5 June 2026

DOCO
By E-mail Only: fyi-request-34852-d717b300@requests.fyi.org.nz

Kia ora,

OFFICIAL INFORMATION REQUEST: FIBRE OPTIC INSPECTION SYSTEM (REF: 3610)

We refer to your official information request dated 4 June 2026. Our response is set out **below**:

Approximately 2 years ago (appx 2023 or 2024), a fiber optic inspection system was used to inspect stormwater pipes in Motueka to determine the source of stormwater entering wastewater pipes in Motueka. I am requesting the results of these inspections. My primary interest is in what percentage of sources are connected to a residence (down pipes or gully traps) and what percentage is from other sources, and if possible what the other sources are.

Please find a copy of the Goodman Park Pump Station Catchment Final Report dated 30 April 2024 **attached**.

If you are unsatisfied with the Council's response, you have the right to seek an investigation and review by the Ombudsman. Information about how to make a complaint is available at www.ombudsman.parliament.nz or freephone 0800 802 602.

Yours sincerely
Legal Services Officer

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Citycare Water

tasman district council

Motueka Wastewater I&I Assessment Using Distributed Temperature Sensing

Goodman Park Pump Station Catchment
Final Report

30th April 2024

1 Document Control

Version	Author	Change Description
Version 1.0 15/11/2023	Kieran Scott	Interim results report. Issued to Jeff Cuthbertson, TDC.
Version 1.1 22/11/2023	Kieran Scott	Interim results report. Updated to include Section Overviews Issued to Juliet Westbury, TDC.
Version 1.2 22/12/2023	Kieran Scott Reviewed by J. Porter	Interim Results Report No.2. Expanded to 50% coverage of project (high probability DTS signals)
Version 1.3 19/2/2024	Kieran Scott	Interim Results Report No.3. Completion of processing of all signals (including medium and low probability) in the area covered by interim report No.2.
Version 3.1 18/4/2024	Kieran Scott Reviewed by J. Porter Reviewed by S. Lansley	Full report for internal review.
Version 4.0 30/4/2024 Approved for release	Kieran Scott Reviewed by J. Porter Reviewed by S. Lansley David Beckwith	Final report issued to Client.

Filepath: https://citycarewater.sharepoint.com/:f:/r/sites/M365WDTS/Shared%20Documents/Projects/TDC-Mot/034_TDC_Motueka%202024/500_Report?csf=1&web=1&e=cpUcmn

2 Summary

Citycare Water has undertaken an inflow and infiltration (I&I) assessment of the Motueka wastewater main in the sections of the network shown in Figure 2-1. This work was conducted under Tasman District Council purchase order number 453736. The purpose of the assessment was to identify sources of I&I in the wastewater network to allow for targeted follow-on inspections and remediation work to be planned.

Distributed temperature sensing (DTS) technology was utilised in this assessment to accurately locate the I&I sources in the catchment. This involved installing fibre optic cable throughout 5,962 metres of wastewater main and monitoring the temperature differences before, during, and after rainfall events. The data capture period for this investigation was 27th October 2022 to 28th February 2023.

Based on the findings of this DTS I&I assessment it is recommended that targeted follow-on inspections at seventy-five locations should occur as described in the Results and Recommendations sections of this report. The recommended inspections resulting from this investigation include:

- Twenty-three manhole inspections.
- Thirty-nine CCTV inspections summing to a total distance of 3,052 metres.
- One hundred and fourty-one property inspections.

A remediation plan can then be developed once the targeted inspections are completed.

Many of the recommended CCTV inspections are to confirm the location of private lateral connections to the wastewater main. The amount of CCTV work may be reduced if Council is able to identify the location of some private laterals using existing data held by Council.

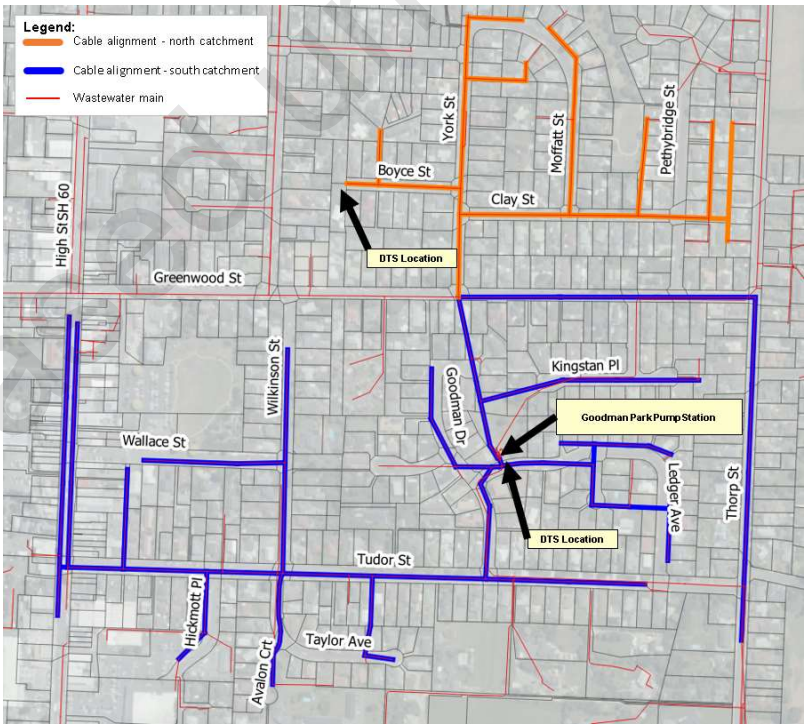


Figure 2-1 DTS fibre optic cable run

3 Contents

4 Acronyms

CCTV	Closed Circuit Television
CCW	Citycare Water
DTS	Distributed Temperature Sensing
DWF	Dry Weather Flow
GIS	Geographical Information System
GWI	Groundwater infiltration
I&I	Inflow and Infiltration
MH	Manhole
RDI	Rainfall dependent Infiltration[1]
RDII	Rainfall dependent Infiltration and Inflow
St	Street
WWF	Wet Weather Flow

[1] Rainfall dependent Infiltration and Inflow is water that enters the wastewater network derived from rainfall. The inflow component refers to water entering that closely coincides with the start and end of the rain event. The infiltration component may have a delay of several hours from the start of the rain event and may continue for an extended period of several days after the end of the rain event.

5 The Catchment

Fibre optic cable was installed in and monitored within the wastewater network as shown in Figure 5-1 and detailed in Table 5-1. Two DTS units were simultaneously deployed as shown in the figure below. The monitored wastewater mains are highlighted in orange for the northern catchment and blue for the southern catchment. Both catchments drain to the Goodman Park Pump Station.

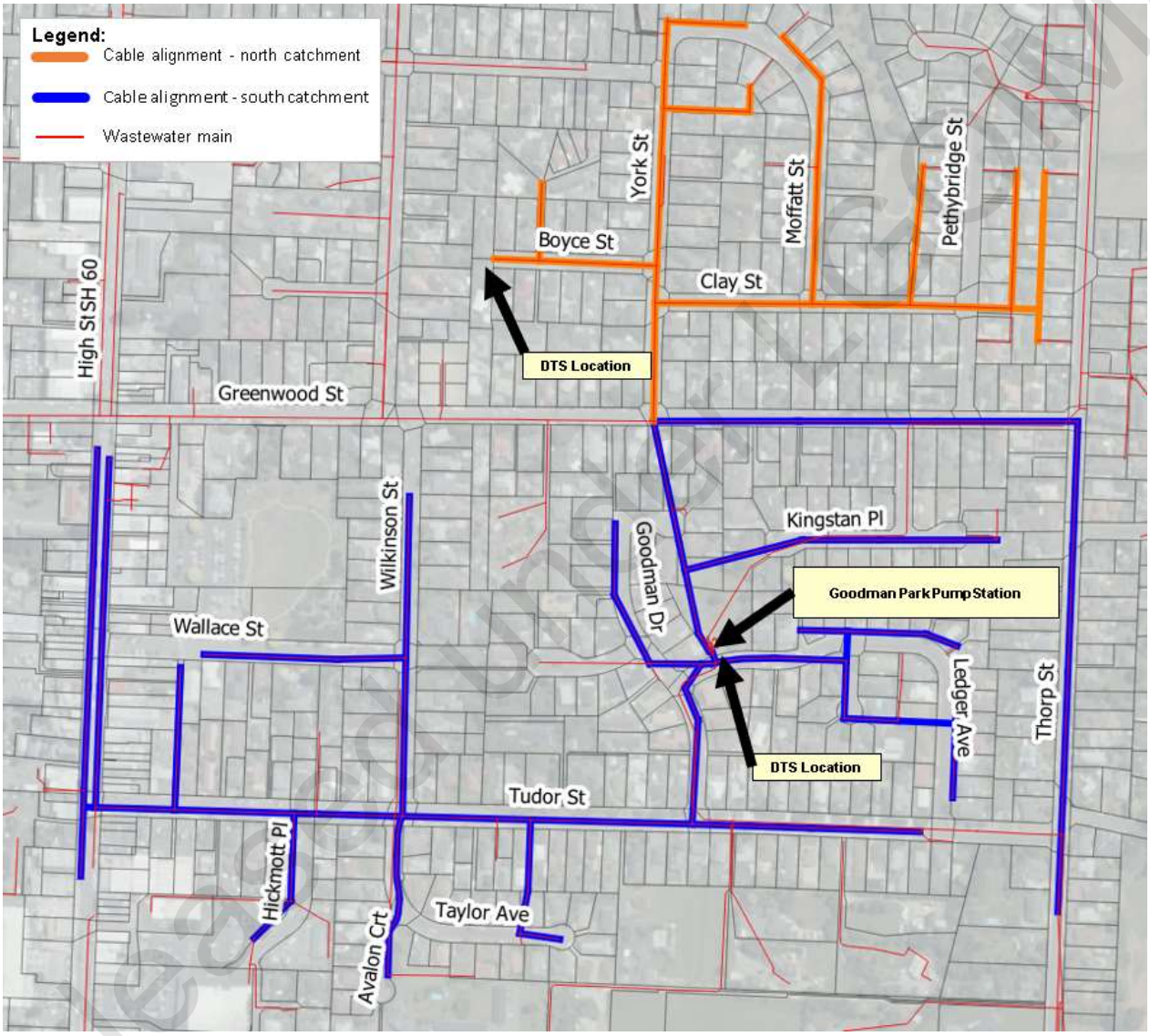


Figure 5-1 DTS fibre optic cable run

Table 5-1 Catchment characteristics

Item	South Catchment	North Catchment	Total
Length of network monitored (m)	4,420	1,542	5,962

6 Installation and Setup

The timing of the cable installation, the data capture period, and cable removal for the DTS project are presented in Table 6-1. Temperature readings were recorded at time intervals of five to fifteen minutes[2] along the length of the fibre optic cable at one metre increments. Figure 6-1 shows the trailers containing the DTS units while operating at 13 Boyce Street and Goodman Park Pump Station. The original proposal was to stop collecting DTS data in December 2022. Council subsequently instructed an extension of the data collection period to the end of February 2023.

Table 6-1 Installation Timeline

Action	Date
Fibre optic cable install started.	22nd August 2022
Fibre optic cable install completed.	2nd September 2022
Fibre optic splicing complete. Start of DTS commissioning.	20th September 2022
DTS recording started.	27th September 2022
End of data capture period.	28th February 2023
Fibre optic cable removed.	8th March 2023

[2] The DTSx3000 unit located at Goodman Park Pump station recorded data at five-minute intervals. The DTSx200 unit located at 13 Boyce Street recorded data at 15-minute intervals. The difference in the duration of the sampling intervals is because the DTSx3000 requires a shorter sampling time to achieve suitably accurate temperature data. Citycare Water has determined these reading intervals and distance increments are appropriate settings to provide quality data for analysis at a high enough resolution for the lengths of fibre optic cable installed.

Figure 6-1 DTSx200 unit in trailer at 13 Boyce Street

Figure 6-2 DTSx3000 unit in trailer at Goodman Park Pump Station

6.1 Sections of pipe not monitored by DTS

The pink lines in Figure 6-3 highlight eight sections of wastewater main that were originally included in the DTS scope but were removed due to a lack of access to the upstream end of the pipe or due to the pipe diameter being less than 150mm. These sections of pipe have a combined length of 510 metres.

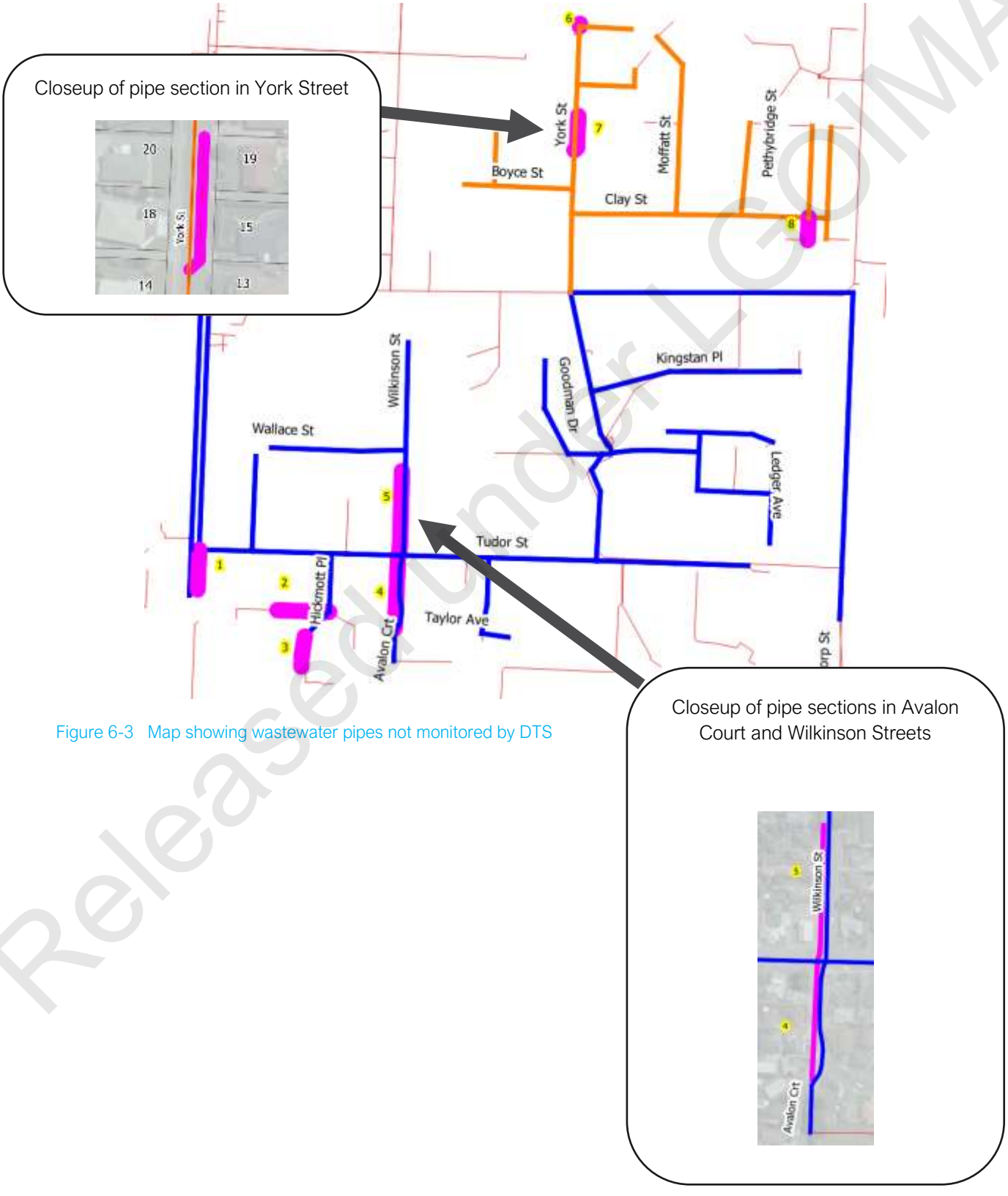


Figure 6-3 Map showing wastewater pipes not monitored by DTS

6.2 Weather and Data Analysis Time Periods

The rainfall recorded by Citycare Water's weather station installed at the Goodman Park Pump Station is presented in Figure 6-4. There were significant rain events prior to the start of the DTS project and during the DTS data capture period.

