Infiltration and Inflow Study – 2023 Phase

Greater Shediac Sewerage Commission

GSSC
Final - 2023 Phase

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Greater Shediac Sewerage Commision

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Table of Contents

TABLES

FIGURES

APPENDICES

1 Introduction

1.1 Background

Englobe Corp was retained by the Greater Shediac Sewerage Commission to complete a comprehensive study on a portion of the wastewater collection system infrastructure. The intent of the study is to identify sources of rainfall-derived inflow and infiltration (RDII) which increases hydraulic loading on the wastewater collection system during and following periods of rainfall.

The existing infrastructure relies on a mix of gravity sewer and forcemains for transmission, delivering the sewage to the wastewater treatment facility located on Chemin Cap Brule.

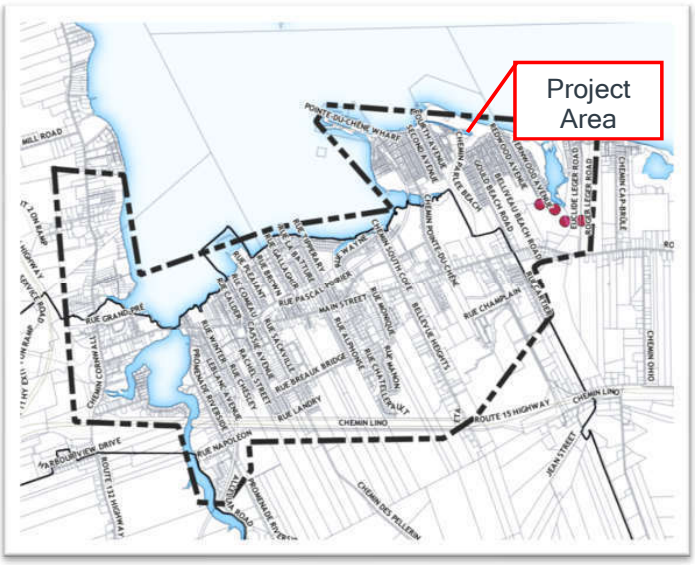


Figure 1: Project Area

1.2 Study Objectives

The objectives of the study are as follows:

- To conduct a flow monitoring program for the collection of wastewater system flow data, and determine the following:
  - **Peak flow** – the maximum flow recorded by each flow meter.
  - **Average dry weather flow** – the average flow recorded by each flow meter during a period of no rain.
  - **Total flow** – total volume of flow recorded at each flow meter.
  - **RDII** (Rainfall derived inflow and infiltration) – the difference between the computed average dry weather flow and the measured flow during a wet weather event.
- To determine quantitative responses of specific areas of the wastewater collection system to rainfall events through interpretation of the flow monitoring data;

1.3 Data Collection

The data collection process began on November 3rd, 2022, and was completed on April 26th, 2023 and was performed by AMG Environmental. A total of seven (7) flow meters were installed at strategic locations within the study area to take instantaneous flow measurements at regular intervals.

Precipitation data was provided by Weather Underground and was resolved into daily totals (mm). The daily totals are presented in Table 1 in Appendix B. As a check on the validity of the precipitation data, Englobe validated it by comparing it to data recorded at the Greater Moncton Romeo LeBlanc Internation Airport rain gauge for the same time period.

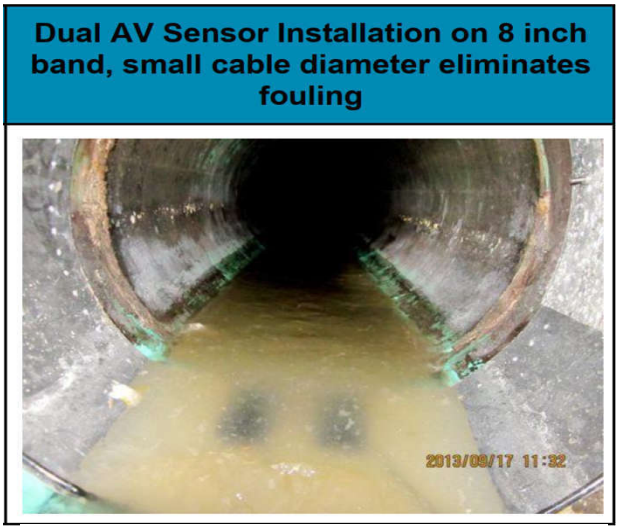


Figure 2: Typical Flow Meter Installation

2 Flow Monitoring

2.1 Project Area Description

The flow metering program was broken down into seven (7) sewersheds, as shown in Drawing 1-1 in Appendix A.

Various residential, RV camping and commercial properties populate the areas.

2.2 Overview

The flow monitoring program for this study was used to quantitatively assess the volume and variation in flows being conveyed by GSSC's wastewater collection system, particularly in response to rainfall events. To achieve this, seven (7) flow monitoring sites were selected to isolate specific areas in the GSSC system for flow measurement. The sites selected were:

1. **Flow Meter #1 - MH 49 South Inlet**

   This flow meter was installed downstream of Horizon Trailer Park, adjacent to Belliveau Beach Road. This location allows measurement of flows from the western portion of the RV Parks sanitary sewer collection system.

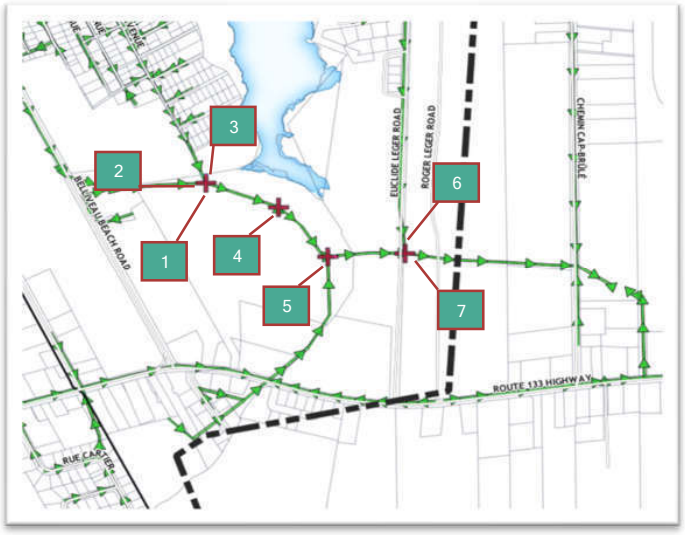


Figure 3: Flow Meter Locations

2. **FM #2 – MH 49 West Inlet**

   This flow meter was installed in Manhole #49 on the Trunk Sewer. This location allows measurement of flows from most of the system, including residential, commercial and RV Park properties. This includes flows from 21 lift stations.

3. **FM #3 – MH 49 North Inlet**

   This flow meter was installed downstream of Ocean Surf RV Park, adjacent to Belliveau Beach Road. This location allows measurement of flows from the RV Parks and the subdivision to its north.

4. **FM #4 – MH 51 South Inlet**

   This flow meter was installed downstream of Horizon Trailer Park. This location allows measurement of flows from the eastern portion of the RV Parks sanitary sewer collection system.

5. **FM #5 – MH 54 South Inlet**

   This flow meter was installed in MH54 at the eastern portion of the Horizon Trailer Park property. This location allows measurement of flows from the sanitary system for a small part of Main Street, including developments off of Mathieu St, Cartier Rd, and Ohio Rd,

6. **FM #6 – MH 58 North Inlet**

   This flow meter was installed in MH58 on Euclide Leger Road. This location allows measurement of flows from the sanitary system to the north of the manhole, including developments off Euclide Leger and Roger Leger Road.

7. **FM #7 – MH 58 East Inlet**

   This flow meter was installed directly in the Trunk Sewer on Euclide Leger Road, adjacent to Horizon RV Park. This location allows measurement of total flows for most of the system. This meter location is downstream of all other meters installed in this program and therefore represents the total combined flow of those meters.

2.3 Flow Monitoring Results

Daily values for flow and precipitation data can be found summarized in Table 1 in **Appendix B**.

Graphs showing both the overall flow monitoring period, and the December 1st, 2022 and January 16th, 2023 rain events, are included in Appendix C for each flow monitoring location. These graphs provide additional context and analysis for each flow monitoring location.

Values for Average Dry Weather Flows (ADWF) in litres per second (l/s) were derived by evaluating flows during dry-weather periods in the flow monitoring program. Base Flow generally represents the lowest observed flow values for each location, occurring during a period of dry weather flow and in the early morning. A summary of each sewershed can be found in **Table 2-2** on the following page.

1. **Flow Meter #1 – MH 49 South Inlet**

   As described above, FM1 was installed on one (1) of two (2) outlets of the Horizon RV Park. As the park was vacant during the flow monitoring period, no flow was observed except for a small spike (2.2 l/s) on January 16th, 2023. This inflow was noted during a wet, warm weather event.

2. **FM #2 – MH 49 West Inlet**

   FM#2 recorded a Peak Flow of 404.3 L/s with an ADWF of 45.3 l/s and a base flow of 18.7 l/s. This flow meter installation site is located on the Commission's Trunk sewer, representing flows from a significant portion of the system. Significant increases were observed during wet weather events.

3. **FM #3 – MH 49 North Inlet**

   FM#3 recorded a Peak Flow of 42.9 l/s with an ADWF of 6.4 l/s and a base flow of 5.6 l/s. Sharp increases in inflow were noted during wet weather events. The data shows no significant daily patterns, suggesting the flow is dominated by RDII.

4. **FM #4 – MH 51 South Inlet**

   FM#4 was installed on the second of two (2) outlets of the Horizon RV Park. The park was vacant during the flow monitoring period, so there was no obvious sign of sanitary flow. However, the connected system shows evidence of direct inflow during wet-weather events. The most significant example was noted on December 1st, with a flow of 23.8 l/s.

5. **FM #5 – MH 54 South Inlet**

   FM#5 recorded a Peak Flow of 81.4 l/s with an ADWF of 22.82 l/s and a base flow of 11.8 l/s. As noted in Appendix D, the pipe being monitored is a lateral into the trunk sewer. When the depth of flow in the trunk sewer was high it would "push" into the lateral causing an increase in flow.

6. **FM #6 – MH 58 North Inlet**

   FM#6 recorded a Peak Flow of 17.8 L/s with an ADWF of 1.52 l/s and a base flow of 1.0 l/s. A moderate increase in inflow was noted during wet weather events, with a sharp increase in inflow during the January 16th, 2023 weather event, with a peak inflow of 17.8L/s noted.

7. **FM #7 – MH 58 East Inlet**

   FM#7 recorded a Peak Flow of 440.6 L/s with an ADWF of 80.38 l/s and a base flow of 63.2 l/s. Flow from this location shows similar patterns to FM#2, which was also installed on the Trunk Sewer upstream. However, flow peaks are generally muted when compared to FM#2, which is likely related to FM#7's proximity to the WWTP and the downstream effect of the pumping station.

   FM#7, representing the majority of flows entering the WWTP, shows a significant influence from RDII. Both rapid (inflow) and longer-term (infiltration) influences are apparent.

The following table summarizes the flow monitoring data review results for each sewershed. Metrics such as Peak RDII (l/s)/ha and % of total rainfall are meant to account for the varying sizes of each sewershed to compare the results more directly. Whereas the system's response to precipitation as rain is easier to correlate than the response to snow-melt, the values presented below were limited to data in November and December of 2022. However, the flow monitoring data also showed a clear impact of snowmelt on system flows.

Table 2-1: Flow Monitoring Results Summary

	FM1	FM2	FM3	FM4	FM5	FM6	FM7
Total Area (ha)	4.1	933.2	29.4	6.0	126.7	15.8	1059.9
ADWF (l/s)	0.0	45.3	6.4	0.0	22.8	1.2	80.4
Peak Instant. Flow (l/s)	2.2	404.3	42.9	23.8	81.4	17.8	440.6
Peak Flow/ADWF	---	8.9	6.7	---	3.6	14.5	5.5
Total Volume of Rain (cu.m) [1]	13,946	3,142,909	98,952	20,208	426,726	53,214	3,569,635
Peak RDII (l/s)	0.00	318.60	33.03	14.75	48.83	10.66	290.60
Peak RDII (l/s/ha)	0.00	0.34	1.12	2.46	0.39	0.67	0.27
RDII Volume (cu.m)	0	79,400	5,721	2,111	32,550	768	96,450
% of Total Rainfall	0.00%	2.53%	5.78%	10.45%	7.63%	1.44%	2.70%

1. Volume of rain is based on a total rain depth of 336.8 mm, from November 1st, 2022, to December 31st, 2022 multiplied by the "Total Area (ha)".

The following table further summarizes and ranks each sewershed with respect to the Peak RDII (l/s/ha) and % of Total Rainfall.

Table 2-2: Sewershed RDII Ranking Summary

Location	Peak RDII (l/s/ha)	Rank	% Rainfall	Rank
FM4	2.46	1	10.45	1
FM3	1.12	2	5.78	3
FM6	0.67	3	1.44	6
FM5	0.39	4	7.63	2
FM2	0.34	5	2.53	5
FM7	0.27	6	2.7	4
FM1	0.00	7	0.00	7

2.4 Flow Meter Comparison

As a confidence check, to help ensure that the data collected from the flow meters are reliable and accurate, Englobe compared the sum of flows from Flow Meter #1 through #6 to the flows from Flow Meter #7. Flow Meter #7 was the most downstream meter in the program and should theoretically equal the sum of all flows from the other meter locations.

