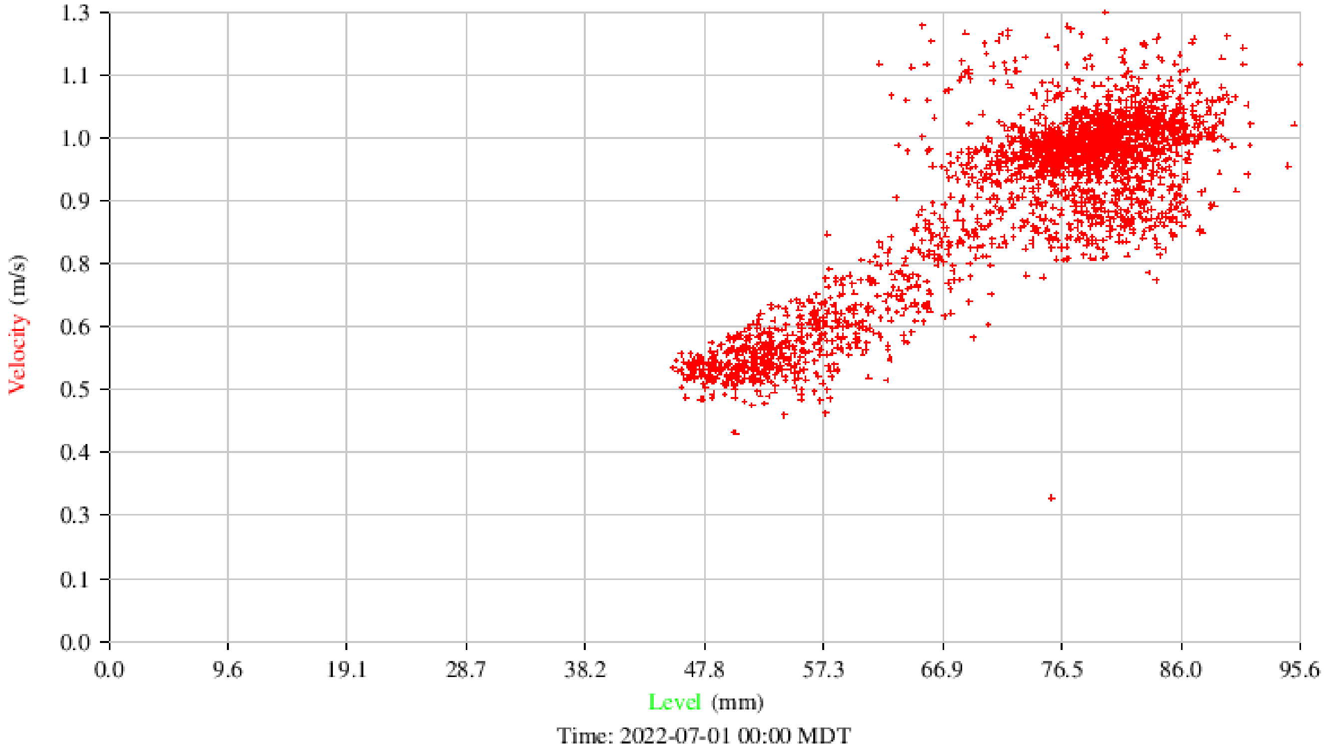
A22-129-04 – Flow with rain intensity



A22-129-04 – Level with velocity and flow



A22-129-04 – Level vs. velocity scatter plot



A22-129-04 – Summary report

	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	4.30	15.66	25.19	1,352.77	0.00
2	4.89	15.74	27.61	1,359.76	0.00
3	4.13	16.13	32.45	1,393.46	0.00
4	4.52	16.01	27.07	1,383.49	5.00
5	4.22	16.07	24.95	1,388.73	5.25
6	4.76	15.00	25.34	1,295.73	0.00
7	4.17	15.06	25.00	1,301.56	0.00
8	3.82	15.10	25.04	1,304.24	3.50
9	4.06	14.36	22.03	1,240.65	0.25
10	4.00	14.19	24.20	1,225.70	0.00
11	4.26	14.85	23.41	1,282.89	0.00
12	3.83	14.55	24.51	1,257.54	0.00
13	3.47	15.35	25.86	1,326.16	0.50
14	-3.37	15.59	25.21	1,347.31	0.00
15	3.50	15.62	25.75	1,349.44	0.00
16	3.91	15.71	24.43	1,357.27	0.00
17	4.55	15.81	24.98	1,365.86	1.50
18	3.86	15.07	29.49	1,301.98	0.00
19	3.82	15.11	24.23	1,305.37	0.00
20	3.76	14.93	24.28	1,289.95	0.00
21	4.77	16.30	24.63	1,408.66	0.00
22	3.28	15.69	26.11	1,355.68	0.00
23	4.55	16.69	27.80	1,442.07	0.00
24	5.39	18.07	28.94	1,561.52	0.00
25	5.69	16.66	28.14	1,439.57	0.00
26	3.76	13.29	24.40	1,147.99	0.25
27	n/a	n/a	n/a	n/a	0.00
28	n/a	n/a	n/a	n/a	0.00
29	n/a	n/a	n/a	n/a	0.00
30	n/a	n/a	n/a	n/a	0.00
31	n/a	n/a	n/a	n/a	0.00
Mean	**3.92**	**15.48**	**25.81**	**1,337.90**	**0.52**
Minimum	**-3.37**	**13.29**	**22.03**	**1,147.99**	**0.00**
Maximum	**5.69**	**18.07**	**32.45**	**1,561.52**	**5.25**
Total	**n/a**	**n/a**	**n/a**	**34,785.35**	**16.25**

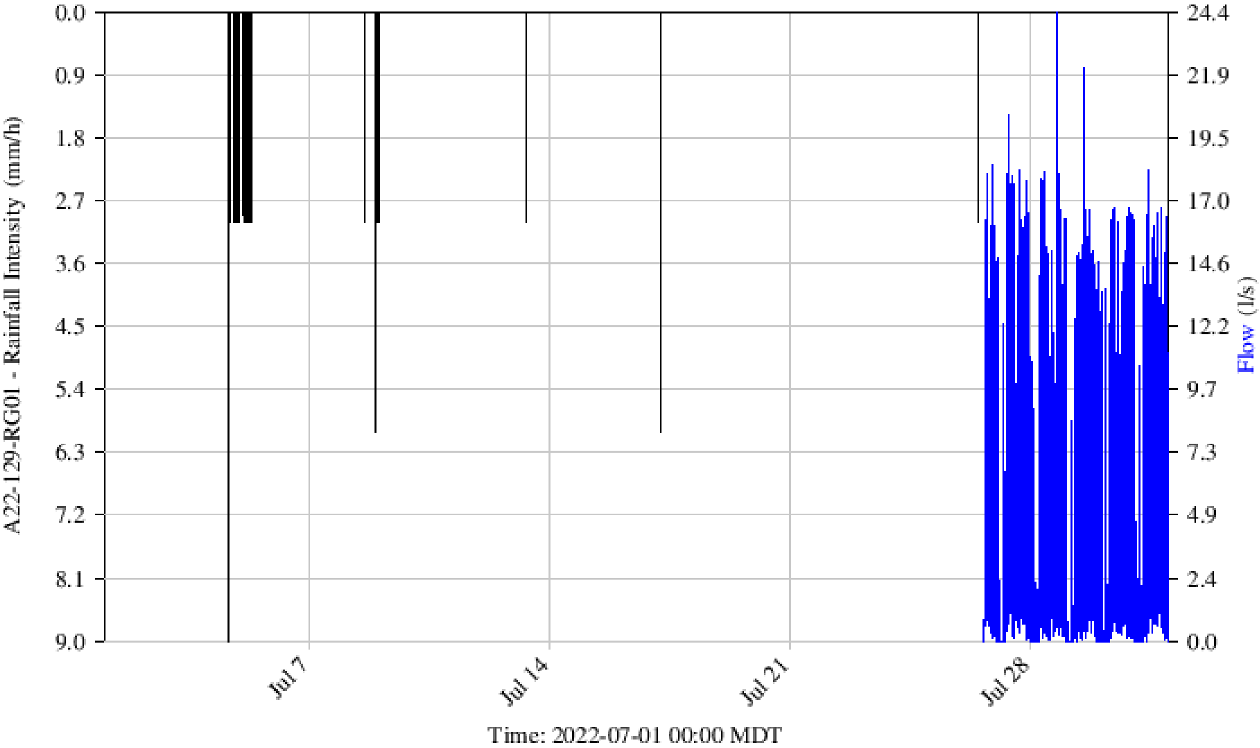
Monthly Report

A22-129 - WSP Jasper TFM

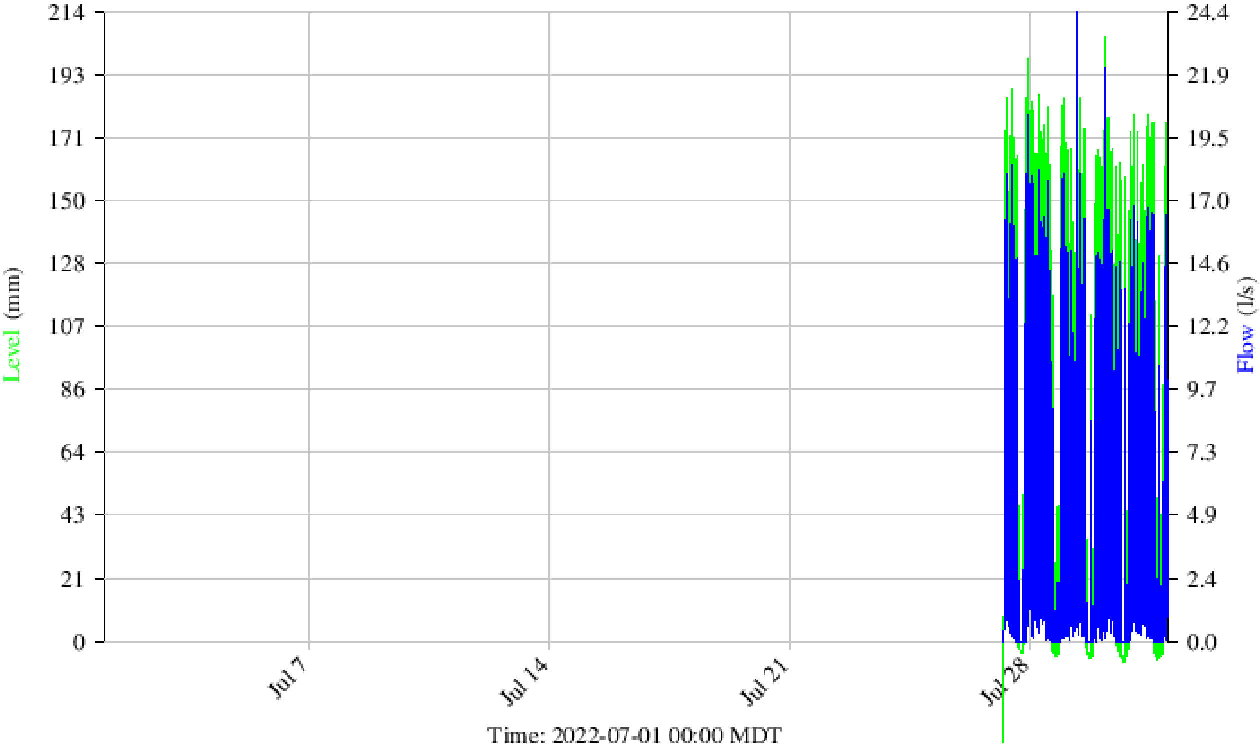
July 2022

A22-129-05

A22-129-05 – Flow with rain intensity



A22-129-05 – Level with flow



A22-129-05 – Summary report

	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	n/a	n/a	n/a	n/a	0.00
2	n/a	n/a	n/a	n/a	0.00
3	n/a	n/a	n/a	n/a	0.00
4	n/a	n/a	n/a	n/a	5.00
5	n/a	n/a	n/a	n/a	5.25
6	n/a	n/a	n/a	n/a	0.00
7	n/a	n/a	n/a	n/a	0.00
8	n/a	n/a	n/a	n/a	3.50
9	n/a	n/a	n/a	n/a	0.25
10	n/a	n/a	n/a	n/a	0.00
11	n/a	n/a	n/a	n/a	0.00
12	n/a	n/a	n/a	n/a	0.00
13	n/a	n/a	n/a	n/a	0.50
14	n/a	n/a	n/a	n/a	0.00
15	n/a	n/a	n/a	n/a	0.00
16	n/a	n/a	n/a	n/a	0.00
17	n/a	n/a	n/a	n/a	1.50
18	n/a	n/a	n/a	n/a	0.00
19	n/a	n/a	n/a	n/a	0.00
20	n/a	n/a	n/a	n/a	0.00
21	n/a	n/a	n/a	n/a	0.00
22	n/a	n/a	n/a	n/a	0.00
23	n/a	n/a	n/a	n/a	0.00
24	n/a	n/a	n/a	n/a	0.00
25	n/a	n/a	n/a	n/a	0.00
26	0.00	4.51	18.45	389.79	0.25
27	0.00	3.77	20.40	325.56	0.00
28	0.00	3.70	24.35	320.00	0.00
29	0.00	4.01	22.20	346.83	0.00
30	0.00	4.42	16.83	382.23	0.00
31	0.00	4.32	18.27	373.37	0.00
Mean	**0.00**	**4.15**	**18.81**	**358.17**	**0.52**
Minimum	**0.00**	**3.70**	**11.19**	**320.00**	**0.00**
Maximum	**0.00**	**4.51**	**24.35**	**389.79**	**5.25**
Total	**n/a**	**n/a**	**n/a**	**2,507.20**	**16.25**

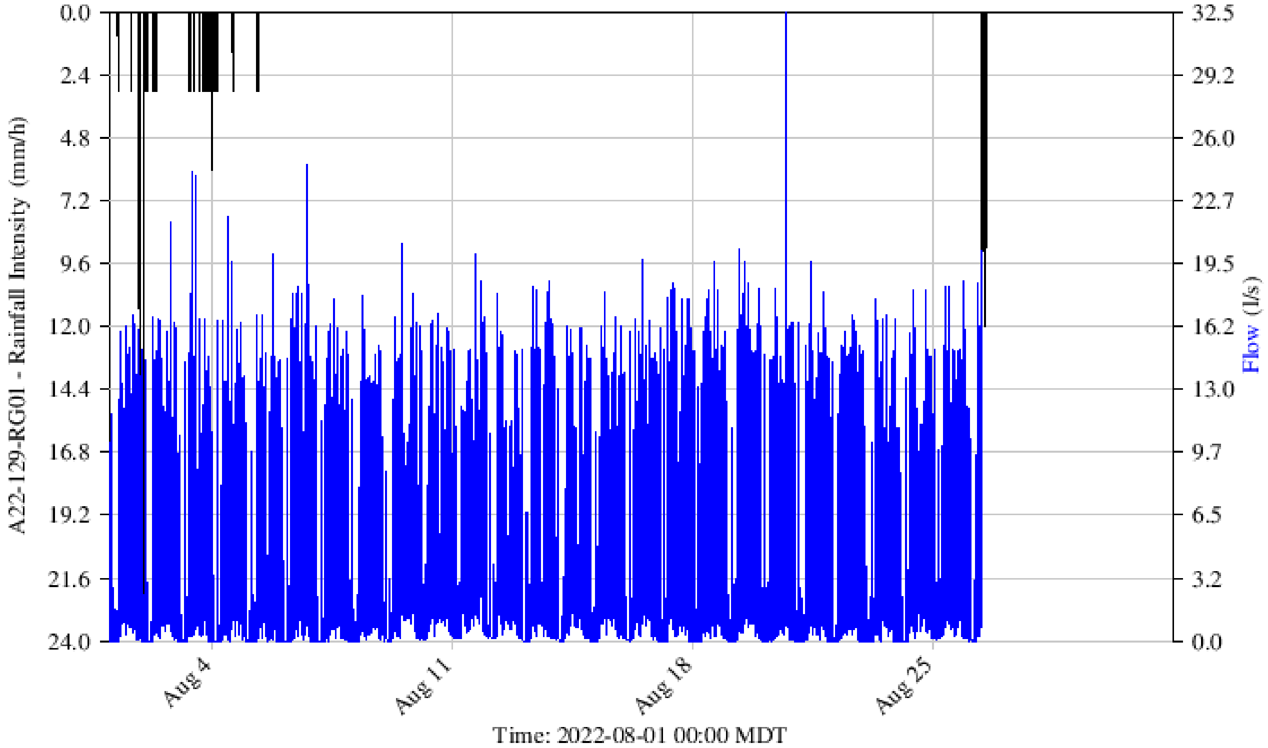
Monthly Report

A22-129 - WSP Jasper TFM

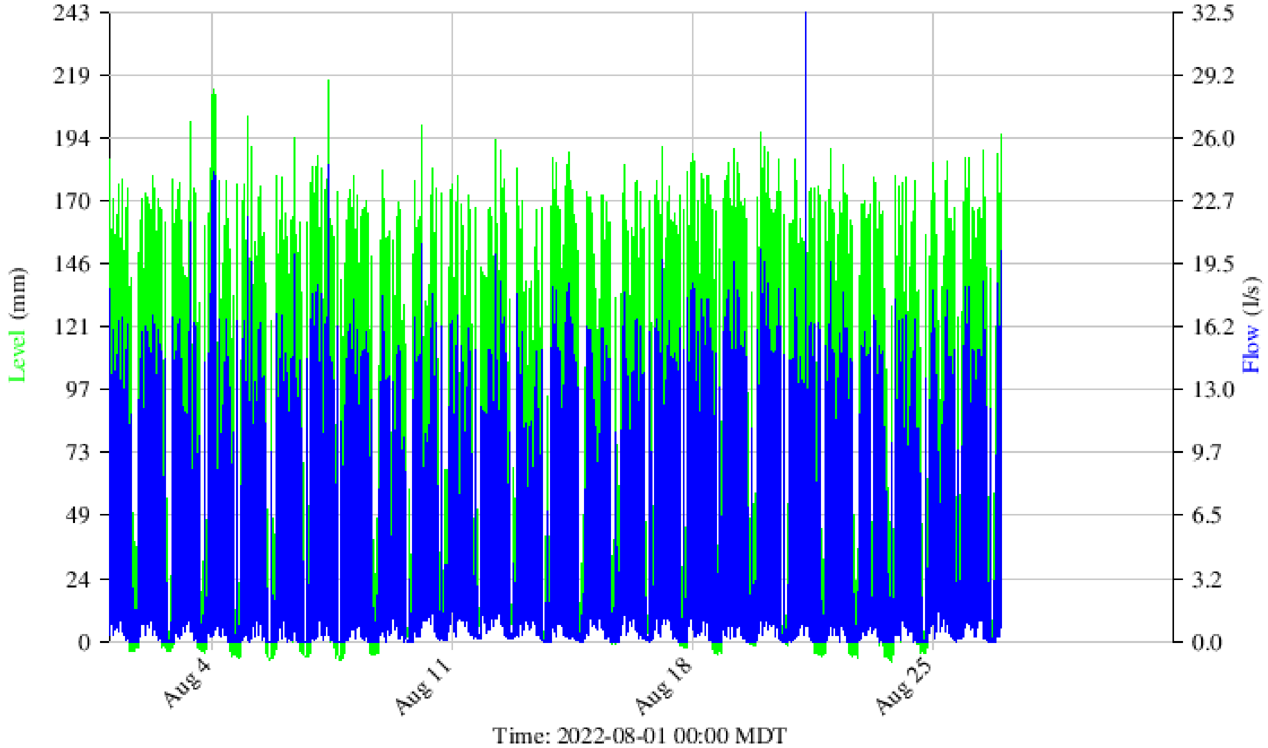
August 2022

A22-129-05

A22-129-05 – Flow with rain intensity



A22-129-05 – Level with flow



A22-129-05 – Summary report

	Min	Avg	Max	Volume	Rainfall
Day	**(l/s)**	**(l/s)**	**(l/s)**	**(m3)**	**(mm)**
1	0.00	3.86	16.89	333.28	5.50
2	0.00	3.72	21.67	321.36	5.25
3	0.00	3.62	24.26	312.86	4.25
4	0.00	3.87	21.92	334.34	7.75
5	0.00	3.60	20.00	311.39	0.50
6	0.00	3.91	24.65	337.52	0.00
7	0.00	3.69	17.67	318.47	0.00
8	0.00	3.75	17.86	323.79	0.00
9	0.00	4.09	20.51	353.06	0.00
10	0.06	4.42	16.89	382.17	0.00
11	0.13	4.37	19.97	377.29	0.00
12	0.15	4.16	17.96	359.28	0.00
13	0.00	4.25	18.55	367.25	0.00
14	0.00	4.17	16.32	360.70	0.00
15	0.00	4.07	18.05	351.93	0.00
16	0.00	4.27	19.70	369.30	0.00
17	0.00	3.88	18.52	335.56	0.00
18	0.00	4.01	19.61	346.75	0.00
19	0.00	4.25	20.26	367.58	0.00
20	0.00	3.89	32.48	336.52	n/a
21	0.00	3.71	19.60	320.88	0.00
22	0.00	3.61	16.87	311.72	0.00
23	0.00	3.55	17.66	306.45	0.00
24	0.00	3.89	18.19	336.08	0.00
25	0.00	3.91	18.60	337.52	0.00
26	0.00	2.45	20.15	211.61	12.00
27	n/a	n/a	n/a	n/a	0.00
28	n/a	n/a	n/a	n/a	0.00
29	n/a	n/a	n/a	n/a	0.00
30	n/a	n/a	n/a	n/a	0.00
31	n/a	n/a	n/a	n/a	0.00
Mean	**0.01**	**3.88**	**19.80**	**335.56**	**1.18**
Minimum	**0.00**	**2.45**	**16.32**	**211.61**	**0.00**
Maximum	**0.15**	**4.42**	**32.48**	**382.17**	**12.00**
Total	**n/a**	**n/a**	**n/a**	**8,724.64**	**35.25**

FIELD MAINTENANCE RECORD

PROJ. #:	A22-129
SFE SITE #:	A22-129-01
ADDRESS:	Bonhomme St
GPS:	N52.8767 W-118.0883
SENSOR TYPE:	ISCO 2150
PRIMARY DEVICE:	SFE 250mm Compound Weir

CONSTANTS		
D1 (mm):	N/A	D1-lip to x-bar
TOM (mm)	N/A	Raw Weir L - lip to water
PIPE SIZE	250	
METER #	213C00618	

LEGEND	
DL - DOWNLOAD	**PC** - PROGRAM COMPLETE
CB - CHG BATTERY	**PM** - PROG. METER
V - VERIFY	**VIS** - VISUAL
LA - LEVEL ADJUST	**VP** - VELOCITY PROFILE
DO - DEPTH ONLY	**CD** - CHG DESICCANT

DATE	TIME	METER TIME	METER DEPTH	FIELD DEPTH	METER VEL	FIELD VEL-VIS	FLOW	BATT	SILT	Raw Weir L	Sensor Cleaned	MTC BY	COMMENTS
DDMMMYY	HH:MM	HH:MM	mm	mm	m/s	m/s	lps	V	mm	mm	(Yes/No)	(INIT.)	
27-Jun-22	12:46	12:46	49	49	N/A	N/A	N/A	12.2	0	49	Yes	NS	Install - PM/LA/V/CB
26-Jul-22	12:12	12:12	44	42	N/A	N/A	N/A	8.9	0	42	Yes	NS	DL/V - Removed Site

FIELD MAINTENANCE RECORD

PROJ. #:	A22-129
SFE SITE #:	A22-129-02
ADDRESS:	CN Railway Yard
GPS:	N52.87564 W-118.07756
SENSOR TYPE:	ISCO 2150
PRIMARY DEVICE:	AV

CONSTANTS		
D1 (mm):	N/A	D1-lip to x-bar
TOM (mm)	N/A	Raw Weir L - lip to water
PIPE SIZE	450	
METER #	25D00563	

LEGEND	
DL - DOWNLOAD	**PC** - PROGRAM COMPLETE
CB - CHG BATTERY	**PM** - PROG. METER
V - VERIFY	**VIS** - VISUAL
LA - LEVEL ADJUST	**VP** - VELOCITY PROFILE
DO - DEPTH ONLY	**CD** - CHG DESICCANT

DATE	TIME	METER TIME	METER DEPTH	FIELD DEPTH	METER VEL	FIELD VEL-VIS	FLOW	BATT	SILT	Raw Weir L	Sensor Cleaned	MTC BY	COMMENTS
DDMMMYY	HH:MM	HH:MM	mm	mm	m/s	m/s	lps	V	mm	mm	(Yes/No)	(INIT.)	
28-Jun-22	11:30	11:30	151	152	0.577	0.6	26	12	34	N/A	Yes	NS	Install - PM/LA/V/CB
26-Jul-22	13:16	13:16	149	147	0.49	0.5	23	8.6	42	N/A	Yes	NS	DL/V - Removed Site

FIELD MAINTENANCE RECORD

PROJ. #:	A22-129
SFE SITE #:	A22-129-03
ADDRESS:	Juniper St - Tonquin Inn
GPS:	N52.88624 W-118.07861
SENSOR TYPE:	ISCO 2150
PRIMARY DEVICE:	SFE 250mm Compound Weir

CONSTANTS		
D1 (mm):	N/A	D1-lip to x-bar
TOM (mm)	N/A	Raw Weir L - lip to water
PIPE SIZE	200	
METER #	24J00341	

LEGEND	
DL - DOWNLOAD	**PC** - PROGRAM COMPLETE
CB - CHG BATTERY	**PM** - PROG. METER
V - VERIFY	**VIS** - VISUAL
LA - LEVEL ADJUST	**VP** - VELOCITY PROFILE
DO - DEPTH ONLY	**CD** - CHG DESICCANT

DATE	TIME	METER TIME	METER DEPTH	FIELD DEPTH	METER VEL	FIELD VEL-VIS	FLOW	BATT	SILT	Raw Weir L	Sensor Cleaned	MTC BY	COMMENTS
DDMMMYY	HH:MM	HH:MM	mm	mm	m/s	m/s	lps	V	mm	mm	(Yes/No)	(INIT.)	
28-Jun-22	10:25	10:25	82	82	N/A	N/A	N/A	12.1	0	82	Yes	NS	Install - PM/LA/V/CB
26-Jul-22	13:45	13:45	67	72	N/A	N/A	N/A	9.3	0		Yes	NS	DL/V - Removed Site

FIELD MAINTENANCE RECORD

PROJ. #:	A22-129
SFE SITE #:	A22-129-04
ADDRESS:	Off Connaught Dr - In grass
GPS:	N52.8924 W-118.0751964
SENSOR TYPE:	ISCO 2150
PRIMARY DEVICE:	AV

CONSTANTS		
D1 (mm):	N/A	D1-lip to x-bar
TOM (mm)	N/A	Raw Weir L - lip to water
PIPE SIZE	450	
METER #	216G00824	

LEGEND	
DL - DOWNLOAD	**PC** - PROGRAM COMPLETE
CB - CHG BATTERY	**PM** - PROG. METER
V - VERIFY	**VIS** - VISUAL
LA - LEVEL ADJUST	**VP** - VELOCITY PROFILE
DO - DEPTH ONLY	**CD** - CHG DESICCANT

DATE	TIME	METER TIME	METER DEPTH	FIELD DEPTH	METER VEL	FIELD VEL-VIS	FLOW	BATT	SILT	Raw Weir L	Sensor Cleaned	MTC BY	COMMENTS
DDMMMYY	HH:MM	HH:MM	mm	mm	m/s	m/s	lps	V	mm	mm	(Yes/No)	(INIT.)	
27-Jun-22	16:15	16:15	82	82	0.75	0.8	14	12.3	0	N/A	Yes	NS	Install - PM/LA/V/CB
26-Jul-22	14:15	14:15	79	83	0.96	0.9	18	9	0	N/A	Yes	NS	DL/V - Removed Site

FIELD MAINTENANCE RECORD

PROJ. #: A22-129
SFE SITE #: A22-129-05
ADDRESS: Stan Wright Dr
GPS: N52.8725 W-118.0771
SENSOR TYPE: ISCO 2150
PRIMARY DEVICE: SFE 250mm Compound Weir

CONSTANTS		
D1 (mm):	N/A	D1-lip to x-bar
TOM (mm)	N/A	Raw Weir L - lip to water
PIPE SIZE	200	
METER #	24J00341	

LEGEND	
DL - DOWNLOAD	**PC** - PROGRAM COMPLETE
CB - CHG BATTERY	**PM** - PROG. METER
V - VERIFY	**VIS** - VISUAL
LA - LEVEL ADJUST	**VP** - VELOCITY PROFILE
DO - DEPTH ONLY	**CD** - CHG DESICCANT

DATE	TIME	METER TIME	METER DEPTH	FIELD DEPTH	METER VEL	FIELD VEL-VIS	FLOW	BATT	SILT	Raw Weir L	Sensor Cleaned	MTC BY	COMMENTS
DDMMMYY	HH:MM	HH:MM	mm	mm	m/s	m/s	lps	V	mm	mm	(Yes/No)	(INIT.)	
26-Jul-22	16:26	16:26	24	24	N/A	N/A	N/A	12.5	0	N/A	Yes	NS	Install - PM/LA/V/CB - Flow on pump cycle
26-Aug-22	10:50	10:50	130	127	N/A	N/A	N/A	11	0	N/A	Yes	NS	DL/V - Removed Site

RAIN GAUGE MAINTENANCE RECORD

PROJ. #: A22-129
SFE SITE #: RG01
ADDRESS: 305 Bonhomme St
GPS: N52.879909 W-118.08448
Logger Type: ISCO 2015G
Tip Amount: .25mm

LEGEND
DL - DOWNLOAD
CB - CHG BATTERY
CA - CALIBRATE
CF - CLEAN FUNNEL

Date	Actual Time	Logger Time	Download	Calibration		Battery	Technician	Comments
DD-MMM-YY	HH:MM	HH:MM		Date	Time			
27-Jun-22	8:45	8:45	Yes	24-Jun-22	7:45	12.2	NS	Install - CF/CB
26-Jul-22	11:25	11:25	Yes	N/A	N/A	11.2	NS	DL/CF/CB - Install modem
26-Aug-22	10:15	10:15	Yes	N/A	N/A	10.1	NS	DL - Removed

Appendix 2

SFE Custom Compound Weirs – Technical Information

SFE Custom Compound Weir - A Technical Discussion

SFE's Custom Compound Weir (CCW) Technology was first developed in 1983. This system consists of the following two components:

- *A customized primary device (Custom Compound Weir or CCW), which provides a predictable relationship of "head" versus "flow"*
- *A water level sensor and data logger*

Testing & Awards

The relationship between "head" and "flow" for the primary device was initially established in a hydraulics lab in conjunction with the Canadian Center for Inland Waterways (CCIW) and published in a report prepared for a local utility. In subsequent years the monitoring techniques were further refined and additional laboratory work was carried out for the primary device. The work was recognized in 1988 by the Association of Consulting Engineers with an Award of Merit at their annual national engineering awards program.