The I&I analysis used DTS temperature data summarised to represent (a) the entire data set, (b) periods of dry weather, and (c) periods of wet weather. The time intervals used for the data analysis are plotted on Figure 6-4 as red squares for dry weather analyses and green lines for wet weather analyses. These periods were selected to maximise the patterns that highlight I&I in the DTS temperature data.

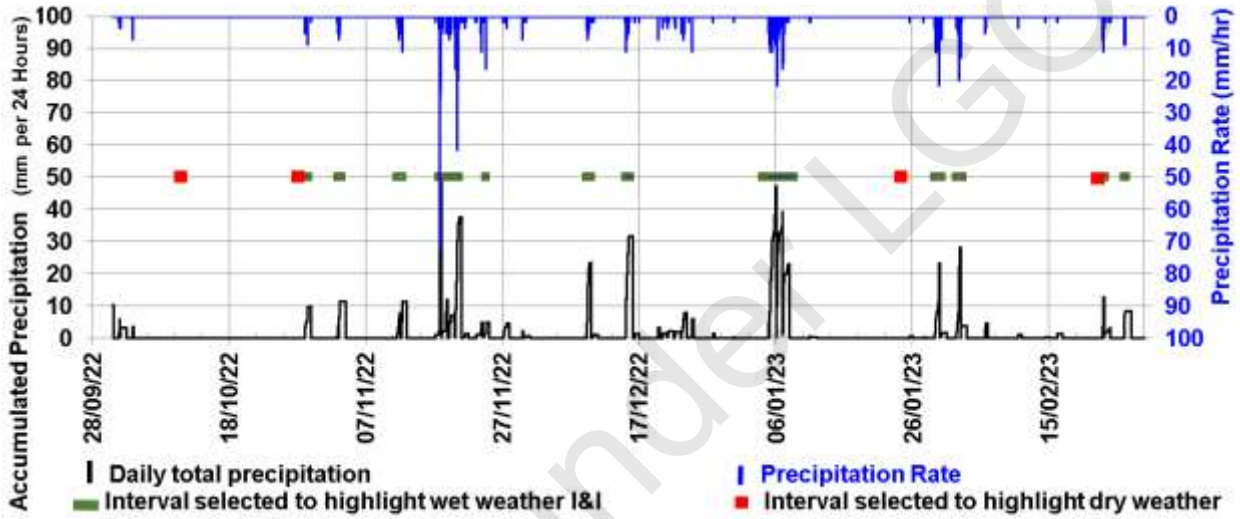


Figure 6-4 Rainfall during the DTS monitoring period

7 Source Identification and Source Analysis Methodology

The wastewater network was divided into thirty-one sections as part of the DTS data analysis. These sections are shown in Figure 7-1.

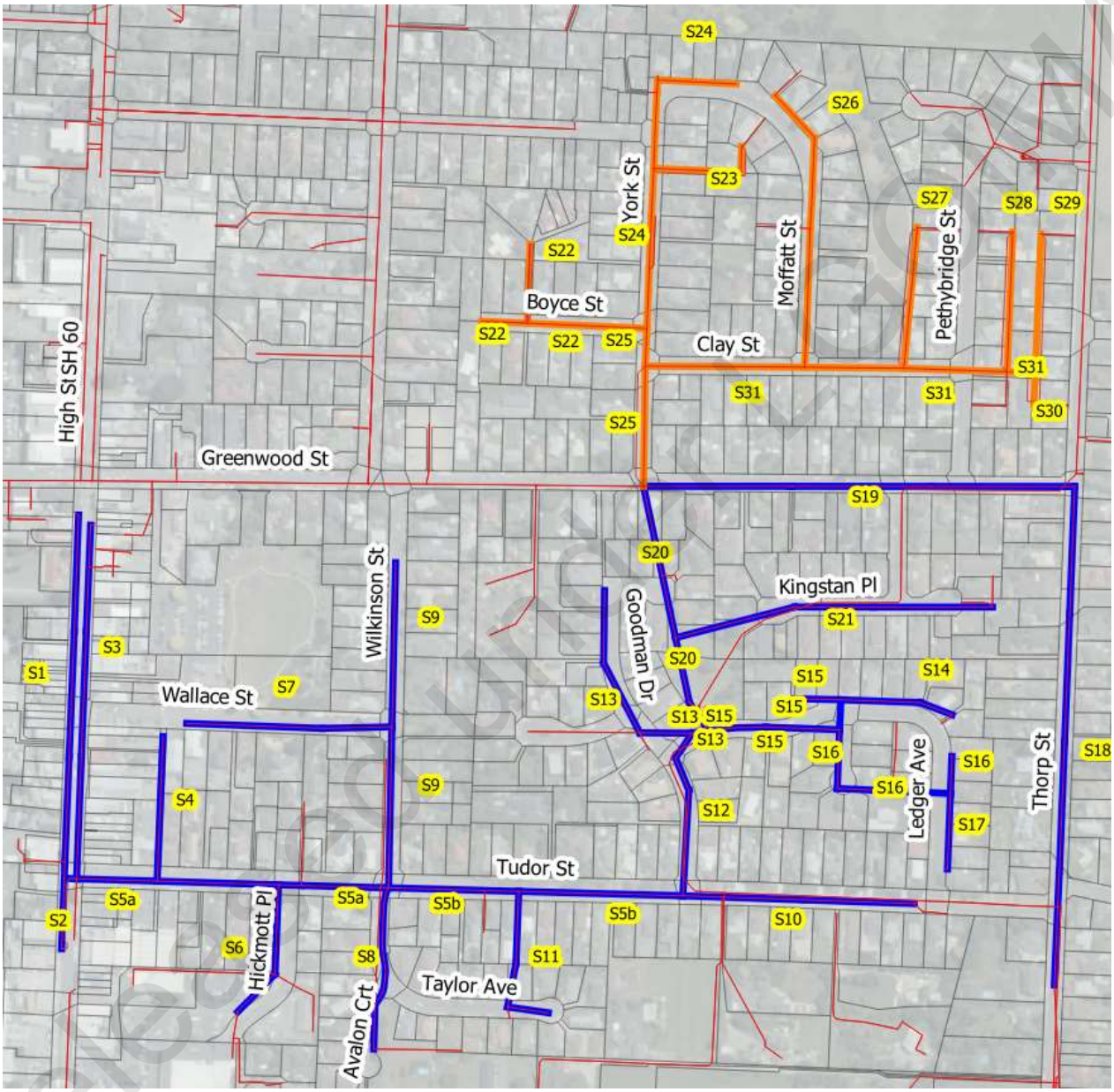


Figure 7-1 Section Splits

7.1 Section Overviews

The analysis of the DTS data is presented in Appendix A using Section Overviews and detailed analyses of individual sources.

Each Section Overview includes:

- A list of the potential I&I sources within the section.
- A map highlighting the location of the potential sources and the identification label[3] of each source.
- A source identification chart showing the average wastewater temperature during selected wet and dry intervals, plotted against the distance along the fibre. Refer to the generic example shown in Figure 7-2.

In the source identification plots:

- The wastewater flow is from left to right.
- Locations of potential I&I sources are highlighted either with:
    - A box with dashed line type highlighting a localised temperature drop (suspected of being a point source of I&I). Refer to example 'S13 / 3593' in the figure below.
    - A downward sloping arrow where there is progressive temperature reduction along a section of pipe (suspected of being infiltration at multiple cracks or joints along a pipe). These are called 'longitudinal' sources to differentiate them from point sources. Refer to example 'S13 / 3480' in the figure below.
- Manhole locations are indicated by vertical dashed lines.
- Fibre optic cable splices which occur within the length of a section are shown as a labelled box.

The red traces in the figure below (see next page) plot the average temperature calculated for selected dry weather intervals. The black trace plots the average temperature calculated for the full duration of the data capture period. A similar plot is used to present the average temperature calculated for selected wet weather intervals.

[3] A unique source identification label is formed by the combination of the section number and the distance between the DTS unit and the source location. For example, 'S2 / 500' is in section S2, located 500m from the DTS unit. The distance from the DTS is the length travelled by the light within the fibre optic cable and includes 'calibration coils' of fibre optic cable at the DTS trailer and coils in manholes with fibre optic splice joints.

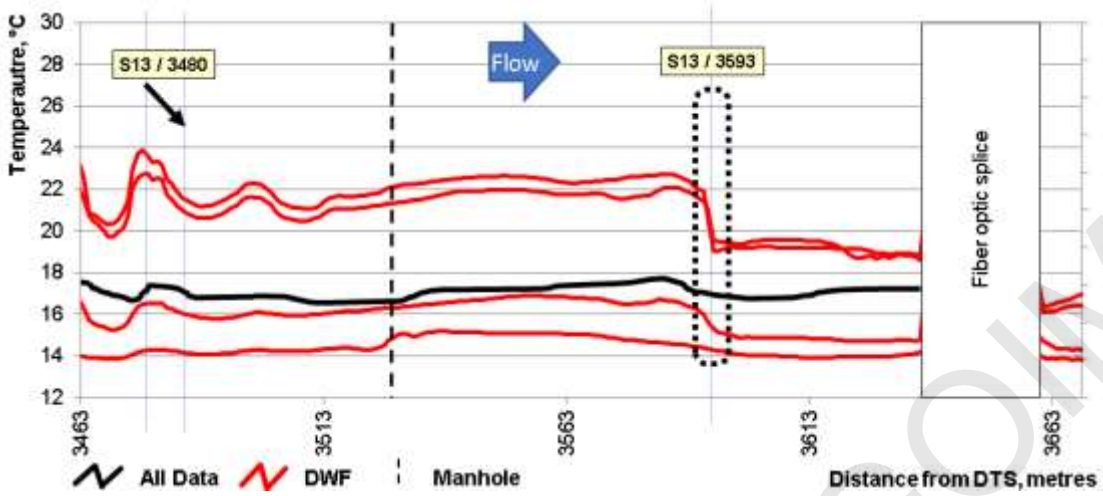


Figure 7-2 Example Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals

In some cases, there are small disturbances in the temperature data for a short distance either side of splices. This does not materially affect the data analysis.

7.2 Analysis of Individual Sources

The analysis of individual sources includes:

- An identifying label matching the labels of sources identified in the Section Overview.
- A source analysis summary table.
- A plot of temperature data versus time for assessing the nature of the source.
- A map based on the GIS database showing a close-up of the source location.

The summary table presents the details of the asset, a description of the technical assessment and recommended inspections for field confirmation.

For each location identified as a potential source of I&I, a plot of temperature versus time is provided. The difference between the downstream and upstream temperature is plotted on the same time scale as rainfall to allow assessment of any correlation with the rainfall or general trends over time.

'Noise' in the data is caused by real world random temperature fluctuations and the limits of accuracy of measuring equipment. Where beneficial, the impact of noise in the data is supressed by analysing a rolling average of two or more data points. The plots presented in the report may show either or both individual DTS data points (shown as individual "+" markers, or a rolling average of two or more data points shown as a continuous black line. Refer to Figure 7-3 below.

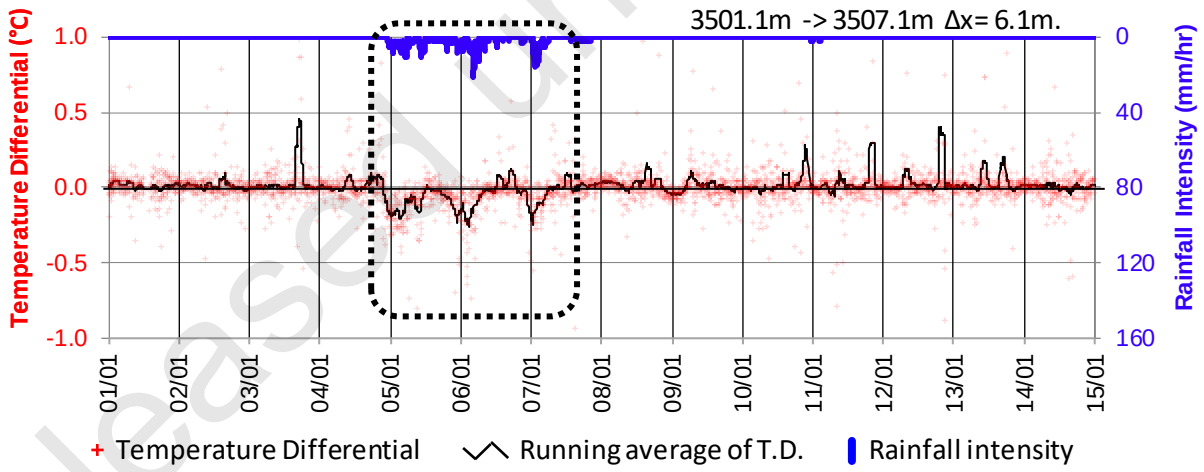


Figure 7-3 Example Source Analysis Plot – Temperature Difference vs Time

Manholes with more than one incoming sewer are analysed by plotting the inlet and outlet temperatures. If the outlet temperature is cooler than all the inlet temperatures, then I&I at the manhole is indicated.