The following graph directly compares the two sets of data, it also includes the flows from FM2, which is the second flow meter installed on the trunk sewer.

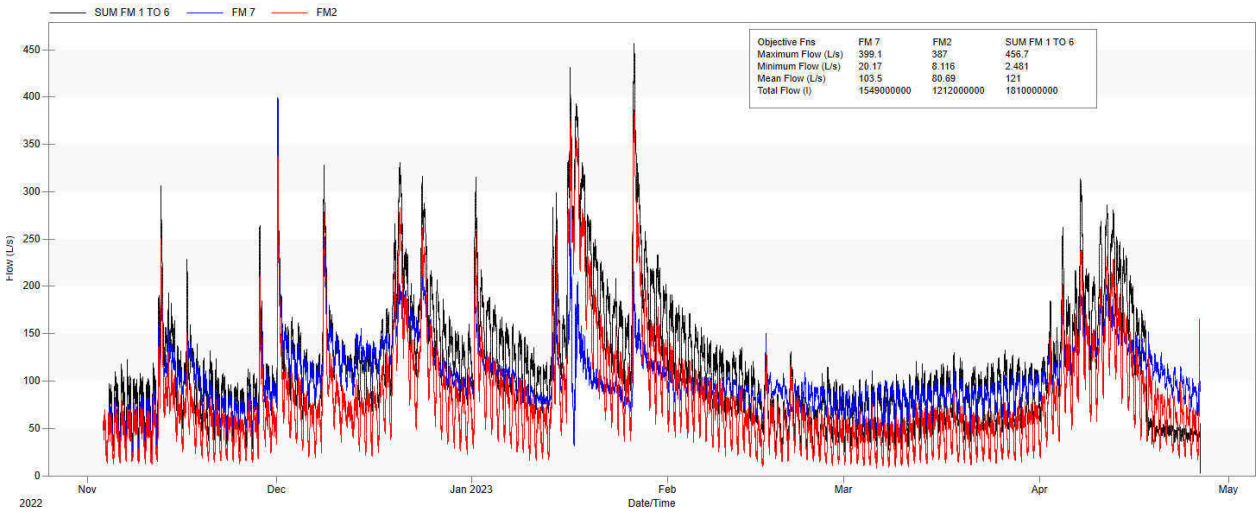


Figure 4 - Flow Meter Comparison

The following conclusions were drawn from the comparison:

- The overall flow volume (area under the curve) for the FM 1 through 6 data set was approximately 17% higher than the total flow at FM#7. This discrepancy is likely related to minor variances in meter calibration and hydraulics in the installed locations.
- FM#7 appears to have underestimated flows somewhat during peak wet-weather periods. The muted results could be caused by some unknown downstream restriction.
- There is no evidence of significant infiltration/inflow into the trunk sewer between FM#2 and FM#7.

Overall, the data as shown in **Figure 4** above, is shown to be reliable and therefore can be used to draw conclusions regarding the behaviour of the sewer infrastructure within the area of study.

2.5 Elevated Hydraulic Grade Line (HGL)

During the January 16th, 2023 event, which was a warm, wet-weather event, the depth of flow in all the flow meters peaked. The elevated hydraulic grade line (HGL) event that occurred during this period is shown in **Figure 5**.

The HGL refers to the level to which water rises under pressure in a system. When the HGL extends above the pipe system, it means the pipe is surcharged and operating in a pressurized state. A surcharged pipe system increases risks such as sewer backups and overflow events.

Surcharging events can be caused by a variety of factors, including heavy rainfall, snow melt, blockages in the system, or inadequate capacity.

During the study, an assessment was conducted on the HGL elevations compared to the manhole rim elevations. During the assessment, it was observed that the max HGL was recorded was 2.606m. In contrast the minimum manhole elevation was determined to be 2.669m. Therefore, while the system was surcharged, no manholes within the study area were overtopped during the period of analysis.

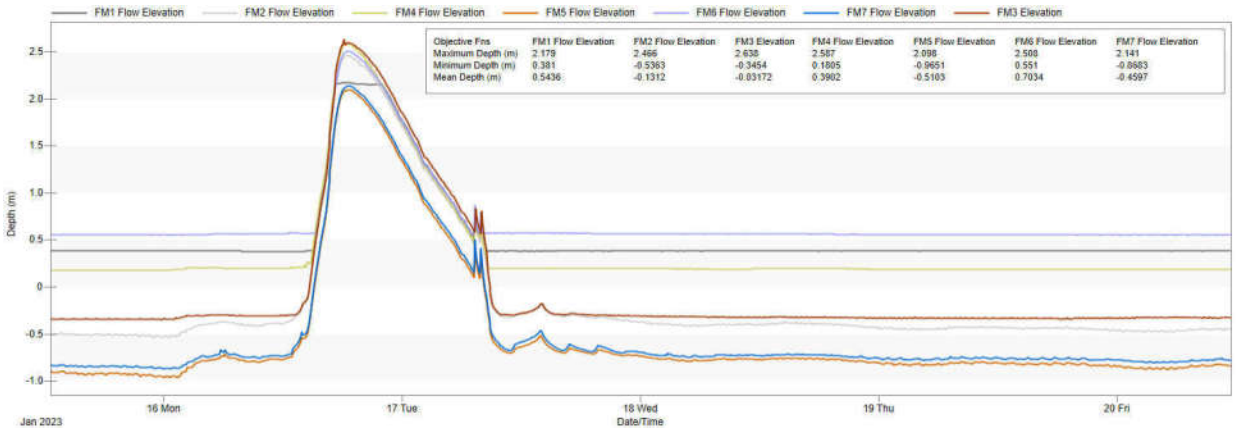


Figure 5 - Elevated HGL Event

3 Recommendations and Conclusions

Below are general conclusions made after carefully examining the flow meter data and precipitation information.

1) Generally, the RDII amounts in the various areas of study are at or above the maximum accepted guidelines as outlined in the Atlantic Canada Wastewater Guidelines Manual. (0.14 l/s/ha to 0.28 l/s/ha)
2) Additional investigation may be warranted in all sewersheds as the RDII contributions are above acceptable values, and are especially high in sewersheds #3 and #4.
3) It is suggested to work with the owners of Ocean Surf RV Park to further investigate the I&I issues within their sanitary infrastructure as shown in the results from FM 4 (Peak RDII of 2.46 L/s/ha.)
4) The January 16th surcharging event saw a significant increase in hydraulic grade line elevations in the trunk sewer system. This was associated with a significant flow event. A preliminary analysis of manhole rim elevations suggests that the HGL did not exceed the ground elevation.
5) The Inflow and Infiltration amounts listed for the two (2) trunk sewer flow meters may be artificially reduced, as the flow from the western end of the Town is limited somewhat by pumping capacity. It is therefore expected the I&I values would be higher than those shown in Section 2 if flow from these areas could be isolated. The additional meter locations proposed for the 2024 phase will refine our understanding of where the I&I amounts are originating in the trunk sewer system.

3.1 Next Steps

The Greater Shediac Sewerage Commission (GSSC) is committed to maintaining ongoing inflow and infiltration (I&I or RDII) reduction in the collection system. Inflow and infiltration consume a

considerable portion of the overall system capacity and therefore increase risks associated with system surcharging and can limit development activities in impacted areas.

By systematically reviewing primary connections along the trunk sewer, the Commission can prioritize service areas for further investigation and improvements. It is therefore recommended that the Commission continue this approach for the next phase of the I&I program.

Englobe has reviewed the collection system and identified twelve (12) locations which would result in a complete review of the trunk sewer and major connections. Furthermore, given FM#5 represented the most significant source of I&I identified in the current phase, two (2) monitoring locations are recommended in that branch.

Please refer to **Figure 6** below for the preliminary flow meter locations for Phase 3.

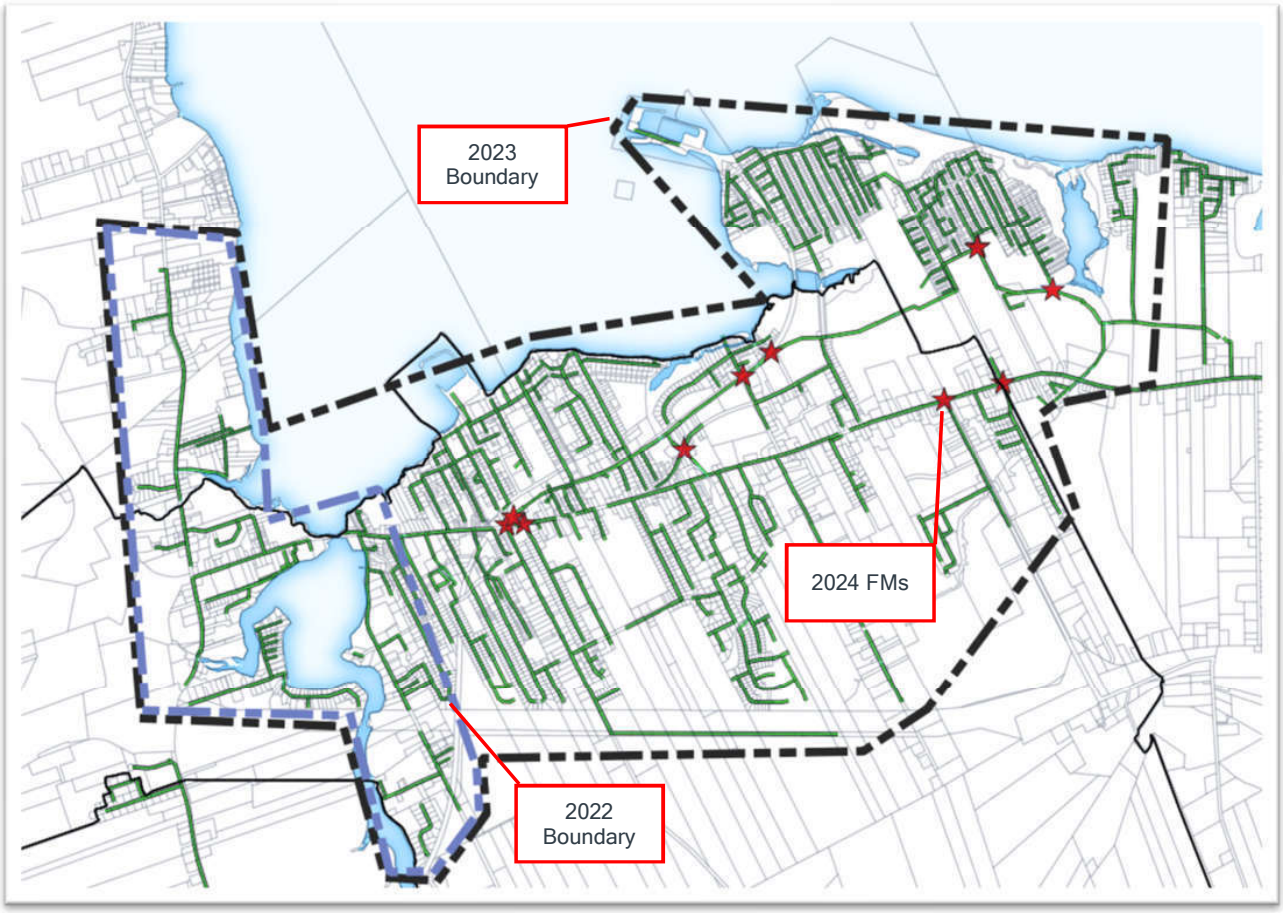


Figure 6 - Proposed FM Locations - Phase

Appendix A
Shediac Drainage Basin

ENGLOBE 10

LEGEND

FlowMeters

Flow Meters

Flowmeter 2023

SewerSheds

2023 Sewersheds

2023 FM1

2023 FM2

2023 FM3

2023 FM4

2023 FM5

2023 FM6

2023 FM7

Project Location:

Project Title:

Greater Shediac Sewerage Commission Inflow and Infiltration - 2023

Map Title:

Overall Site Plan -2023

Map ID:

MAP No: P100

PAGE No: 1 of 1

Revision

July 24, 2023 BY: CTP

Project # 2208729 APPR: CG

GREATER SHEDIAC SEWERAGE COMMISSION DES ÉGOUTS SHEDIAC ET BANLIEUES

LEGEND

FlowMeters

Flow Meters

Flowmeter 2023

Flowmeter 2022

Flow Meter Location 2024

SewerSheds

2023 Sewersheds

2023 FM1

2023 FM2

2023 FM3

2023 FM4

2023 FM5

2023 FM6

2023 FM7

2022 Sewersheds

2022 FM1

2022 FM2

2022 FM3

2022 FM4

2022 FM5

2022 FM6

Project Location:

Project Title:

Greater Shediac Sewerage Commission Inflow and Infiltration

Map Title:

Phase Plan

Map ID:

MAP No: P200

PAGE No: 1 of 1

Revision

July 2, 2023 BY: CTP

Project # 2208729 APPR: CG

GREATER SHEDIAC SEWERAGE COMMISSION DES ÉGOUTS SHEDIAC ET BANLIEUES

Appendix B Flow/Precipitation Data

Table 1 - Daily Summary of Precipitation and Flow Data

DATE	Precipitation (mm)	Daily Average Flow (l/s)						
		FM1	FM2	FM3	FM4	FM5	FM6	FM7
3-Nov	0.00	0.00000	49.40	5.38	0.00	27.99	0.63	61.34
4-Nov	0.00	0.00000	43.67	5.34	0.00	20.99	0.64	59.75
5-Nov	11.43	0.00000	44.70	5.15	0.00	20.62	0.66	60.34
6-Nov	10.92	0.00000	45.47	5.12	0.00	20.87	0.64	60.20
7-Nov	0.00	0.00000	47.68	5.20	0.00	23.34	0.64	62.19
8-Nov	0.00	0.00000	45.20	5.53	0.00	21.61	0.67	67.33
9-Nov	1.27	0.00000	45.20	5.65	0.00	22.28	0.65	69.60
10-Nov	0.00	0.00000	43.72	5.59	0.00	22.10	0.68	74.77
11-Nov	49.78	0.00000	45.11	5.70	0.00	21.85	0.98	165.05
12-Nov	7.87	0.00000	121.86	17.47	1.26	24.59	0.83	123.92
13-Nov	3.56	0.00000	87.48	9.92	0.29	44.60	0.87	119.16
14-Nov	3.30	0.00000	85.26	9.49	0.32	47.70	0.67	104.23
15-Nov	13.21	0.00000	62.45	6.41	0.02	33.85	0.77	121.76
16-Nov	0.51	0.00000	73.09	7.66	0.11	36.67	0.86	120.86
17-Nov	0.00	0.00000	69.62	7.38	0.17	43.78	0.78	104.33
18-Nov	0.00	0.00000	56.09	5.79	0.01	32.86	0.83	97.50
19-Nov	2.03	0.00000	48.36	5.57	0.00	28.65	0.90	83.98
20-Nov	0.00	0.00000	47.94	5.94	0.00	29.01	0.77	73.58
21-Nov	0.00	0.00000	44.98	5.67	0.00	25.68	0.72	73.88
22-Nov	0.00	0.00000	45.20	5.69	0.00	25.27	0.73	76.25
23-Nov	0.00	0.00000	45.07	5.65	0.00	20.98	0.69	71.18
24-Nov	3.56	0.00000	43.51	5.56	0.00	22.35	0.82	71.46
25-Nov	1.02	0.00000	41.50	5.78	0.00	21.27	0.96	78.10
26-Nov	15.49	0.00000	47.01	6.32	0.00	21.79	0.91	73.26
27-Nov	23.37	0.00000	45.02	6.22	0.00	22.20	1.28	125.46
28-Nov	0.00	0.00000	97.17	11.70	0.50	24.06	0.94	93.67
29-Nov	1.27	0.00000	58.68	5.93	0.05	31.76	1.11	89.15
30-Nov	0.00	0.00000	49.91	5.19	0.00	33.35	2.05	174.52
1-Dec	34.80	0.00000	165.77	14.86	1.50	24.33	1.51	135.82
2-Dec	0.00	0.00000	88.21	7.24	0.03	36.37	1.72	126.94
3-Dec	0.25	0.00000	73.95	6.36	0.00	40.55	1.58	122.79
4-Dec	3.05	0.00000	70.40	6.94	0.00	39.42	1.29	111.67
5-Dec	0.00	0.00000	59.61	6.13	0.00	34.81	1.33	106.92
6-Dec	0.00	0.00000	55.48	5.93	0.00	39.30	1.61	107.69
7-Dec	3.05	0.00000	55.38	6.04	0.00	39.55	2.45	209.86
8-Dec	27.18	0.00000	152.77	15.81	0.79	31.35	2.36	147.17
9-Dec	3.05	0.00000	104.83	10.64	0.21	35.08	2.15	134.35
10-Dec	47.75	0.00000	78.18	9.03	0.04	40.19	2.07	123.62
11-Dec	0.00	0.00000	69.36	8.35	0.00	41.20	1.99	112.35
12-Dec	0.00	0.00000	65.19	8.00	0.01	41.72	1.87	137.29
13-Dec	0.00	0.00000	68.06	8.64	0.00	39.19	1.56	129.28
14-Dec	0.00	0.00000	61.91	8.47	0.00	35.70	1.42	131.16
15-Dec	5.59	0.00000	63.83	8.69	0.01	33.70	1.36	125.34
16-Dec	0.00	0.00000	64.51	9.11	0.03	33.92	1.52	139.96
17-Dec	3.81	0.00000	76.20	12.03	0.43	33.38	1.81	138.73
18-Dec	0.76	0.00000	88.00	13.05	0.36	33.06	2.12	164.87
19-Dec	27.43	0.00000	126.67	15.85	0.54	31.04	3.06	186.16
20-Dec	9.14	0.00000	212.32	21.04	0.98	28.01	2.73	173.23
21-Dec	0.00	0.00000	161.47	13.61	0.25	32.80	2.30	161.24
22-Dec	0.00	0.00000	114.36	10.88	0.07	38.17	2.59	155.26
23-Dec	7.62	0.00000	110.67	11.60	0.03	39.28	3.31	175.45
24-Dec	10.67	0.00000	205.21	16.08	0.46	30.91	2.65	140.55
25-Dec	0.00	0.00000	123.37	10.83	0.08	43.29	2.51	120.90
26-Dec	0.00	0.00000	100.36	9.98	0.02	47.53	2.21	116.80
27-Dec	0.00	0.00000	83.83	9.20	0.00	44.31	2.16	107.67
28-Dec	0.00	0.00000	74.98	8.76	0.00	45.41	2.18	102.92
29-Dec	0.00	0.00000	69.92	8.40	0.00	48.42	2.25	98.45
30-Dec	4.06	0.00000	66.23	8.28	0.00	39.91	2.29	99.78
31-Dec	0.00	0.00000	68.75	8.78	0.00	38.62	3.10	160.22
1-Jan	22.35	0.00000	139.34	16.66	0.65	35.61	2.93	121.58
2-Jan	0.51	0.00000	120.88	12.24	0.28	38.98	2.53	119.28
3-Jan	1.52	0.00000	99.63	9.50	0.07	46.48	2.49	113.11
4-Jan	3.30	0.00000	90.94	9.41	0.07	44.14	2.39	110.13
5-Jan	0.00	0.00000	80.63	8.64	0.02	42.23	2.49	108.17
6-Jan	0.00	0.00000	76.61	8.08	0.00	42.33	2.46	104.63
7-Jan	0.00	0.00000	68.48	7.92	0.00	41.56	2.40	95.64
8-Jan	0.00	0.00000	68.04	7.78	0.00	39.86	2.45	89.40
9-Jan	0.00	0.00000	61.82	7.61	0.00	39.52	2.16	86.57
10-Jan	0.00	0.00000	57.14	8.26	0.00	38.56	2.04	81.05
11-Jan	0.00	0.00000	51.34	7.36	0.00	36.24	1.94	79.04

Table 1 - Daily Summary of Precipitation and Flow Data

DATE	Precipitation (mm)	Daily Average Flow (l/s)						
		FM1	FM2	FM3	FM4	FM5	FM6	FM7
12-Jan	0.00	0.00000	50.72	7.17	0.00	35.96	2.35	106.56
13-Jan	37.34	0.00000	85.78	11.55	0.44	35.30	2.93	117.81
14-Jan	1.78	0.00000	141.84	16.29	0.62	32.36	2.48	100.21
15-Jan	0.00	0.00000	83.63	8.86	0.04	41.87	5.68	178.13
16-Jan	24.13	0.02250	263.16	19.11	1.49	21.26	6.88	165.95
17-Jan	12.95	0.01372	306.51	21.47	0.92	1.16	4.04	126.34
18-Jan	2.54	0.00000	254.12	17.54	0.57	20.61	3.30	107.82
19-Jan	1.02	0.00000	198.25	13.47	0.37	32.85	2.93	99.64
20-Jan	0.00	0.00000	160.35	14.19	0.23	39.44	2.66	93.52
21-Jan	0.00	0.00000	127.33	12.54	0.15	47.21	2.48	91.92
22-Jan	0.00	0.00000	109.09	11.17	0.10	45.89	2.48	95.03
23-Jan	0.00	0.00000	106.85	9.32	0.08	45.59	2.30	82.91
24-Jan	0.00	0.00000	95.43	9.44	0.04	45.22	2.20	78.44
25-Jan	0.51	0.00000	82.69	9.02	0.00	43.47	3.29	163.87
26-Jan	54.86	0.00000	207.01	20.05	1.42	31.25	3.91	136.48
27-Jan	0.00	0.00000	230.78	16.61	0.47	34.15	3.14	120.64
28-Jan	0.25	0.00000	157.21	10.13	0.14	43.12	2.91	114.19
29-Jan	0.00	0.00000	126.05	9.00	0.08	49.17	2.74	111.84
30-Jan	0.00	0.00000	125.41	8.95	0.05	48.97	2.61	105.93
31-Jan	0.00	0.00000	113.15	8.16	0.01	46.97	2.49	100.25
1-Feb	0.25	0.00000	99.40	7.40	0.00	44.58	2.35	92.50
2-Feb	0.00	0.00000	90.19	7.77	0.00	48.04	2.21	97.94
3-Feb	0.00	0.00000	89.79	8.24	0.00	41.83	2.02	101.36
4-Feb	0.00	0.00000	83.30	7.82	0.00	36.88	1.96	98.63
5-Feb	0.00	0.00000	81.96	7.15	0.00	36.02	1.97	94.75
6-Feb	0.00	0.00000	78.43	8.01	0.00	33.96	1.83	98.50
7-Feb	0.00	0.00000	72.49	8.32	0.00	32.15	1.88	89.95
8-Feb	2.03	0.00000	67.13	7.24	0.02	32.18	1.63	94.35
9-Feb	0.00	0.00000	68.15	7.36	0.03	30.58	1.73	101.86
10-Feb	0.00	0.00000	61.88	6.98	0.04	29.99	1.54	98.17
11-Feb	0.00	0.00000	62.45	7.02	0.00	30.82	1.65	91.05
12-Feb	4.06	0.00000	61.74	7.14	0.00	32.22	1.60	89.81
13-Feb	0.00	0.00000	51.75	7.19	0.00	31.63	1.48	83.44
14-Feb	0.00	0.00000	50.17	7.57	0.00	30.01	1.39	80.87
15-Feb	1.78	0.00000	36.97	7.46	0.00	29.19	1.95	102.46
16-Feb	0.00	0.00000	65.54	9.66	1.05	29.14	1.94	87.21
17-Feb	0.00	0.00000	54.17	6.54	0.04		1.75	93.31
18-Feb	0.00	0.00000	46.10	6.43	0.00		1.75	89.82
19-Feb	3.81	0.00000	44.35	6.70	0.00		2.03	69.49
20-Feb	3.05	0.00000	65.14	8.86	0.41		1.95	88.60
21-Feb	0.00	0.00000	59.61	8.46	0.05		1.89	93.61
22-Feb	0.00	0.00000	50.87	7.54	0.00		1.66	87.07
23-Feb	2.29	0.00000	43.13	6.91	0.00		1.62	87.25
24-Feb	0.00	0.00000	43.05	6.73	0.00		1.51	87.80
25-Feb	0.00	0.00000	41.76	6.84	0.00	27.78	1.42	81.18
26-Feb	0.00	0.00000	42.45	7.37	0.00	25.29	1.51	77.81
27-Feb	0.00	0.00000	37.35	7.06	0.00	24.37	1.41	76.43
28-Feb	0.00	0.00000	37.85	6.78	0.00	23.41	1.46	76.10
1-Mar	0.25	0.00000	38.87		0.00	23.46	1.43	75.46
2-Mar	0.00	0.00000	38.44		0.00	24.81	1.48	81.11
3-Mar	7.87	0.00000	38.41		0.00	24.64	1.41	78.57
4-Mar	1.78	0.00000	37.27	6.78	0.00	24.20	1.53	78.23
5-Mar	0.25	0.00000	38.55	6.93	0.00	23.37	1.56	87.99
6-Mar	2.03	0.00000	37.37	7.08	0.00	23.55	1.58	90.74
7-Mar	0.51	0.00000	35.82	7.06	0.00	24.63	1.45	85.58
8-Mar	1.78	0.00000	34.48	7.38	0.00	26.09	1.25	85.92
9-Mar	0.00	0.00000	35.44	7.36	0.00	25.46	1.26	82.11
10-Mar	0.00	0.00000	37.34	7.16	0.00	25.06	1.07	81.29
11-Mar	0.00	0.00000	38.57	8.04	0.00	24.09	1.05	84.56
12-Mar	0.00	0.00000	44.32	8.54	0.00	27.30	1.03	83.32
13-Mar	0.00	0.00000	44.07	7.81	0.00	26.81	1.20	82.53
14-Mar	0.00	0.00000	44.48	6.79	0.00	26.65	1.18	90.58
15-Mar	3.56	0.00000	49.07	7.03	0.00	27.31	1.04	85.68
16-Mar	0.00	0.00000	48.18	7.30	0.00	29.26	1.23	89.53
17-Mar	11.43	0.00000	47.84	7.69	0.00	32.02	1.29	90.25
18-Mar	1.27	0.00000	49.73	8.18	0.00	29.36	1.28	91.63
19-Mar	0.51	0.00000	46.15	7.47	0.03	33.40	1.19	84.46
20-Mar	0.00	0.00000	40.45	6.68	0.01	28.37	1.26	85.26
21-Mar	0.00	0.00000	42.07	6.54	0.00	34.26	1.33	85.63
22-Mar	0.25	0.00000	41.88	6.43	0.00	34.28	1.32	85.68