Any level sensing device may be used to reliably measure flows including ultrasonic level indicators, pressure transducers and floats. The system was designed to make it economically feasible for even small utilities to be able to operate a network of stations for a long duration - the low operating costs & high accuracy/reliability prevailing over other measurement systems.

Self-Cleaning

The primary device has a rectangular notch, which then flares out into a "V" section and then a rectangular upper portion. The notch and "V" section have chamfered 1 ½ inch thick "lips" which make them self-cleaning and result in a very high weir flow coefficient.

The self-cleaning properties of these weirs have been amply field proven over the past 20 years at approximately 2200 such stations. Each of our Custom Compound Weirs is custom designed by an open channel hydraulics specialist, for the manhole, chamber or channel configuration it is to be used in.

Low Flow Accuracy

For sewers up to 21 inches in diameter the notch is typically 4 inches wide and 5 ½ inches deep. This results in a flow rate of roughly 0.25 GPM for a head of 1 inch. Since a 2.5 psi pressure transducer or narrow beam ultrasonic indicator is usually capable of measuring water levels within +/- ¼”, flow rates down to 0.25 GPM can readily be measured (a special unit has previously been designed to measure pre-treated wastewater flow rates down to 0.025 GPM).

No Sewer Backups

The lower notch magnifies the variation of the water level with small changes in flow rate (e.g. for the base flow regime). The overall primary device or "weir" normally has an opening greater than the pipe cross sectional area and capacities greater than that of the sewer in which they are placed.

Any Size, Any Shape

SFE has installed custom compound weirs in sewers from 6 inch to 12 foot as well as in varying sizes of pond outlets, creeks, WWTP’s, etc. Custom designing the primary device for the manhole or channel in which it will be placed means that you have considerable control over the final flow regime. This has allowed many difficult hydraulic situations to be handled including bends, junctions, slopes over 10%, drop connections, and drops in the main pipe invert.

Velocity Measurements Not Required

One of the major advantages of SFE’s Custom Compound Weir is that it only requires a depth sensor and logger; a velocity sensor is not used. Many of the problems associated with sewer flow monitoring are related to the velocity sensor and the need to measure average velocity. Velocity sensors are prone to fouling with subsequent "drifting" of the signal whereas pressure sensors will still accurately register variations in water level even if they have debris on them.

No “In the flow” Probes

The use of SFE’s Custom Compound Weir further improves the performance of pressure sensors since they no longer represent an effective obstruction in the flow (they are installed behind the weir). They will always have a reasonable "head" on them as the weir lip elevation maintains a minimum depth of 4 inches behind the weir. As pressure transducers are much less accurate when depths approach zero; this situation becomes a problem for Area-Velocity A-V) type meters in small pipes where base flow rates are low.

Less Expensive

"Level only" monitors such as those used with our Custom Compound Weir are less expensive than A-V meters and need less power to operate. Flow profiling is needed for conventional A-V meters to ensure that the velocity sensed at a point or across a band of flow is properly transformed into average velocity across the pipe section. Since the Custom Compound Weir does not use velocity, profiling becomes redundant.

High Accuracy

Dye dilution and full-scale lab comparisons have been conducted and the results have been excellent. In most cases +/- 5% over the full range of flows is readily achievable.

No Surcharges

Is there a possibility of sewer surcharges causing basement flooding because of the use of such primary devices or weirs? The question has been raised many times and was addressed on a project when the Custom Compound Weir was first designed. The purpose of that first project was to determine the cause of persistent sewer related basement flooding. The client was very concerned that the study procedures did not create more flooding since two Custom Compound Weir stations were just downstream of the area receiving the flooding. The design and placement of the Custom Compound Weirs addressed this as follows:

> *Each CCW was located in a manhole, and not in the pipe, approximately 12 inches from the downstream end so that if the weir were to ever get blocked it could simply overflow safely. (This event has never occurred).*
>
> *For manholes with a chamber larger than the pipe (i.e. 18 inch pipe in standard 42 inch manhole), the weir opening is greater than the pipe area. The flow over the weir is also at critical depth and therefore at a higher velocity than normally occurs in the pipe itself. As a result, the weir capacity is much greater than the pipe capacity in most installations.*

Laboratory Tested

Hydraulic model testing conducted at the Canada Center for Inland Waters (CCIW), provided the opportunity of observing the pipe / weir / manhole performance as the flow rates in the system were increased to the point that it surcharged. As the system started to surcharge, the "control" shifted from the weir to the downstream pipe and there was essentially no drop in the water surface across the weir (under surcharge, the weir was not influencing the water levels upstream).

Custom Designs

Every Custom Compound Weir is custom designed with a rectangular low flow notch and chamfered lips to give it a high weir flow coefficient. This means that it passes a greater flow for a given head than normal sharp crested weirs. Custom designed means specific concerns are addressed at specific sites.

Appendix 3

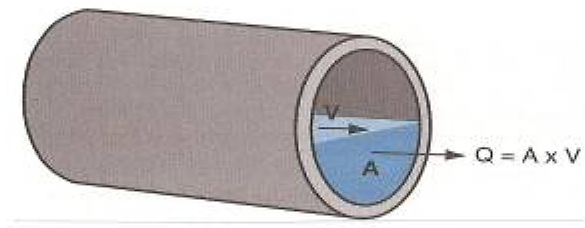
Area Velocity Metering – Technical Information

Area Velocity Meter - Calibration & Verification of Monitor Sensors

Pipe Conduit Measurements

The measurement and condition of all sites were recorded during meter installation.

General Site Installation



Meter velocity was field calibrated according to the manufacturer's methodology and data was verified utilizing SFE Standard Protocol as outlined below.

Depth Verification

Depth verification was conducted at site and all data included on the field report. Five depth measurements from the meter and corresponding water depth are obtained simultaneously at sequential time intervals and recorded on the field worksheet. The lowest and highest measurements are discarded. The remaining three (3) measurements must be within 2.0 cm of each other. The averaged monitor reading must be within 5 % of the averaged field measurement to be acceptable.

Velocity Verification

Depth and velocity profiles were performed utilizing a Marsh McBirney Flow Mate point velocity meter. This instrument uses the Faraday principle to measure water velocity flowing over three electrodes. This allows an accurate velocity to be measured in a small area of the total flow.

SFE standard procedure is to use the 2-D method to determine average velocity. Numerous measurements are taken form the invert to water surface at the left, center and right thirds of the pipe. These measurements are averaged with the inclusion of readings taken from the upper left and right corner of flow.

SFE's alternate procedure when the pipe diameter is small or flow is sufficient is to use the .9-Vmax method. Point velocity readings are taken throughout the cross section of flow. The highest repeatable Velocity obtained is multiplied by 0.9 to determine average velocity. This average velocity is then correlated to the average velocity reading from the meter and must be within 10 %.

APPENDIX

C FLOW GAUGE DATA ANALYSIS

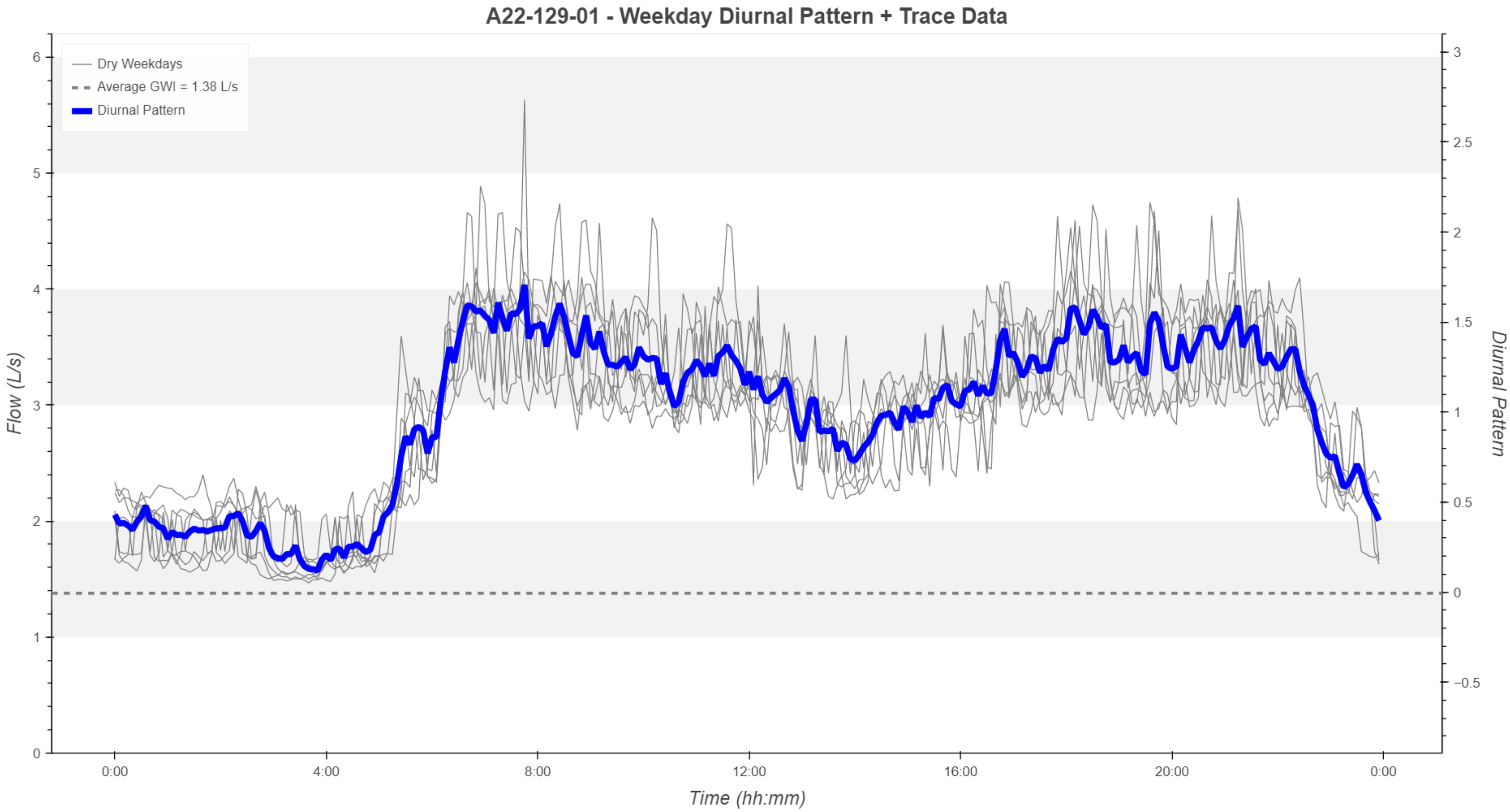
APPENDIX C-1

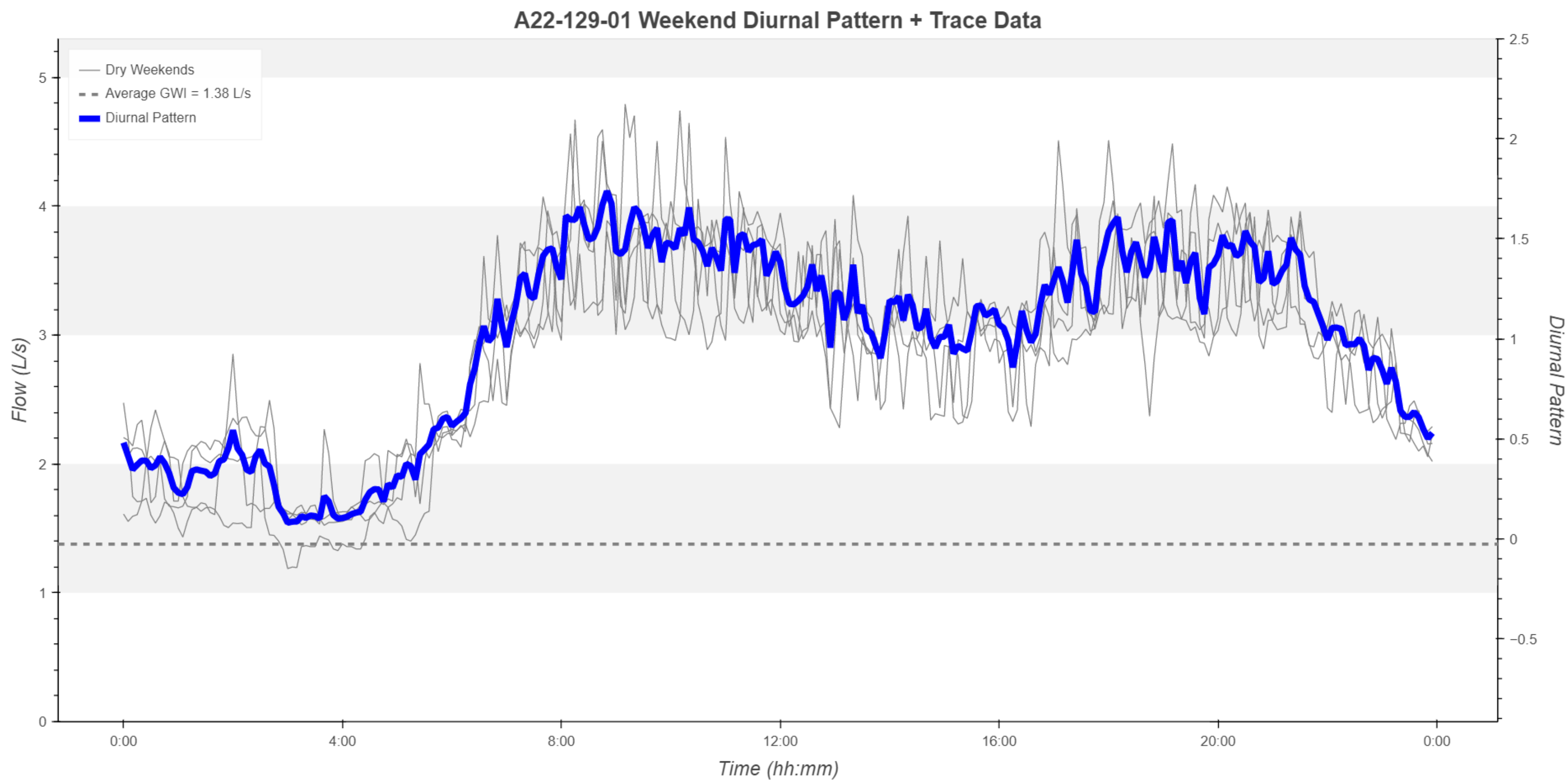
FLOW GAUGE A22-129-01

DATA REVIEW

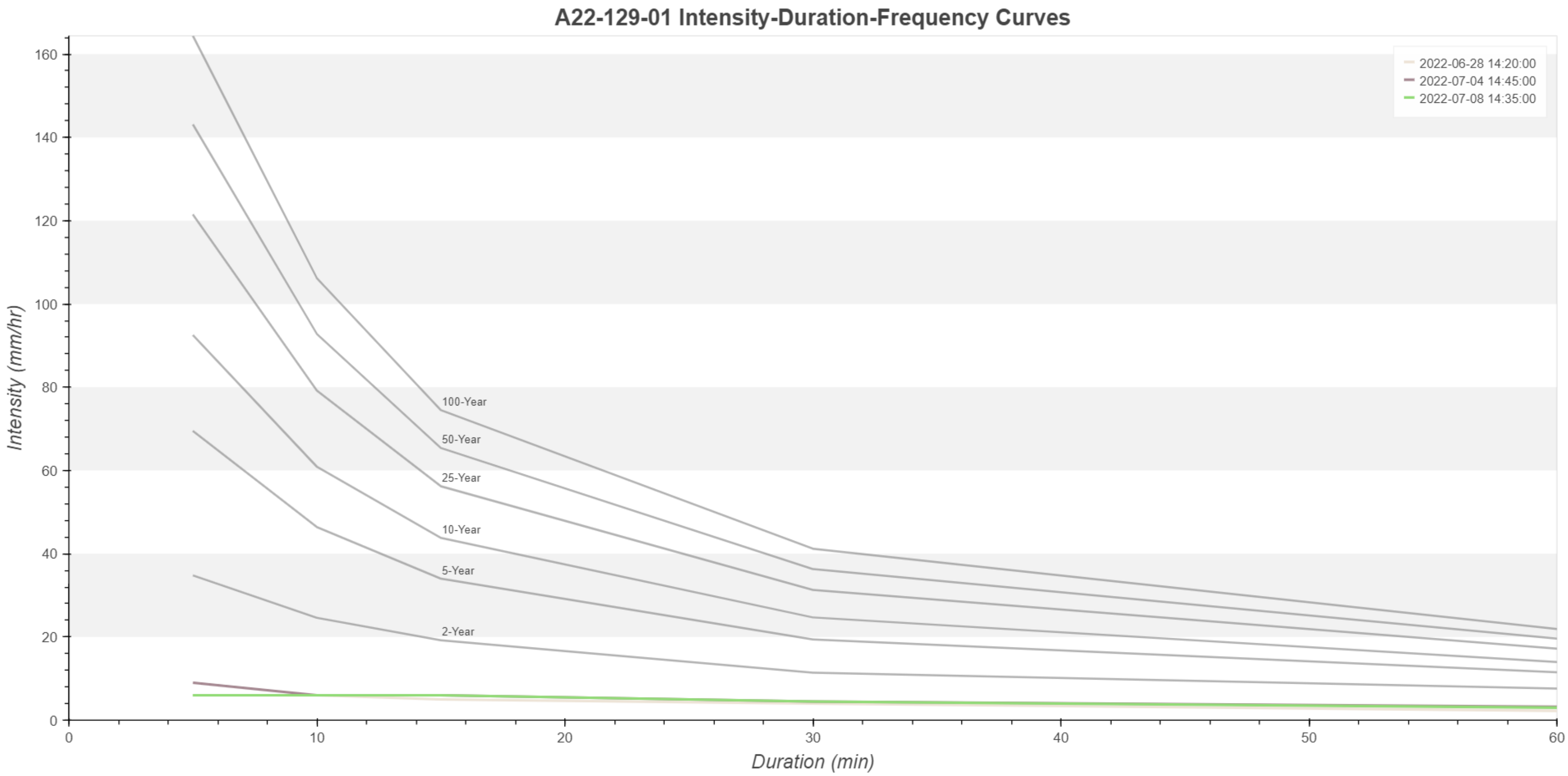
A22-129-01 Time Series Plot
Rainfall Intensity (mm/hr)
Depth (mm)
Flow (L/s)
2022-07-01 00:00
2022-07-08 00:00
2022-07-15 00:00
2022-07-22 00:00

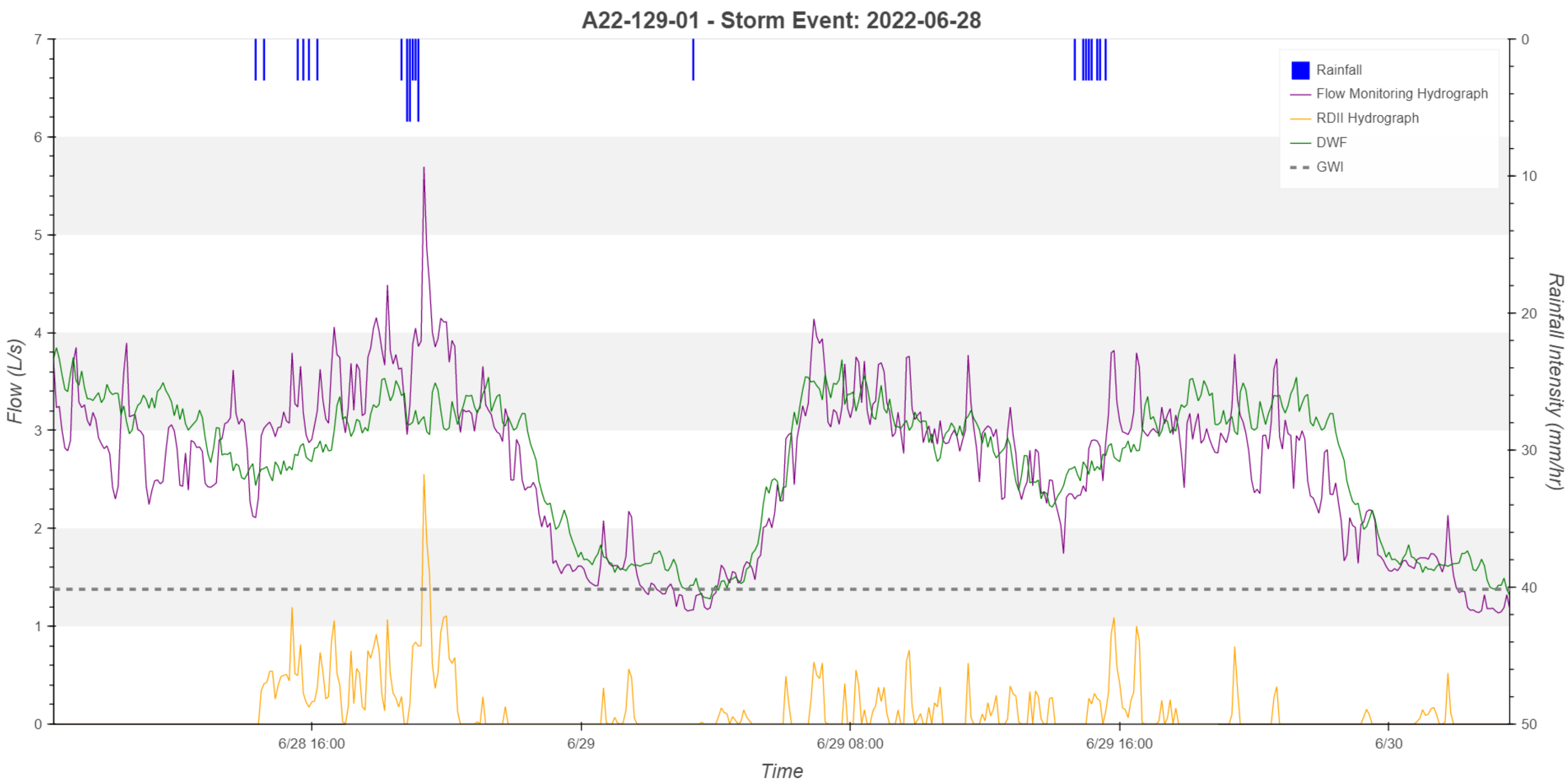
DRY WEATHER FLOW ANALYSIS

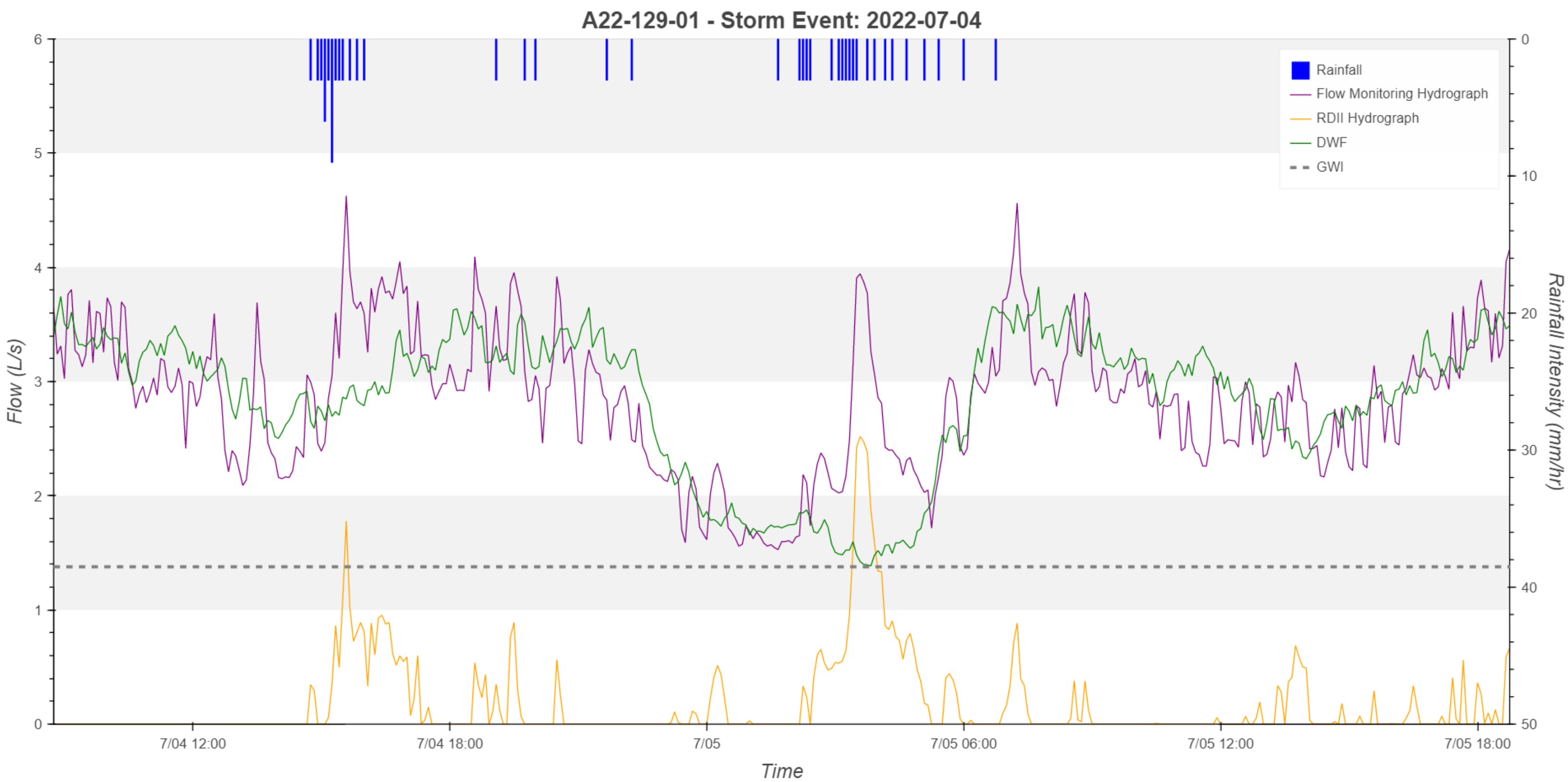



A22-129-01 Weekend Diurnal Pattern + Trace Data
Dry Weekends
Average GWI = 1.38 L/s
Diurnal Pattern
Flow (L/s)
Diurnal Pattern
Time (hh:mm)
0
1
2
3
4
5
−0.5
0
0.5
1
1.5
2
2.5
0:00
4:00
8:00
12:00
16:00
20:00
0:00