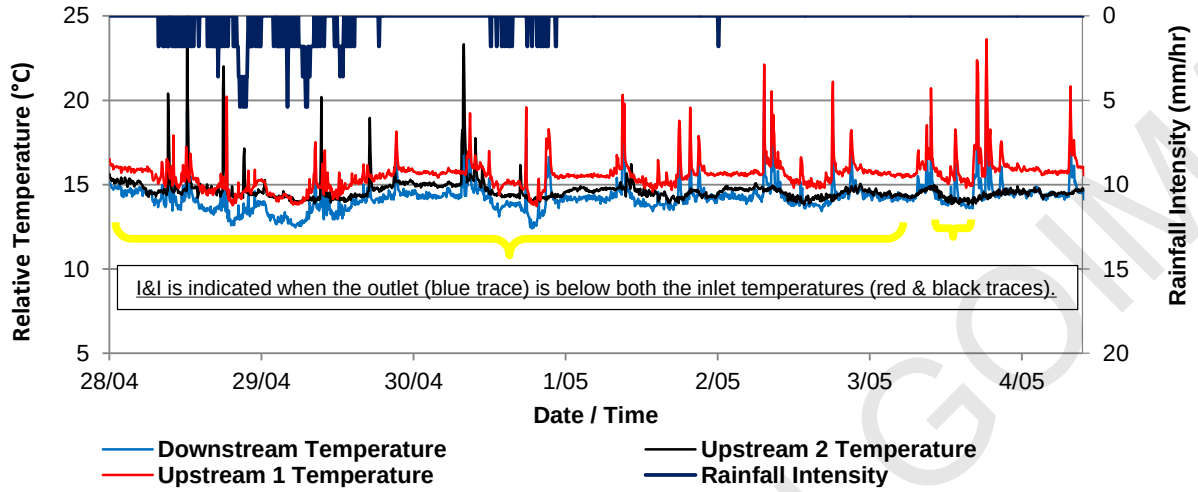


Figure 7-4 Example Temperature Analysis for a manhole with two inlets

The map shows the location of each source based on comparing the source's distance along the fibre optic cable with GIS data.

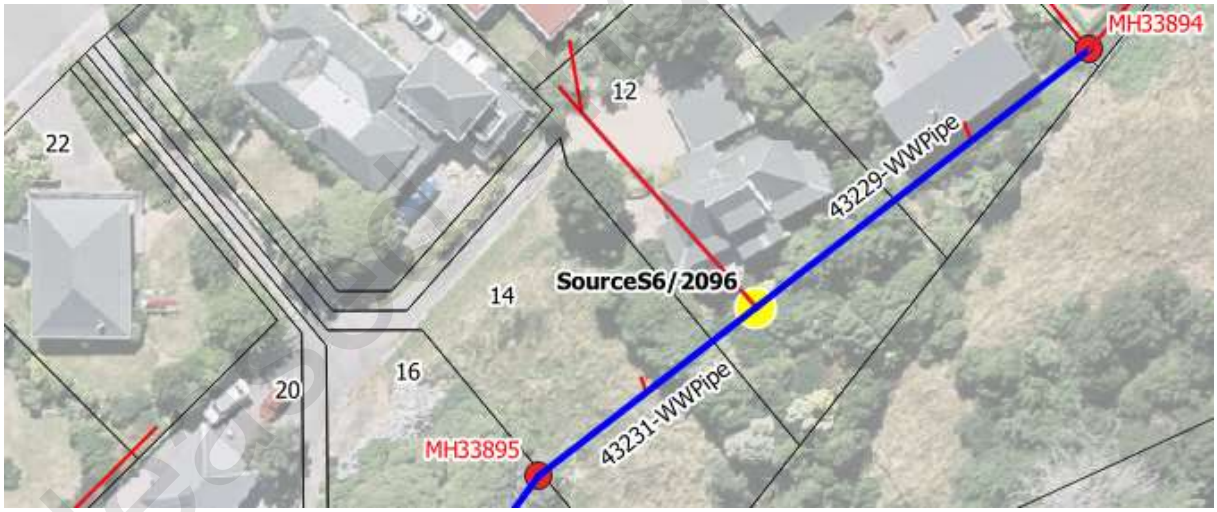


Figure 7-5 Example Source Location Map

7.3 Common features in temperature versus time analyses

Common features in temperature versus time analyses have been described in Appendix C.

7.4 Categorising DTS I&I signals as 'strong', 'medium', or 'weak'

The detailed analyses for sources assessed to have 'strong' or 'medium' strength DTS I&I signals are presented in Appendix A. The detailed analyses for sources assessed to have 'weak' DTS I&I signals are presented in Appendix B. The inclusion and separation of potential sources with 'weak' DTS signals was to minimise the likelihood that a genuine I&I source location was not reported, while also alerting the reader that the basis for reporting a particular source is weak. Compared to the 'strong' and 'medium' signals, there is a higher probability that a location reported for a 'weak' DTS signal is not a real I&I source.

Reasons for assessing a DTS I&I signal to be weak can include one or more of the following:

- The magnitude of the observed temperature difference was small.
- Inconsistent occurrence of temperature differences[4].
- Occurrence of false positives of similar magnitude[5].
- Possible confusion with the effects of solar heating[6].
- Temperature changes caused by natural cooling of wastewater in the pipe[7].
- The observed signal was not consistent with patterns expected to be caused by I&I.

[4] Inconsistent occurrence of temperature differences. A signal may occur during only a portion of the data capture period and the occurrence/absence is not easily attributed to seasonal groundwater trends or antecedent rain.

[5] Occurrence of false positives. Temperature difference patterns of similar magnitude that look like stormwater inflow signals occur on dry days.

[6] Possible confusion with the effects of solar heating. Solar heating of ground surfaces, such as bitumen or concrete paving, can increase the temperature of the wastewater pipe by several degrees. This effect can be more pronounced during the low flow hours of early morning. The potential for an observed pattern to be caused by solar heating can make it unclear if an observed pattern is caused by infiltration or by solar heating.

[7] Temperature changes caused by natural cooling of wastewater in the pipe. Wastewater cools as it progresses downstream from a warmer point caused by input of warm wastewater or solar heating. The more significant the localised effect of 'natural' heating and cooling, the more challenging it is to use DTS data to accurately identify sources of I&I.

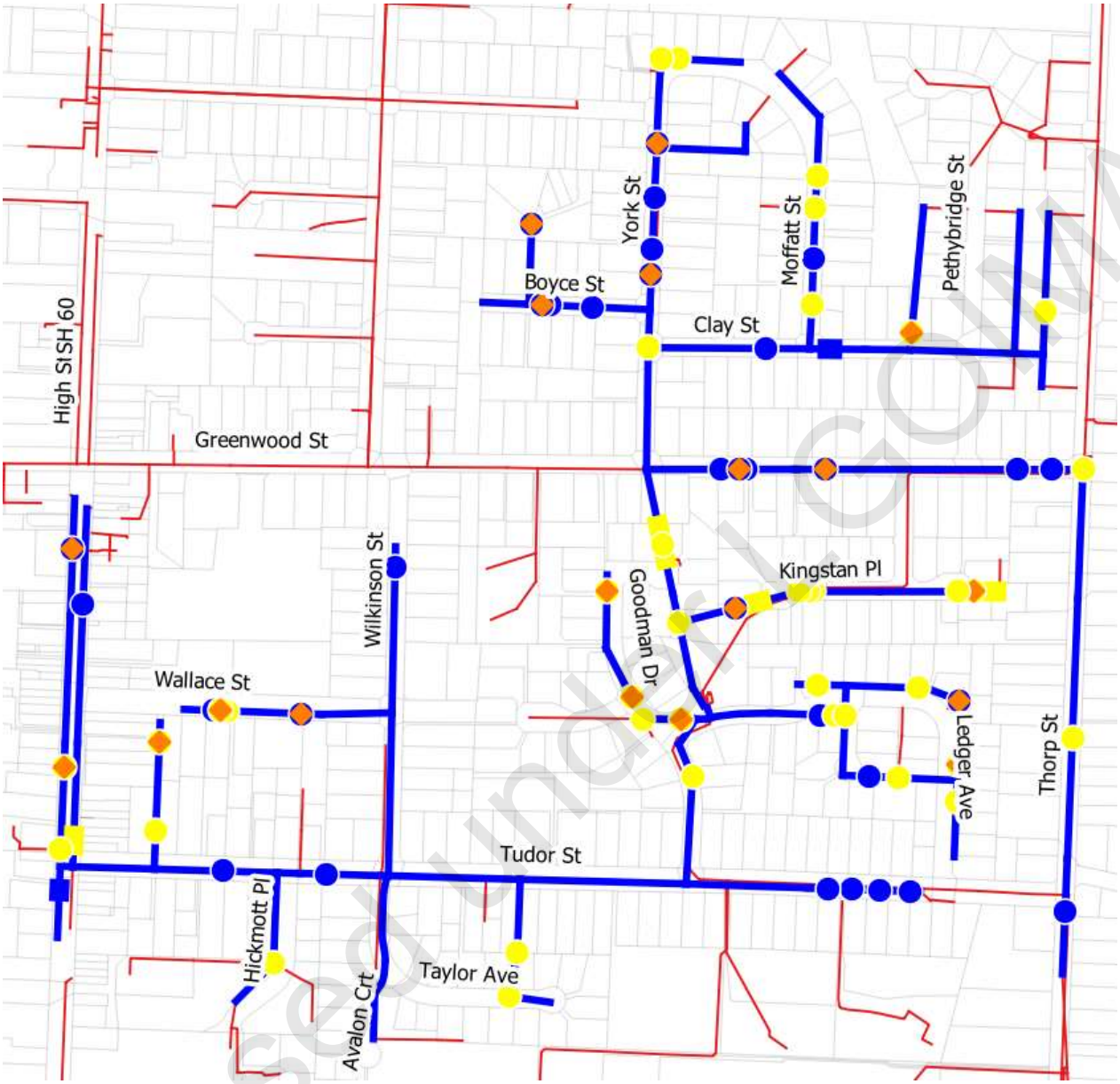
8 Results

The DTS I&I source monitoring campaign identified seventy-five locations to be included for targeted inspections:

- 31 stormwater inflow sources.
- 2 combined stormwater inflow and rain dependent infiltration source.
- 26 groundwater infiltration sources.
- 7 combined stormwater inflow and groundwater infiltration sources.
- 5 combined rain dependent infiltration and groundwater infiltration sources.
- 4 combined stormwater inflow, rain dependent infiltration and groundwater infiltration sources.

The Section Overviews results are presented in Appendix A. The detailed analyses for sources assessed to have 'strong' or 'medium' strength DTS I&I signals are also presented in Appendix A. The detailed analyses for sources assessed to have 'weak' DTS I&I signals are presented in Appendix B. The method and motivation for identifying some sources as 'weak' DTS I&I signals are discussed in Section 7.4. In Appendix A and Appendix B, sources marked with green highlighted 'new' are source locations added after Interim Report No.3.

A graphical summary of the DTS results is presented in Figure 8-1 on the (next page).



Legend:

Icon	Description
	Sites indicated with a blue icon are assessed to have a stormwater inflow component.
	Sites indicated with a yellow icon are assessed to have a groundwater inflow component.
	Sites indicated with an orange diamond are assessed to have a weak DTS I&I signal.
	DTS monitored wastewater main.
	Unmonitored wastewater main

Figure 8-1 Graphical Summary of DTS Results

9 Recommendations

Based on the data and analysis presented in this report, it is recommended that targeted follow-on inspections should occur including:

- 23 manhole inspections.
- 39 CCTV inspections comprising a total of 3,052 m.
- 141 property inspections.

The recommended follow-on inspections are summarised in Table 9-1 to Table 9-3. These will allow for confirmation of the sources identified in this report and assist when developing a remediation plan. An Excel spreadsheet containing Table 9-1 to Table 9-4 has been separately provided to Council.

Definitions of the follow-on inspections are provided in Appendix C.

Many of the recommended CCTV inspections are to confirm the location of private lateral connections to the wastewater main. The amount of CCTV work may be reduced if Council is able to identify the location of some private laterals using existing data held by Council.

Table 9-1 List of Recommended Manhole Inspections

Count of Manholes	Manhole Asset ID	Address	DTS I&I Source ID	Refer to Note	Weak DTS signal	New in Final Report
3	12354, 21918, 21919	218 High Street	S1 / 3054		-	New
1	15251	8 Hickmott Place	S6 / 1021		-	New
1	12321	12 Taylor Avenue	S11 / 1202		-	-
1	13454	47B Tudor Street	S11 / 1240	14	-	-
1	20935	6 Goodman Drive	S12 / 3199	15	-	-
2	16123, 16124	12 Goodman Drive, 6 McCarthy Crescent	S13 / 3593	16	-	-
1	16871	20A Ledger Avenue	S14 / 4619	18	Weak	-
1	13115	9 Ledger Avenue	S15 / 4842		-	New
2	13113, 14959	6 Marion Place	S16 / 4358	24	-	-
1	14905	83A Thorp Street	S18 / 7158		-	-
1	16121	Ledger Goodman Park	S20 / 7689		-	New
1	16134	6 Kingstan Place	S21 / 5623	39	-	-
1	14353	10 Boyce Street	S22 / 386		Weak	New
1	24330	33 Moffatt Street	S24 / 2183		-	New
1	24314	22 Moffatt Street	S24 / 2346		-	New
2	24327, 24328	15 & 19 Moffatt Street	S24 / 2389		-	New
1	12332	6 York Street	S25 / 613		-	New
1	12337	12 Moffatt Street	S26 / 1189		-	New
23	Total					