Table 1 - Daily Summary of Precipitation and Flow Data

DATE	Precipitation (mm)	Daily Average Flow (l/s)						
		FM1	FM2	FM3	FM4	FM5	FM6	FM7
23-Mar	0.00	0.00000	42.85	6.36	0.00	34.19	1.24	90.41
24-Mar	8.64	0.00000	42.02	6.32	0.00	38.13	1.52	89.40
25-Mar	4.06	0.00000	42.39	6.84	0.00	35.50	1.38	91.53
26-Mar	0.00	0.00000	47.41	6.58	0.00	36.24	1.29	96.76
27-Mar	17.78	0.00000	46.28	6.72	0.00	36.35	1.28	96.69
28-Mar	0.00	0.00000	48.29	6.57	0.00	34.70	1.27	97.98
29-Mar	0.00	0.00000	50.04	6.98	0.00	30.72	1.13	102.48
30-Mar	0.00	0.00000	51.92	7.46	0.00	32.54	1.09	98.79
31-Mar	3.56	0.00000	54.55	7.63	0.00	28.65	1.38	105.97
1-Apr	5.08	0.00000	59.42	8.48	0.00	28.81	1.39	122.31
2-Apr	0.25	0.00000	81.00	11.83	0.15	31.27	1.27	110.06
3-Apr	0.00	0.00000	74.88	10.78	0.10	32.28	1.74	155.31
4-Apr	0.00	0.00000	112.33	16.30	0.80	31.81	1.62	126.88
5-Apr	0.00	0.00000	109.84	13.38	0.20	28.08	2.01	139.23
6-Apr	12.45	0.00000	113.76	12.42	0.27	31.03	2.82	177.29
7-Apr	0.00	0.00000	163.88	20.55	2.36	29.96	2.25	148.63
8-Apr	0.00	0.00000	138.53	15.31	0.18	33.86	2.54	143.45
9-Apr	0.00	0.00000	114.19	14.82	0.13	36.28	3.92	167.23
10-Apr	0.00	0.00000	136.93	19.08	0.36	35.84	4.44	183.19
11-Apr	0.00	0.00000	168.39	18.02	0.55	31.15	4.09	166.23
12-Apr	0.00	0.00000	178.54	17.80	0.44	30.33	3.45	154.28
13-Apr	0.00	0.00000	155.17	16.87	0.27	34.50	3.30	142.65
14-Apr	0.00	0.00000	135.98	19.05	0.11	42.98	3.07	135.39
15-Apr	0.00	0.00000	108.20	17.09	0.00	49.41	2.97	131.13
16-Apr	0.00	0.00000	96.66	12.18	0.00	45.46	2.98	122.83
17-Apr	0.00	0.00000	80.92	11.79	0.00	47.19	3.01	121.14
18-Apr	0.00	0.00000	81.51		0.00	50.50	2.81	112.74
19-Apr	5.08	0.00000	68.30		0.00	47.43	2.73	106.49
20-Apr	1.52	0.00000	64.49		0.00	47.32	2.46	100.06
21-Apr	0.00	0.00000	63.19		0.00	47.51	2.52	95.67
22-Apr	0.00	0.00000	54.56		0.00	44.36	2.48	96.67
23-Apr	0.00	0.00000	55.72		0.00	43.55	2.50	92.02
24-Apr	0.00	0.00000	52.86		0.00	41.79	2.43	88.57
25-Apr	0.00	0.00000	49.27		0.00	42.82		

Complete Data Set							
Peak Daily (l/s)	2.2	404.3	42.86	23.83	81.38	17.83	440.6
Average Dry Weather (l/s)	0	45.26	6.4	0.0008	22.82	1.23	80.38
Total Flow (cu.m)	3	1,212,000	130,600	2,116	484,500	28,830	1,549,000
Peak RDII (l/s)	0	318.60	33.03	14.75	48.83	10.66	290.6
Volume RDII (cu.m)	0	79,400	5,721	2,111	32,550	768	96,450

December 1 Event							
Peak Flow (l/s)	0	357.4	30.19	23.83	42.55	3.87	440.6
Total Flow (cu.m)	0	14,360	1,287	130	2,114	177.9	16,540
Peak RDII (l/s)	0	307.9	23.98	14.75	18.18	2.20	290.6
Volume RDII (cu.m)	0	10,420	781	130	408	76.20	9,822

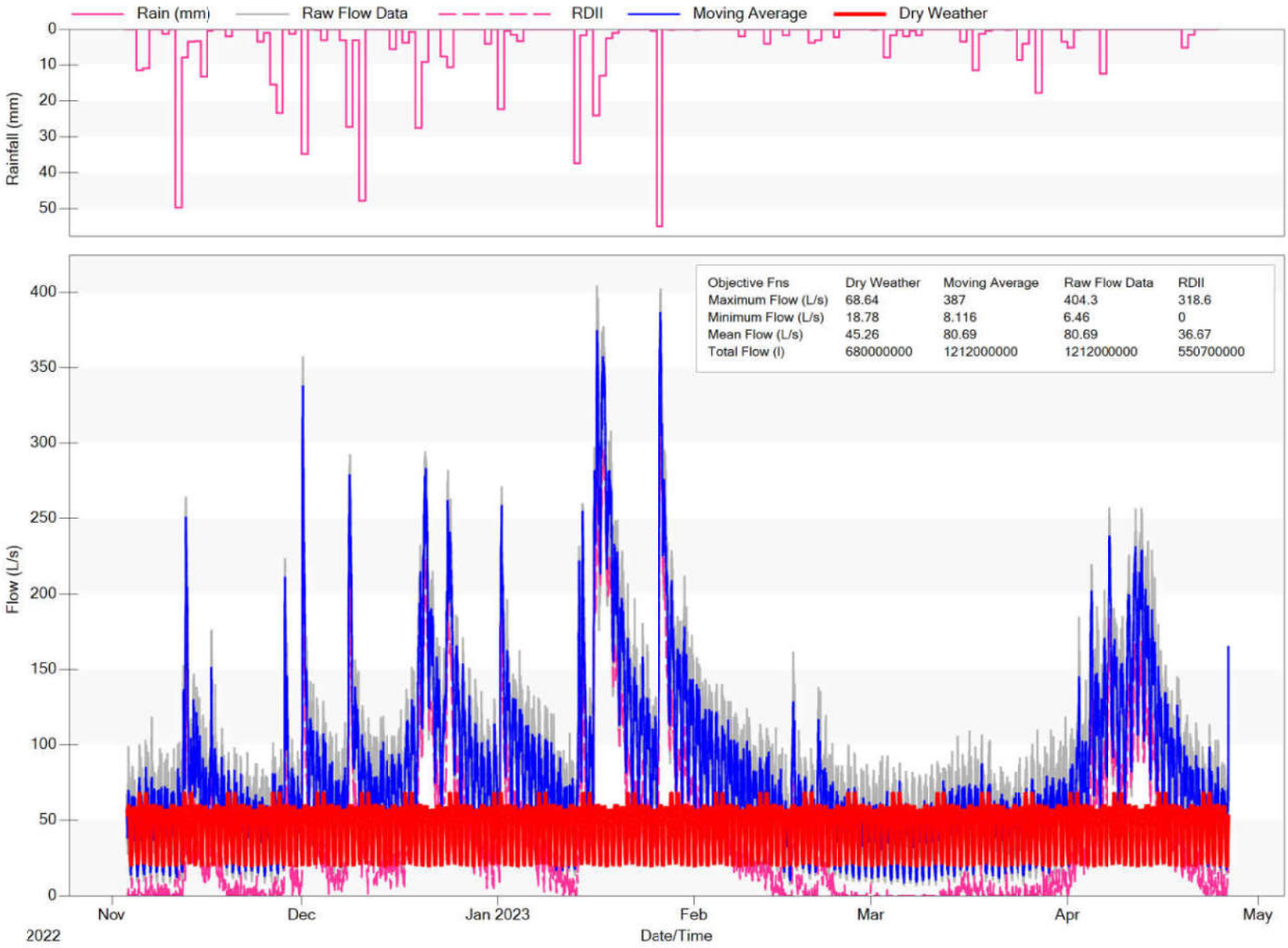
January 16 Event							
Peak Flow (l/s)	2.2	404.3	37.19	11.78	58.61	12.27	316.5
Total Flow (cu.m)	1.944	22,890	1,652	129	1,818	496.2	13,670
Peak RDII (l/s)	0	304.5	25.82	4.86	35	9.78	186.7
Volume RDII (cu.m)	0	18,950	1,102	129	543	39.17	6,861