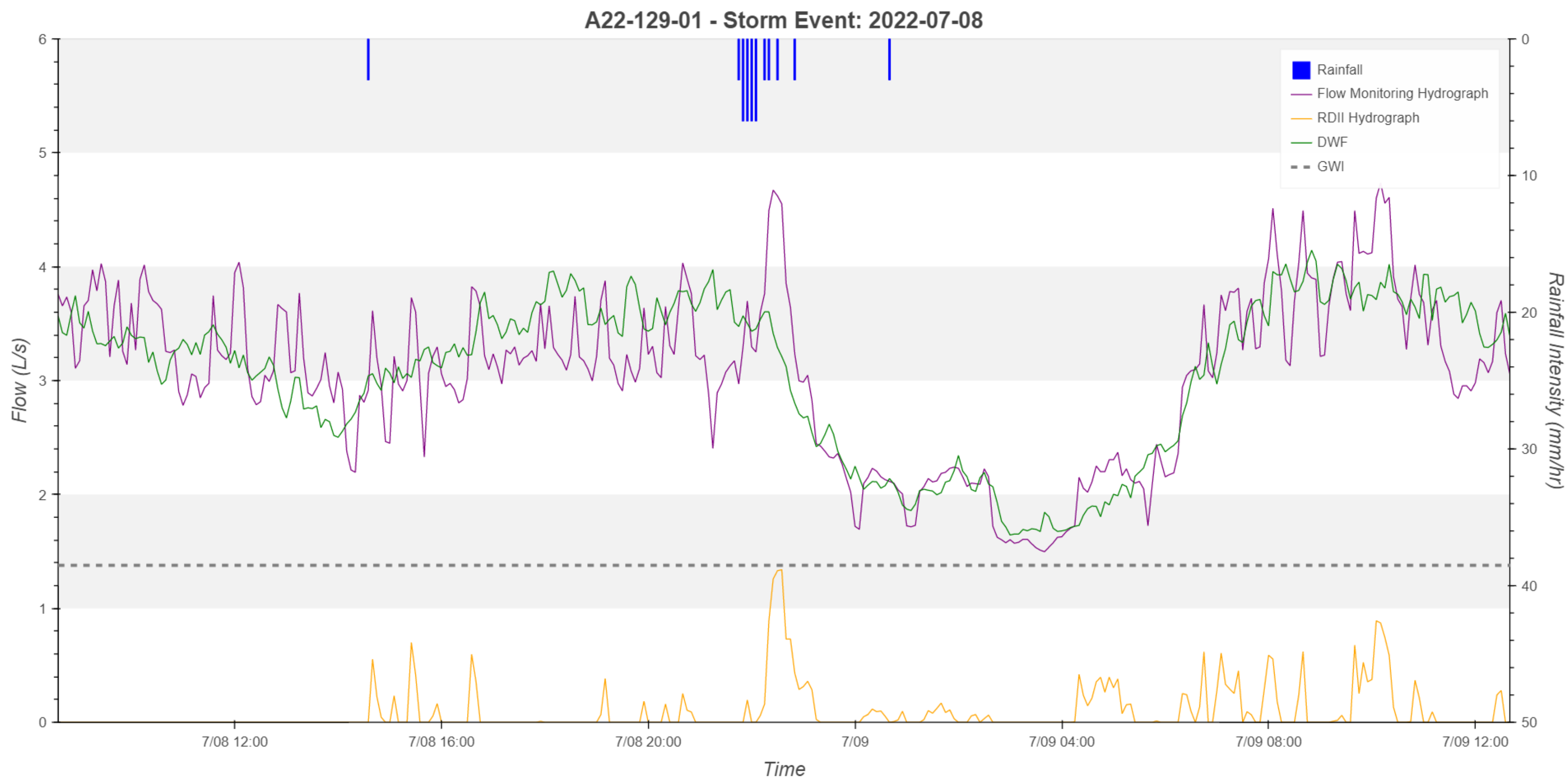
WET WEATHER FLOW ANALYSIS




A22-129-01 - Storm Event: 2022-06-28
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
6/28 16:00
6/29
6/29 08:00
6/29 16:00
6/30
0
1
2
3
4
5
6
7
10
20
30
40
50

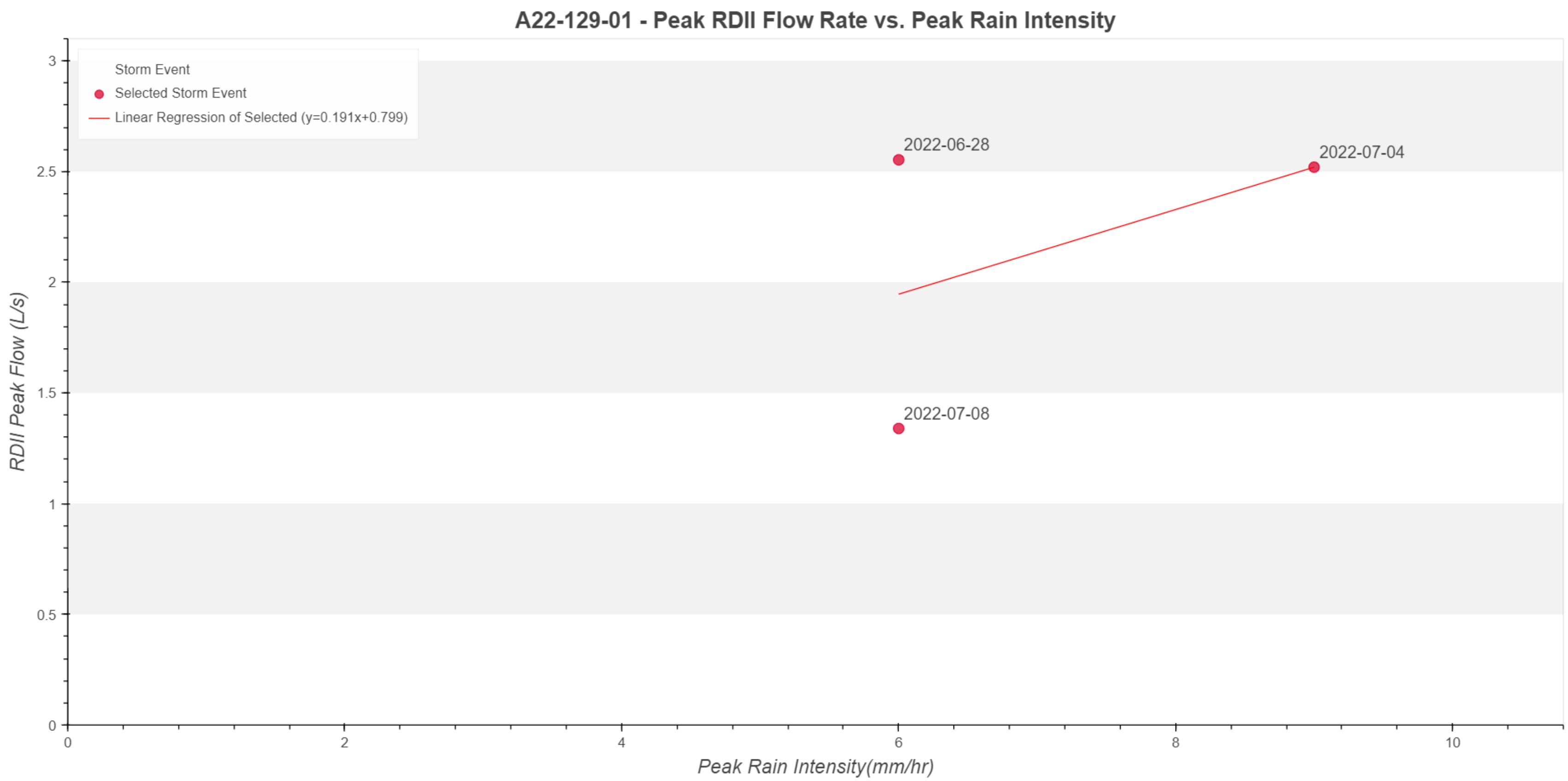


A22-129-01 - Storm Event: 2022-07-04
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
0
1
2
3
4
5
6
10
20
30
40
50
7/04 12:00
7/04 18:00
7/05
7/05 06:00
7/05 12:00
7/05 18:00

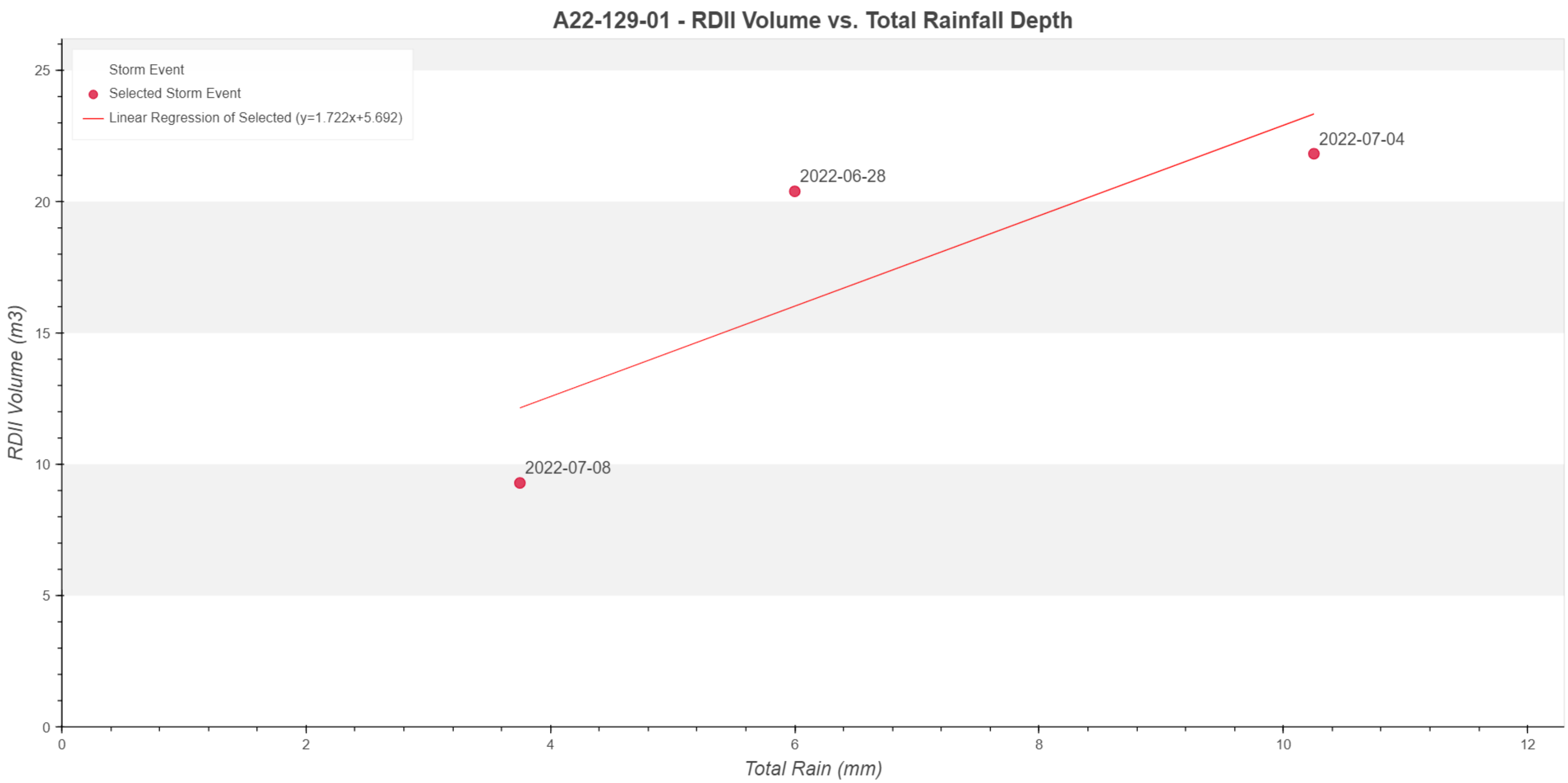


A22-129-01 - Storm Event: 2022-07-08
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
0
1
2
3
4
5
6
10
20
30
40
50
7/08 12:00
7/08 16:00
7/08 20:00
7/09
7/09 04:00
7/09 08:00
7/09 12:00

Q VS I PLOTS



A22-129-01 - Peak RDII Flow Rate vs. Peak Rain Intensity
Storm Event
Selected Storm Event
Linear Regression of Selected (y=0.191x+0.799)
2022-06-28
2022-07-04
2022-07-08
RDII Peak Flow (L/s)
Peak Rain Intensity(mm/hr)
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10

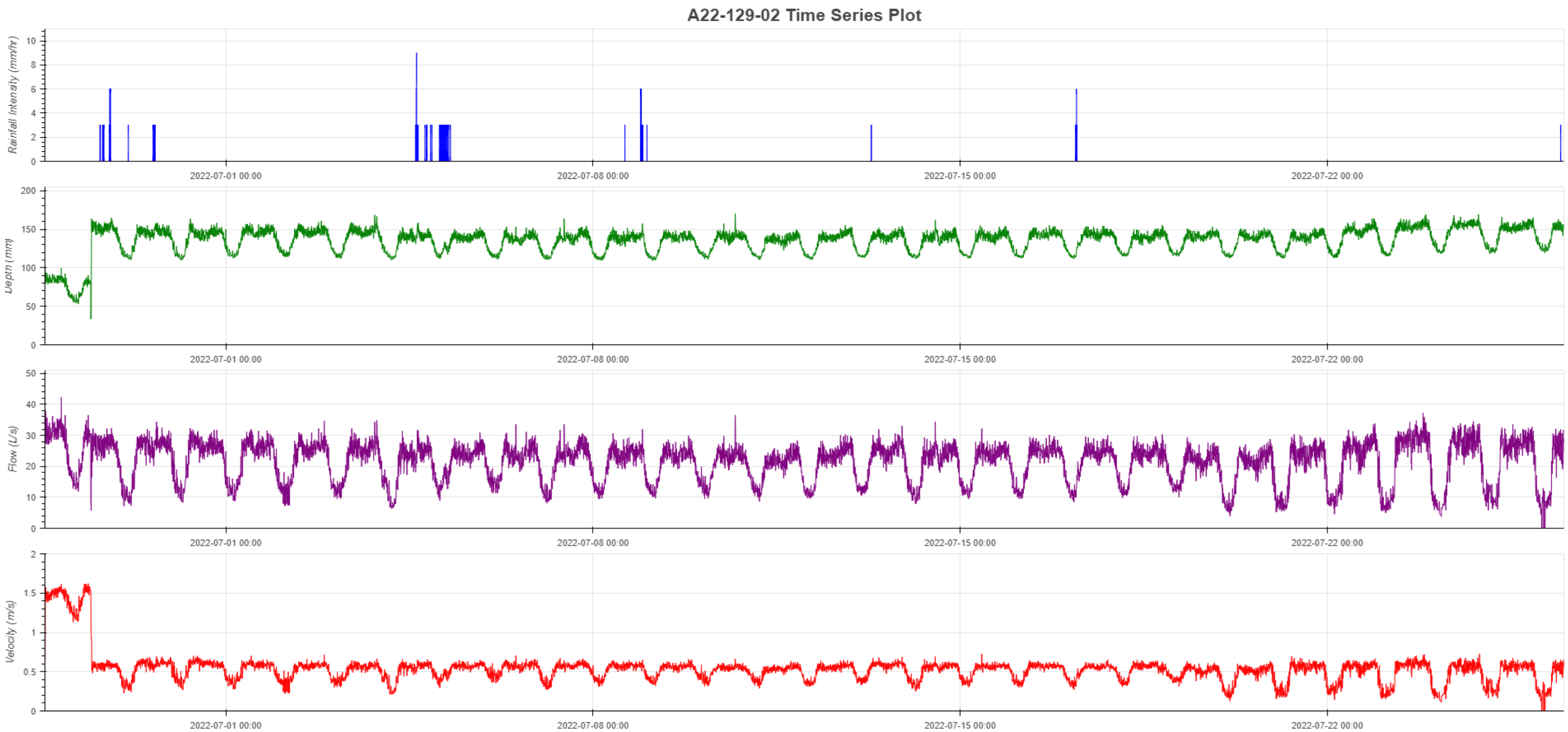


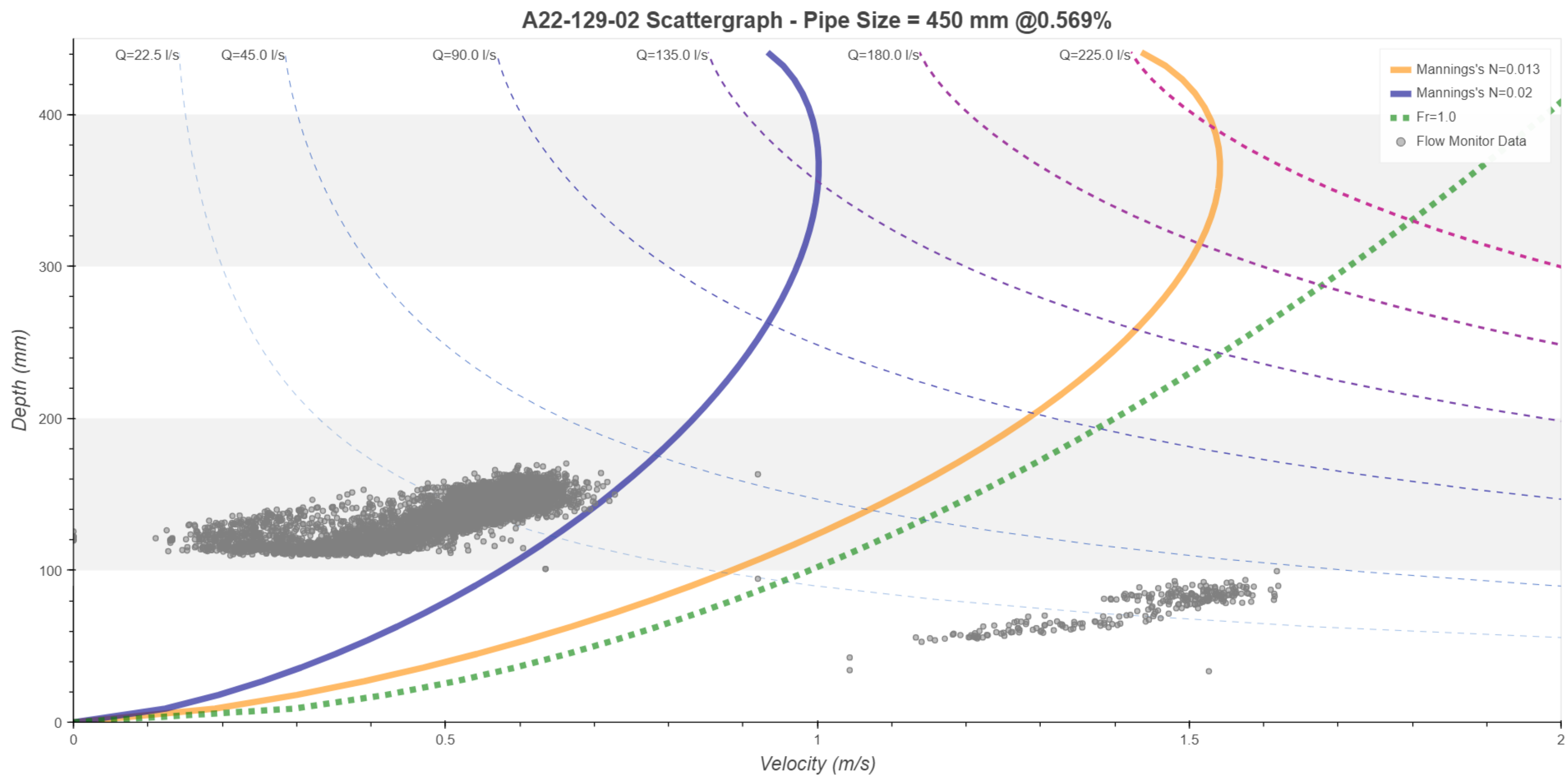
A22-129-01 - RDII Volume vs. Total Rainfall Depth
Storm Event
Selected Storm Event
Linear Regression of Selected (y=1.722x+5.692)
2022-07-04
2022-06-28
2022-07-08
RDII Volume (m3)
Total Rain (mm)
0
5
10
15
20
25
0
2
4
6
8
10
12

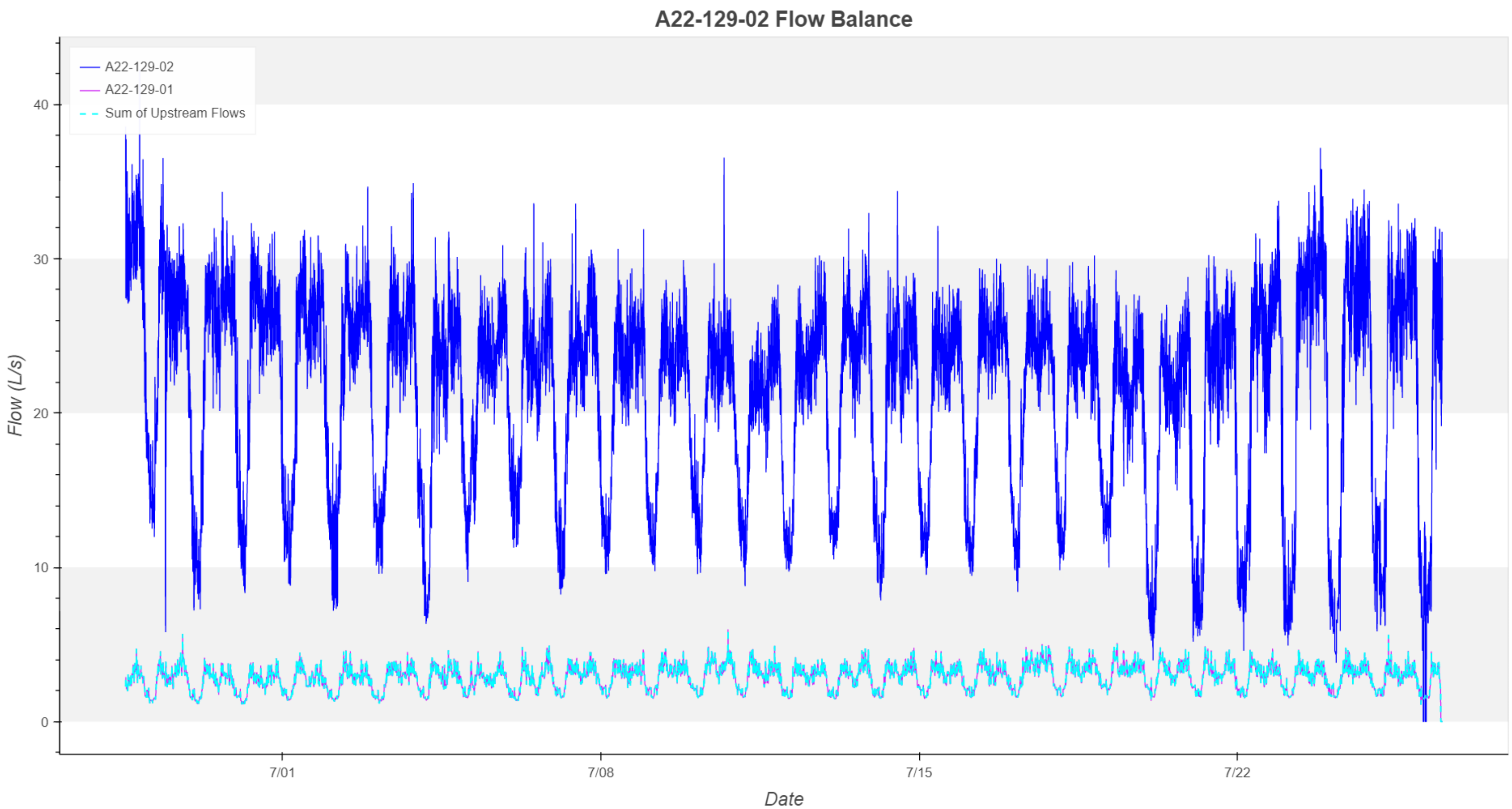
APPENDIX C-2

FLOW GAUGE A22-129-02

DATA REVIEW

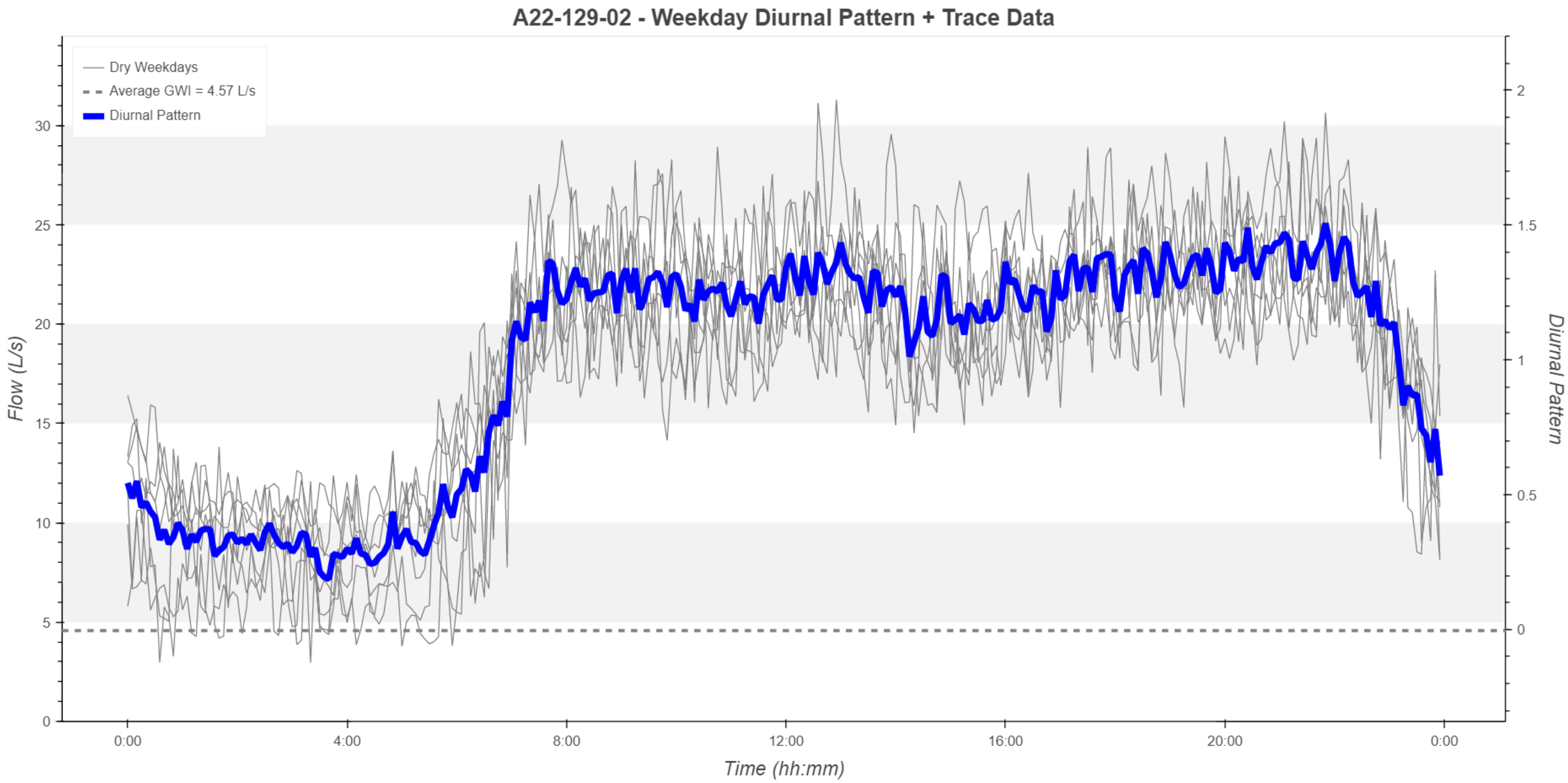

A22-129-02 Time Series Plot
Rainfall Intensity (mm/hr)
Depth (mm)
Flow (L/s)
Velocity (m/s)
2022-07-01 00:00
2022-07-08 00:00
2022-07-15 00:00
2022-07-22 00:00