Table 9-2 List of Recommended CCTV Inspections

Count of pipes	Pipe Asset ID	Length of pipe (m)	Address	DTS I&I Source ID	Refer to Note	Weak DTS signal	New in Final Report
1	36283	88	196 High Street	S1 / 2986	2	Weak	New
3	49924, 40923, 40922	55	218 High Street	S1 / 3054		-	New
1	36282	59	230 High Street	S2 / 3191	3	-	New
1	29279	89	157 High Street	S3 / 2031	4	-	New
1	36285	103	219 High Street	S3 / 2232		-	New
1	36238	122	14B Tudor Street	S4 / 1477		-	New
1	31206	114	27 Wallace Street	S7 / 2160	7	Weak	-
1	36229	93	88 Tudor Street	S10 / 647	10	-	-
1	36221	66	13A Goodman Drive	S13 / 3572		Weak	-
1	36220	94	McCarthy Crescent	S13 / 3593	16	-	-
1	36225	44	11 Goodman Drive	S13 / 3626	17	Weak	-
1	31114	67	18 Ledger Avenue	S14 / 4646	19	-	
1	28730	41	8 Ledger Avenue	S15 / 4792	20	Weak	-
1	28745	62	9 Ledger Avenue	S15 / 4871		-	-
1	28732	64	30 Ledger Avenue	S16 / 4200	22	-	-
1	28736	32	26A Ledger Avenue	S16 / 4296	23	Weak	-
2	23738, 41534	58	6 Marion Place	S16 / 4358	24	-	-
1	28739	46	6 Marion Place	S16 / 4382	25	-	-
1	36207	96	121 Thorp Street	S18 / 6785	26	-	-
1	28728	108	107 Thorp Street	S18 / 6932	27	-	-
1	36214	121	84 Thorp Street (on Greenwood Street frontage)	S19 / 7196	28	-	-
1	36215	116	75A Greenwood Street	S19 / 7386	30	Weak	-
1	36219	123	67 Greenwood Street	S19 / 7475	33	-	-

Table 9-2 List of Recommended CCTV Inspections

Count of pipes	Pipe Asset ID	Length of pipe (m)	Address	DTS I&I Source ID	Refer to Note	Weak DTS signal	New in Final Report
1	36414	106	31 Goodman Drive	S20 / 7629	35	-	-
1	31125	100	21 Kingstan Place	S21 / 5474	37	-	-
1	36216	67	7 Kingstan Place	S21 / 5611		-	-
1	36217	103	1 Kingstan Place	S21 / 5663	40	-	-
1	24459	101	6 Boyce Street	S22 / 465	42	Weak	New
1	24520	66	31 Moffatt Street	S24 / 2171		-	New
1	31256	76	12 Moffatt Street	S26 / 1162		-	New
1	31303	117	2 Moffatt Street	S26 / 1232	48		
1	31260	119	20 Clay Street	S27 / 1400	50	Weak	New
1	31262	117	74 Thorp Street	S29 / 2140	51	-	New
2	31302, 31304	85	11 Clay Street	S31 / 2476	52	-	New
1	31301	134	5 Clay Street	S31 / 2554	53	-	New
39		3,052	Total				

Table 9-3 List of Recommended Property Inspections

Count of properties	Address	DTS I&I Source ID	Refer to Note	Weak DTS signal	New in Final Report
1	140 High Street	S1 / 2802	1	Weak	New
1	196 High Street	S1 / 2986	2	Weak	New
1	218 High Street	S1 / 3054		-	New
1	230 High Street	S2 / 3191	3	-	New
3	157, 159, 161 High Street	S3 / 2031	4	-	New
2	191A, 191B High Street	S4 / 1402	5	Weak	New
1	14B Tudor Street	S4 / 1477		-	New
2	18 & 20 Tudor Street	S5a / 3393		-	New
1	27 Tudor Street	S5a / 3504	6	-	New
2	7 & 8 Hickmott Place	S6 / 1021		-	New
1	27 Wallace Street	S7 / 2157		-	-
1	20 Wallace Street	S7 / 2168	8	-	-
2	4 and 7 Wilkinson Street	S9 / 2502		-	-
3	88, 89, and 91 Tudor Street	S10 / 647	10	-	-
2	86 and 87 Tudor Street	S10 / 673	11	-	-
2	84 and 85A Tudor Street	S10 / 696	12	-	-
2	81 and 82 Tudor Street	S10 / 715	13	-	-
3	2 Avalon Court, 12 and 14 Taylor Avenue	S11 / 1202		-	-
3	11, 13 Taylor Avenue, and 47B Tudor Street	S11 / 1240	14	-	-
3	4,5,6 Goodman Drive	S12 / 3199	15	-	-
3	13A, 13B, 15 Goodman Drive	S13 / 3572		Weak	-
16	4, 6,10, 12A, 12B, 11, 9, 7, 5, 3, 1 McCarthy Cresent, and 8, 10A, 10B, 12, 16 Goodman Drive.	S13 / 3593	16	-	-
1	11 Goodman Drive	S13 / 3626	17	Weak	-
3	20A, 20B, 22 Ledger Avenue	S14 / 4619	18	Weak	-
1	18 Ledger Avenue	S14 / 4646	19	-	-

Table 9-3 List of Recommended Property Inspections

Count of properties	Address	DTS I&I Source ID	Refer to Note	Weak DTS signal	New in Final Report
1	8 Ledger Avenue	S15 / 4792	20	Weak	-
1	9 Ledger Avenue	S15 / 4872		-	-
1	30 Ledger Avenue	S16 / 4200	22	-	-
2	26A & 26B Ledger Ave.	S16 / 4296	23	-	-
6	8 Marion Place, 11, 11A, 13A, 13B, 15 Ledger Avenue	S16 / 4358	24	-	-
2	6 and 7 Marion Place	S16 / 4382	25	-	-
3	121 and 124 Thorp Street, 1 Harbour Road	S18 / 6785	26	-	-
2	107 and 110 Thorp Street	S18 / 6932	27	-	-
1	84 Thorp Street	S19 / 7196	28	-	-
2	88 and 91 Greenwood Street	S19 / 7224	29	-	-
3	74, 75A and 75B Greenwood Street	S19 / 7386	30	Weak	-
6	66, 67, 67A, 67B, 69, 69A Greenwood Street	S19 / 7454	31	-	-
2	64 Greenwood Street	S19 / 7475	33	-	-
4	25, 27, 31, 33 Goodman Drive	S20 / 7629	35	-	-
1	98A Thorp Street	S21 / 5458	36	-	-
2	21 and 22A Kingstan Place	S21 / 5474	37	-	-
4	19A, 19B, 22A Kingstan Place, 98B Thorp Street	S21 / 5489	38	-	-
1	6 Kingstan Place	S21 / 5623	39	-	-
1	1 Kingstan Place	S21 / 5663	40	-	-
6	8A, 8B, 8C, 8D, 10 Boyce Street, and 29A York Street	S22 / 386		Weak	New
2	5 & 6 Boyce Street	S22 / 472		-	New
2	1 & 2 Boyce Street	S22 / 507			
1	31 Moffatt Street	S24 / 2171		-	New

Table 9-3 List of Recommended Property Inspections

Count of properties	Address	DTS I&I Source ID	Refer to Note	Weak DTS signal	New in Final Report
2	33 & 30A Moffatt Street	S24 / 2183		-	New
2	26 and 27 York Street	S24 / 2279	43	Weak	New
1	22 Moffatt Street	S24 / 2346	44	-	New
4	15, 17, 19, 21 York Street	S24 / 2389	45	-	New
1	11 York Street	S24 / 2412	46	Weak	New
2	12 and 13 Moffatt Street	S26 / 1162		-	New
3	8 & 10 Moffatt Street, 17 York Street	S26 / 1189		-	New
3	2, 3, 6 Moffatt Street	S26 / 1232	48	-	New
1	1A Moffatt Street	S26 / 1271	49	-	New
1	20 Clay Street	S27 / 1400	50	Weak	New
1	74 Thorp Street	S29 / 2140	51	-	New
2	11 & 12 Clay Street	S31 / 2476	52	-	New
1	5 Clay Street	S31 / 2554	53	-	New
141	**Total Count**				

The ‘Notes’ from the Source Analysis Summary tables in Appendix A and Appendix B are grouped together in Table 9-4. These can be used as supplemental information for staff conducting follow-on inspections in the field.

Example: When conducting a CCTV inspection of Pipe 36283, find the pipe asset number in Table 9-2 ‘List of Recommended CCTV Inspections’. Check Table 9-2 and determine if there is a note for this pipe inspection. If there is a note, then use the sequential number of the note to find the relevant discussion in Table 9-4 ‘Supplemental Notes for Recommended Inspections’. In this example the relevant note is Note 2.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
1	S1 / 2802	When checking the lateral, look for connection or leakage from the very stormwater assets that are very close to the alignment of the lateral. The daily heat spike during office/school hours indicates there are significant hot water discharges during those hours. It may be worth the owner checking for unintended sources of hot water discharges. This DTS signal is assessed as 'weak' rather than 'strong' because the pattern characteristic of stormwater inflow was not observed for other rain events.
2	S1 / 2986	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. This DTS signal is assessed as 'weak' because the pattern characteristic of early morning groundwater infiltrations was inconsistent and entirely absent for some periods.
3	S2 / 3191	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
4	S3 / 2031	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
5	S4 / 1402	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. CCTV inspection for pipe 36238 is included under the recommendations for I&I source S4 / 1477.
6	S5a / 3504	The DTS signal suggests a stormwater inflow, likely from a private property, requiring a hydraulic connection to surface features. As the wastewater main is underground and unlikely to have direct stormwater entry, it hasn’t been included in the CCTV inspection.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
7	S7 / 2160	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface. Signal strength rating is weak because it is difficult to ascertain if the reduction in temperature along this section of pipe is a separate source of I&I, or is it related to the sources at 2157m and 2168m,or is it 'natural' cooling along the length of the pipe.
8	S7 / 2168	The inspection of 27 Wallace Street is provided in the recommendations for S7 / 2157.
9	S7 / 2232	CCTV inspection for pipe 31206 is included under the recommendations for I&I source S7 / 2160. DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface.
10	S10 / 647	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Inspection of 91 Tudor Street has been included because it is not fully clear if 91 Tudor Steet is serviced by the lateral in the footpath in front of the driveway of 91 Tudor Street. CCTV records will show if the lateral for 91 Tudor Street connects to the wastewater main near source S10 / 647.
11	S10 / 673	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. CCTV inspection for pipe 36229 is included under the recommendations for I&I source S10 / 647. Include property inspections only if they are within five metres of the DTS signal.
12	S10 / 696	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
13	S10 / 715	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
14	S11 / 1240	The location of the laterals for these three properties is not shown on the GIS map. A manhole inspection will confirm which properties connect at/near the manhole.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
15	S12 / 3199	The signal in the GIS data appears to be centred on the manhole. The extent and magnitude of the temperature drop support assessing the wastewater main for five metres either side of the manhole (using a Push Camera or similar) and inspecting the two properties connected less than four meters from the manhole.
16	S13 / 3593	There could be sources of I&I in both the DTS monitored manhole and in the upstream unmonitored catchment. The strength of the I&I signal warrants inspection of the assets in McCarthy Crescent even if a source of I&I is found in the DTS monitored manhole.
17	S13 / 3626	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. The masking of I&I during rain events indicates significant upstream I&I.
18	S14 / 4619	Inspect the 80mm PVC flushing pipe 41533 looking for deterioration or stormwater connections.
19	S14 / 4646	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
20	S15 / 4792	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
21	S15 / 4872 & S15 / 4882	Two separate signals were found within the boundaries of 9 Ledger Avenue.
22	S16 / 4200	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Inspection of the private properties has been included to assess if the laterals are contributing infiltration. The masking of I&I during rain events indicates significant upstream I&I. Given the age and pipe materials, remediation of significant amounts of the upstream catchment may be required. No sources of I&I were clearly identified from the DTS data upstream of the point. This is due to the significant thermal gradients caused by solar heating of driveways impacting the DTS data.
23	S16 / 4296	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. When reviewing CCTV footage pay close attention to the section of pipe 8m either side of the boundary between 26A and 28 Ledger Avenue.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
24	S16 / 4358	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
25	S16 / 4382	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
26	S18 / 6785	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
27	S18 / 6932	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
28	S19 / 7196	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
29	S19 / 7224	CCTV inspection for this pipe is included under the recommendations for another I&I source. Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
30	S19 / 7386	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
31	S19 / 7454	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within six metres of the DTS signal. CCTV inspection for pipe 36219 is included under the recommendations for I&I source S19 / 7475.
32	S19 / 7459	CCTV inspection of pipe and property inspections of 66 and 67 Greenwood Street are listed under the recommendations for I&I source S19 / 7454 and S19 / 7475.
33	S19 / 7475	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Property inspection of 67 Greenwood Street is listed under the recommendations for I&I source S19 / 7454.
34	S20 / 7609	This is a very weak signal. It is weaker than would normally be reported. It has been included because it is in a part of the catchment that would be expected to have a significant wastewater flow, even during the early hours of the morning. Therefore, a very small temperature drop may indicate a significant leak. It is rated as a weak signal, because the temperature drop is very small, of a magnitude that may only be caused by ground temperature differences due to changes in ground cover and sun exposure along the pipe.
35	S20 / 7629	Inspection of the private properties has been included to assess if the laterals are contributing infiltration.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
36	S21 / 5458	CCTV inspection for pipe 31125 is included under the recommendations for I&I source S21 / 5474. Use the CCTV data to update the connection points for the laterals not shown in the GIS map (98A Thorp Street). Include property inspections only if they are within five metres of the DTS signal. This analysis included assessment of the impacts of differential solar heating of ground surfaces. Solar differentials were assessed not to be the cause of the observed wastewater temperature differentials.
37	S21 / 5474	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
38	S21 / 5489	If a significant source of ground water infiltration is not found in the wastewater main then inspect the private laterals of nearby connected properties (19A, 19B, 22A Kingstan Place, 98B Thorp Street) looking for signs of deterioration and infiltration. These four lateral inspections are included due to uncertainty if the groundwater source is in the wastewater main, or the nearby laterals. CCTV inspection of pipe 31125 is included under the recommendations for source S21 / 5474. The groundwater intrusion signal was seasonal. The DTS data for same location did not exhibit any I&I patterns in October 2022.
39	S21 / 5623	The masking of I&I during rain events indicates significant upstream I&I. Given the age and pipe materials, remediation of significant amounts of the upstream catchment may be required.
40	S21 / 5663	The masking of I&I during rain events indicates significant upstream I&I. Given the age and pipe materials, remediation of significant amounts of the upstream catchment may be required.
41	S21 / 5680	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface. CCTV inspection for pipe 36217 is included under the recommendations for I&I source S21 / 5663. This signal is described as a weak signal. This is because the location exhibited what appears to be a DTS stormwater inflow signal for the rain event of the 19th November 2022 but not for any other rain events.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
42	S22 / 465	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for any unintended connections to the surface, including pipe faults. Check for any unintended hydraulic connection to the stormwater pipe that crosses the wastewater pipe at this point. The connection could be via exfiltration of stormwater to pipe bedding and infiltration from the pipe bedding to the wastewater main. This DTS signal is assessed as 'weak' rather than 'strong' because the pattern characteristic of stormwater inflow was not observed for other rain events. This DTS signal is assess as 'weak' because the magnitude of the signal is small.
43	S24 / 2279	This signal is assessed as weak because there are similar but larger temperature differentials on some dry days.
44	S24 / 2346	This DTS signal is assessed as 'medium' rather than 'strong' because the pattern characteristic of stormwater inflow was not observed for other rain events.
45	S24 / 2389	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface.
46	S24 / 2412	This DTS signal is assess as 'weak' because the magnitude of the signal is small.
47	S25 / 613	Leak in this manhole identified by visual inspection during DTS site works.
48	S26 / 1232	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
49	S26 / 1271	CCTV inspection for pipe 31303 is included under the recommendations for I&I source S26 / 1232.
50	S27 / 1400	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
51	S29 / 2140	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.
52	S31 / 2476	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Table 9-4 Supplemental Notes for Recommended Inspections