Appendix C Flow Meter Graphs

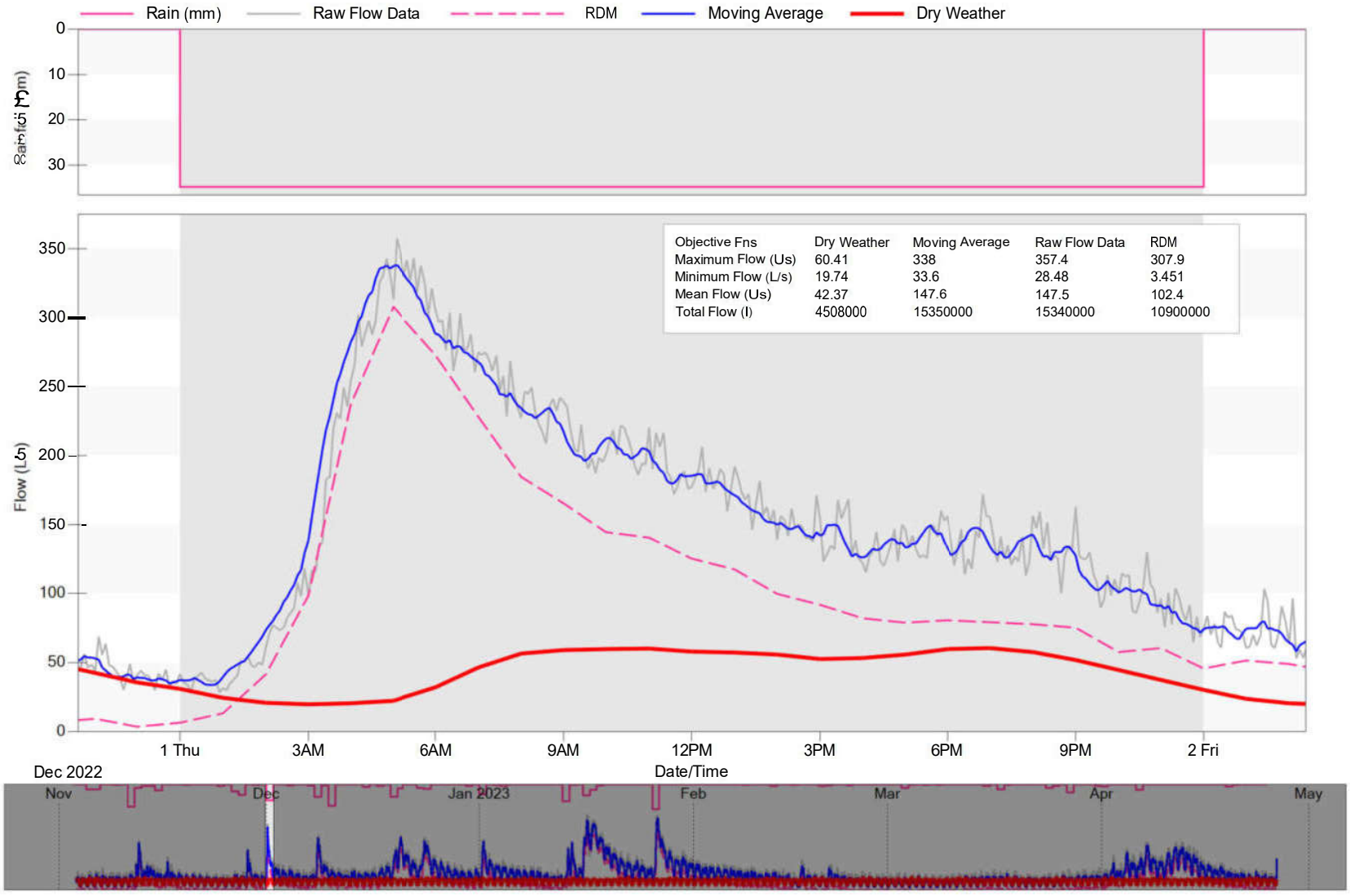
ENGLOBE

FLOW METER 1 - MH 49 SOUTH
OVERALL

FLOW METER 2 - MH 49 NORTH
OVERALL

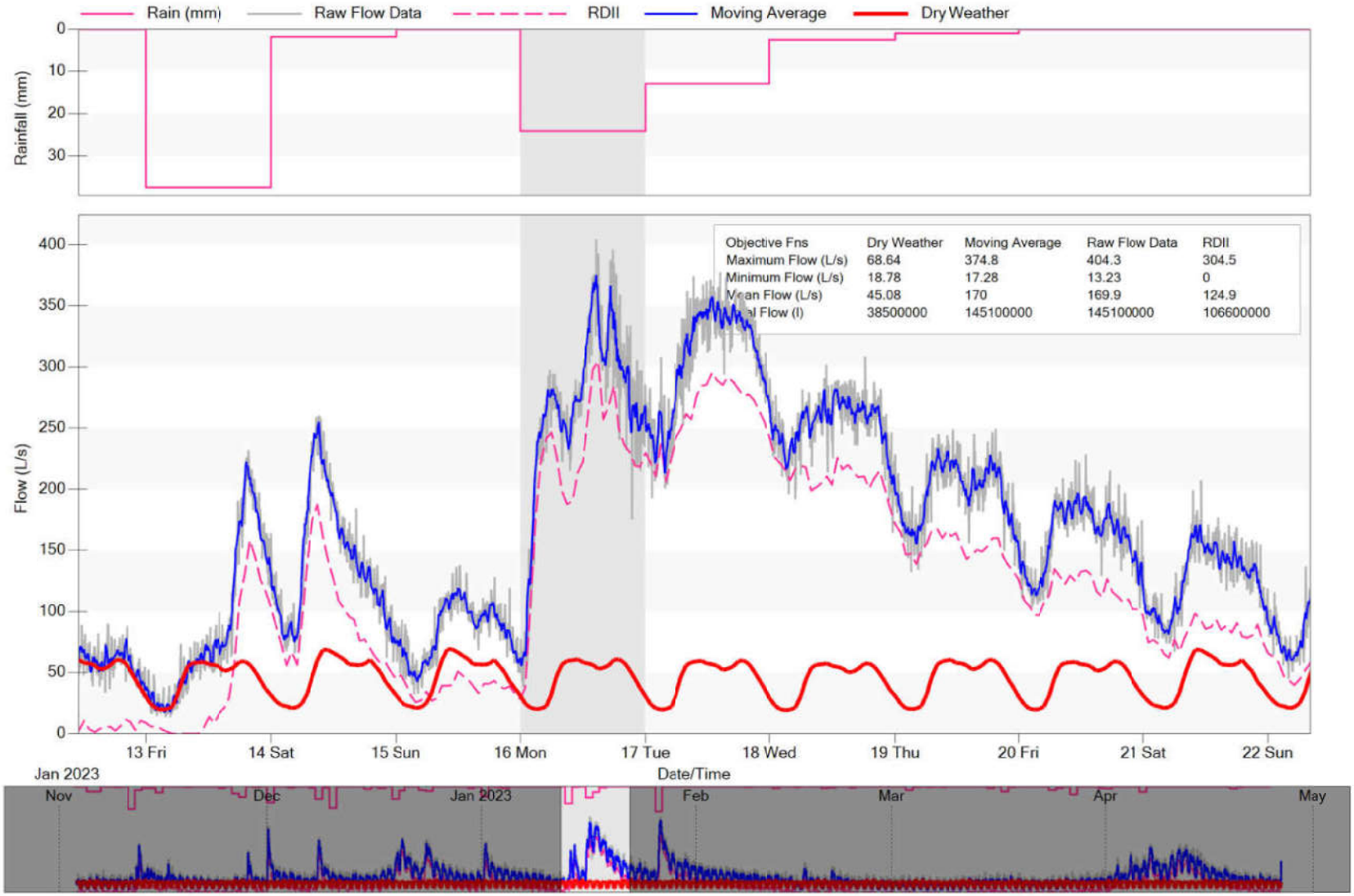


FLOW METER 2 - MH 49 NORTH
DECEMBER 1 EVENT



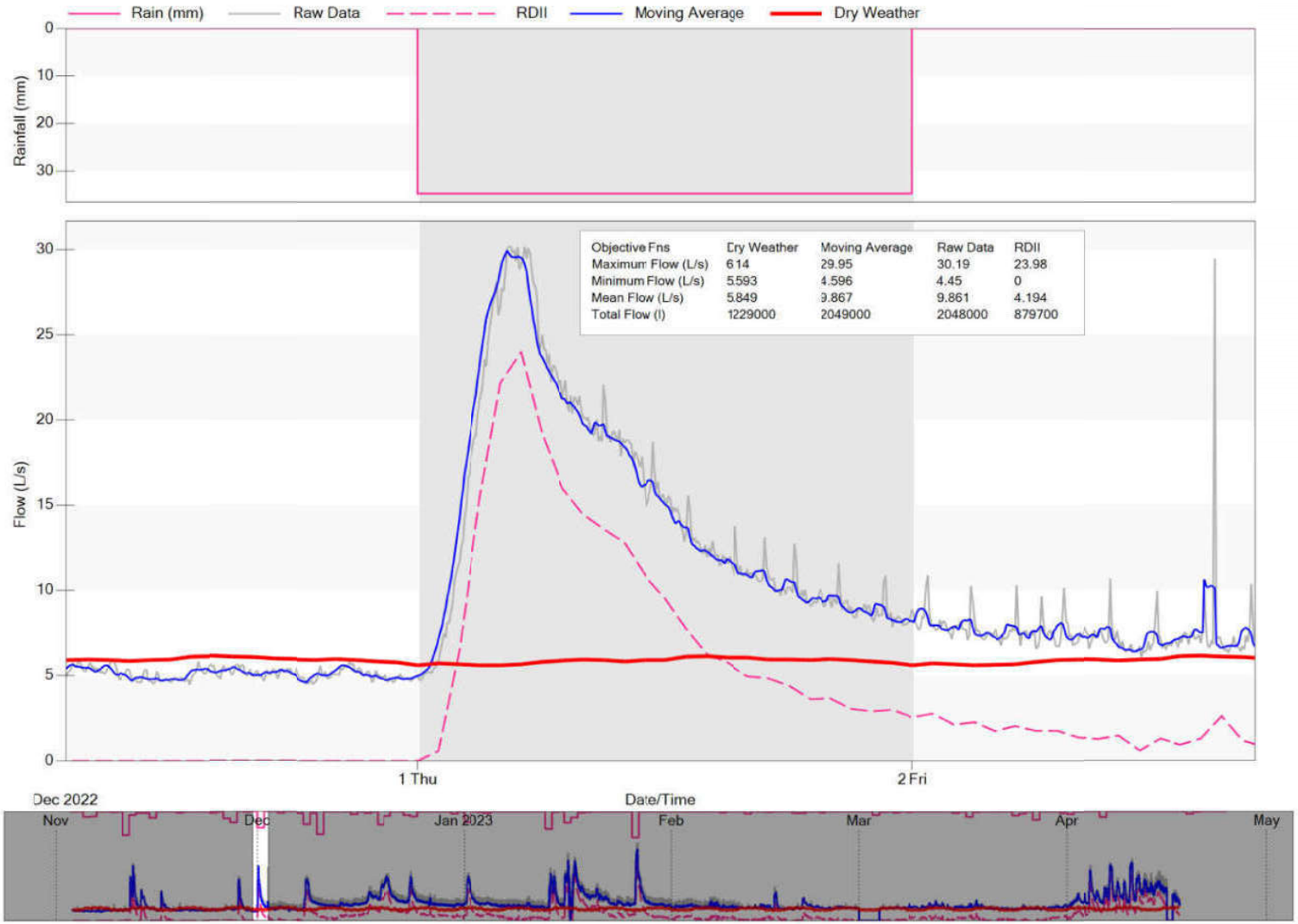
Objective Fns	Dry Weather	Moving Average	Raw Flow Data	RDM
Maximum Flow (Us)	60.41	338	357.4	307.9
Minimum Flow (L/s)	19.74	33.6	28.48	3.451
Mean Flow (Us)	42.37	147.6	147.5	102.4
Total Flow (l)	4508000	15350000	15340000	10900000