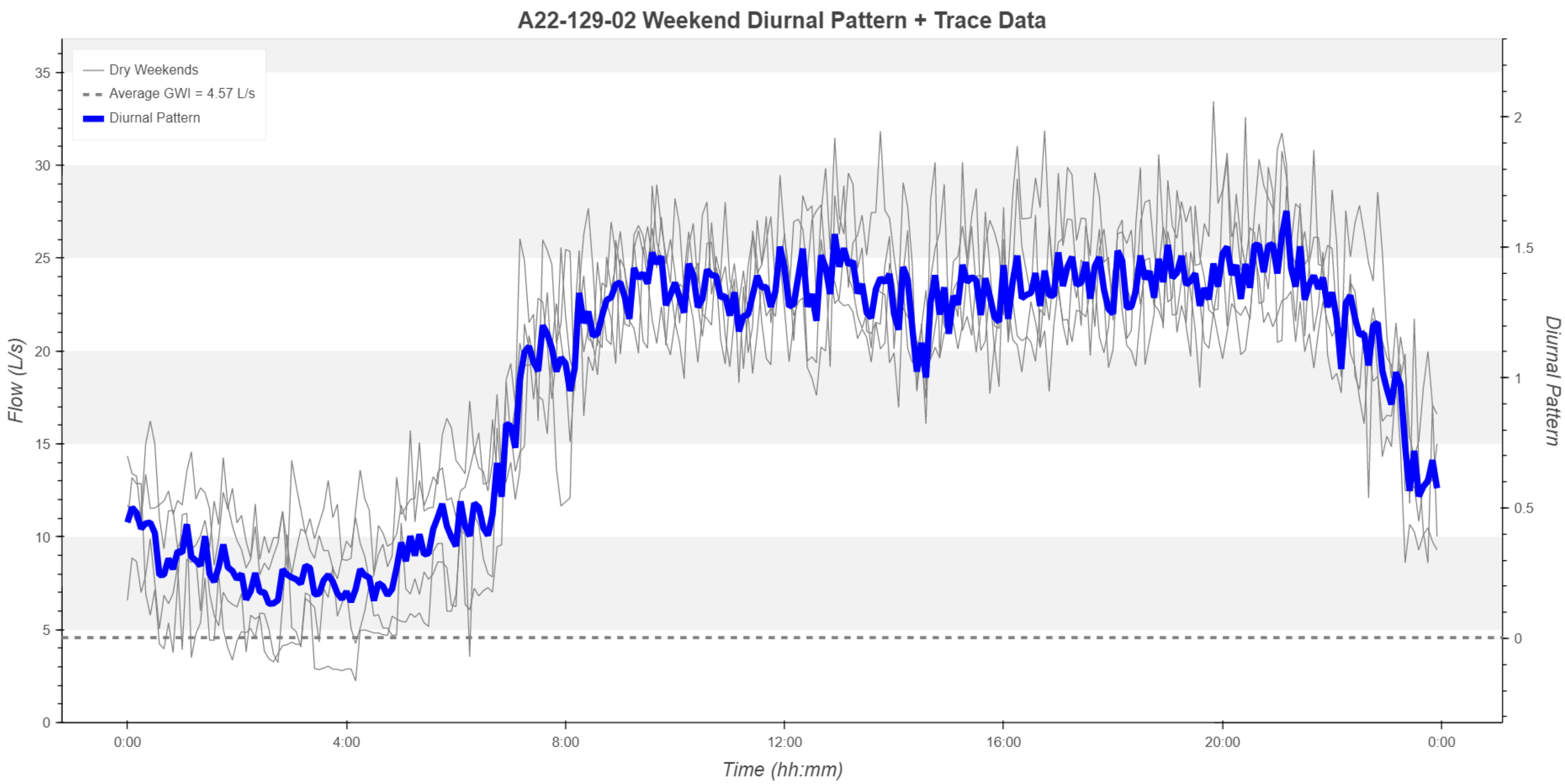

A22-129-02 Scattergraph - Pipe Size = 450 mm @0.569%
Q=22.5 l/s
Q=45.0 l/s
Q=90.0 l/s
Q=135.0 l/s
Q=180.0 l/s
Q=225.0 l/s
Mannings's N=0.013
Mannings's N=0.02
Fr=1.0
Flow Monitor Data
Depth (mm)
Velocity (m/s)
0
100
200
300
400
0
0.5
1
1.5
2



A22-129-02 Flow Balance
A22-129-02
A22-129-01
Sum of Upstream Flows
Flow (L/s)
40
30
20
10
0
7/01
7/08
7/15
7/22
Date

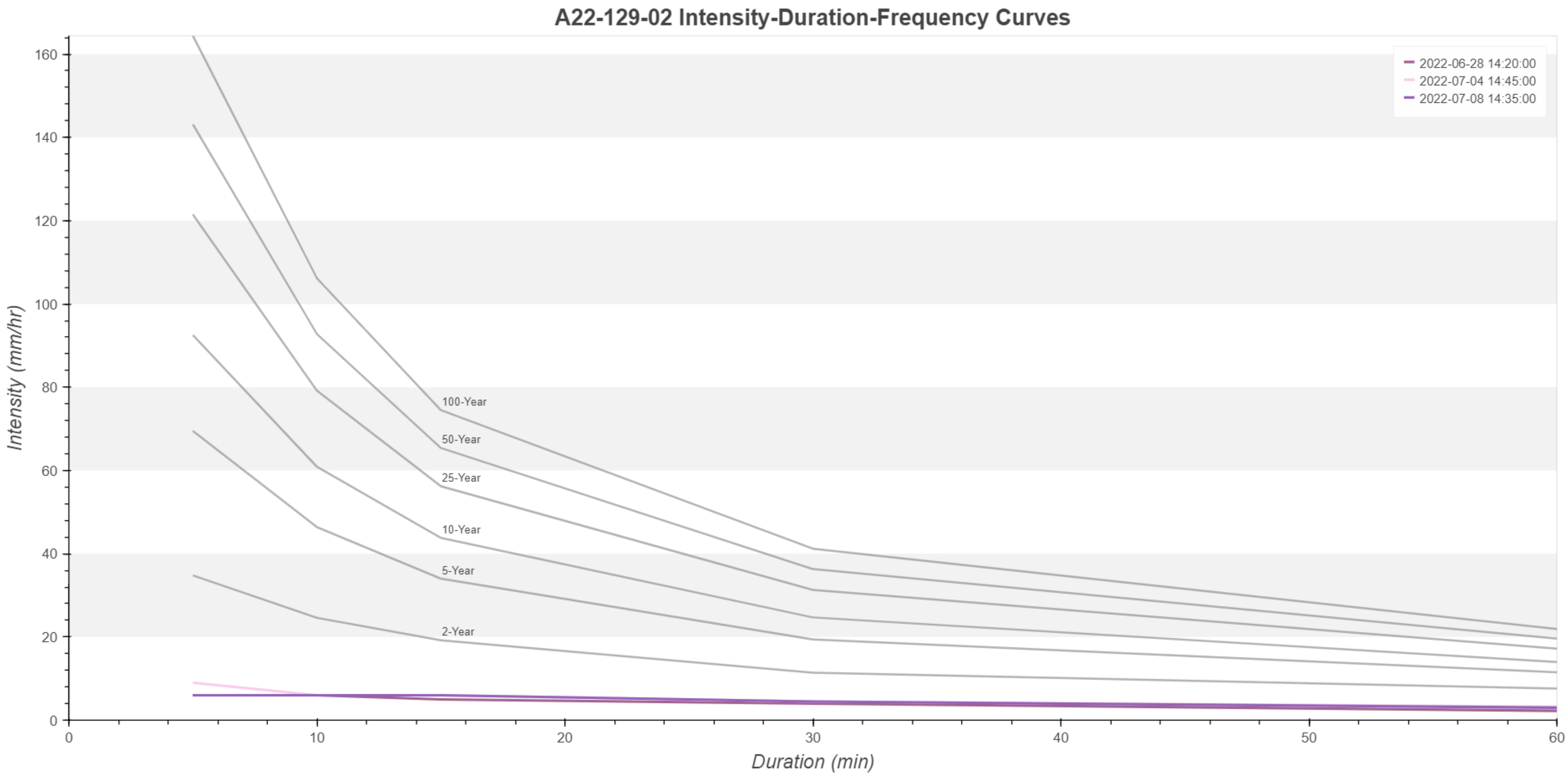
DRY WEATHER FLOW ANALYSIS

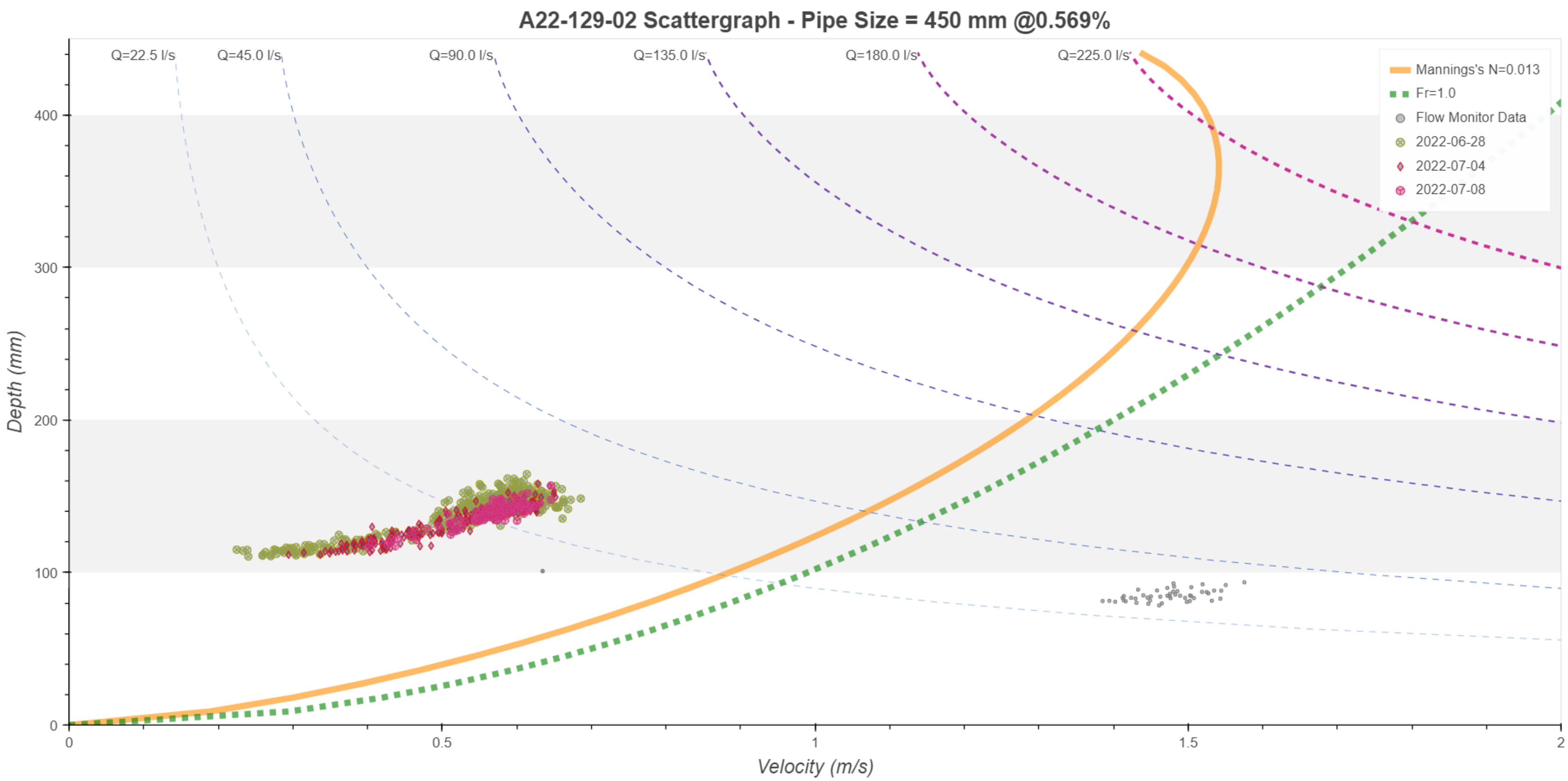


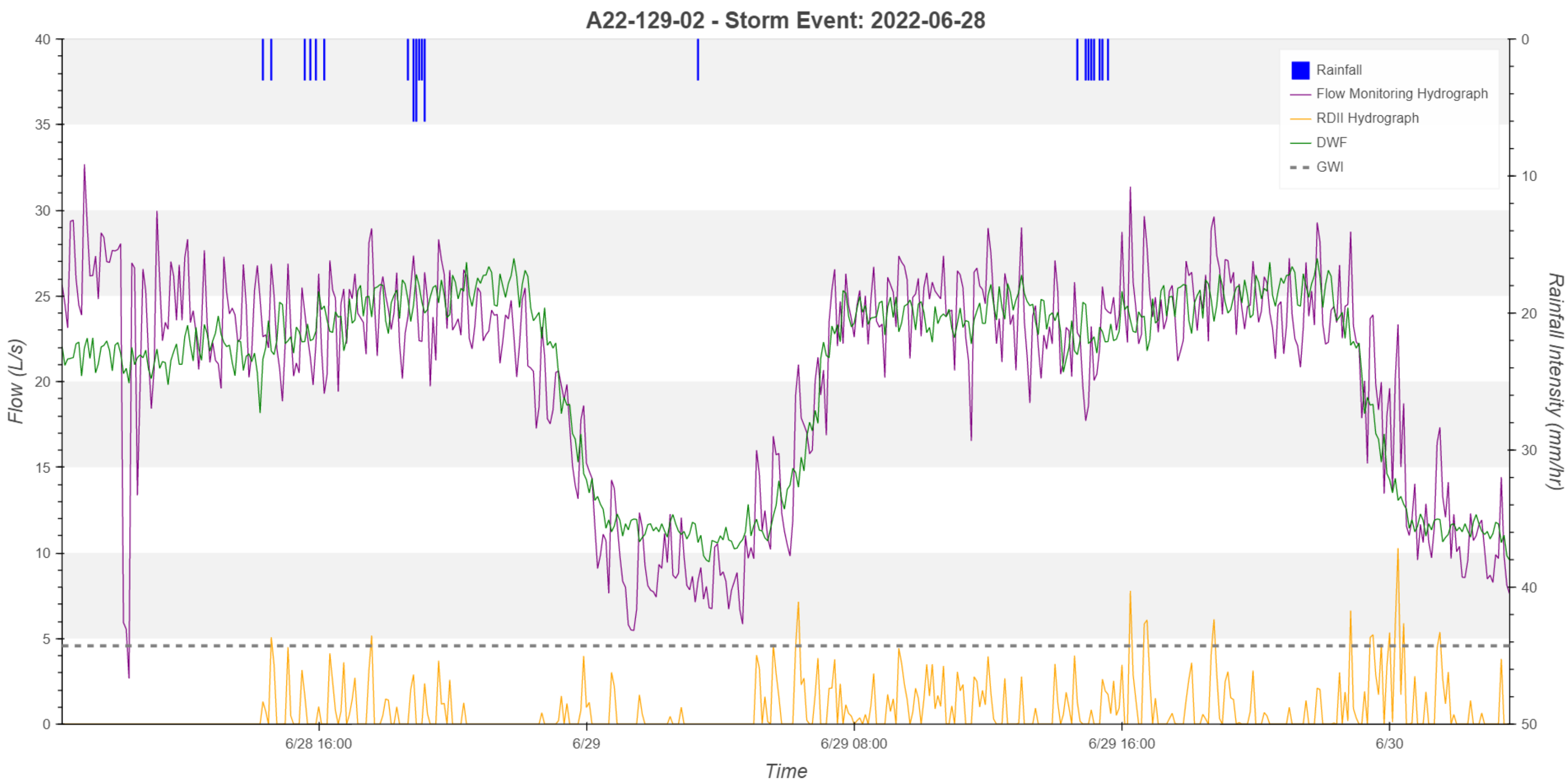


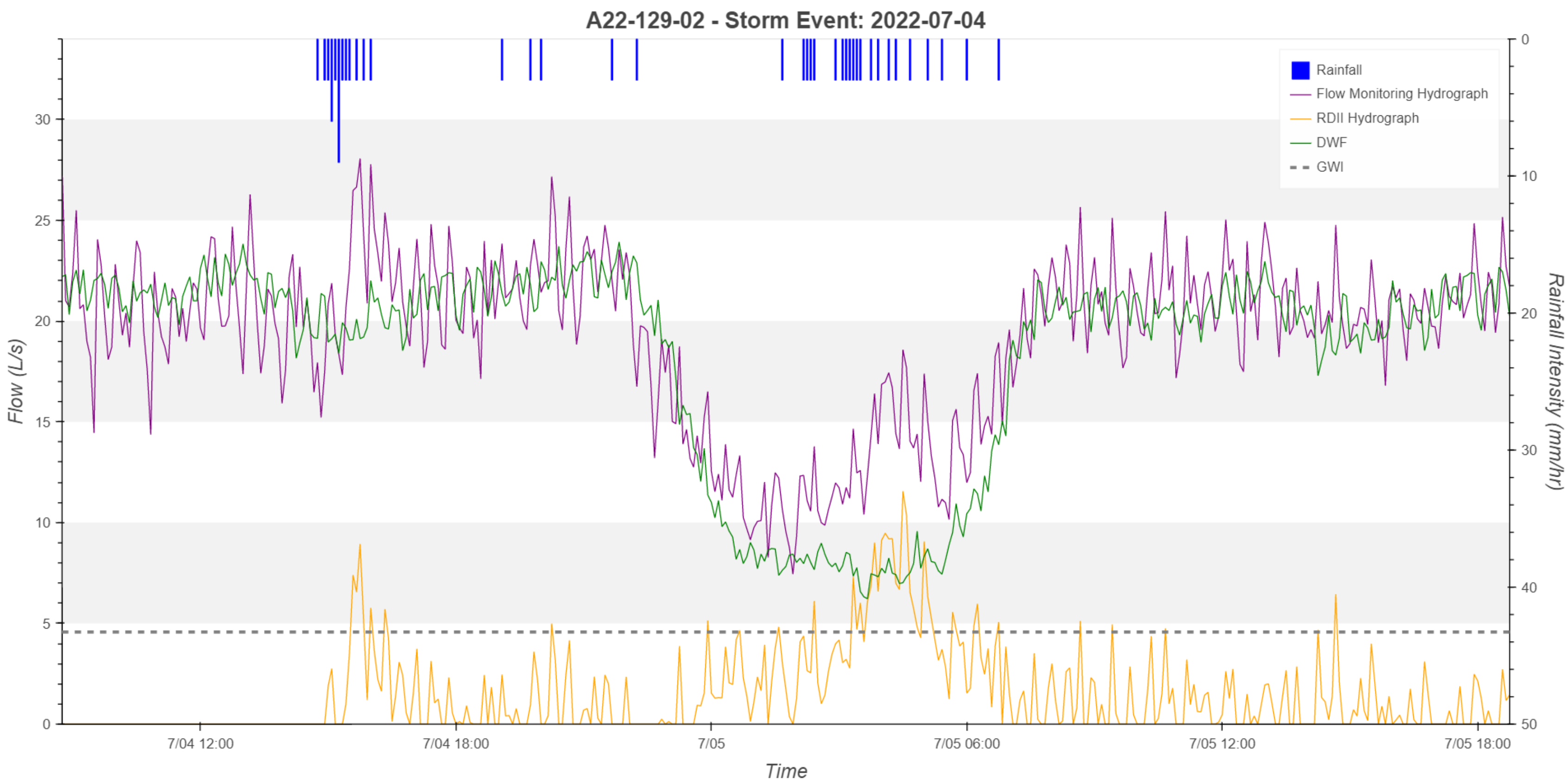
A22-129-02 Weekend Diurnal Pattern + Trace Data
Dry Weekends
Average GWI = 4.57 L/s
Diurnal Pattern
Flow (L/s)
Diurnal Pattern
Time (hh:mm)
0
5
10
15
20
25
30
35
0
0.5
1
1.5
2
0:00
4:00
8:00
12:00
16:00
20:00
0:00

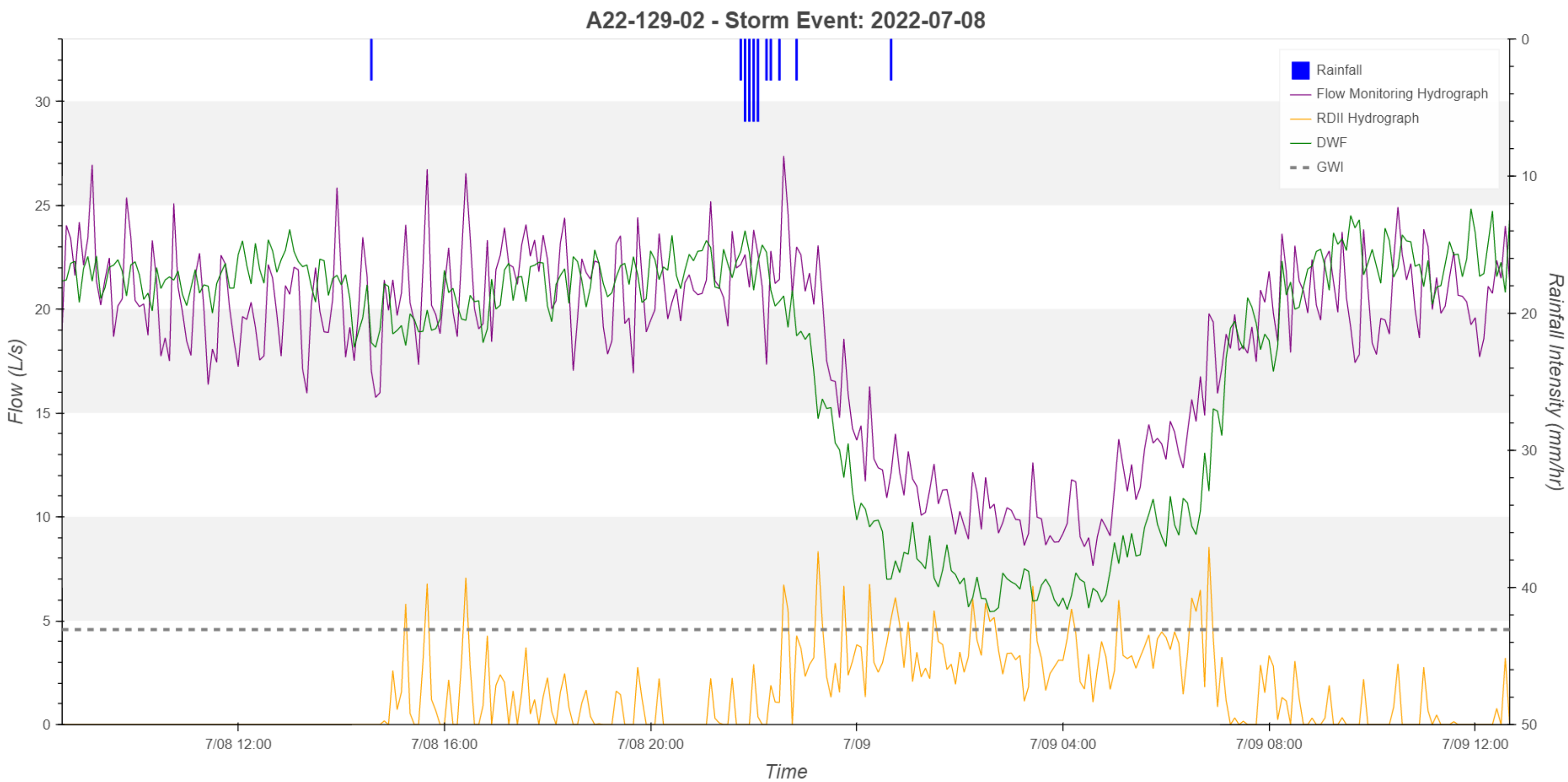
WET WEATHER FLOW ANALYSIS



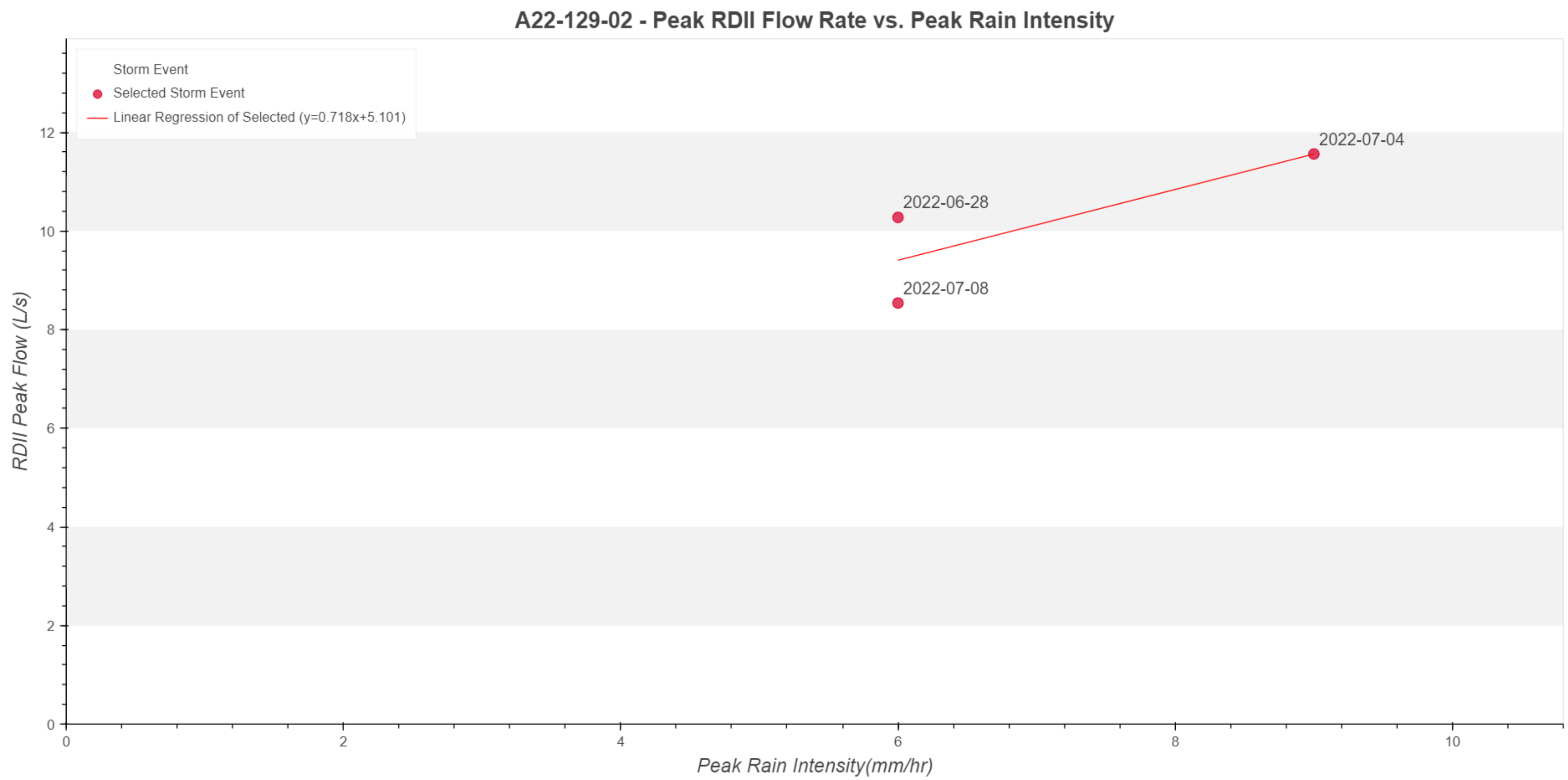

A22-129-02 Scattergraph - Pipe Size = 450 mm @0.569%
Q=22.5 l/s
Q=45.0 l/s
Q=90.0 l/s
Q=135.0 l/s
Q=180.0 l/s
Q=225.0 l/s
Mannings's N=0.013
Fr=1.0
Flow Monitor Data
2022-06-28
2022-07-04
2022-07-08
Depth (mm)
Velocity (m/s)
0
100
200
300
400
0
0.5
1
1.5
2