Note	DTS I&I Source ID	Note or Comment
53	S31 / 2554	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Appendices

Contents

Appendix A DTS Data Analysis Section Overviews and Individual Sources (for strong & medium DTS signals)

A.1 Section S1: 124 – 226 High Street <new>

Three potential source of I&I was identified in this section using the DTS data:

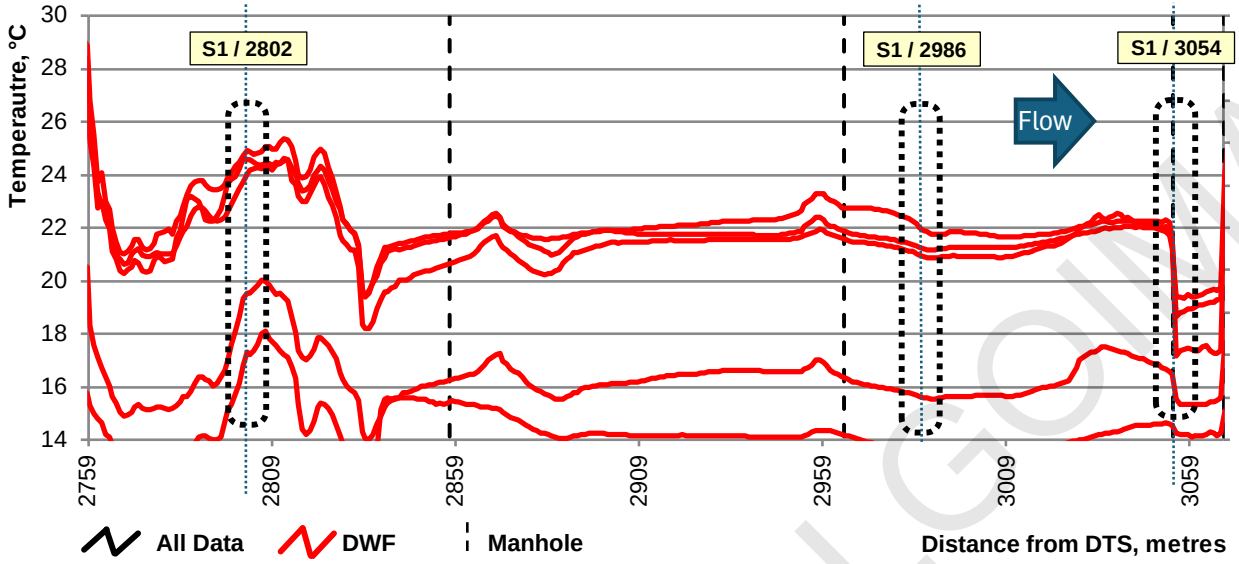
- Stormwater inflow source S1 / 2802** in Pipe 36281 at 140 High Street. <new>
- Groundwater infiltration source S1 / 2986** in Pipe 36283 at 196 High Street. <new>
- Groundwater infiltration source S1 / 3054 at Manhole 12354 at 218 High Street. <new>

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

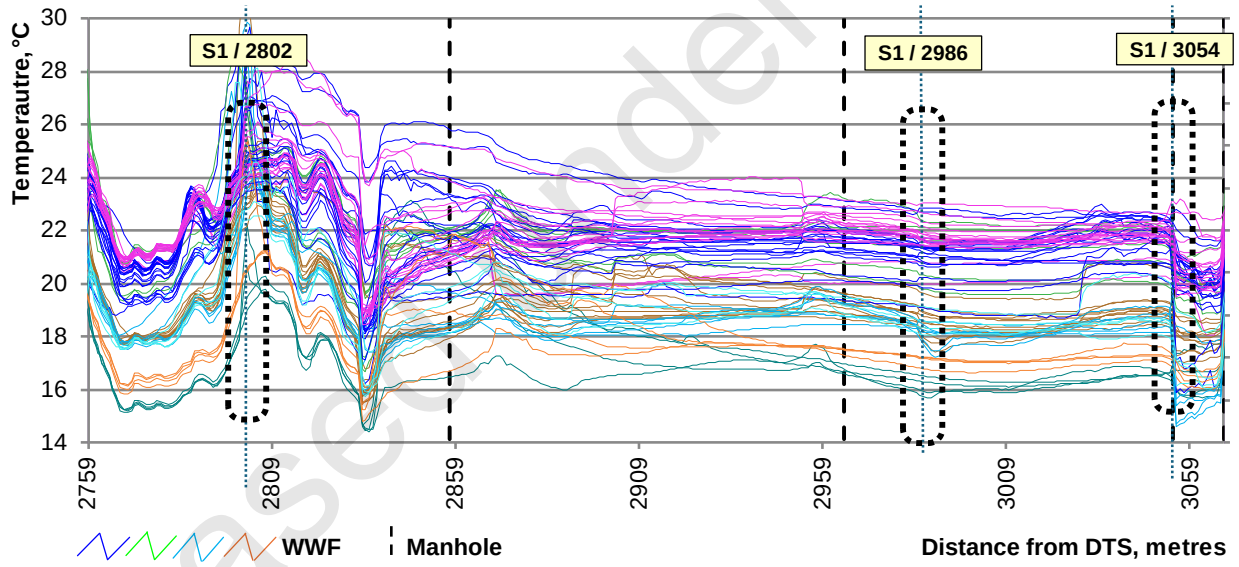
Source Identification Map

Notes:
1. Upstream manhole 12357 @ 124 High Street @ 2758 m.
2. Downstream manhole 13482 @ 226 High Street @ 3068 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

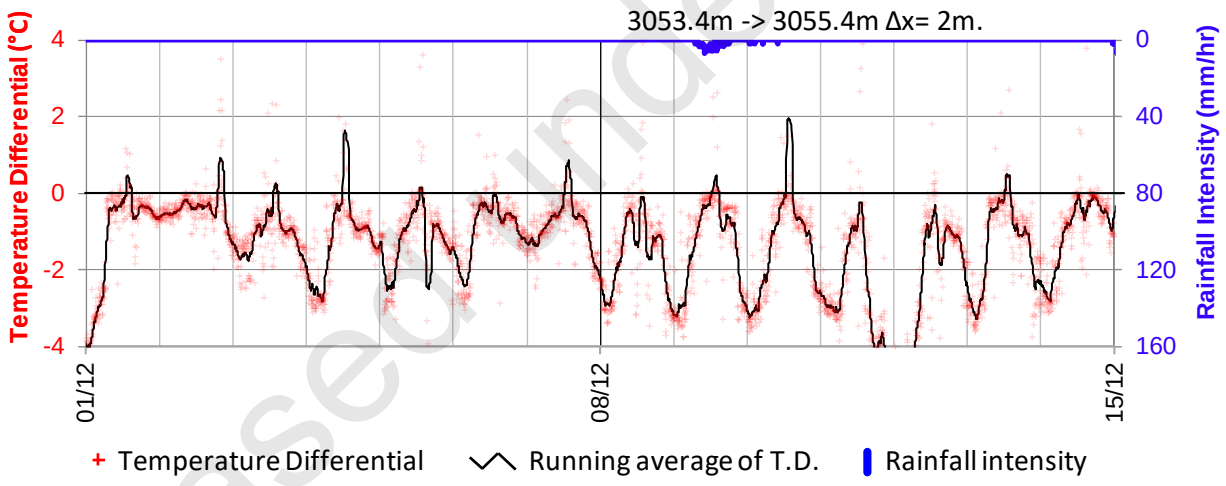


A.1.1 Source S1 / 3054 <new>

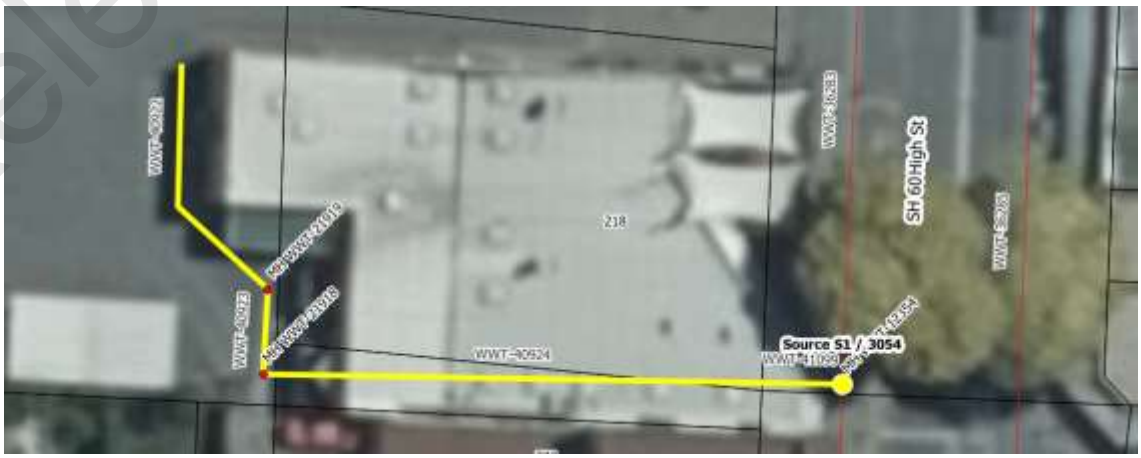
Source Analysis Summary

Asset	Manhole 12354.
Address	218 High Street.
DTS signal	Strong, At manhole 12354.
Analysis	Temperature differential below 0°C during low wastewater flows in the early hours of the morning indicating ground water infiltration.
Recommendation	Inspection of manhole 12354 checking for signs of deterioration and infiltration. The DTS I&I signal was detected at a manhole connected to a section of the catchment that was not directly monitored using DTS. Inspection of the upstream catchment looking for signs of I&I is also recommended. Inspections: Manholes 12354, 21918, 21919. Pipes 49924, 40923, 40922. Property 218 High Street)

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

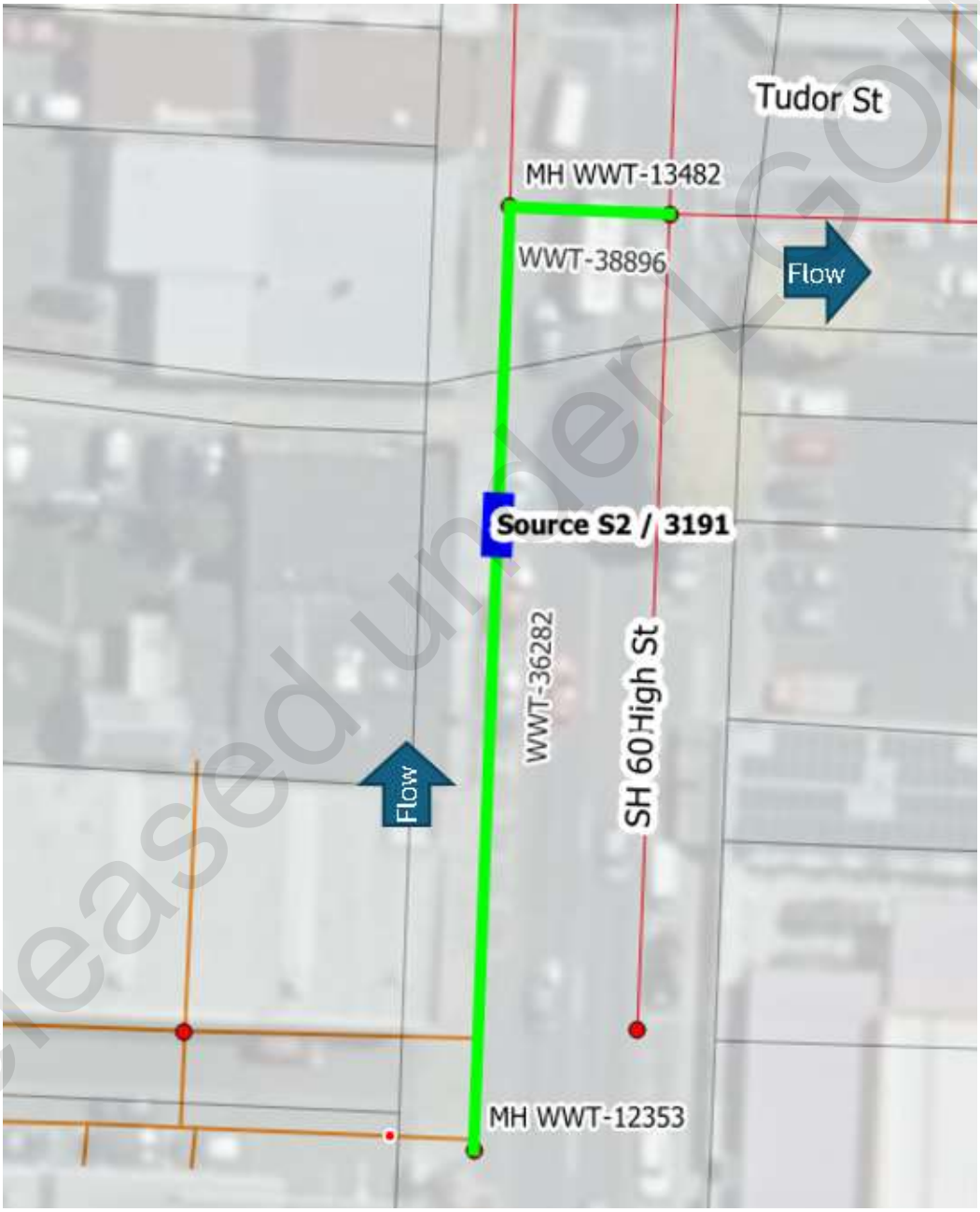


A.2 Section S2: 238 – 226 High Street <new>

One potential source of I&I was identified in this section using the DTS data:

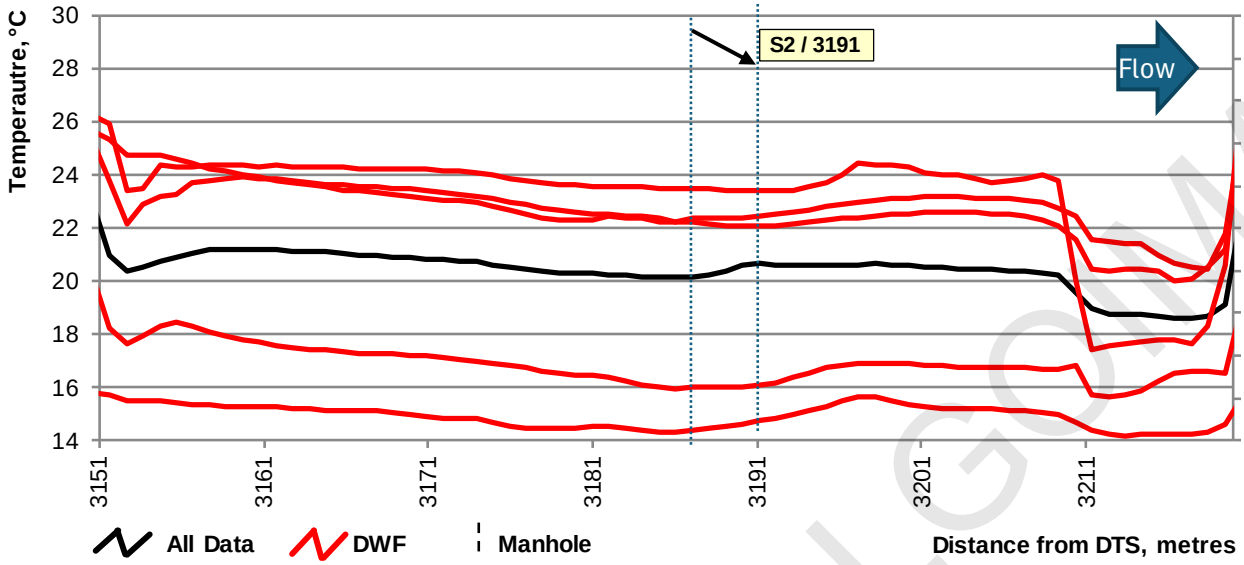
- Stormwater inflow source S2 / 3191 in Pipe 36282 at 230 High Street. <new>

Source Identification Map

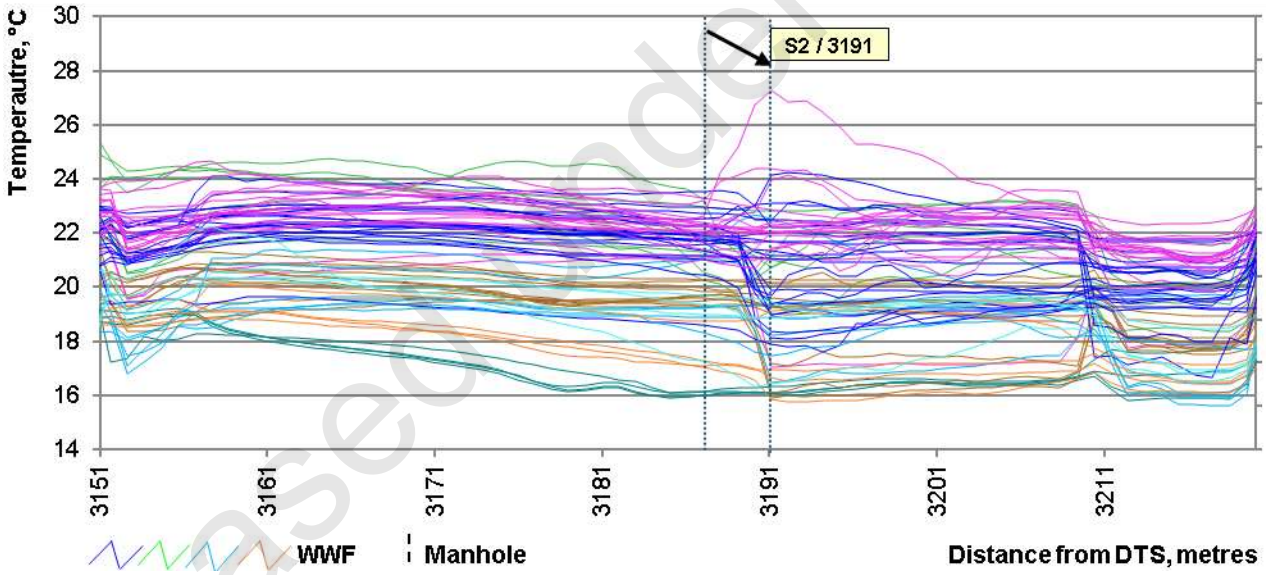


Notes:
1. Upstream manhole 12353 @ 238 High Street @ 3151 m.
2. Downstream manhole 14925 @ 219 High Street @ 3220 m

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

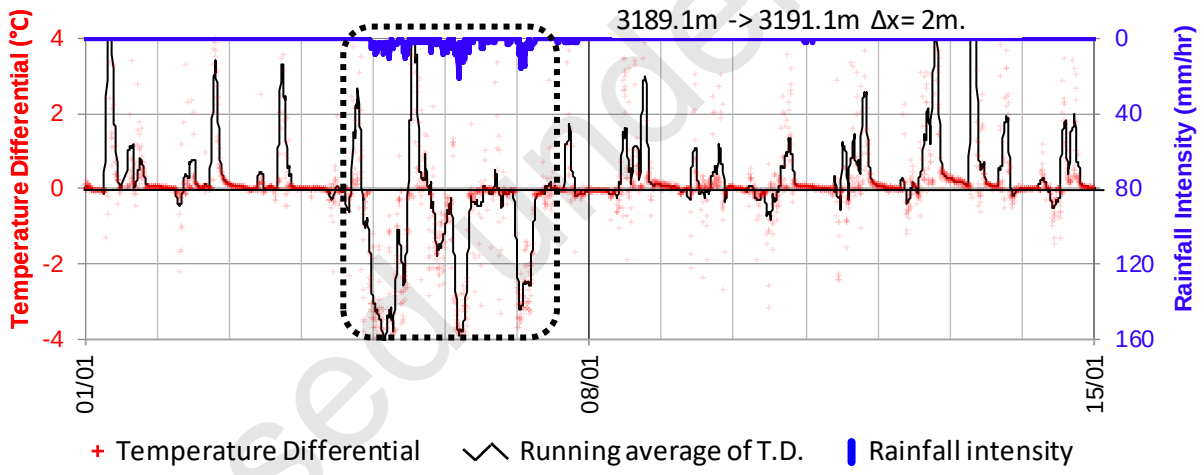


A.2.1 Source S2 / 3191 <new>

Source Analysis Summary

Asset	Pipe 36282 DN150, 59m, Asbestos Cement, 1949.
Address	230 High Street.
DTS signal	Strong, 20m ±3m upstream of manhole 13482.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 36282 to determine the connection point of laterals not shown on the GIS map (230 High St.). Inspection of nearby connected properties (230 High St.) looking for deterioration and inflow.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.3 Section S3: 127 – 210 High Street <new>

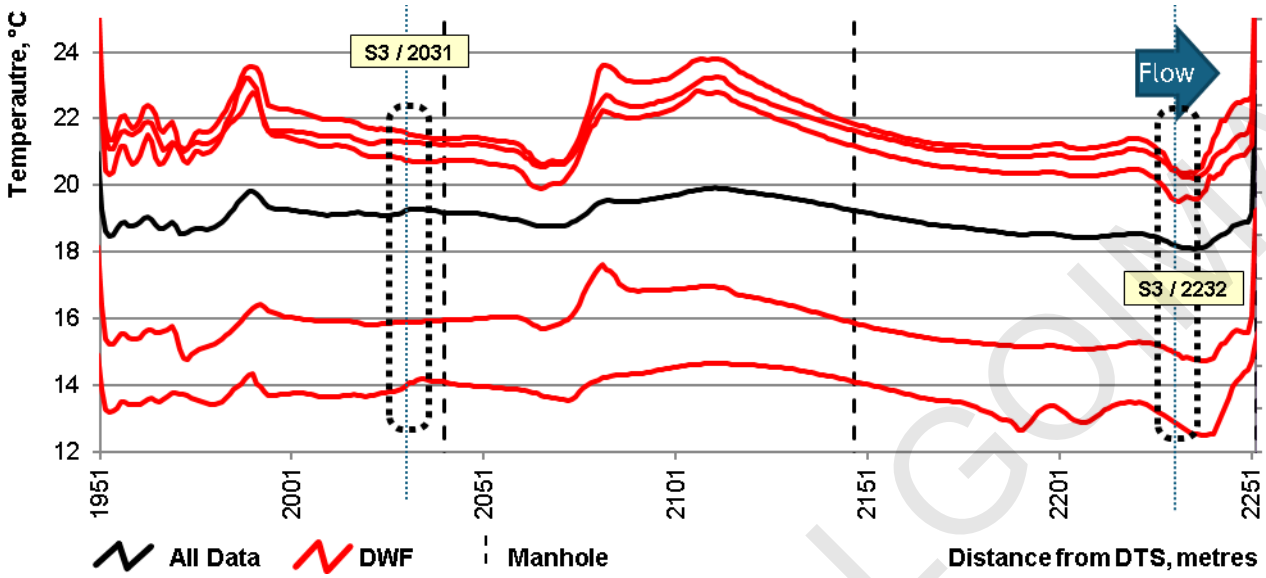
Two potential sources of I&I were identified in this section using the DTS data:

- Stormwater inflow source S3 / 2031 in Pipe 29279 at 157 High Street. <new>
- Groundwater infiltration source S3 / 2232 in Pipe 36285 at 219 High Street. <new>

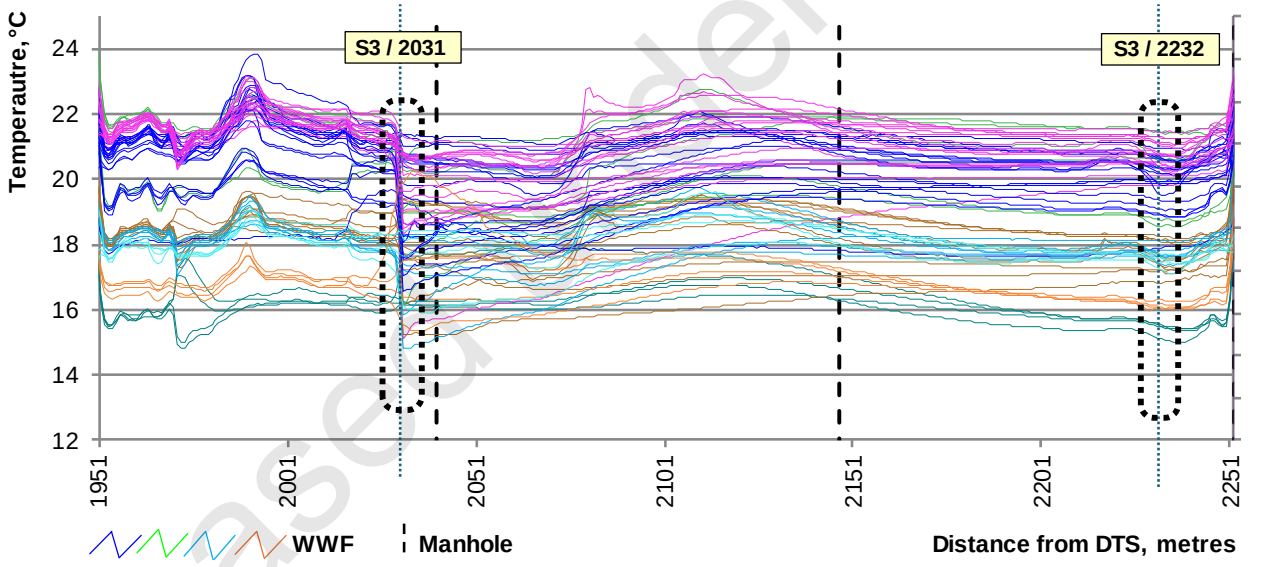
Source Identification Map

Notes:
1. Upstream manhole 17052 @ 131 High Street @ 1950m.
2. Downstream manhole 14925 @ 219 High Street @ 2252 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

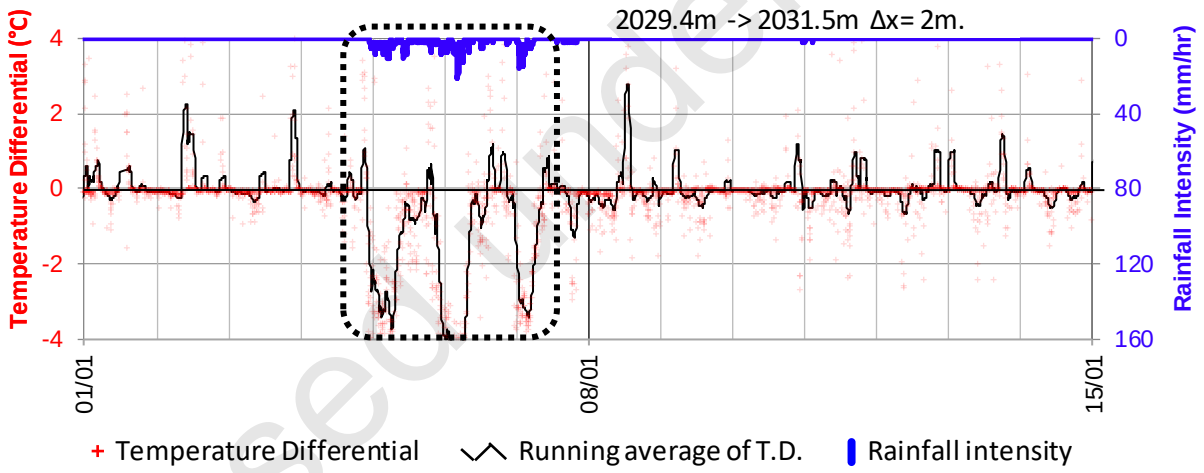


A.3.1 Source S3 / 2031 <new>

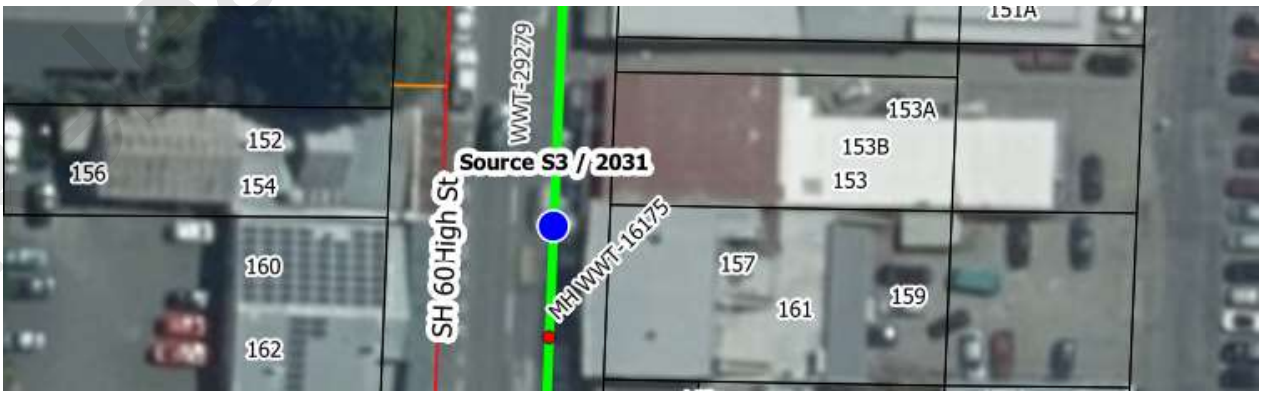
Source Analysis Summary

Asset	Pipe 29279 DN150, 89m, Concrete, 1949.
Address	157 High Street.
DTS signal	Strong, 10m ±3m upstream of manhole 16175.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 29279 to determine the connection point of laterals not shown on the GIS map (157, 159, 161 High St.). Inspection of nearby connected properties (157, 159, 161 High St.) looking for deterioration and inflow.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