FLOW METER 2 - MH 49 SOUTH
JANUARY 16 EVENT



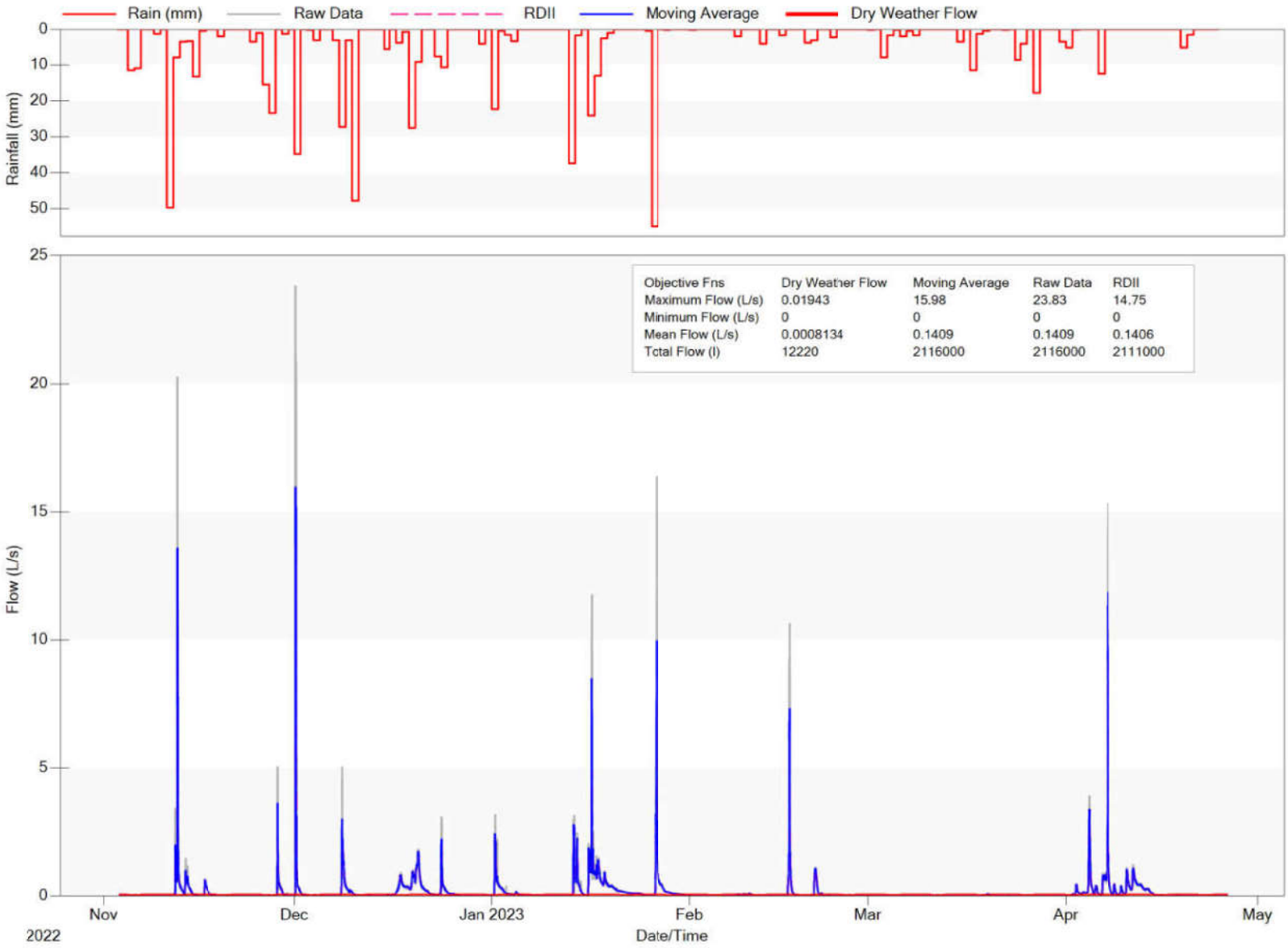
FLOW METER 3 - MH 49 WEST
OVERALL

FLOW METER 3 - MH 49 WEST
DECEMBER 1 EVENT

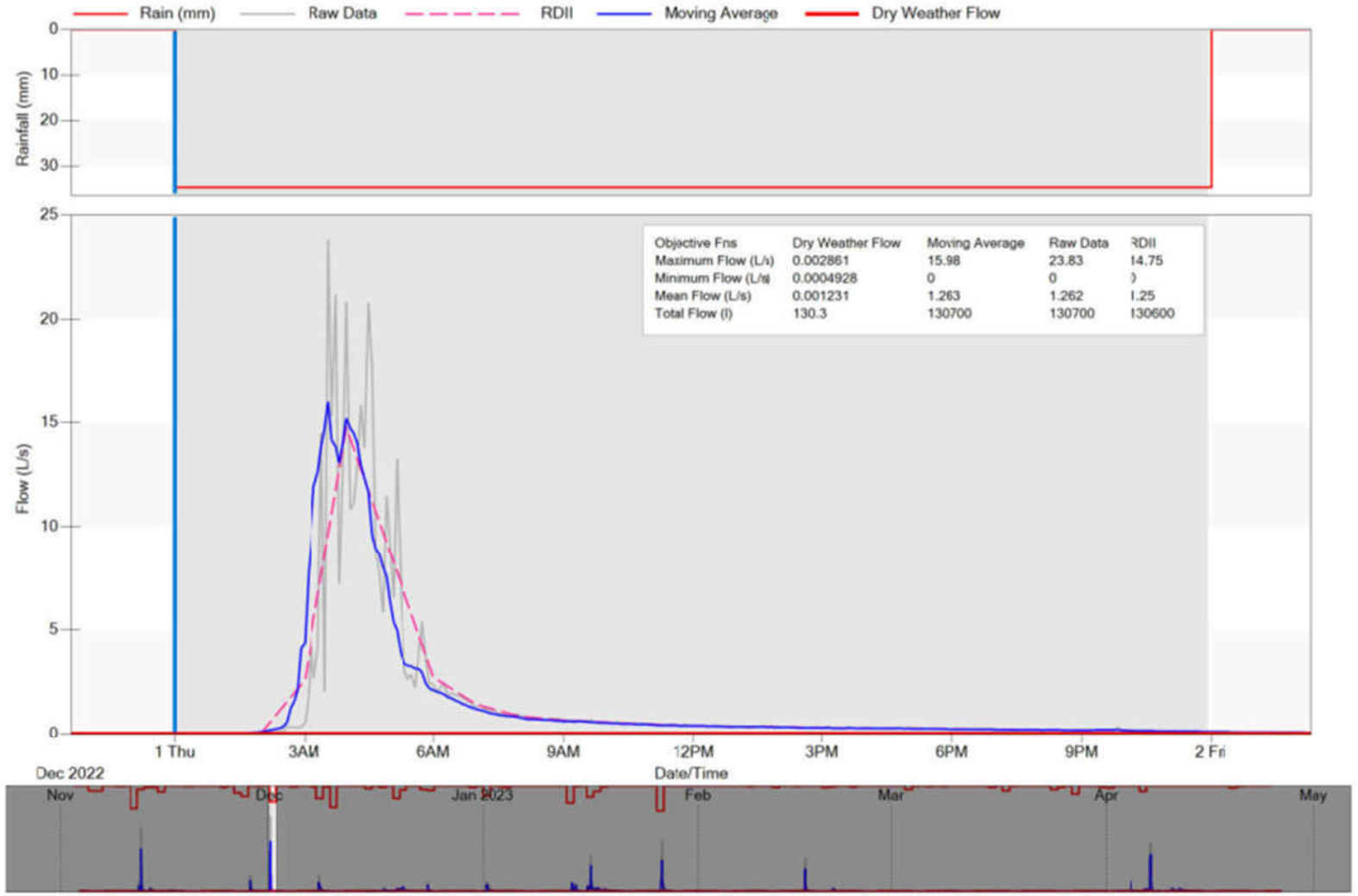


FLOW METER 3 - MH 49 WEST
JANUARY 16 EVENT

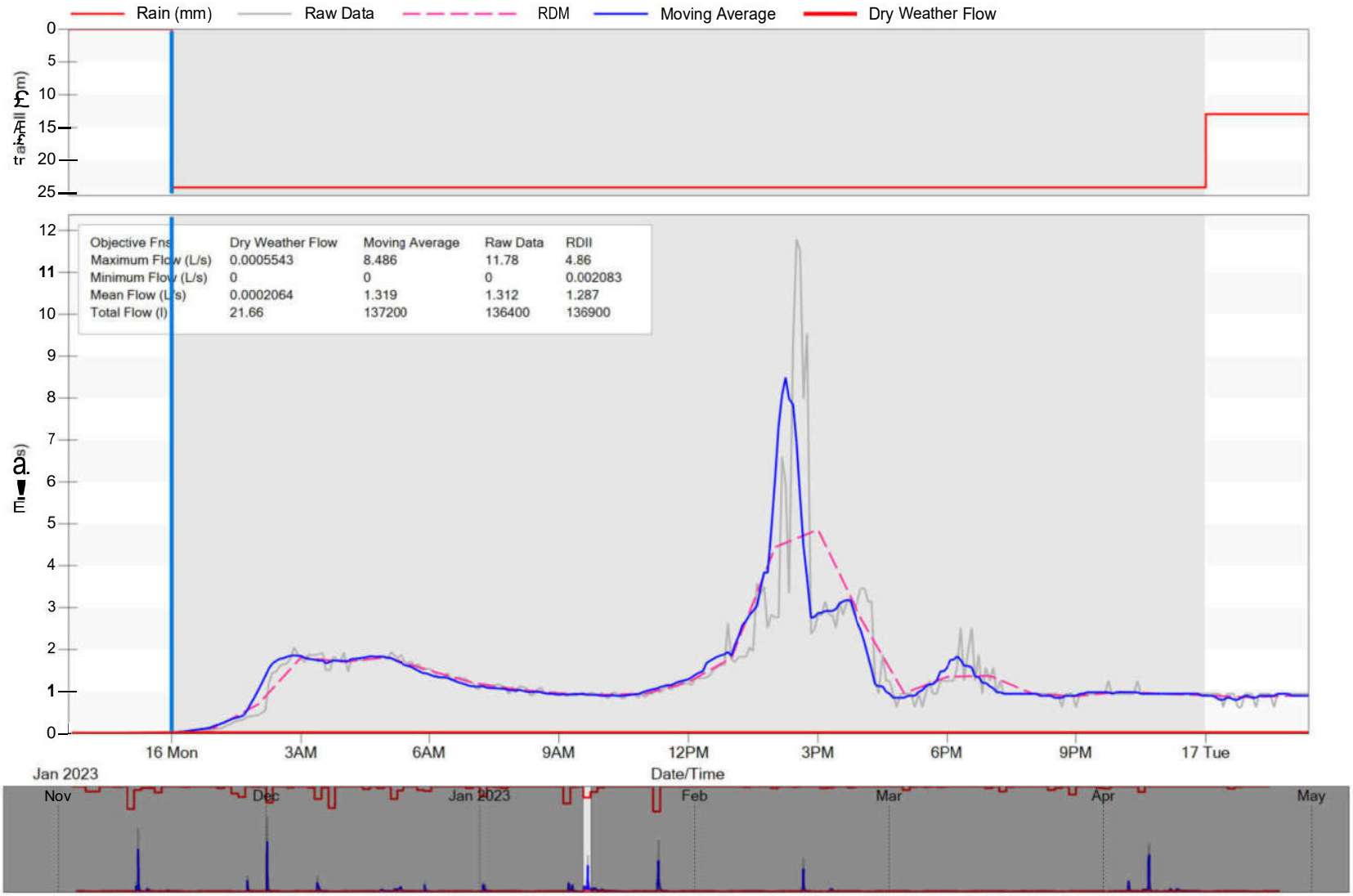
FLOW METER 4 - MH 51 SOUTH
OVERALL



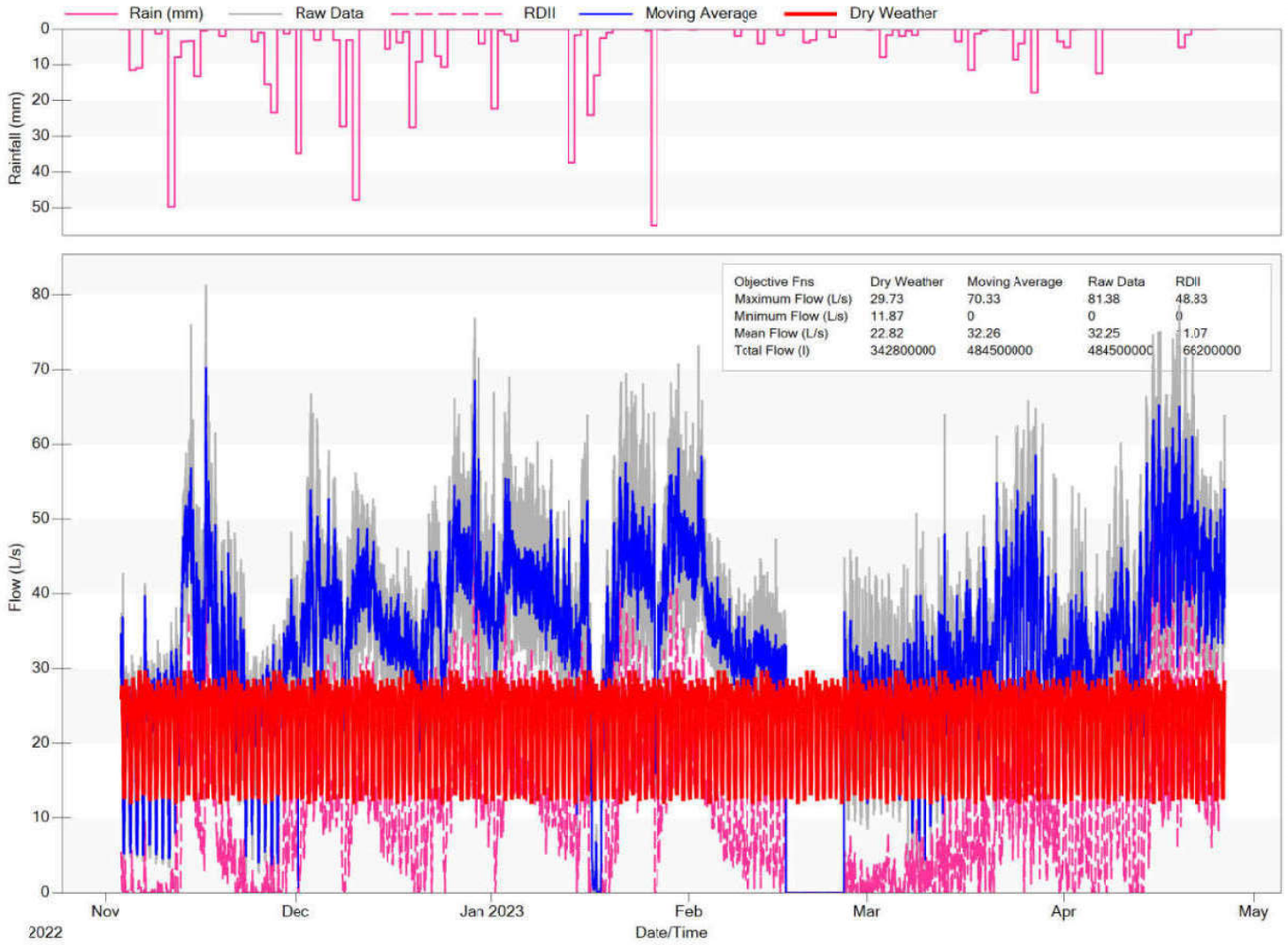
FLOW METER 4 - MH 51 SOUT
DECEMBER 1 - EVENT



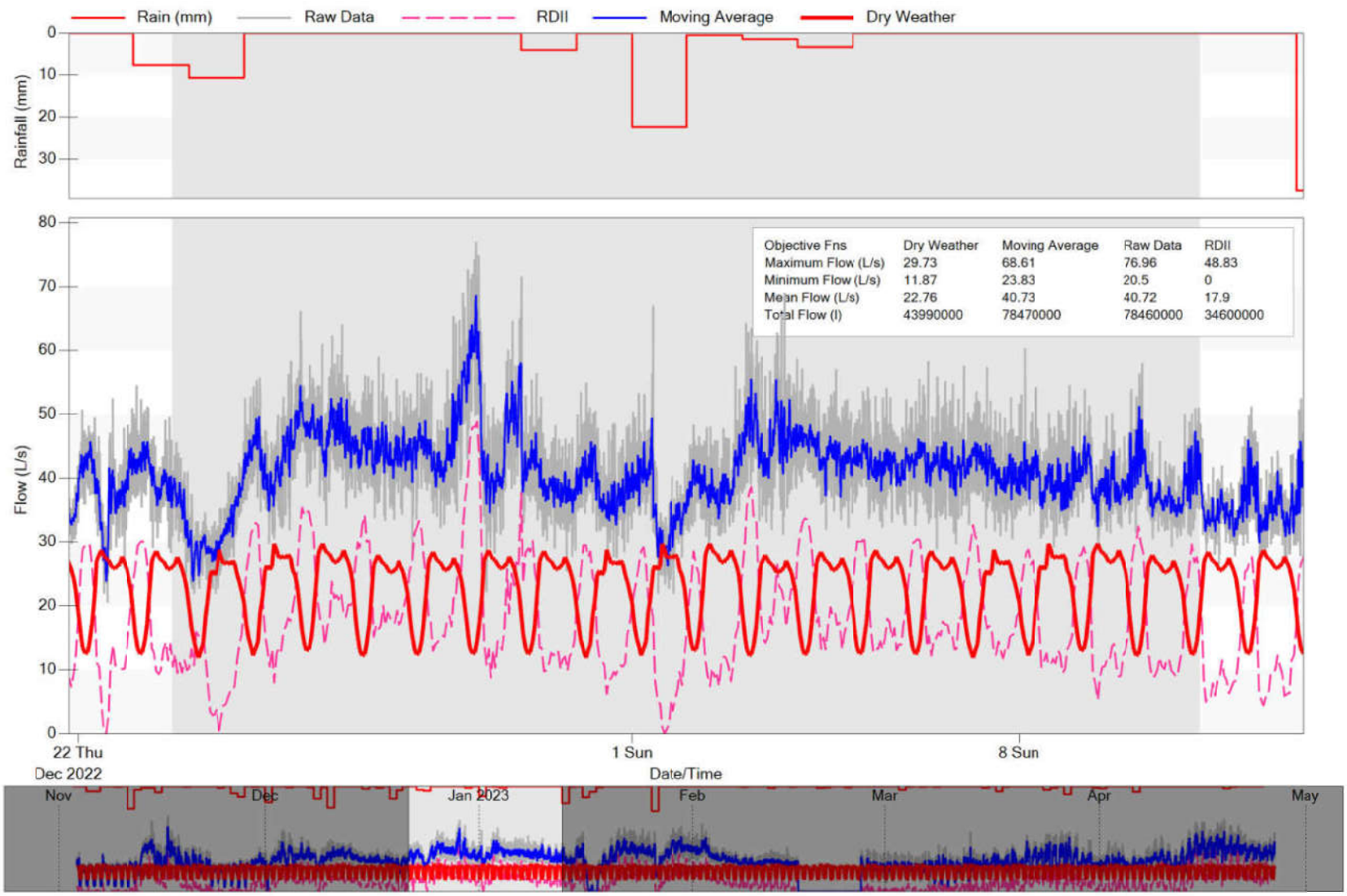
FLOW METER 4 - MH 51 SOUTH
JANUARY 16 EVENT