A22-129-02 - Storm Event: 2022-06-28
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
6/28 16:00
6/29
6/29 08:00
6/29 16:00
6/30

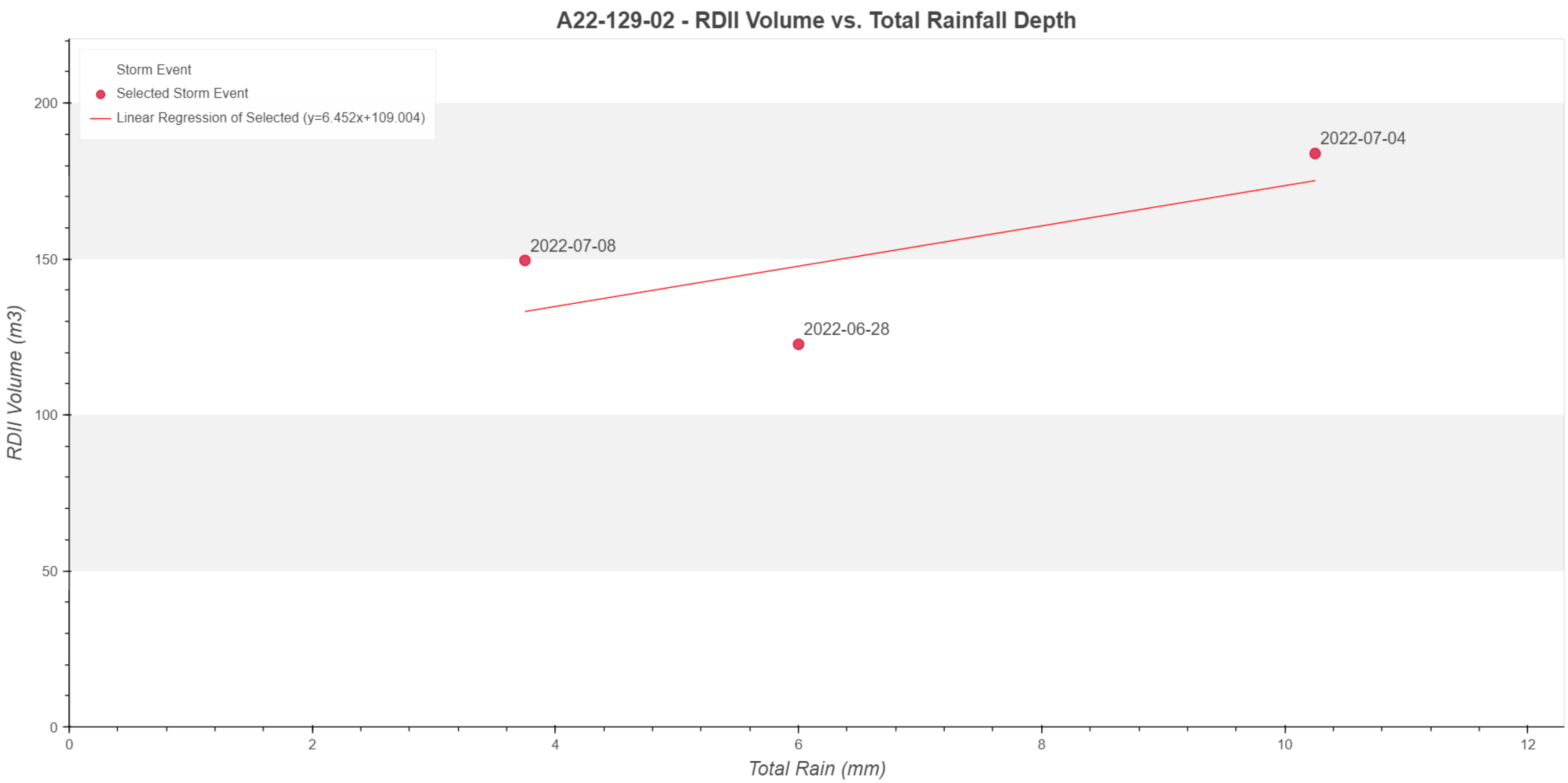

A22-129-02 - Storm Event: 2022-07-04
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
7/04 12:00
7/04 18:00
7/05
7/05 06:00
7/05 12:00
7/05 18:00
0
5
10
15
20
25
30
40
50


A22-129-02 - Storm Event: 2022-07-08
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
7/08 12:00
7/08 16:00
7/08 20:00
7/09
7/09 04:00
7/09 08:00
7/09 12:00

Q VS I PLOTS



A22-129-02 - Peak RDII Flow Rate vs. Peak Rain Intensity
Storm Event
Selected Storm Event
Linear Regression of Selected (y=0.718x+5.101)
2022-07-04
2022-06-28
2022-07-08
RDII Peak Flow (L/s)
Peak Rain Intensity(mm/hr)
0
2
4
6
8
10
12


A22-129-02 - RDII Volume vs. Total Rainfall Depth
Storm Event
Selected Storm Event
Linear Regression of Selected (y=6.452x+109.004)
2022-07-04
2022-07-08
2022-06-28
RDII Volume (m3)
Total Rain (mm)
0
50
100
150
200
0
2
4
6
8
10
12

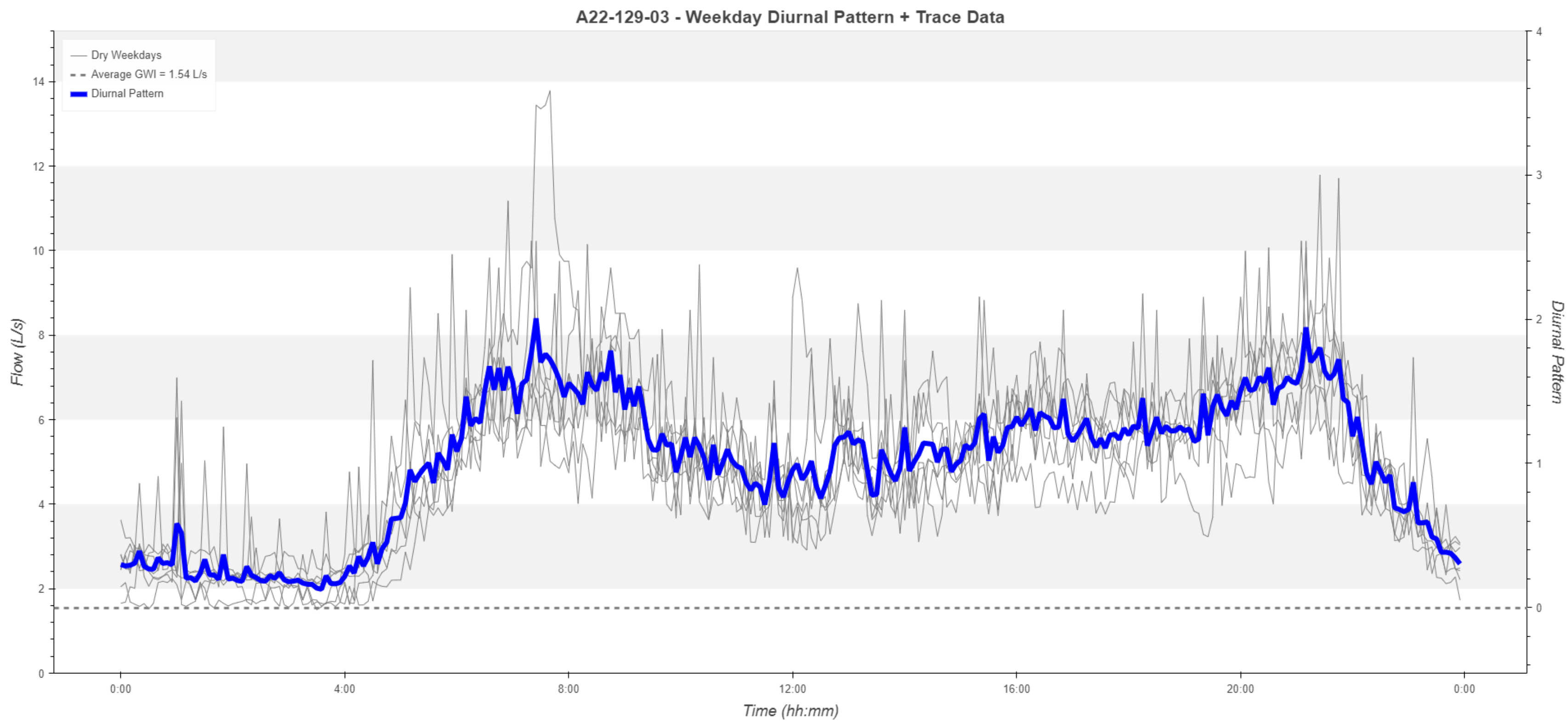
APPENDIX C-3

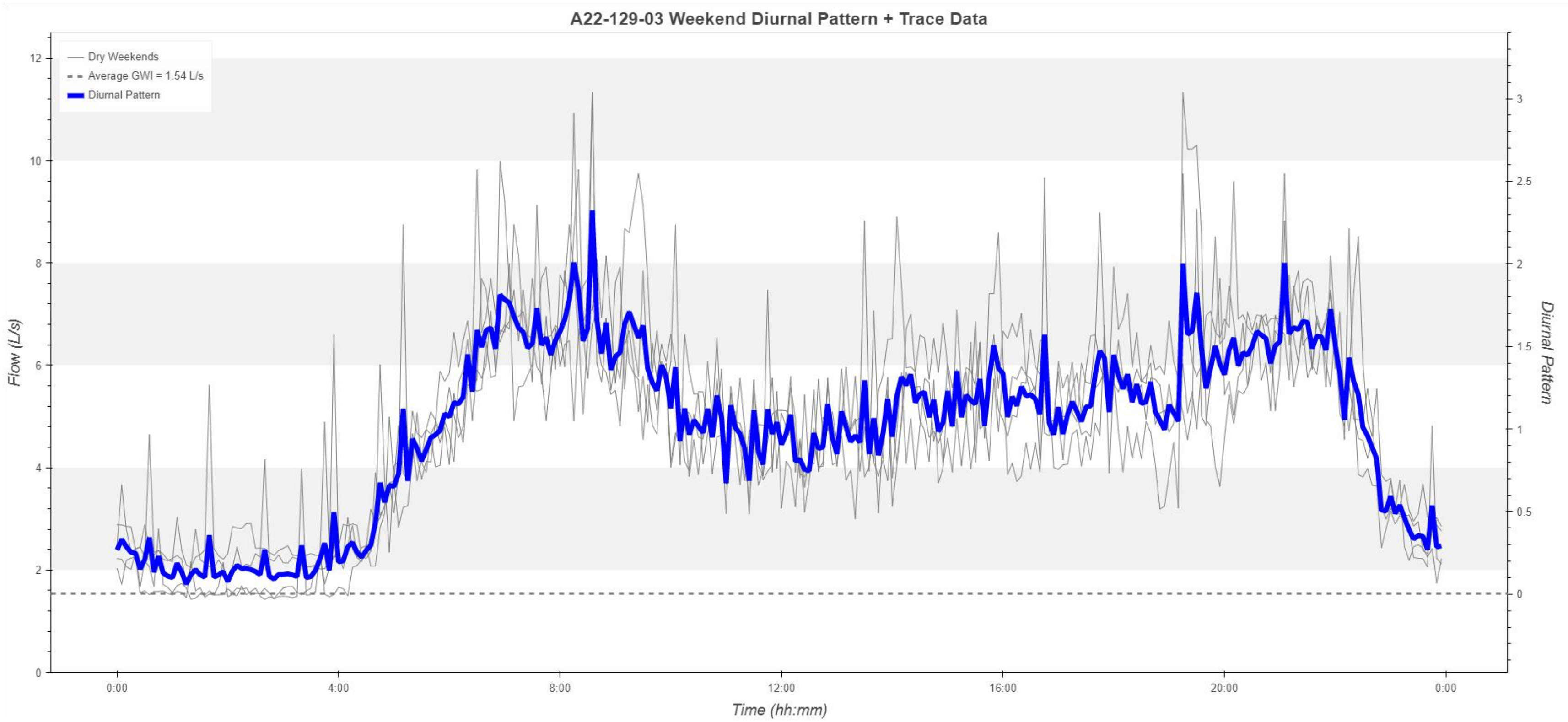
FLOW GAUGE A22-129-03

DATA REVIEW


A22-129-03 Time Series Plot
Rainfall Intensity (mm/hr)
Depth (mm)
Flow (L/s)
2022-07-01 00:00
2022-07-08 00:00
2022-07-15 00:00
2022-07-22 00:00

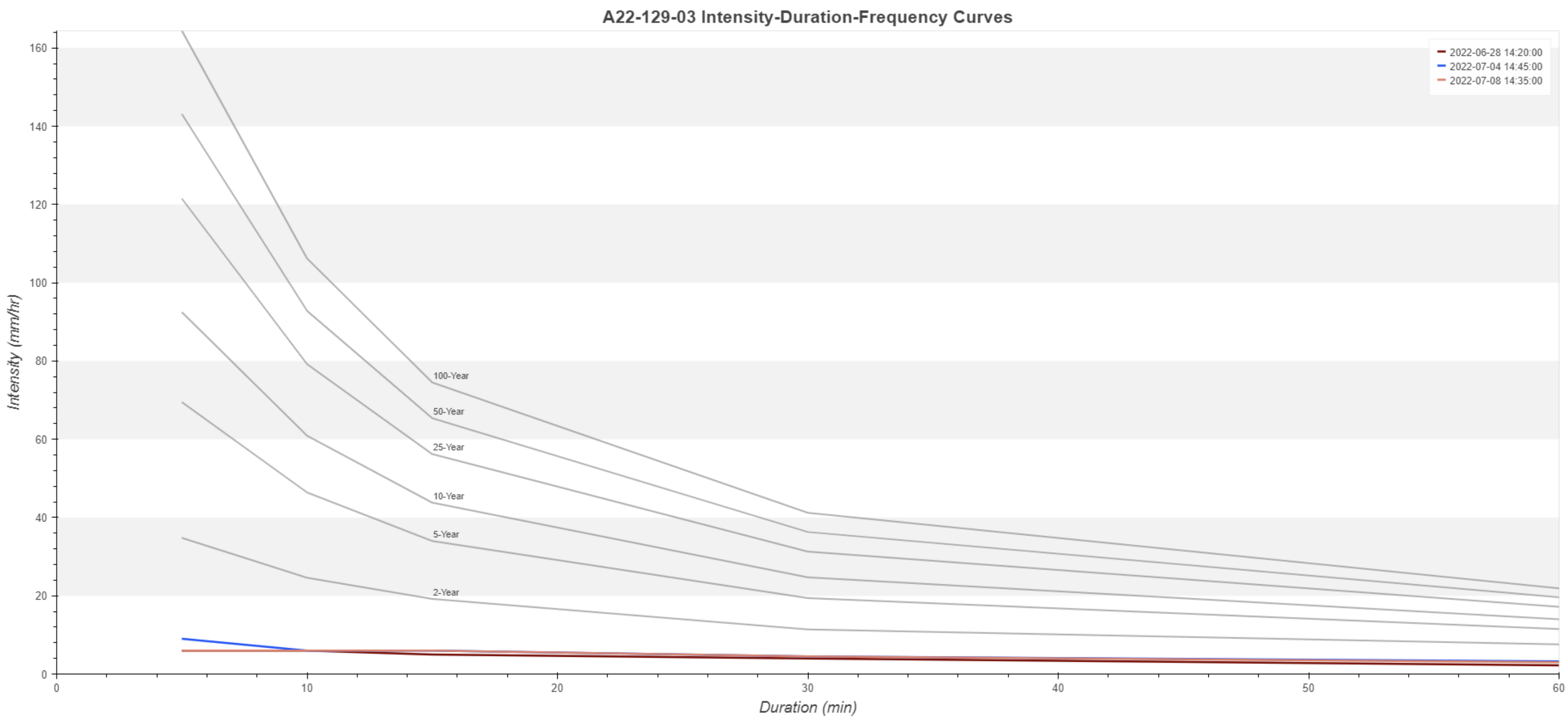
DRY WEATHER FLOW ANALYSIS

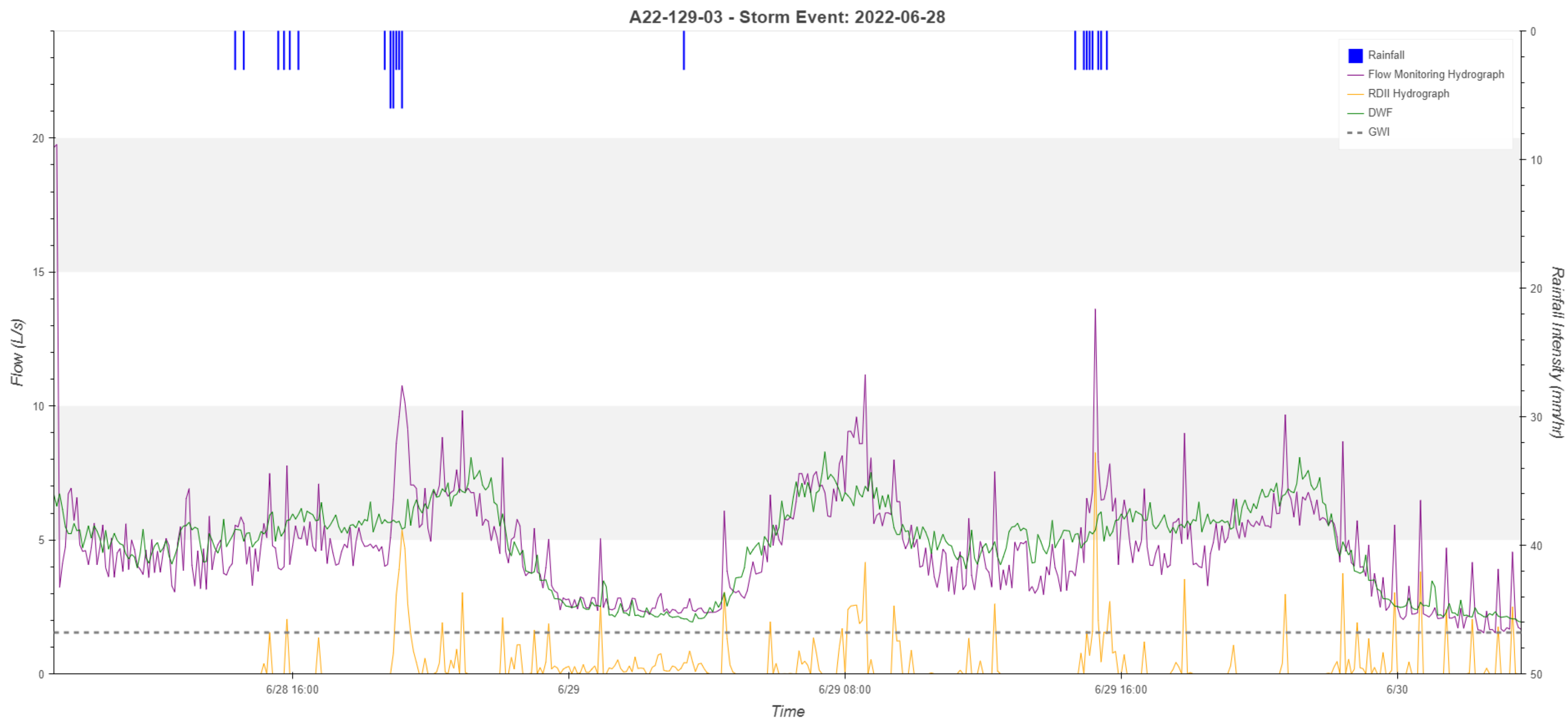




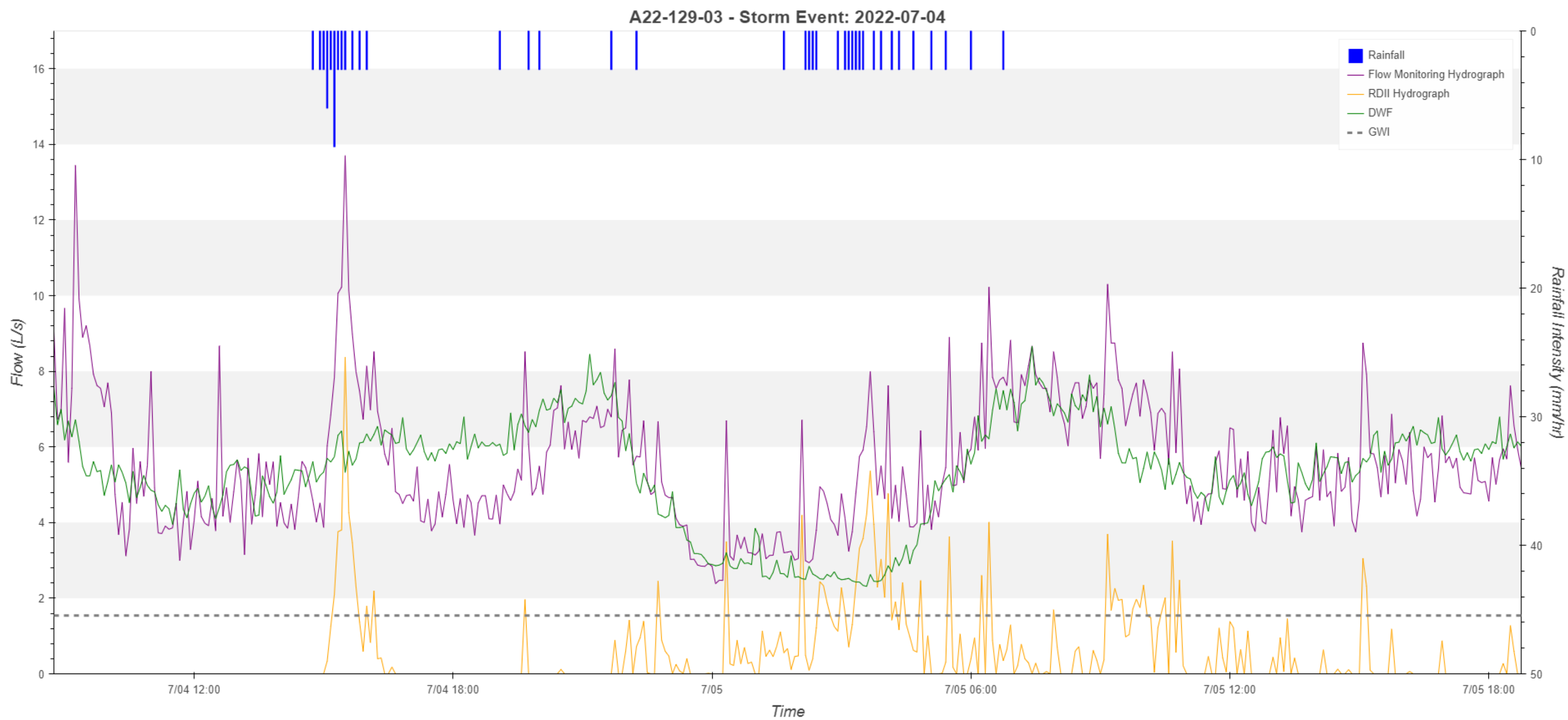
A22-129-03 Weekend Diurnal Pattern + Trace Data
Dry Weekends
Average GWI = 1.54 L/s
Diurnal Pattern
Flow (L/s)
Diurnal Pattern
Time (hh:mm)
0:00
4:00
8:00
12:00
16:00
20:00
0:00

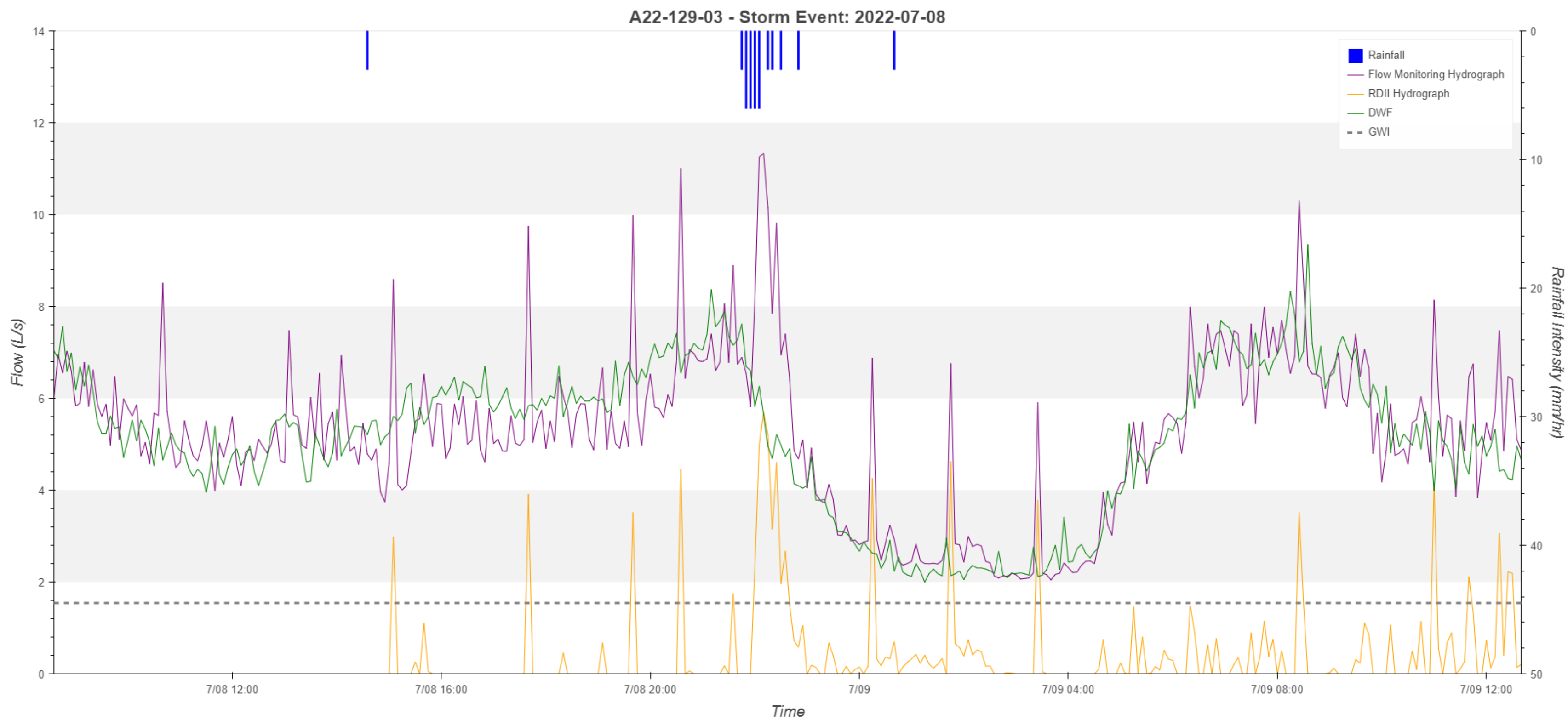
WET WEATHER FLOW ANALYSIS



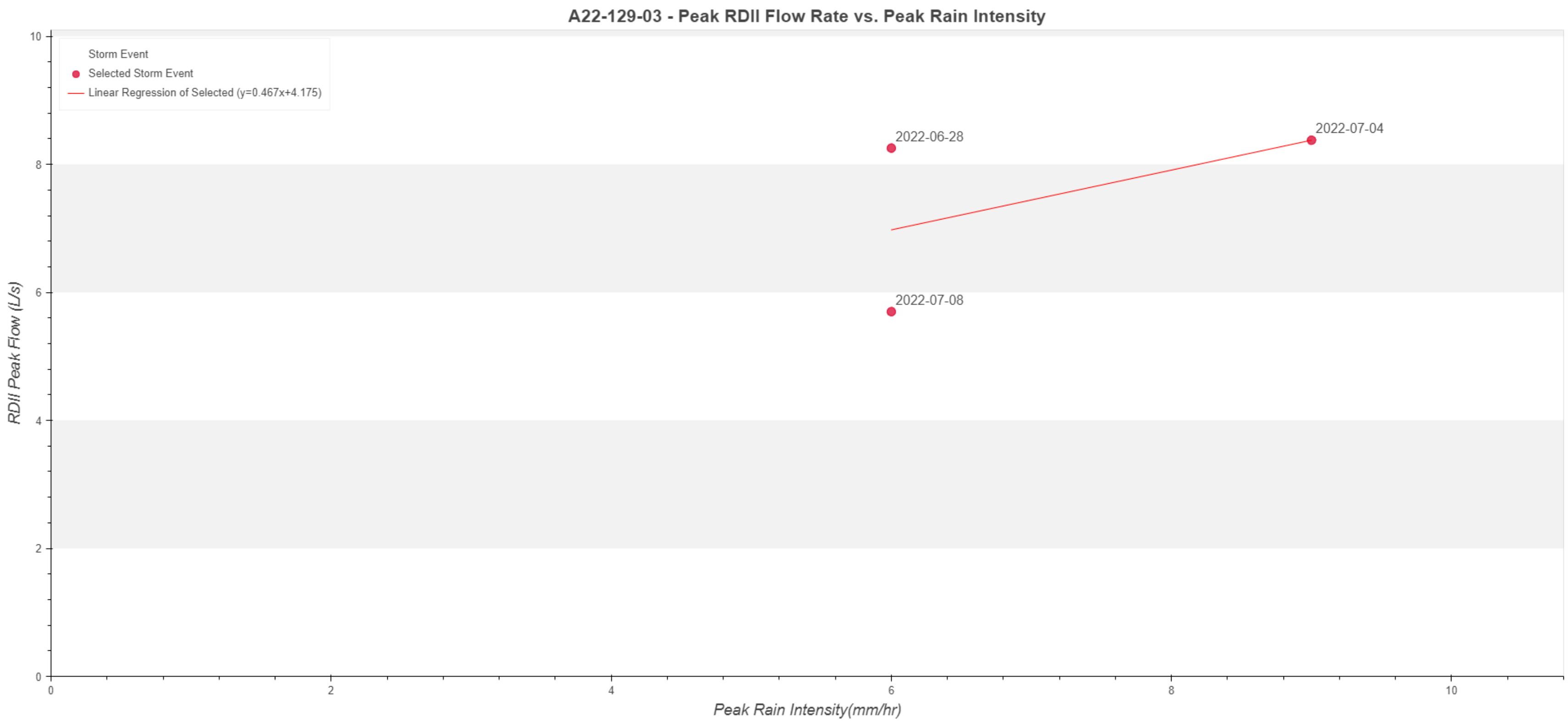


A22-129-03 - Storm Event: 2022-06-28
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
6/28 16:00
6/29
6/29 08:00
6/29 16:00
6/30