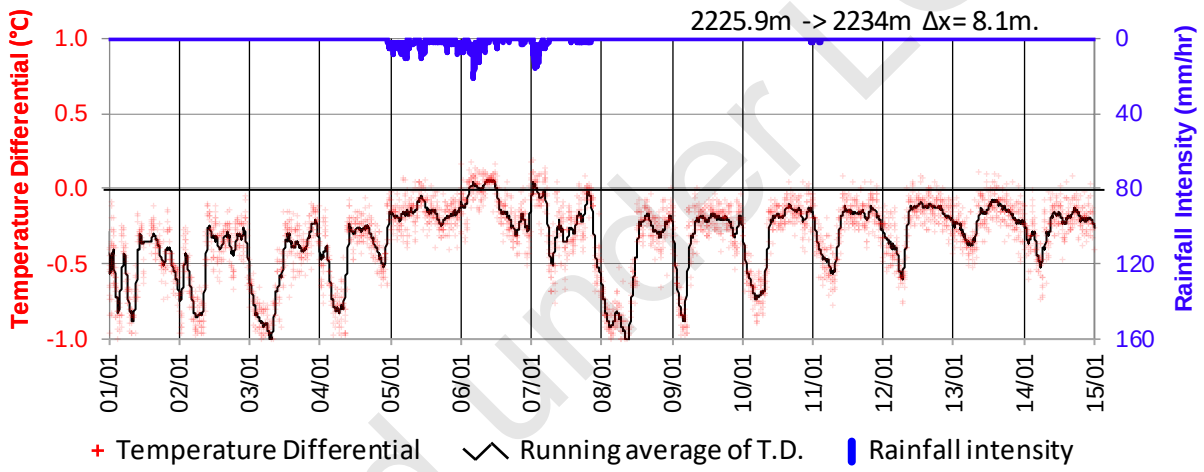


A.3.2 Source S3 / 2232 <new>

Source Analysis Summary

Asset	Pipe 36285 DN150, 103m, Concrete, 1949.
Address	219 High Street.
DTS signal	Strong. 23m ±3m upstream of manhole 14925.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 36285 checking for signs of deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.4 Section S4: Hart Lane <new>

Two potential sources of I&I were identified in this section using the DTS data:

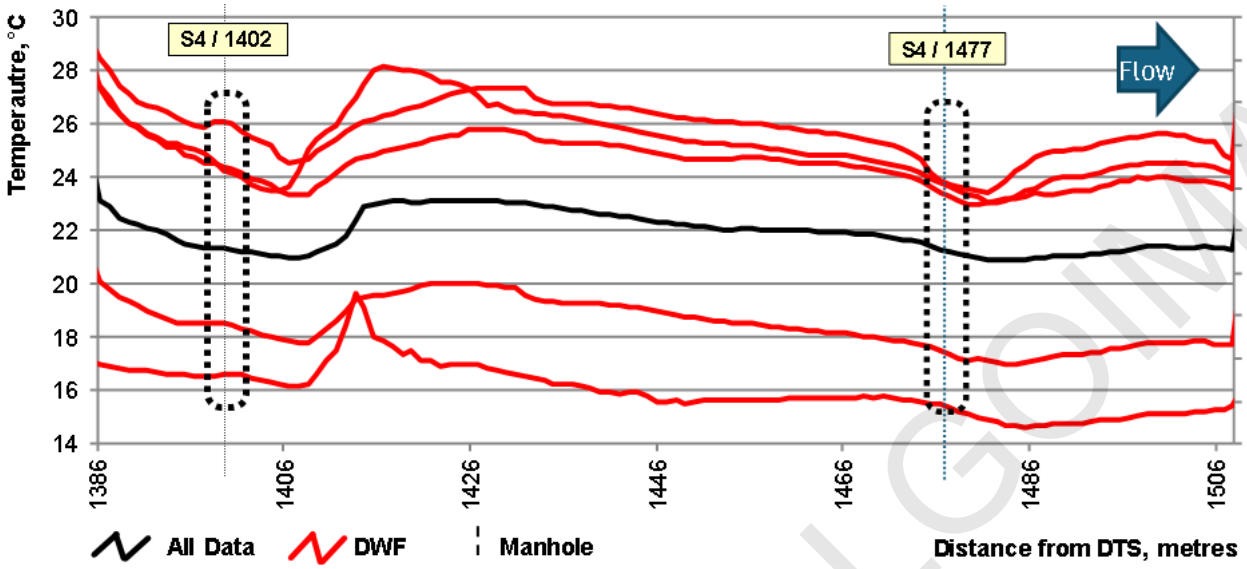
- Groundwater infiltration source S4 / 1402** in Pipe 36238 at 191B High Street. <new>
- Groundwater infiltration source S4 / 1477 in Pipe 36238 at 14B Tudor Street. <new>

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

Source Identification Map

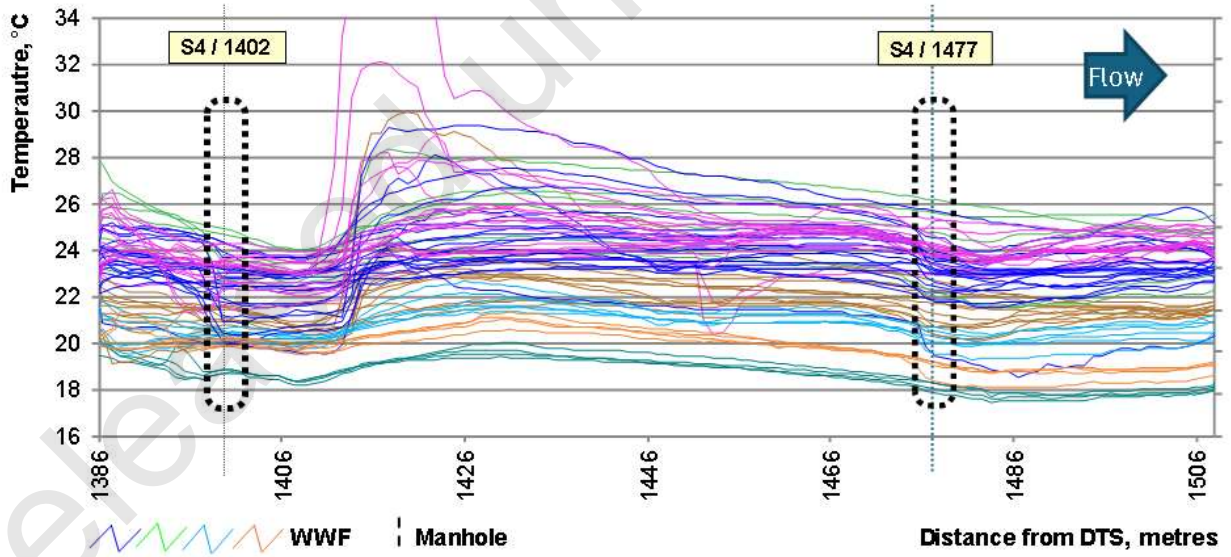
Notes:
1. Upstream manhole 12006 @ 21 Wallace Street @ 1385 m.
2. Downstream manhole 12342 @ 11 Tudor Street @ 1508 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

The temperature drop at 1452 m highlighted by the pink trace in the plot below was assessed not to be I&I. This location exhibits temperature drops during the middle of the day during the medium to high wastewater flows. This suggests a source of *wastewater* that is cooler than the upstream wastewater rather than indicating a source of cool I&I.

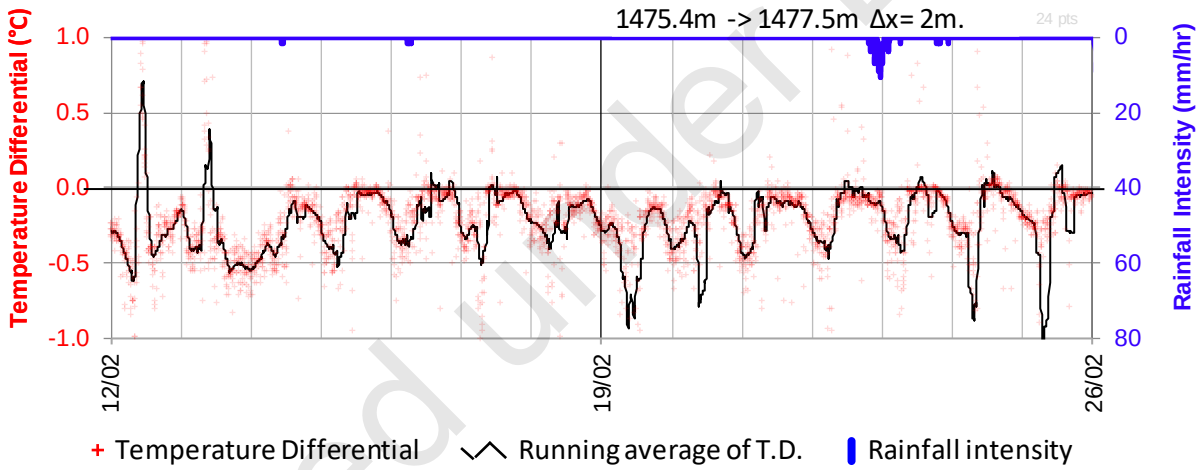


A.4.1 Source S4 / 1477 <new>

Source Analysis Summary

Asset	Pipe 36238 DN150, 122m, Concrete, 1996.
Address	14B Tudor Street.
DTS signal	Strong, 32m ±3m upstream of manhole 12342.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 36238 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (14B Tudor St.) looking for deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.5 Section S5: Tudor Street <new>

This section is split into two parts, Section S5a and Section S5b.

Section S5a: 219 High Street to 35 Tudor Street

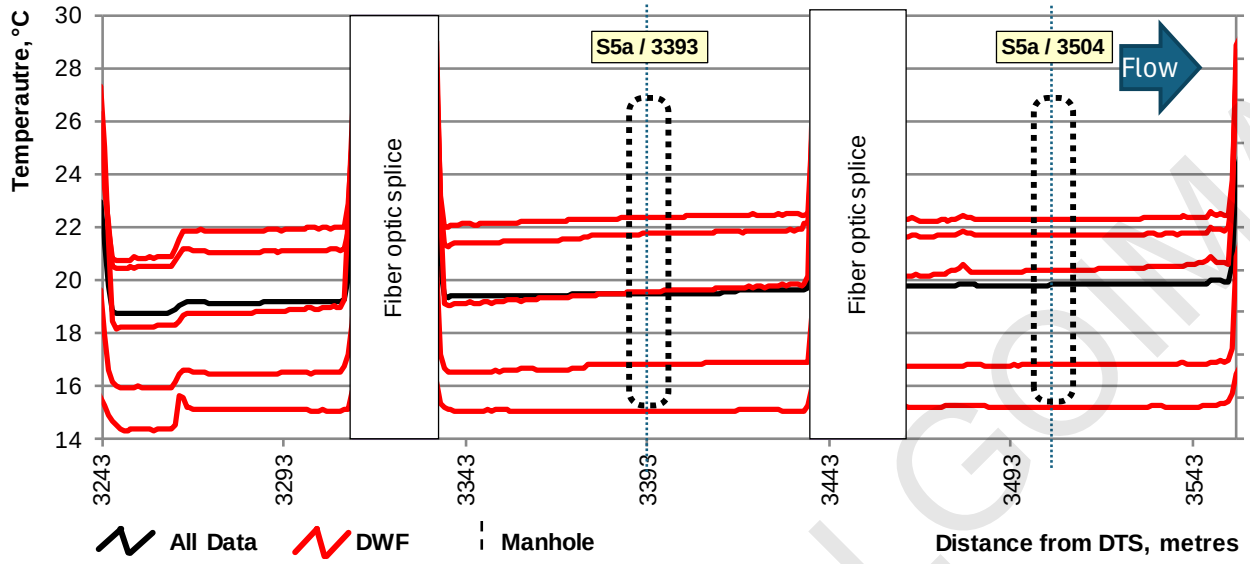
Two potential sources of I&I were identified in this section using the DTS data:

- Stormwater inflow source S5a / 3393 in Pipe 38897 at 18 Tudor Street. <new>
- Stormwater inflow source S5a / 3504 in Pipe 38900 at 27 Tudor Street. <new>