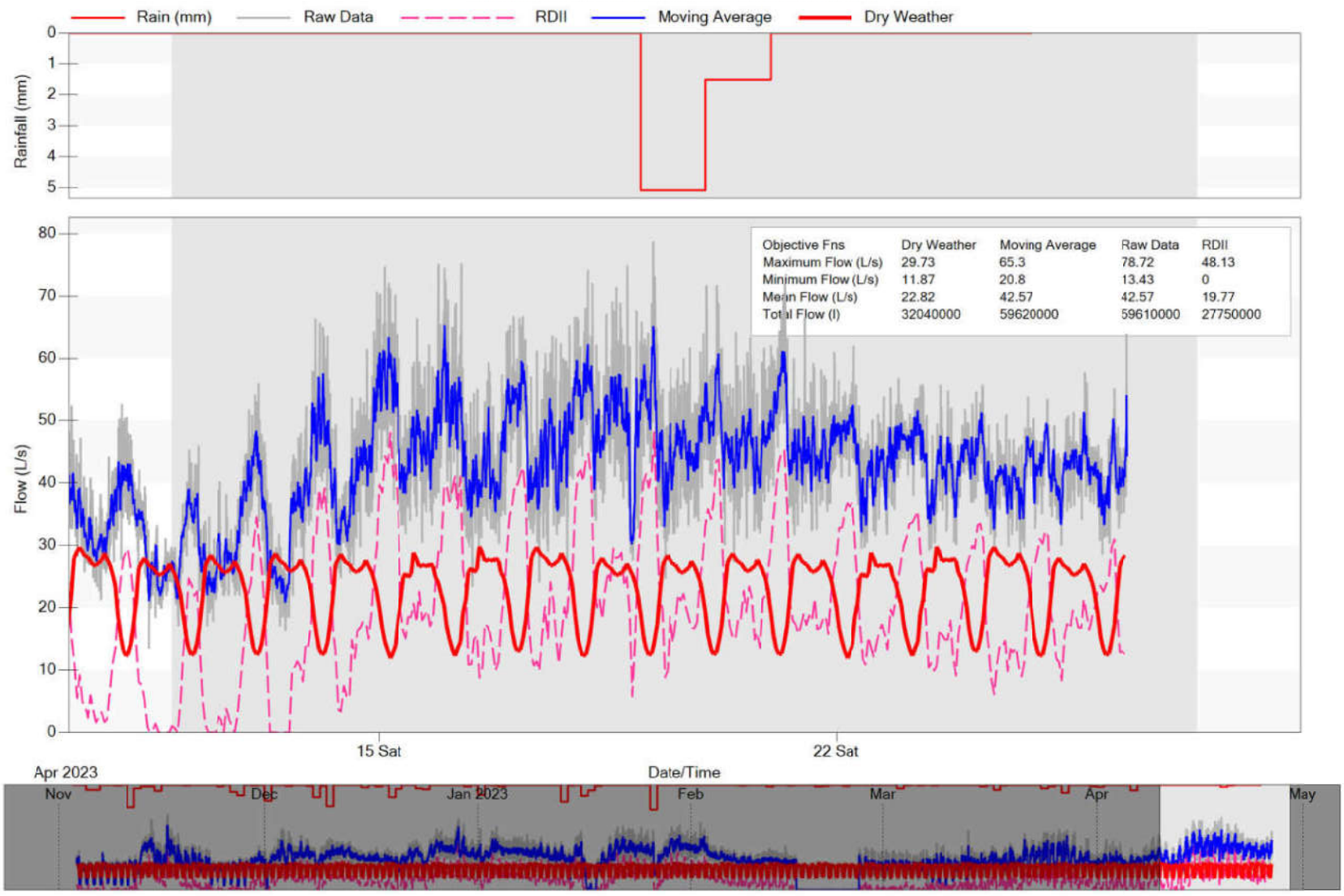
FLOW METER 5 - MH 54 SOUTHEAST
OVERALL



FLOW METER 5 - MH 54 SOUTHEAST
DECEMBER EVENT

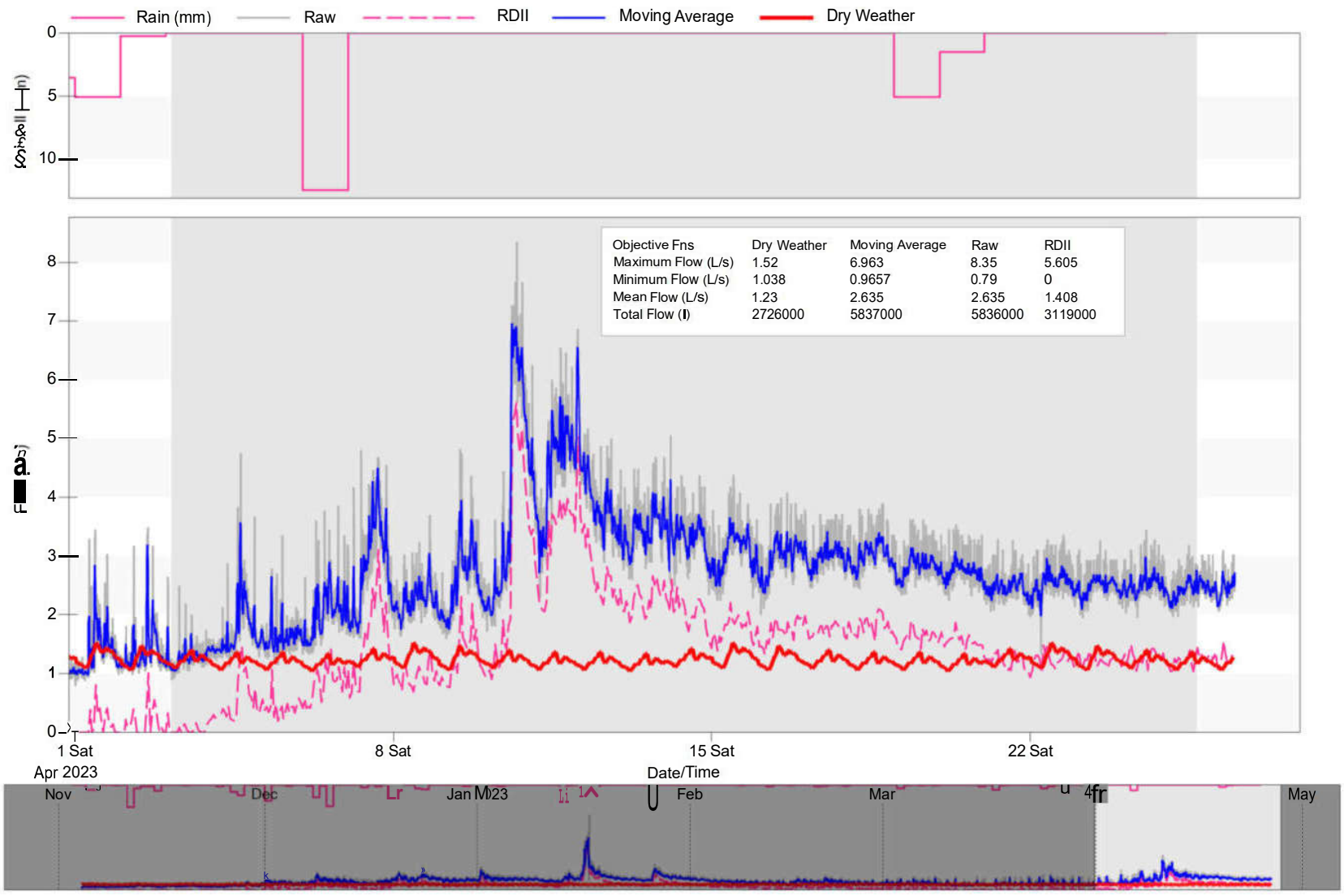


FLOW METER 5 - MH 54 SOUTHEAST
APRIL EVENT

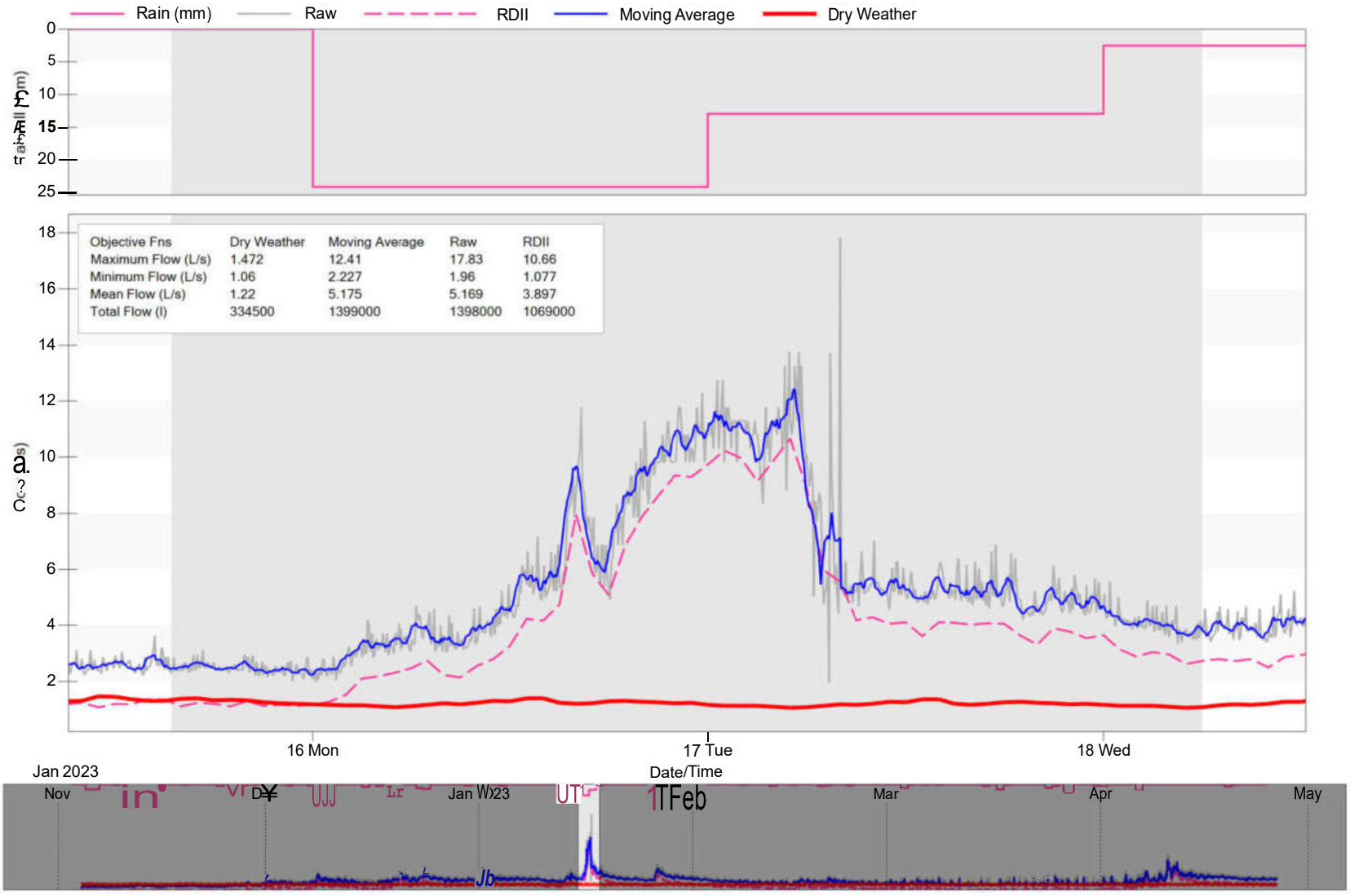


FLOW METER 6 - MH 58 NORTH
OVERALL

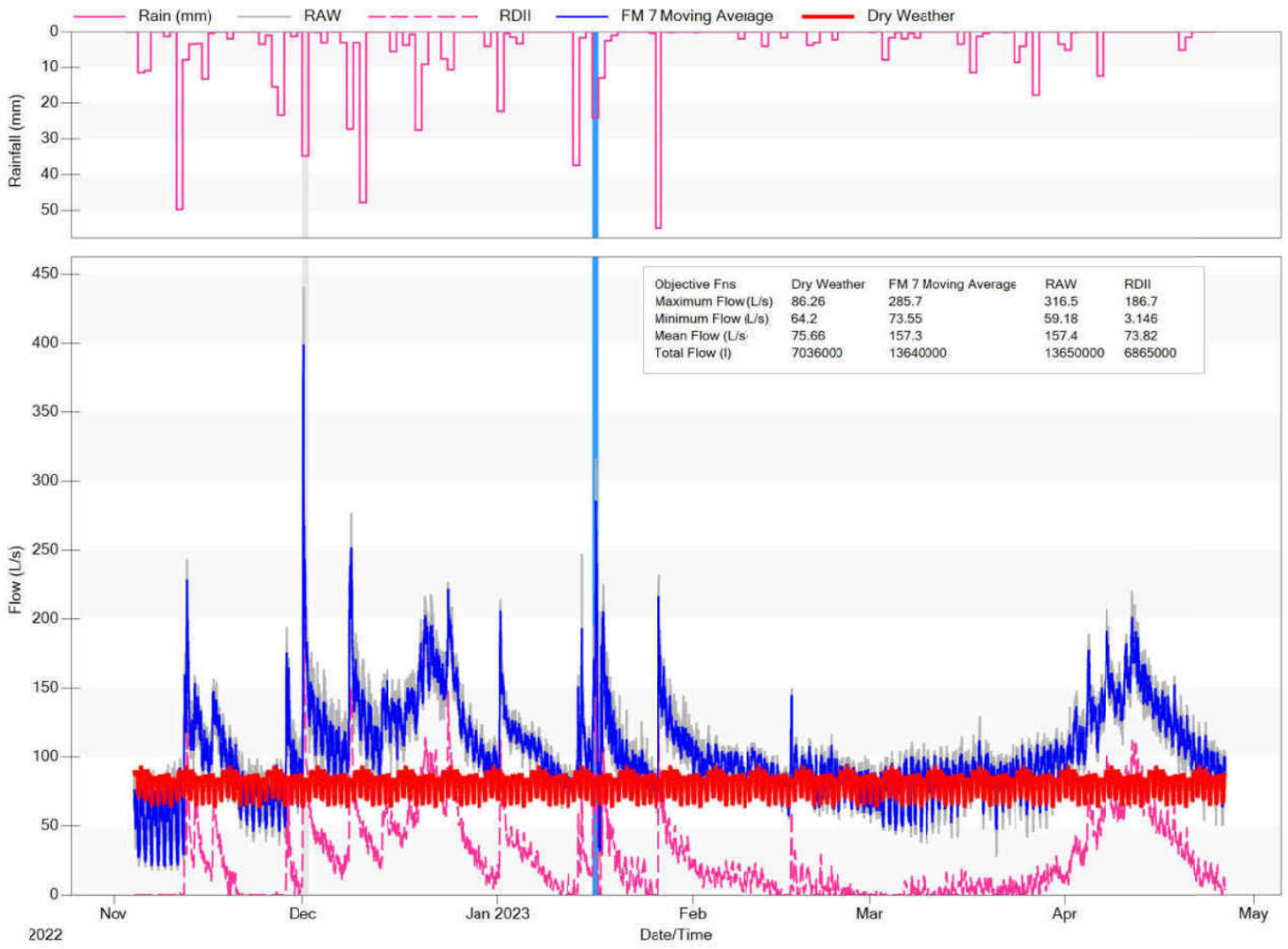
FLOW METER 6 - MH 58 NORTH
APRIL 3 EVENT



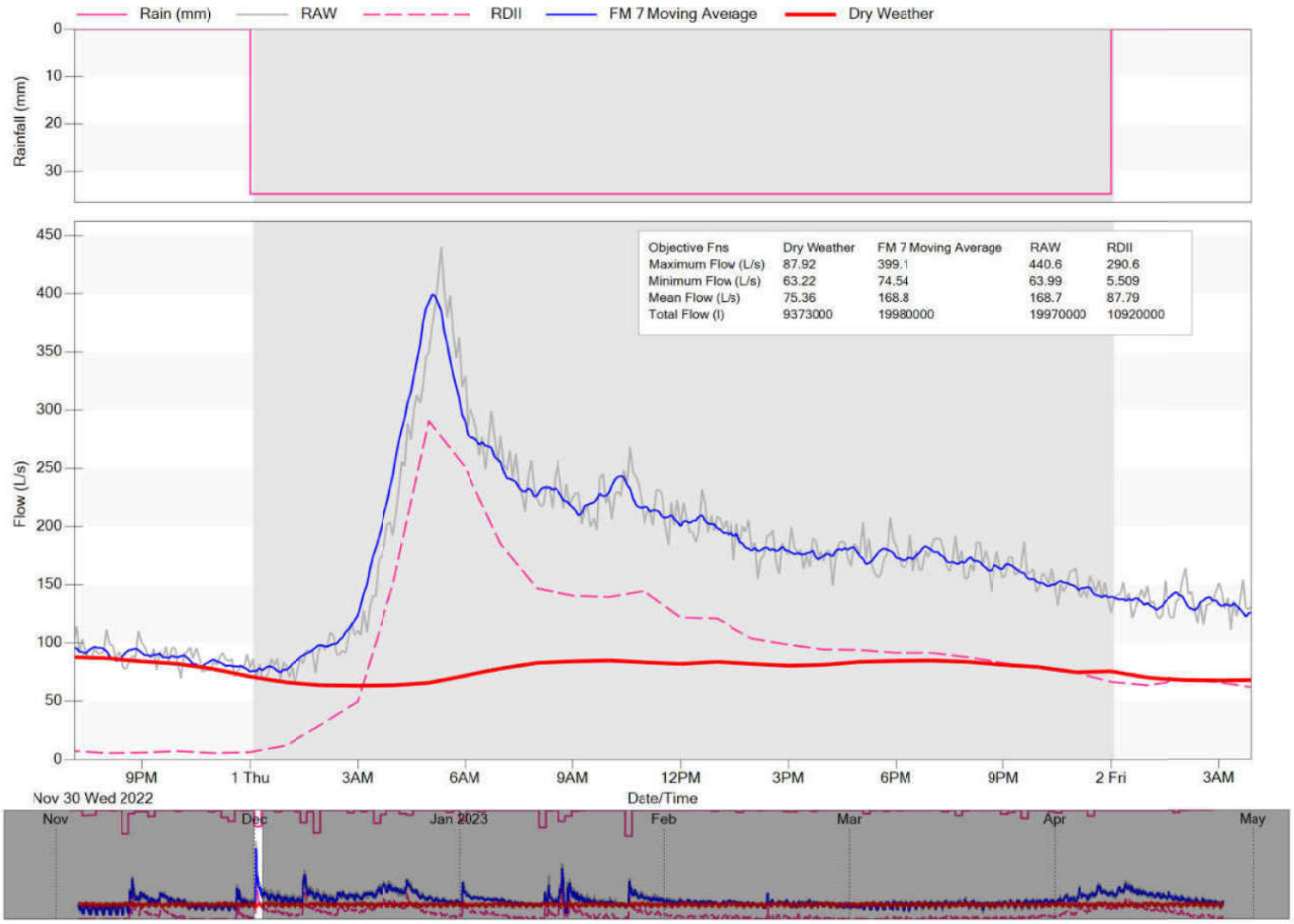
FLOW METER 6 - MH 58 NORTH
JAN 15 EVENT



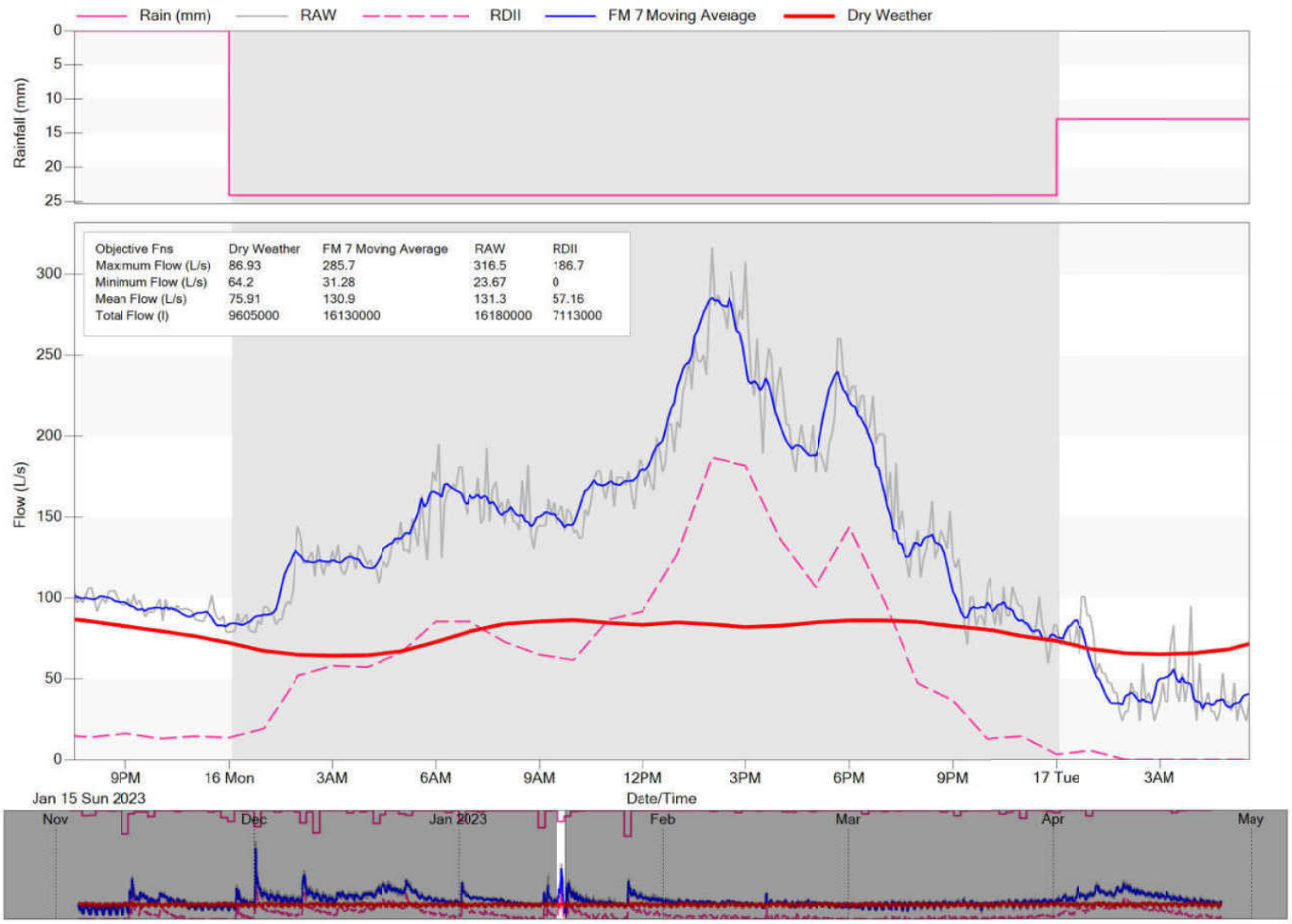
FLOW METER 7 - MH 58 EAST
OVERALL



FLOW METER 7 - MH 58 EAST
DECEMBER 1 EVENT



FLOW METER 7 - MH 58 EAST
JANUARY 16 EVENT



Appendix D Sewershed RDII Re-Ranking Summary Table

Sewershed RDII Re-Ranking Summary (2022-2023)

Location	Peak RDII (l/s/ha)	Rank	% Rainfall	Rank
2023 FM4	2.46	1	10.45%	1
2023 FM3	1.12	2	5.78%	4
2023 FM6	0.67	3	1.44%	11
2022 FM1	0.40	4	5.27%	5
2023 FM5	0.39	5	7.63%	2
2023 FM2	0.34	6	2.53%	8
2023 FM7	0.27	7	2.70%	7
2022 FM2	0.18	8	5.89%	3
2022 FM3	0.10	9	2.71%	6
2022 FM4	0.08	10	1.73%	9
2022 FM5	0.06	11	1.73%	9
2022 FM6	0.04	12	0.73%	12

Appendix E AMG Report

Site Name	Site Condition	Site Condition Notes	Data Quality	Data Quality Notes
FM1-MH49-South	Fair	Dry pipe at install	fair	Pipe was dry for the majority of the project. There was a surcharge event on Jan 16/17. After the rain event the sensor is noisier but the flow is still 0.
FM2-MH49-North	good	Good monitoring site. Murky smooth flow	good	All sensors reacting well after rain event. Increased flows observed over April (rain and snow melt probable).
FM3-MH49-West	Fair	Clear low flow	fair	Clear flow noted during installation; velocity coefficients left at a factory 1. Reacted well to rain events over the course of the monitoring period. Large rain event caused a surcharge on 01/16 (drop in flow recorded when velocity stagnated). Increased flows observed over April (rain and snow melt probable). Data gap from 02/28 - 03/04 due to monitor malfunction. Data feeds ended early on 4/17 due to monitor malfunction