A22-129-03 - Storm Event: 2022-07-04
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
7/04 12:00
7/04 18:00
7/05
7/05 06:00
7/05 12:00
7/05 18:00
0
2
4
6
8
10
12
14
16
10
20
30
40
50

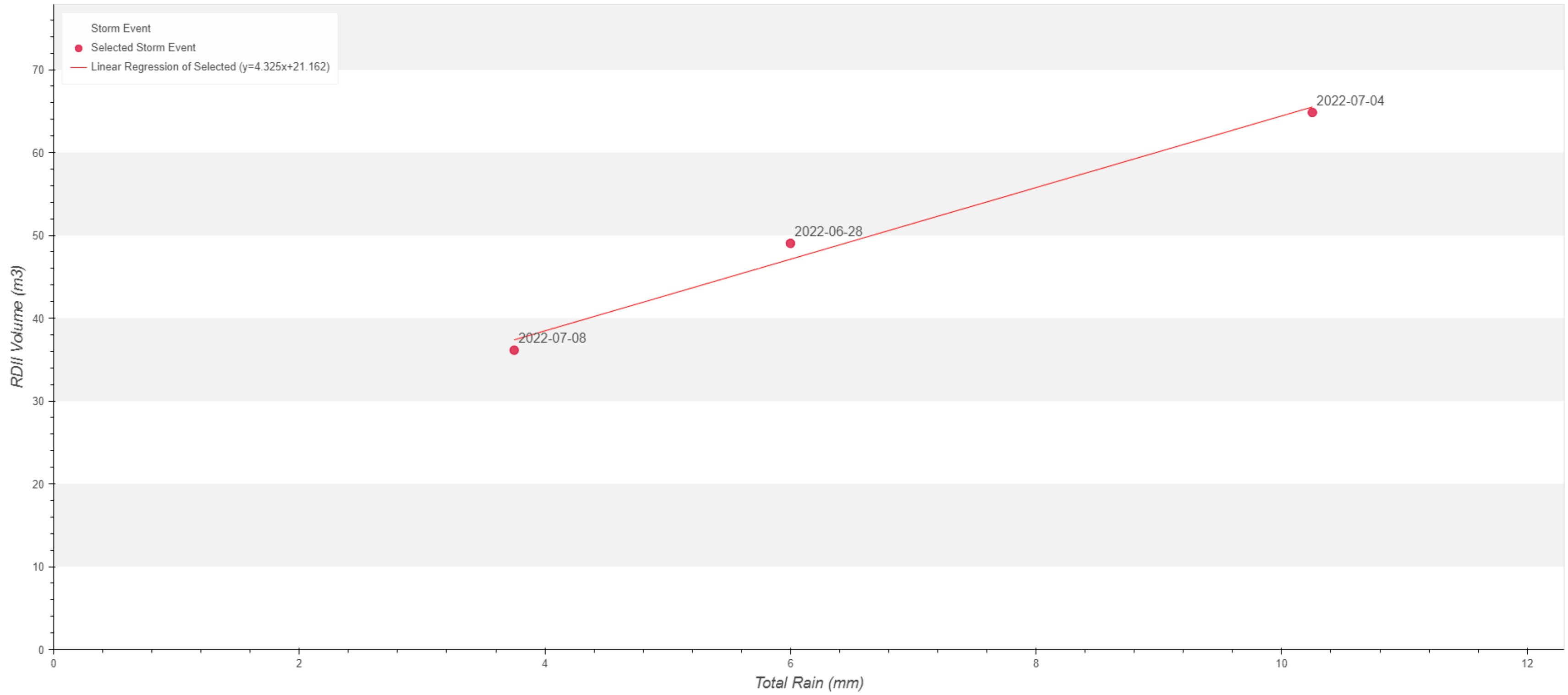

A22-129-03 - Storm Event: 2022-07-08
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
7/08 12:00
7/08 16:00
7/08 20:00
7/09
7/09 04:00
7/09 08:00
7/09 12:00

Q VS I PLOTS



A22-129-03 - Peak RDII Flow Rate vs. Peak Rain Intensity
Storm Event
Selected Storm Event
Linear Regression of Selected (y=0.467x+4.175)
2022-06-28
2022-07-04
2022-07-08
RDII Peak Flow (L/s)
Peak Rain Intensity(mm/hr)

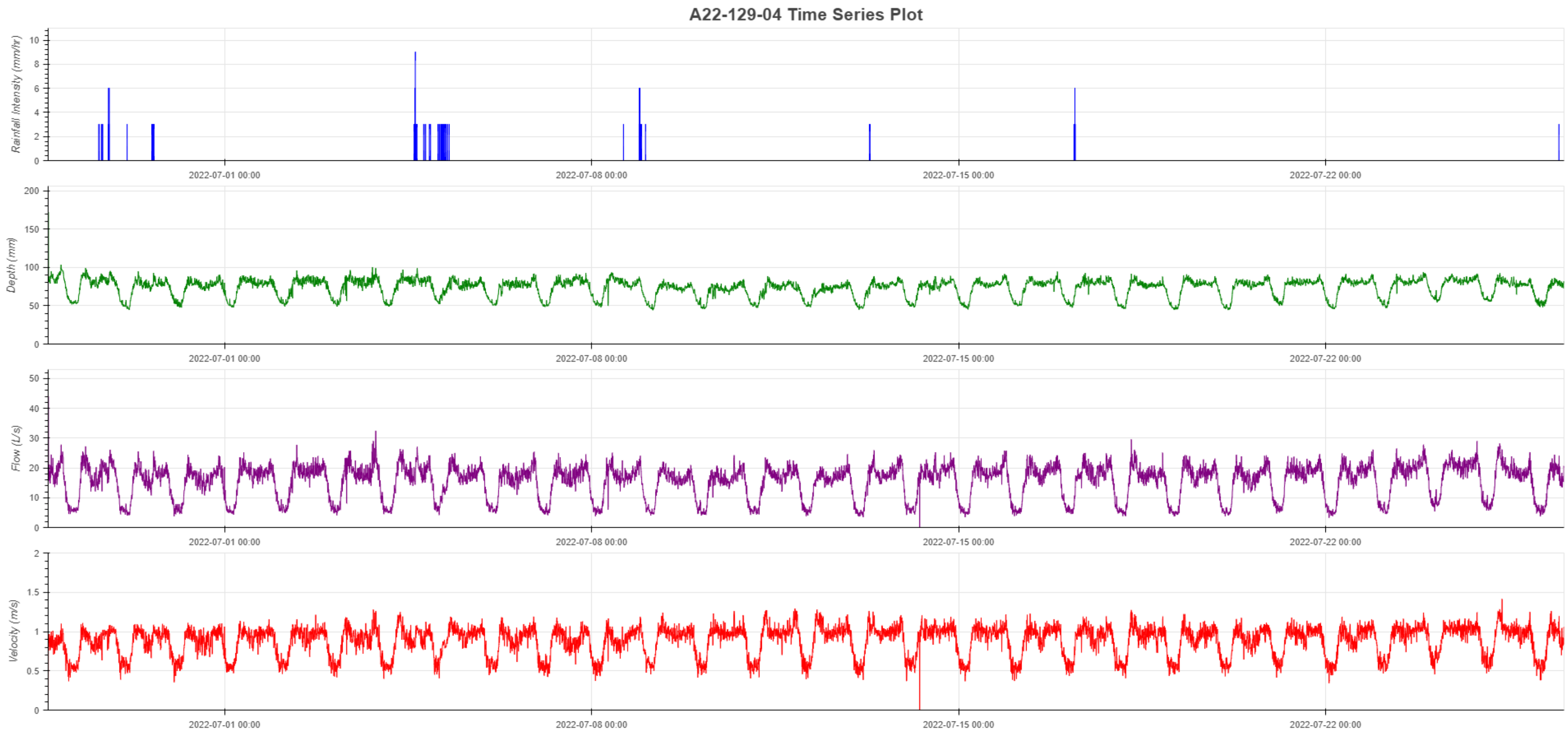
A22-129-03 - RDII Volume vs. Total Rainfall Depth



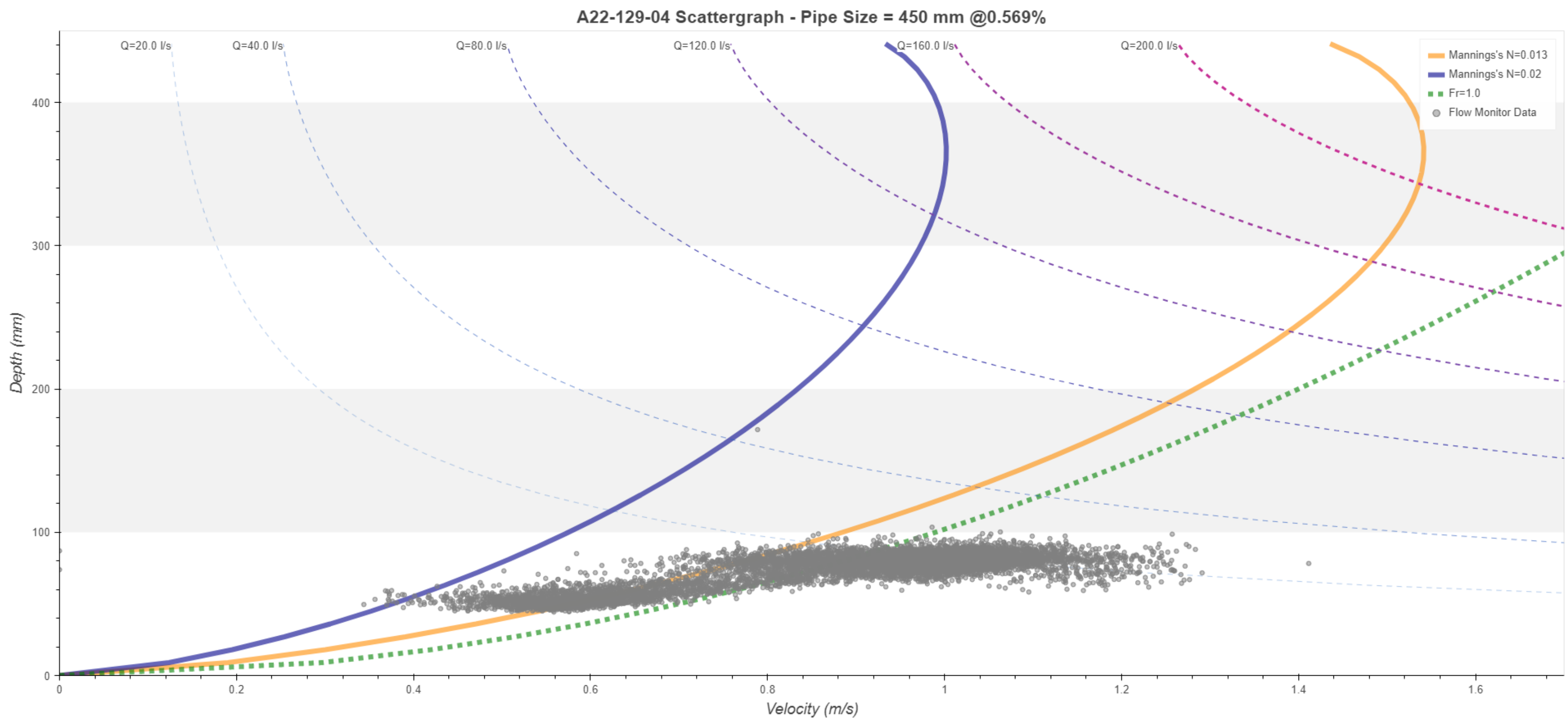
APPENDIX C-4

FLOW GAUGE A22-129-04

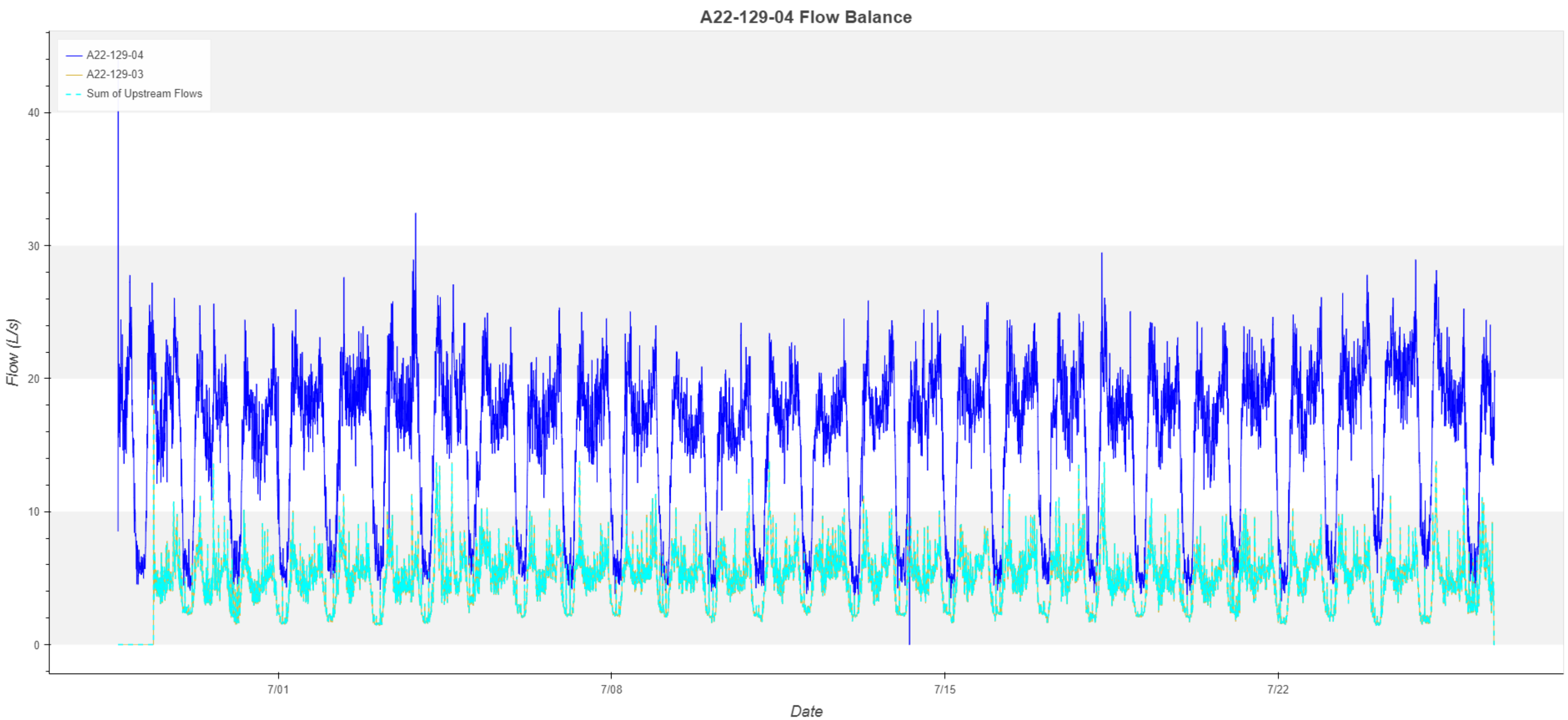
DATA REVIEW



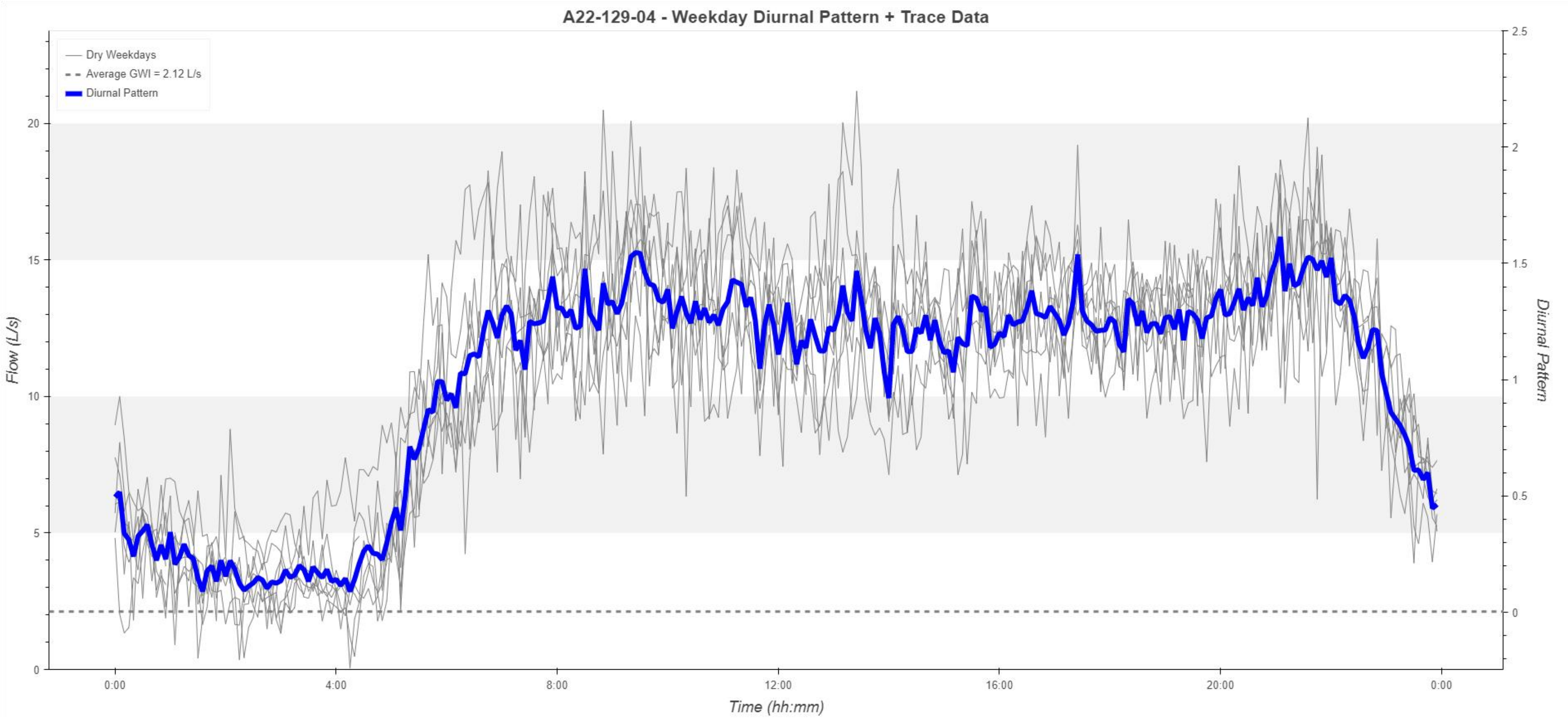
A22-129-04 Time Series Plot
Rainfall Intensity (mm/hr)
Depth (mm)
Flow (L/s)
Velocity (m/s)
2022-07-01 00:00
2022-07-08 00:00
2022-07-15 00:00
2022-07-22 00:00

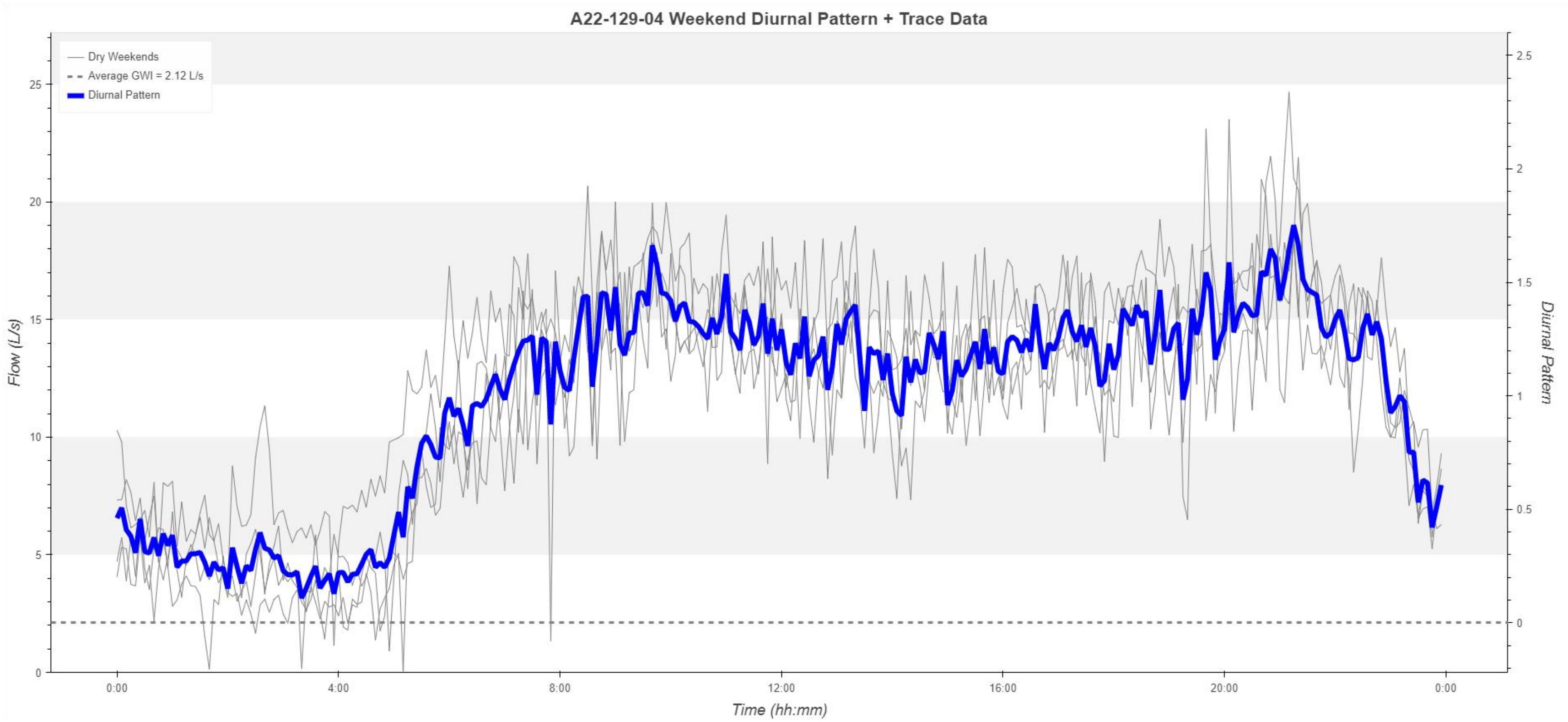


A22-129-04 Scattergraph - Pipe Size = 450 mm @0.569%
Q=20.0 l/s
Q=40.0 l/s
Q=80.0 l/s
Q=120.0 l/s
Q=160.0 l/s
Q=200.0 l/s
Mannings's N=0.013
Mannings's N=0.02
Fr=1.0
Flow Monitor Data
Depth (mm)
Velocity (m/s)
0
100
200
300
400
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


A22-129-04 Flow Balance
A22-129-04
A22-129-03
Sum of Upstream Flows
Flow (L/s)
0
10
20
30
40
7/01
7/08
7/15
7/22
Date