FM4-MH51-South	Fair	Dry pipe at installation	fair	Pipe is dry during dry weather. Sensors reacted well to rain events. Anticipating clear flow from rain events the velocity coefficients here were left at a factory 1. Surcharge event during rain event on 01/16.
FM5-MH54-South East	poor	Fast flow with waves and turbulence at pipe lip. Pipe is often near capacity.	poor	Pipe being monitored is a lateral into a larger main channel, when depths are high we would note that the main channel flow can push into the pipe and cause overnight increases in flows. Surcharge event during rain event on 01/16 (drop in flow recorded when velocity stagnated). Pipe was noted to be nearing capacity which affected the depth/velocity relationship. Increased flows observed over April (rain and snow melt probable). Data gap from 02/16 - 02/25 due to battery malfunction.
FM6-MH58-North	Fair	Clear low flow	fair	Clear flow was noted during installation; velocity coefficients remain at 1. Ramping was noted over the AV sensor, band pushed in as far as possible to avoid but may cause an overestimation of baseflows. Depth velocity pattern often out of sync due to the clear flow conditions and the effects on velocity. Surcharge event during rain event on 01/16. Increased flows observed over April (rain and snow melt probable).
FM7-MH58-East	Poor	Outflow with an active drop lateral. 110mm of silt on average	fair	Silt present. Active drop lateral (FM6) but has limited effect on the flow during dry weather but during wet weather and recovery periods it causes more turbulnece and velocity to be underestimated. Sensors placed on shortened band out of silt. Surcharge event during rain event on 01/16 (drop in flow recorded when velocity stagnated). Increased flows observed over April (rain and snow melt probable).