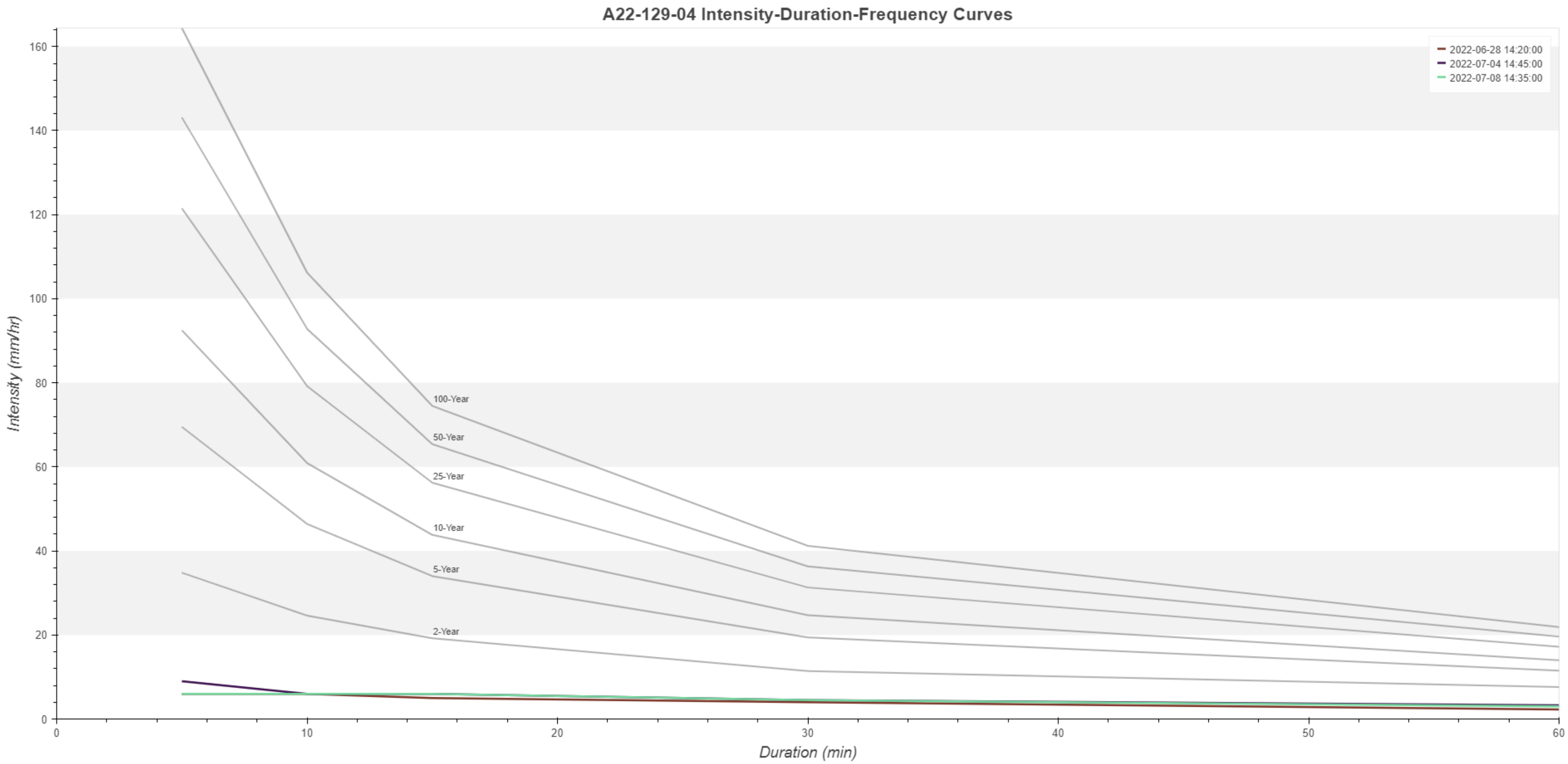
DRY WEATHER FLOW ANALYSIS



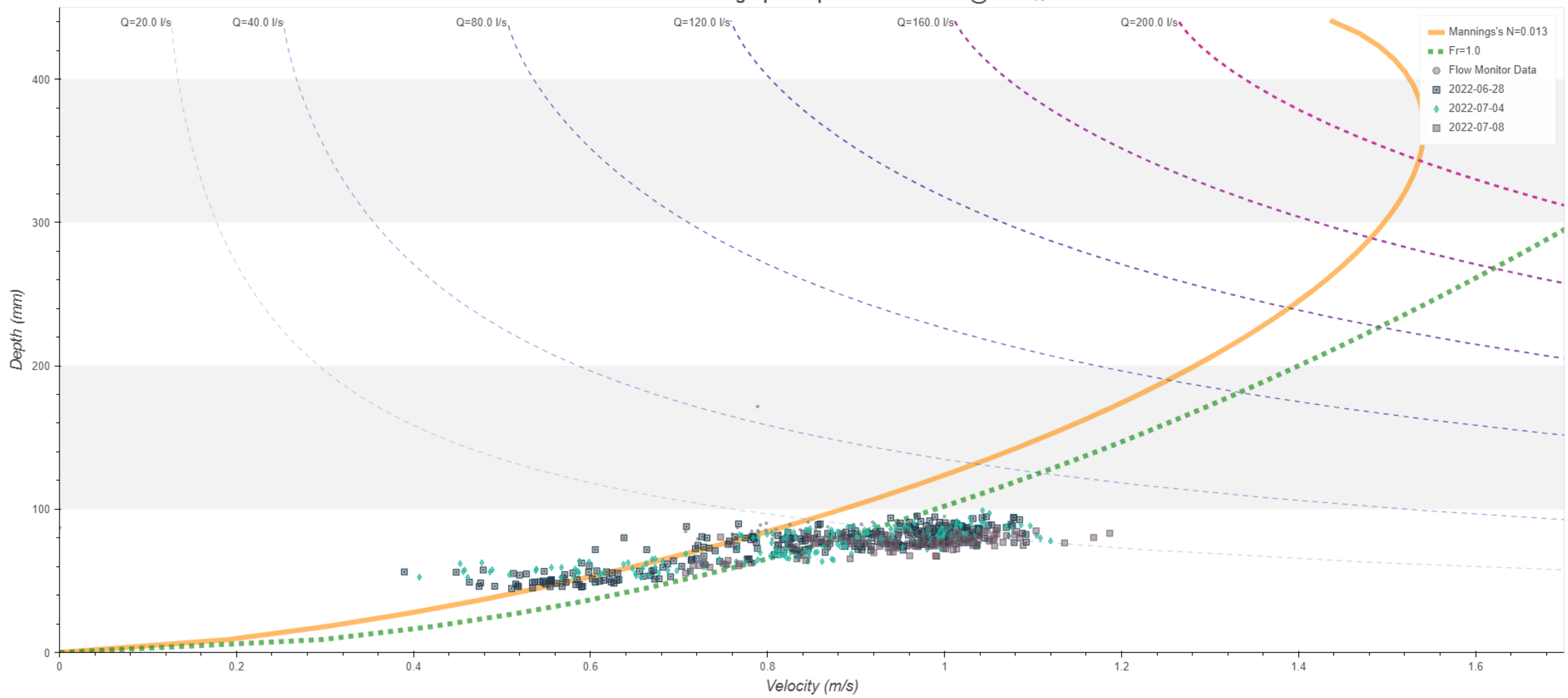


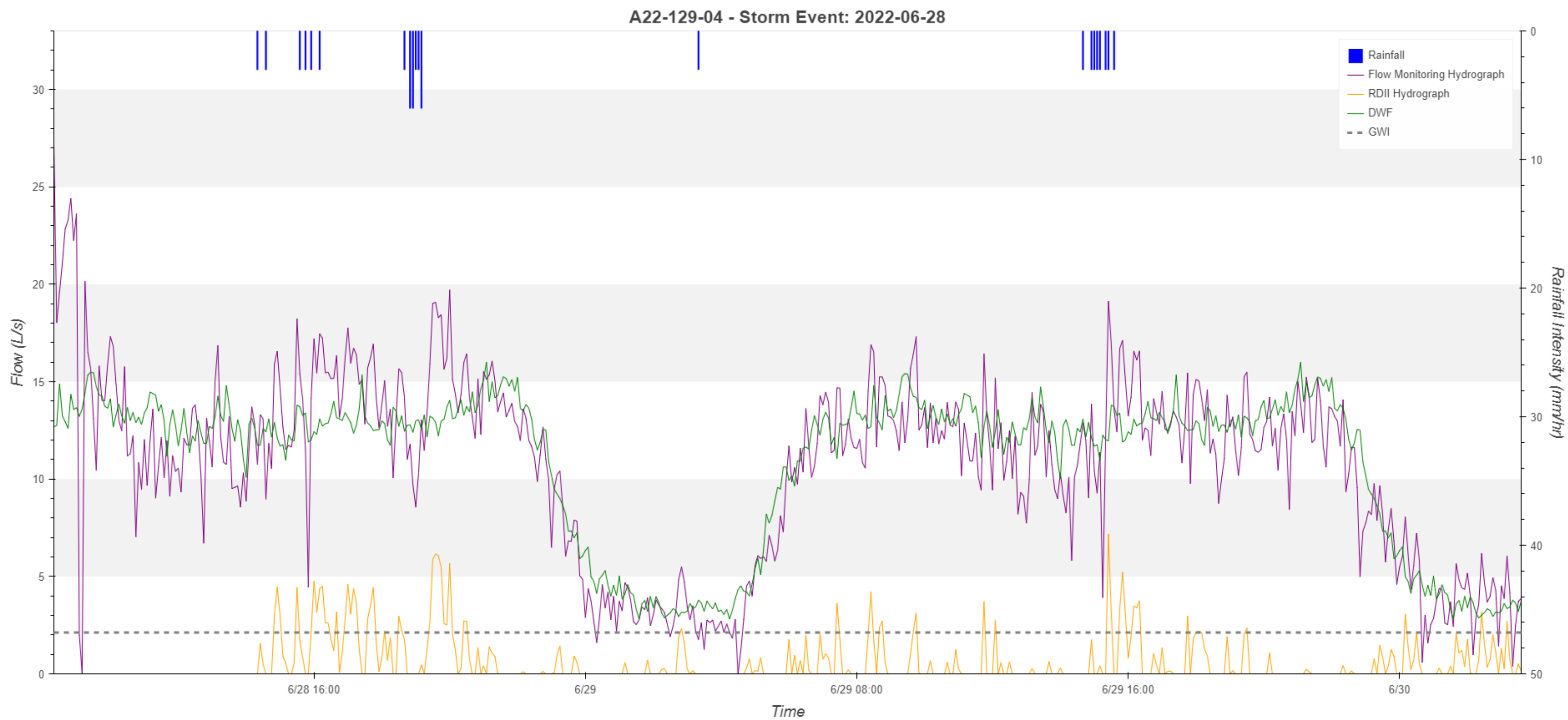
A22-129-04 Weekend Diurnal Pattern + Trace Data
Dry Weekends
Average GWI = 2.12 L/s
Diurnal Pattern
Flow (L/s)
Diurnal Pattern
Time (hh:mm)
0
5
10
15
20
25
0
0.5
1
1.5
2
2.5
0:00
4:00
8:00
12:00
16:00
20:00
0:00

WET WEATHER FLOW ANALYSIS

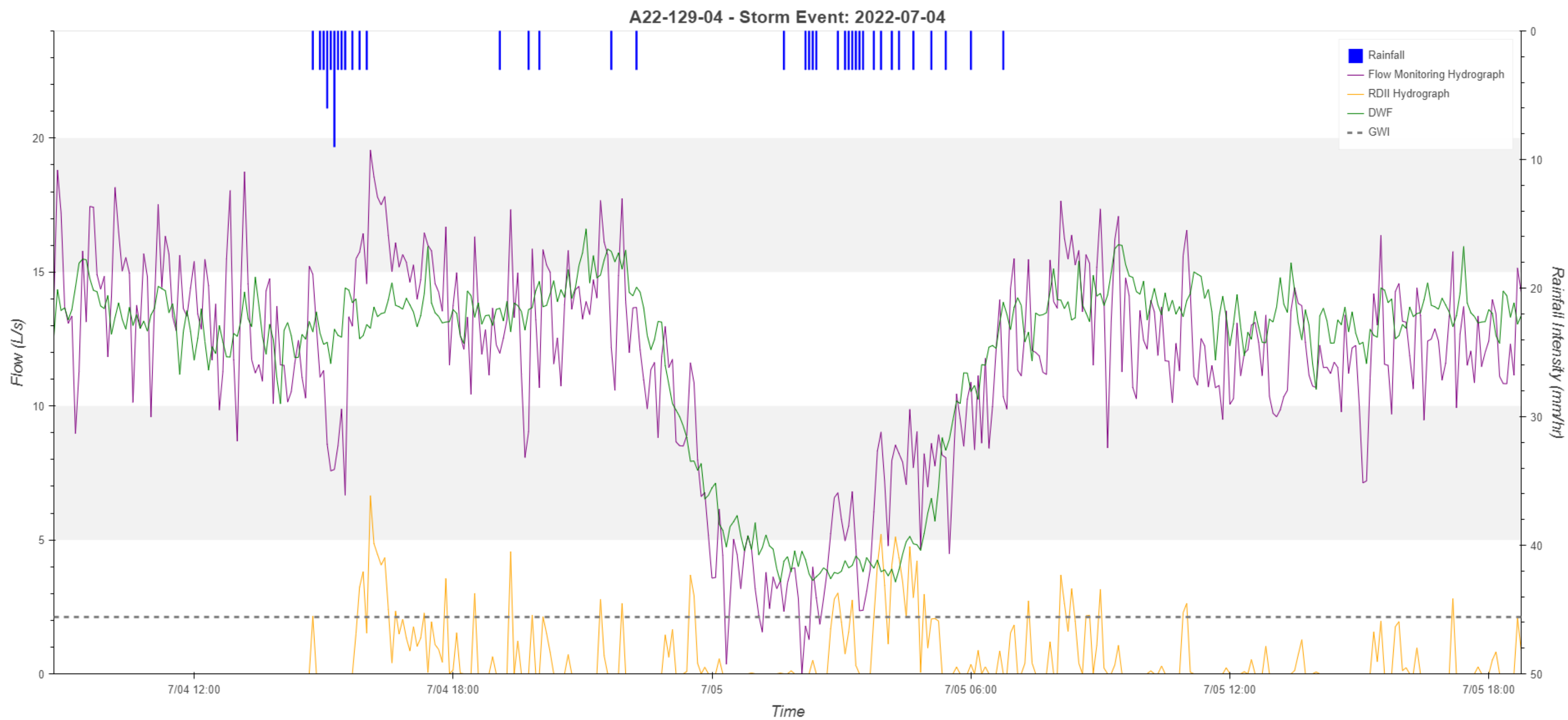


A22-129-04 Scattergraph - Pipe Size = 450 mm @0.569%

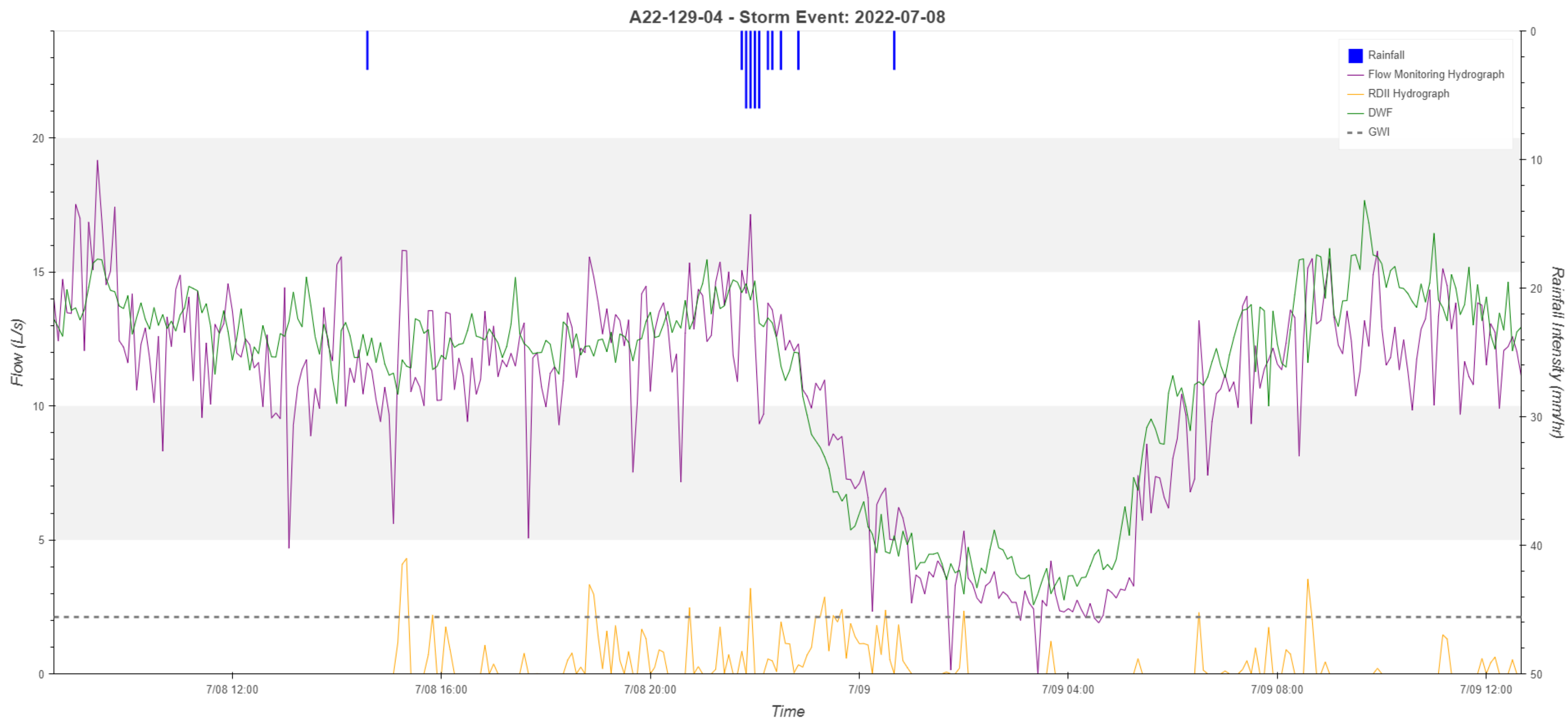




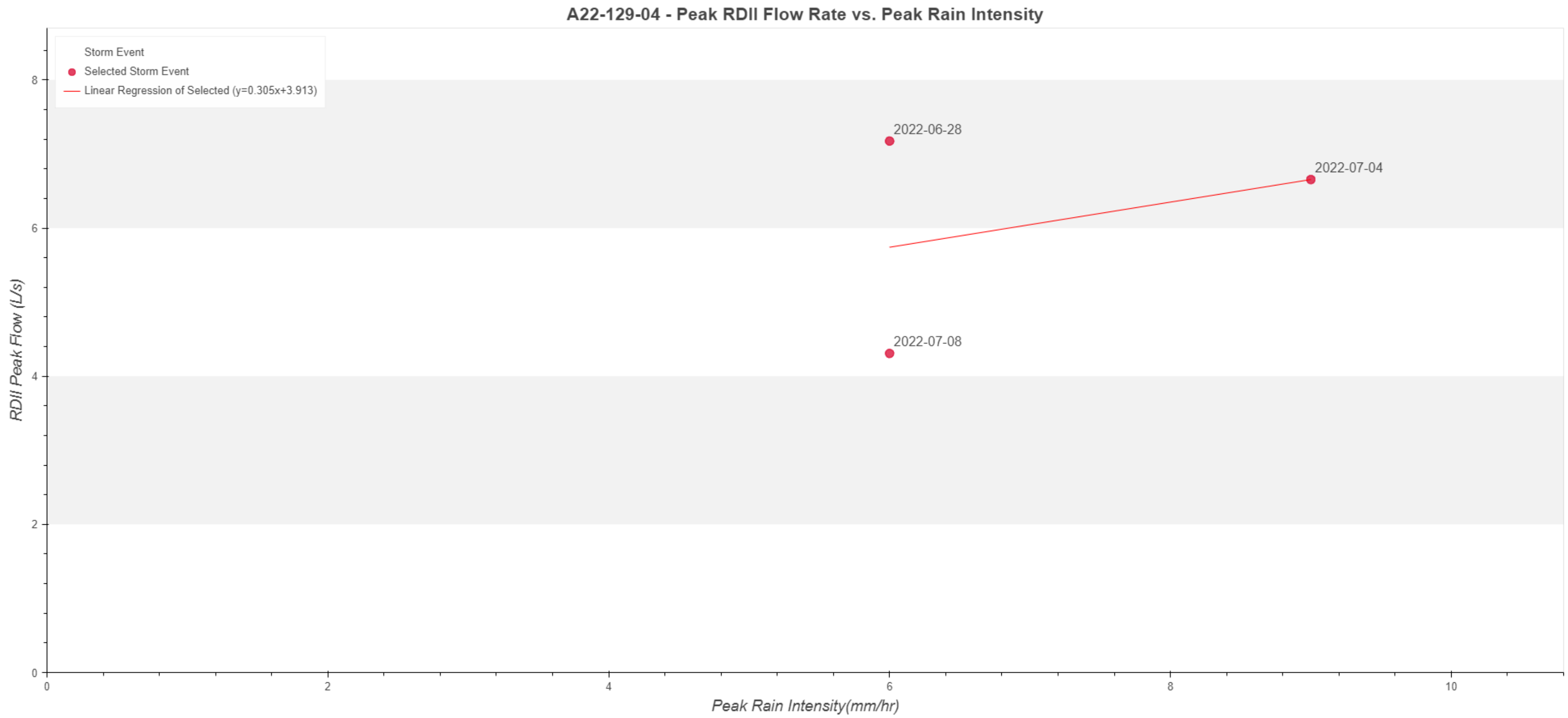
A22-129-04 - Storm Event: 2022-06-28
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
6/28 16:00
6/29
6/29 08:00
6/29 16:00
6/30

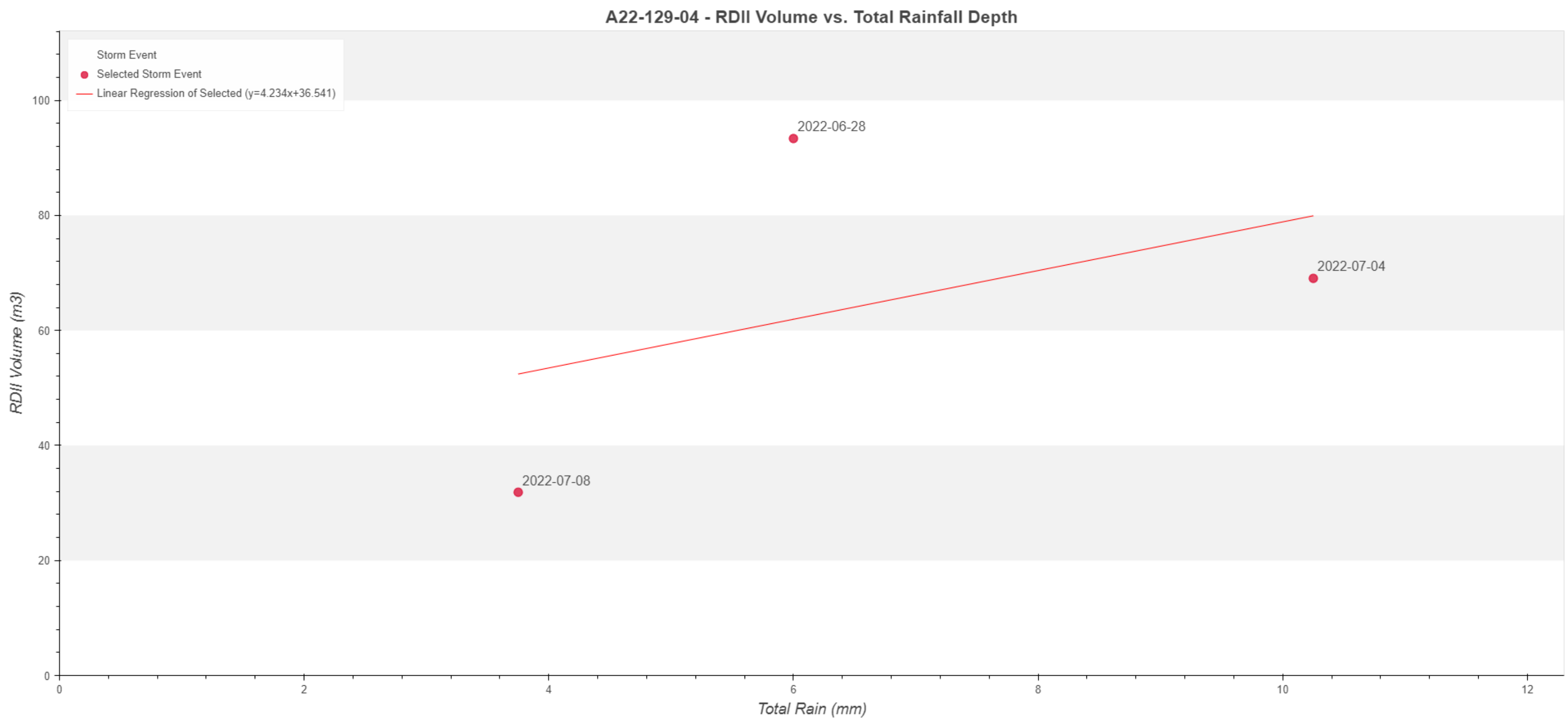


A22-129-04 - Storm Event: 2022-07-04
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
7/04 12:00
7/04 18:00
7/05
7/05 06:00
7/05 12:00
7/05 18:00


A22-129-04 - Storm Event: 2022-07-08
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
7/08 12:00
7/08 16:00
7/08 20:00
7/09
7/09 04:00
7/09 08:00
7/09 12:00

Q VS I PLOTS


A22-129-04 - Peak RDII Flow Rate vs. Peak Rain Intensity
Storm Event
Selected Storm Event
Linear Regression of Selected (y=0.305x+3.913)
2022-06-28
2022-07-04
2022-07-08
RDII Peak Flow (L/s)
Peak Rain Intensity(mm/hr)
0
2
4
6
8
10



A22-129-04 - RDII Volume vs. Total Rainfall Depth
Storm Event
Selected Storm Event
Linear Regression of Selected (y=4.234x+36.541)
2022-06-28
2022-07-04
2022-07-08
RDII Volume (m3)
Total Rain (mm)
0
20
40
60
80
100
0
2
4
6
8
10
12

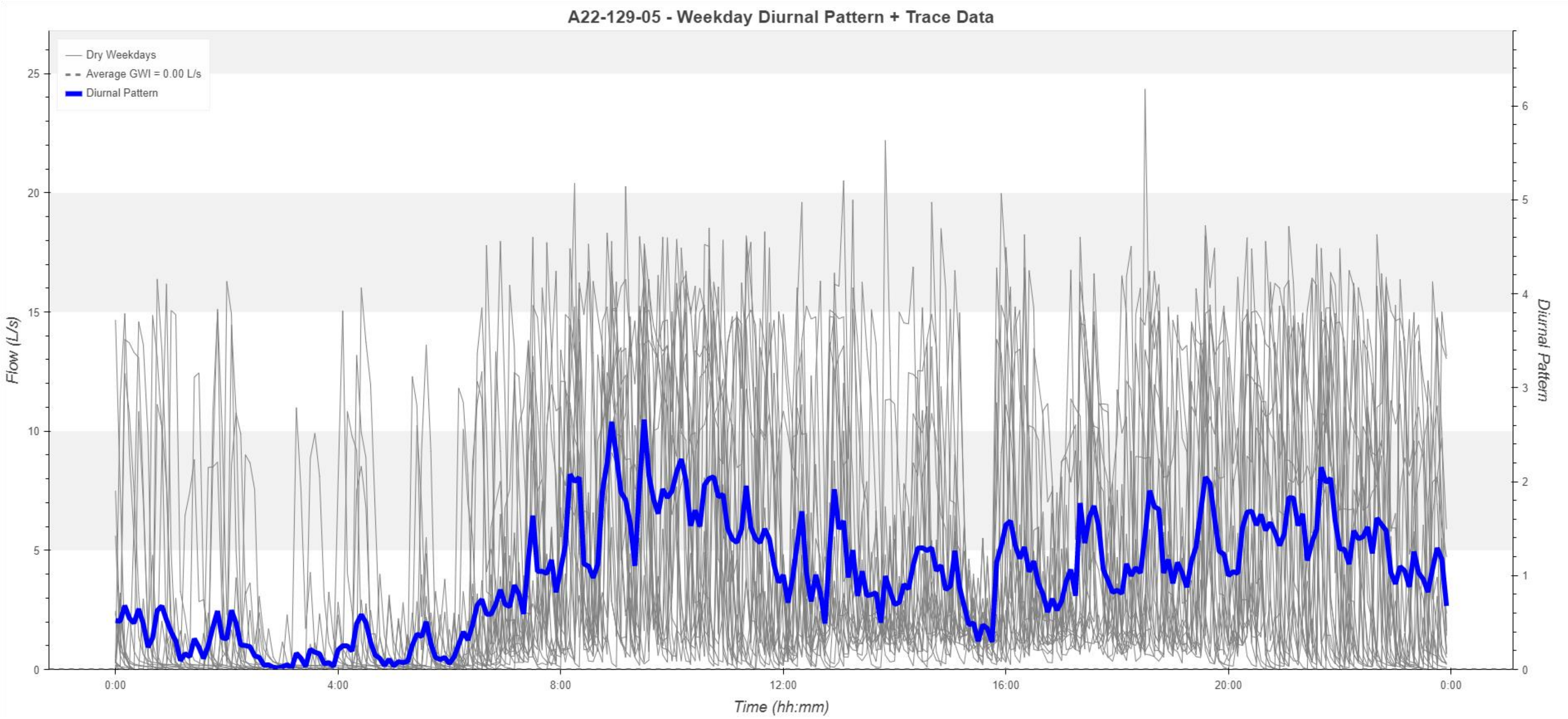
APPENDIX C-5

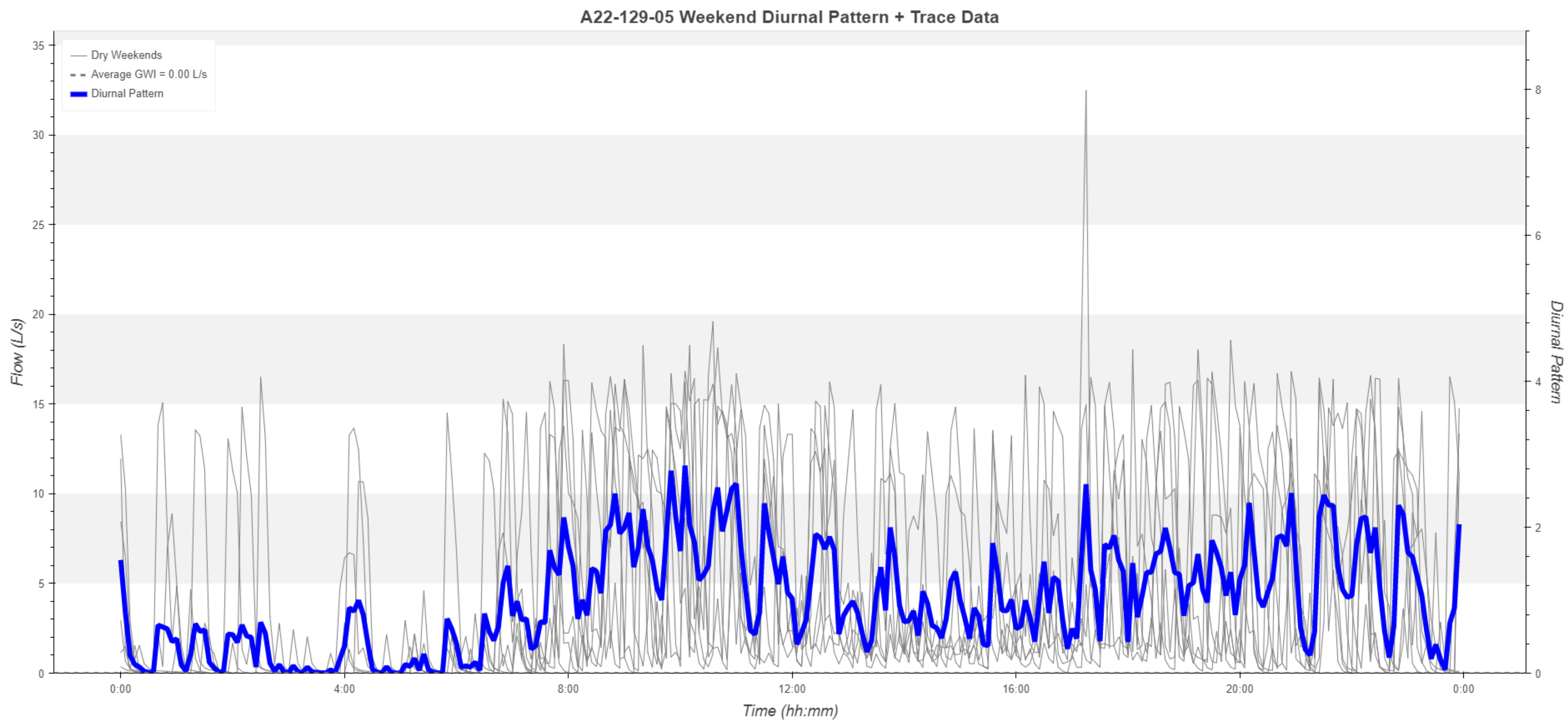
FLOW GAUGE A22-129-05

DATA REVIEW

A22-129-05 Time Series Plot
Rainfall Intensity (mm/hr)
Depth (mm)
Flow (L/s)
2022-08-01 00:00
2022-08-08 00:00
2022-08-15 00:00
2022-08-22 00:00

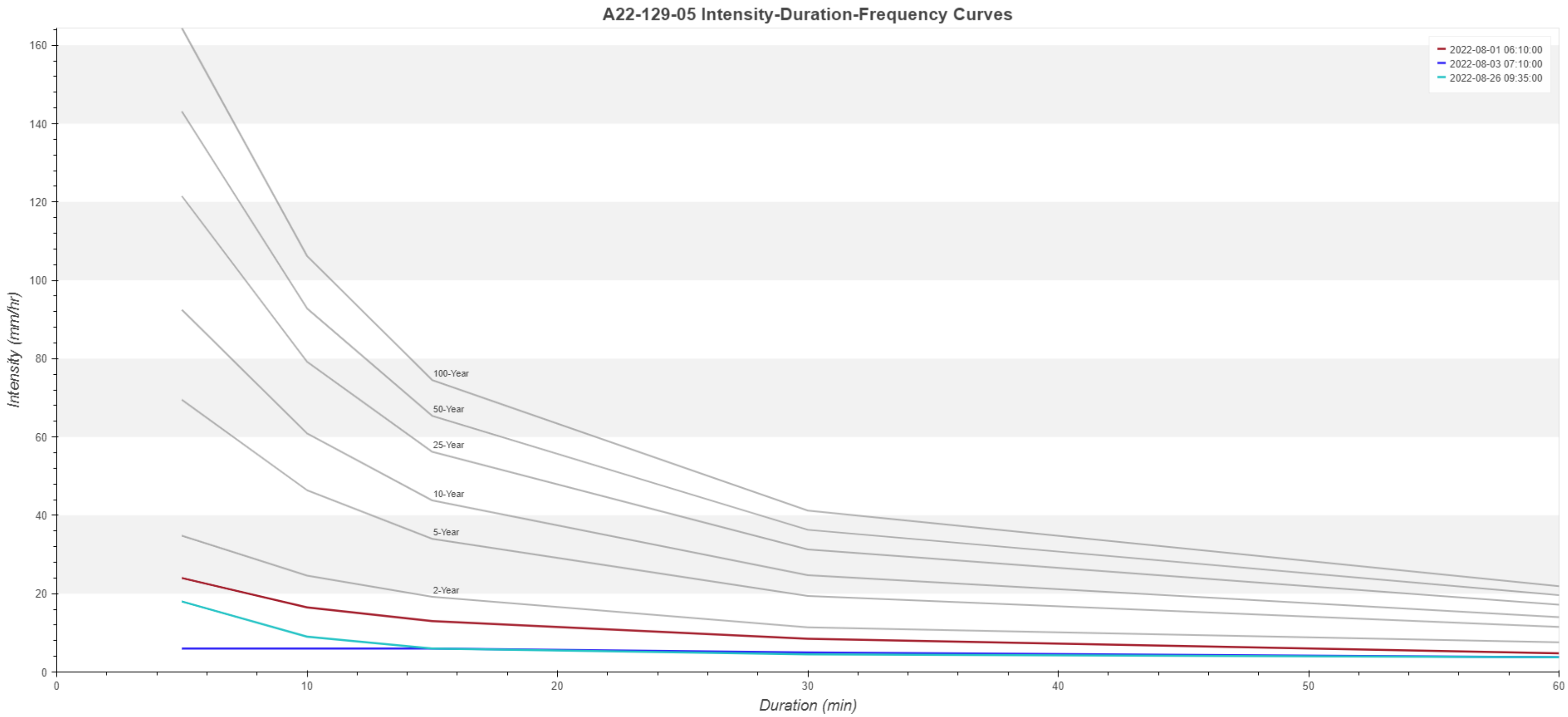
DRY WEATHER FLOW ANALYSIS



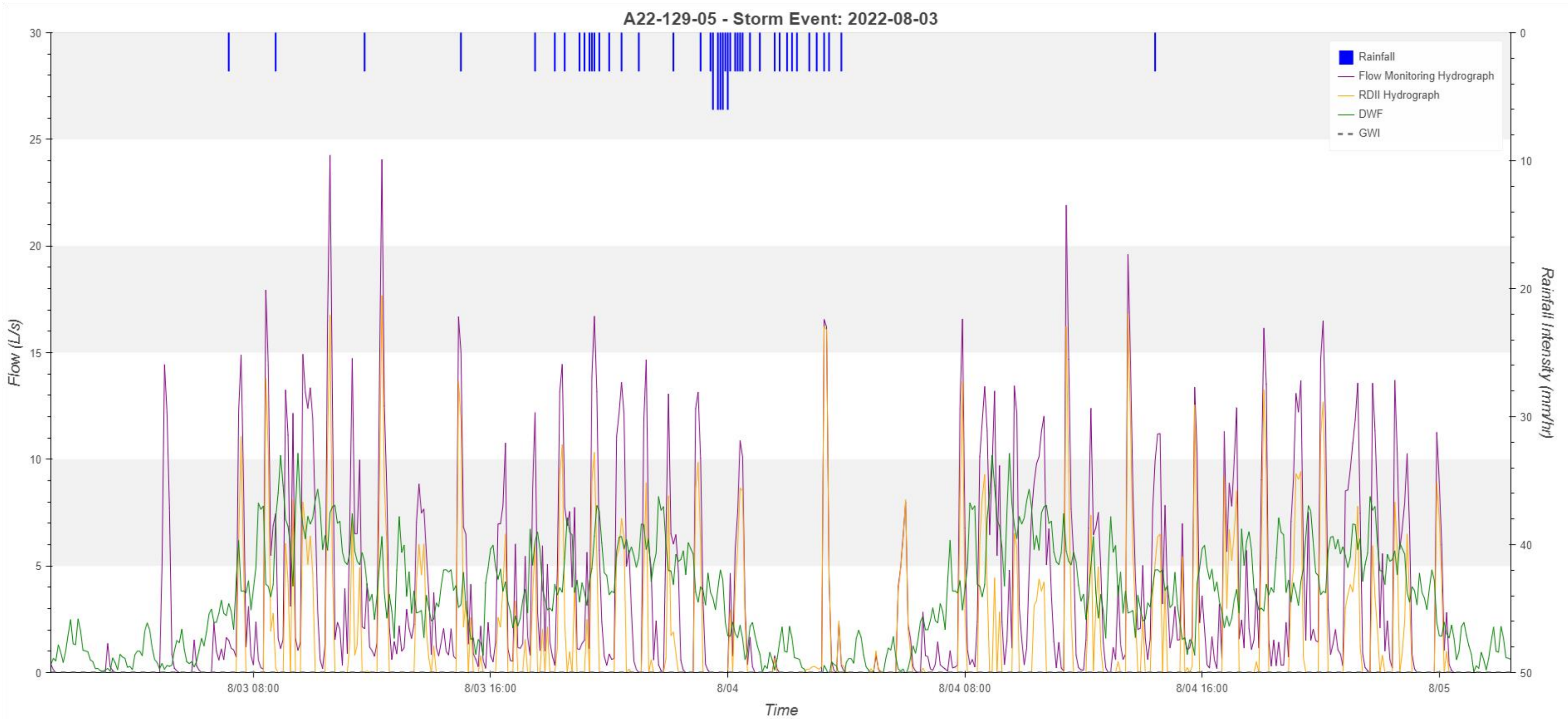


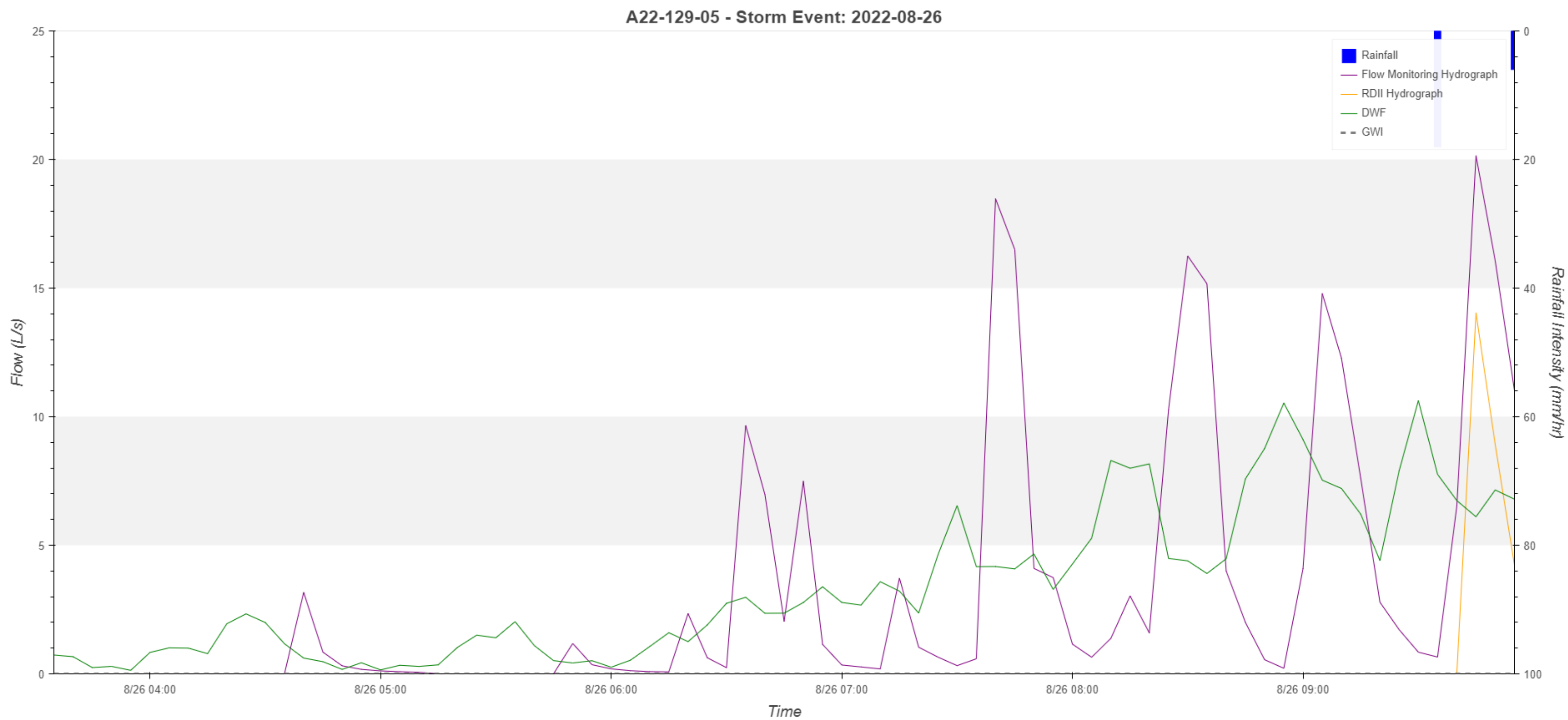
A22-129-05 Weekend Diurnal Pattern + Trace Data
Dry Weekends
Average GWI = 0.00 L/s
Diurnal Pattern
Flow (L/s)
Diurnal Pattern
Time (hh:mm)
0
5
10
15
20
25
30
35
0
2
4
6
8
0:00
4:00
8:00
12:00
16:00
20:00
0:00

WET WEATHER FLOW ANALYSIS

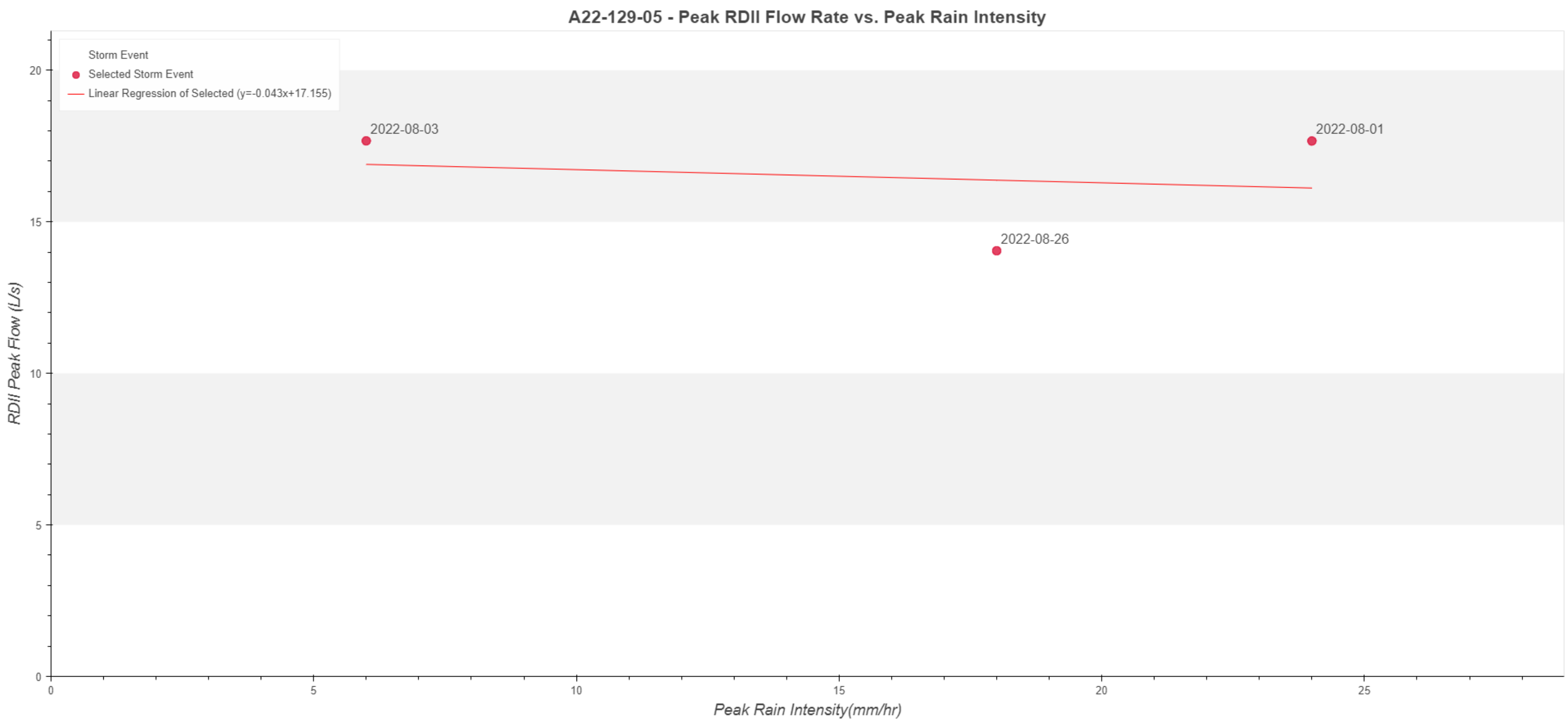



A22-129-05 - Storm Event: 2022-08-01
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
8/01 08:00
8/01 16:00
8/02
8/02 08:00
8/02 16:00


A22-129-05 - Storm Event: 2022-08-03
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
30
25
20
15
10
5
0
10
20
30
40
50
8/03 08:00
8/03 16:00
8/04
8/04 08:00
8/04 16:00
8/05

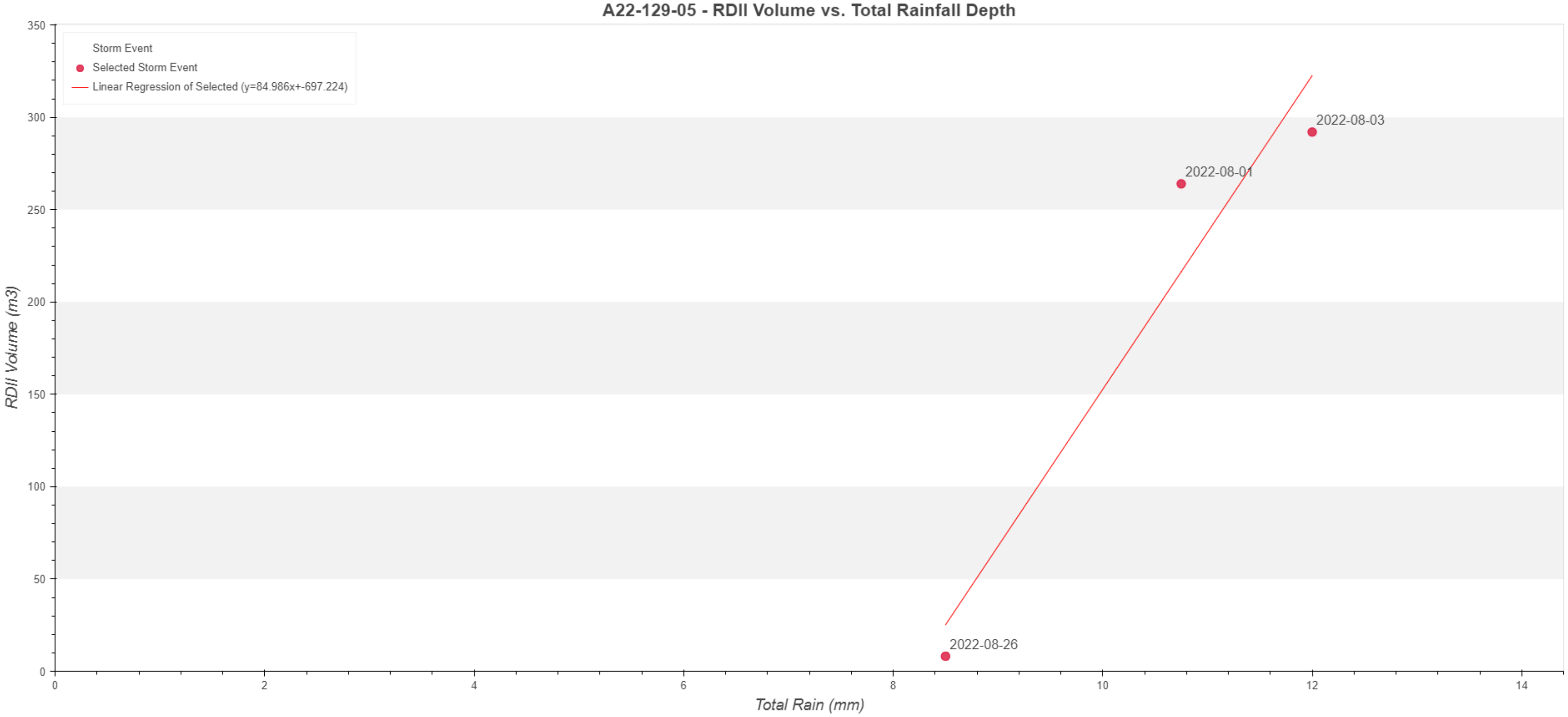

A22-129-05 - Storm Event: 2022-08-26
Rainfall
Flow Monitoring Hydrograph
RDII Hydrograph
DWF
GWI
Flow (L/s)
Rainfall Intensity (mm/hr)
Time
0
5
10
15
20
25
0
20
40
60
80
100
8/26 04:00
8/26 05:00
8/26 06:00
8/26 07:00
8/26 08:00
8/26 09:00

Q VS I PLOTS



A22-129-05 - Peak RDII Flow Rate vs. Peak Rain Intensity
Storm Event
Selected Storm Event
Linear Regression of Selected (y=-0.043x+17.155)
2022-08-03
2022-08-01
2022-08-26
RDII Peak Flow (L/s)
Peak Rain Intensity(mm/hr)
0
5
10
15
20
25

A22-129-05 - RDII Volume vs. Total Rainfall Depth

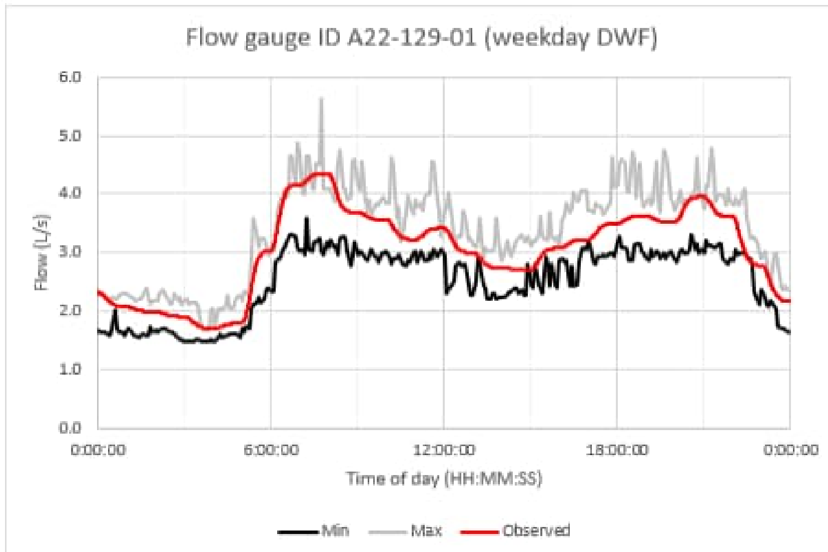


APPENDIX

D

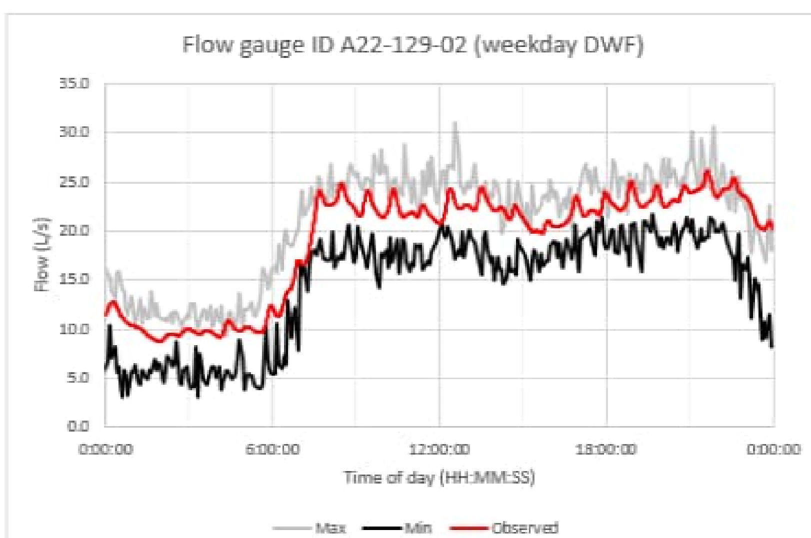
DRY WEATHER FLOW VERIFICATION

DRY WEATHER FLOW VERIFICATION



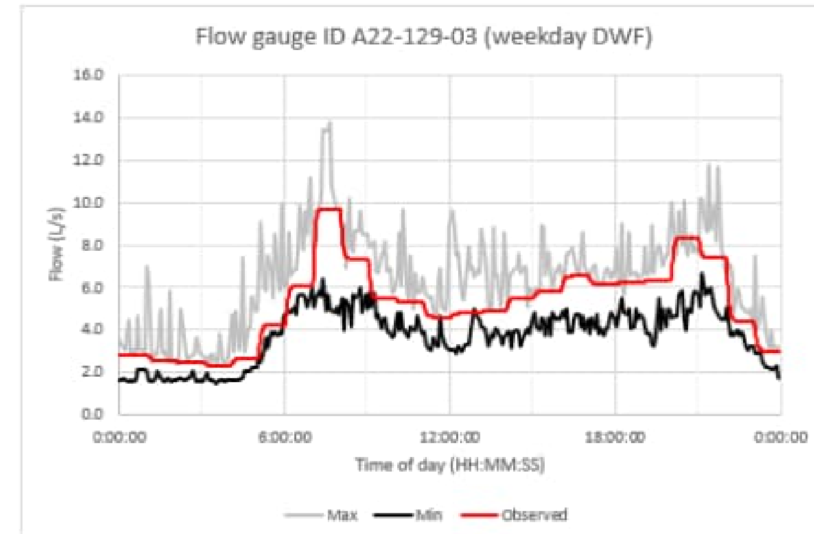
Observed peak flow	5.018 L/s	Observed volume	1796 m^3
Simulated peak flow	4.359 L/s	Simulated volume	1833 m^3
Flow NSEC	0.712	Volume error	2.1%

For the week of July 11-18



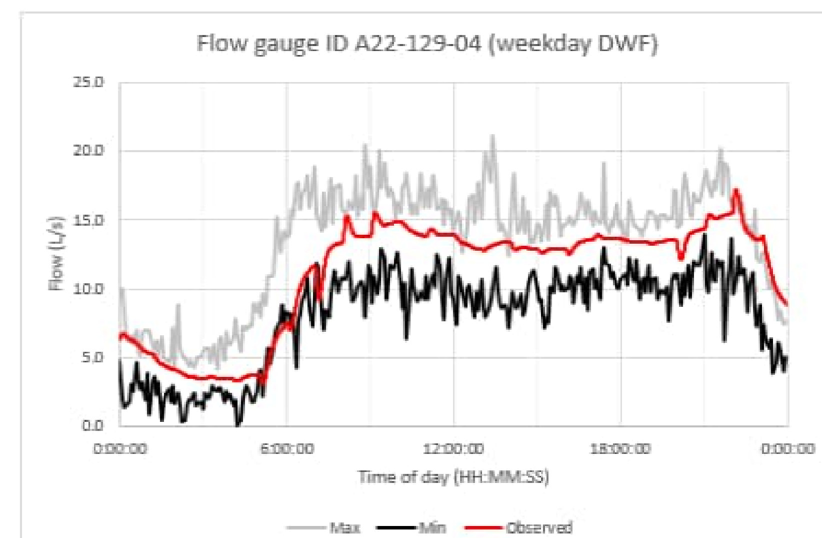
Observed peak flow (net)	31.141 L/s	Observed volume (gross)	12590 m^3
Simulated peak flow (net)	27.246 L/s	Simulated volume (gross)	13450 m^3
Flow NSEC	0.684	Volume error	6.8%

For the week of July 11-18



Observed peak flow	13.79 L/s	Observed volume	3069 m^3
Simulated peak flow	10.62 L/s	Simulated volume	3153 m^3
Flow NSEC	0.546	Volume error	2.7%

For the week of July 11-18



Observed peak flow (net)	21.192	Observed volume (gross)	9293
Simulated peak flow (net)	15.733	Simulated volume (gross)	9919
Flow NSEC	0.822	Error	6.7%

For the week of July 11-18

Note: The flow values and hydrographs for gauges A22-129-02 and -04 provide a comparison against net values. Volumes compare gross values.