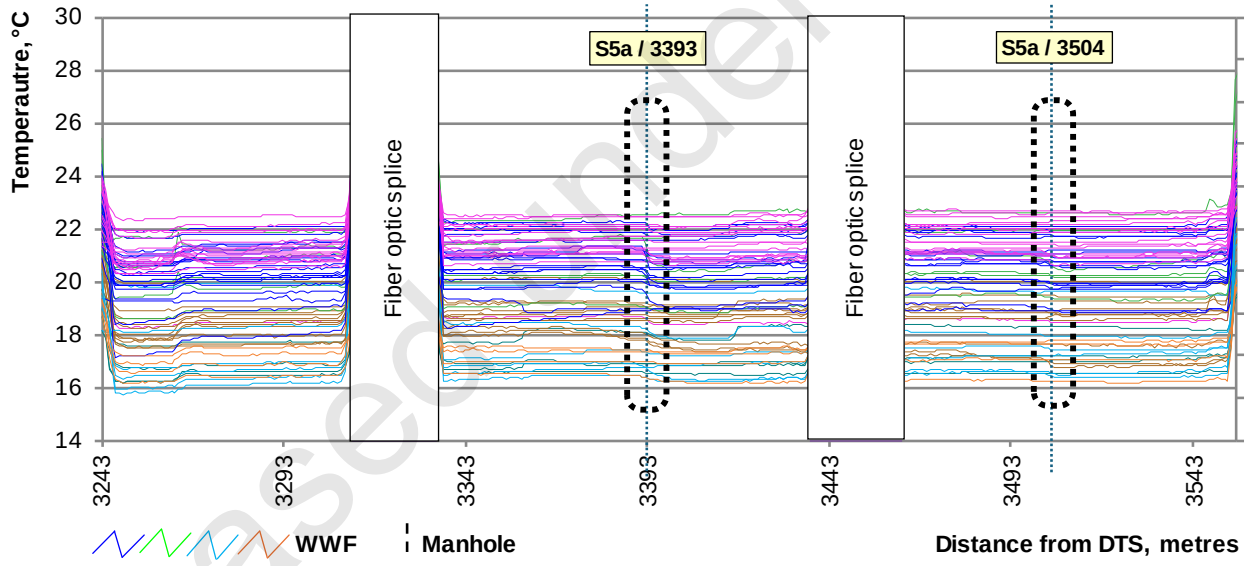
Source Identification Map

Notes:
1. Upstream manhole 14925 @ 219 High Street @ 3242 m.
2. Downstream manhole 16126 @ 35 Tudor Street @ 3555 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

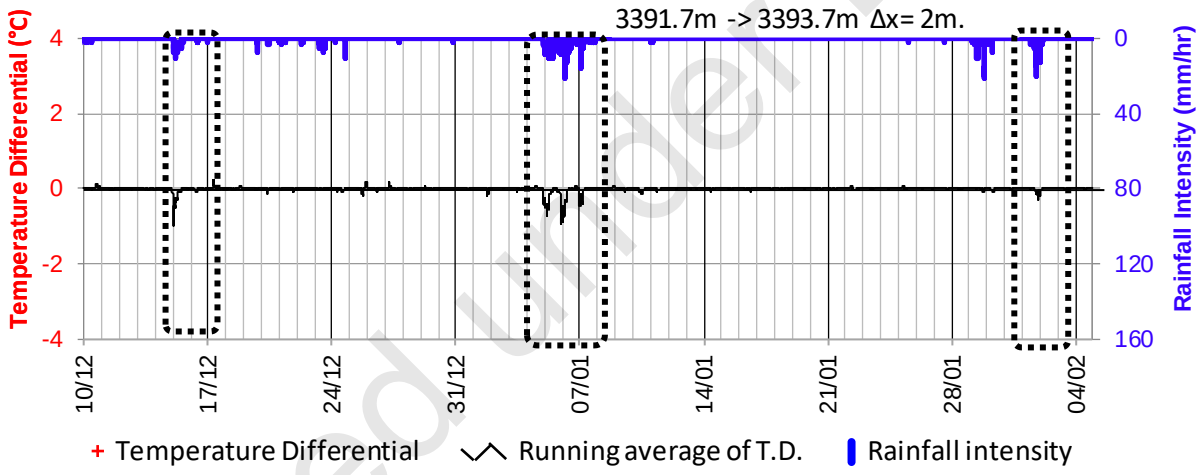


A.5.1 Source S5a / 3393 <new>

Source Analysis Summary

Asset	Pipe 38897 DN225, 102m, uPVC, 2008.
Address	18 Tudor Street.
DTS signal	Strong, 45m ±3m upstream of manhole 12008.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (18, 20 Tudor St.) looking for deterioration and/or SW connections.

Source Analysis Plot – Temperature Difference vs Time



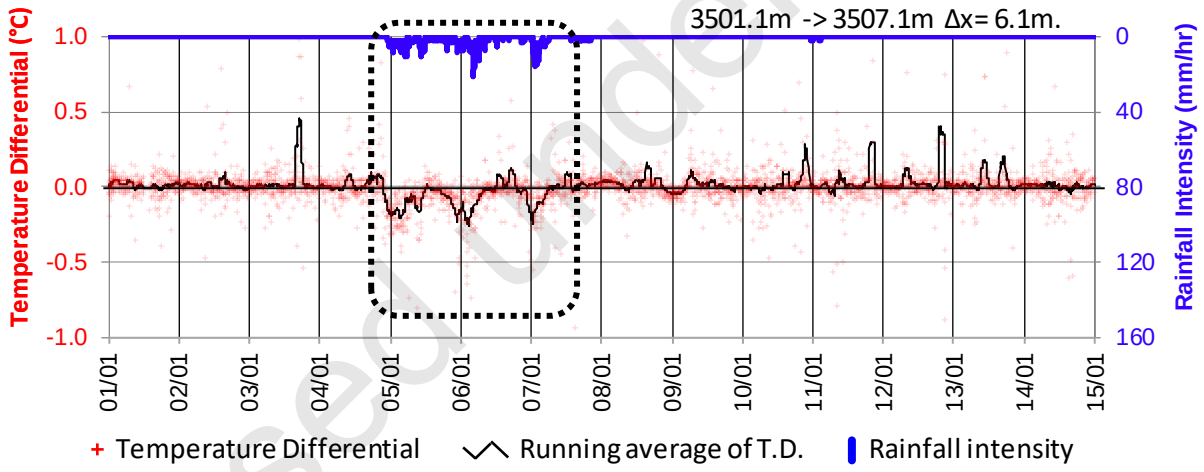
Source Location Map

A.5.2 Source S5a / 3504 <new>

Source Analysis Summary

Asset	Pipe 38900 DN225, 67m, uPVC, 2008.
Address	27 Tudor Street.
DTS signal	Medium. 21m ±3m downstream of manhole 12007.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (27 Tudor St.) looking for deterioration and/or SW connections.
Note	The DTS signal suggests a stormwater inflow, likely from a private property, requiring a hydraulic connection to surface features. As the wastewater main is underground and unlikely to have direct stormwater entry, it has not been included in the CCTV inspection.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

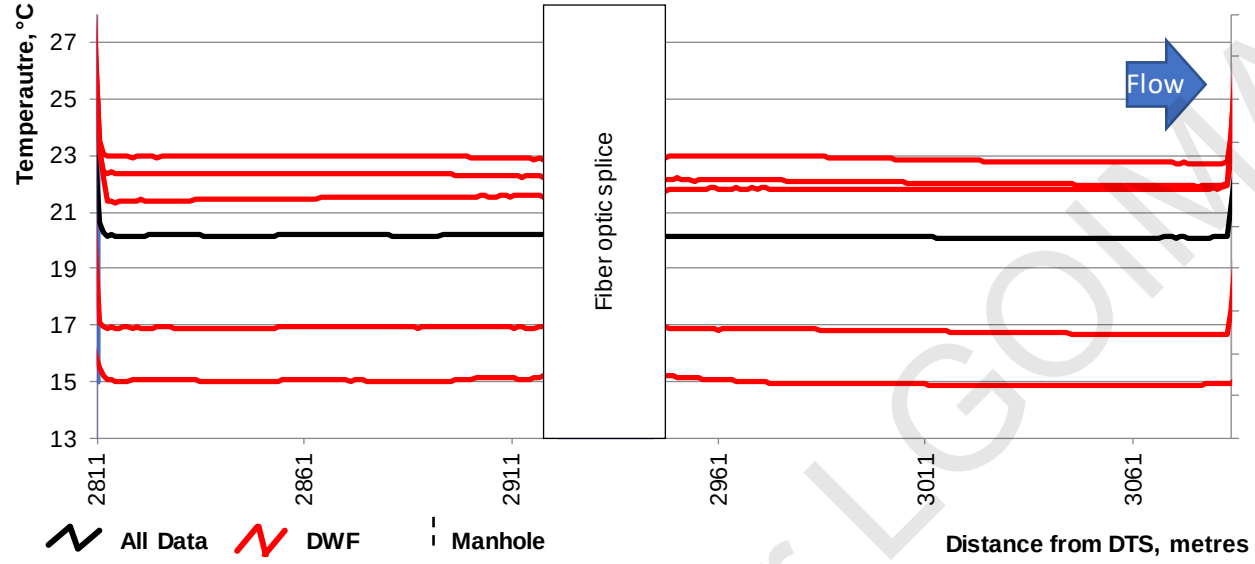
Section S5b: 35 - 67 Tudor Street

No potential sources of I&I were identified in this section using the DTS data.

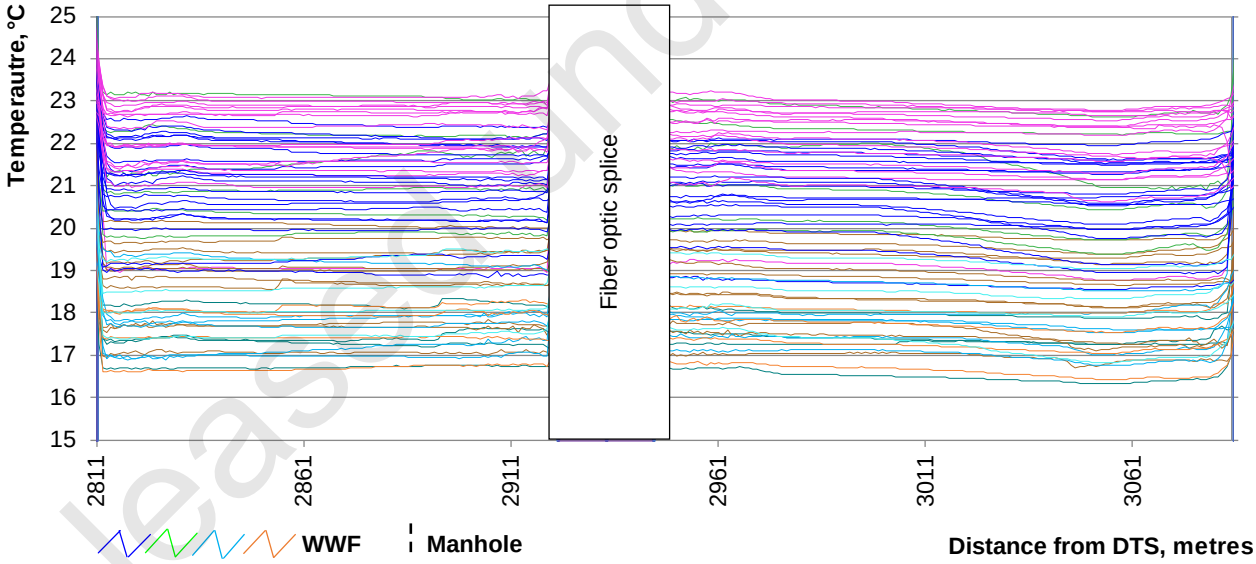
Source Identification Map

Notes:
1. Upstream manhole 16126 @ 35 Tudor Street @ 2811 m.
2. Downstream manhole 14579 @ 67 Tudor Street @ 3085 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

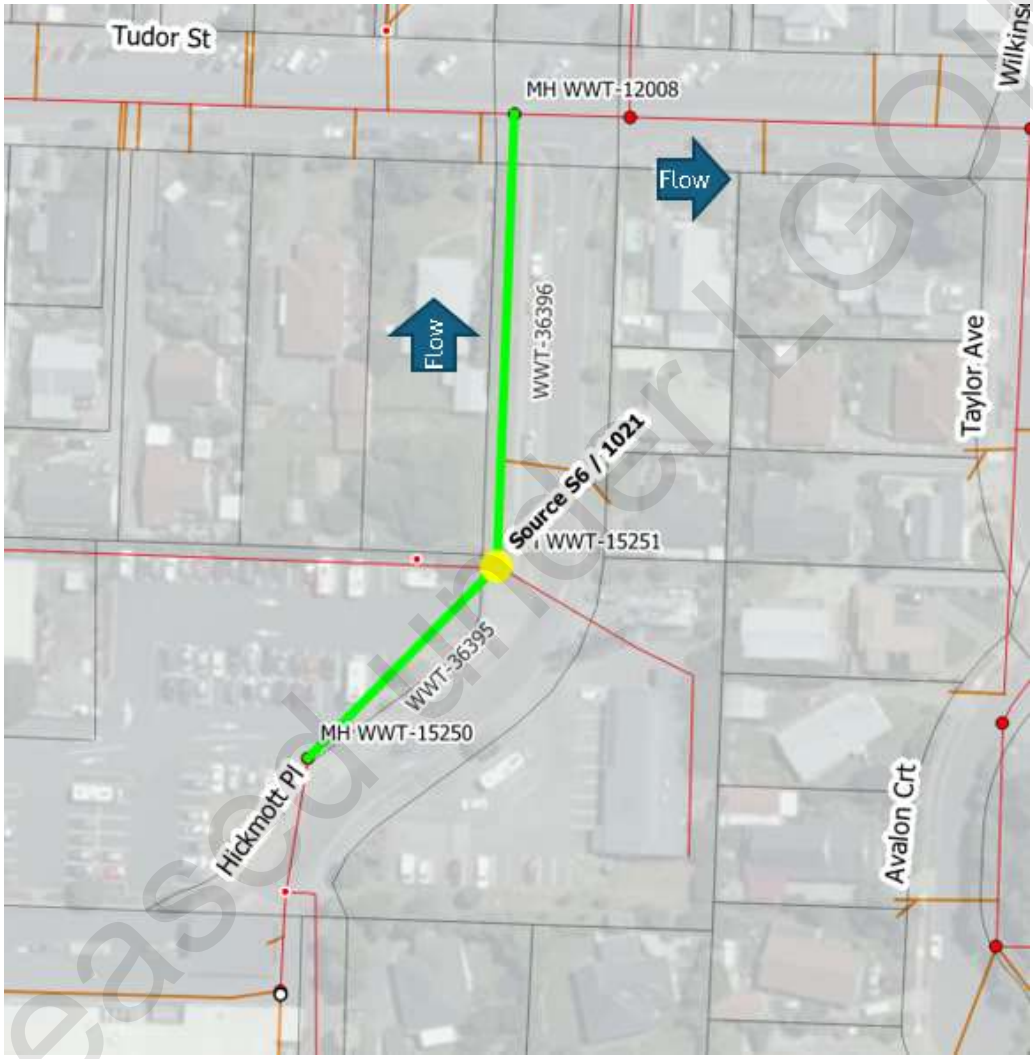


A.6 Section S6: Hickmott Place <new>

One potential source of I&I was identified in this section using the DTS data:

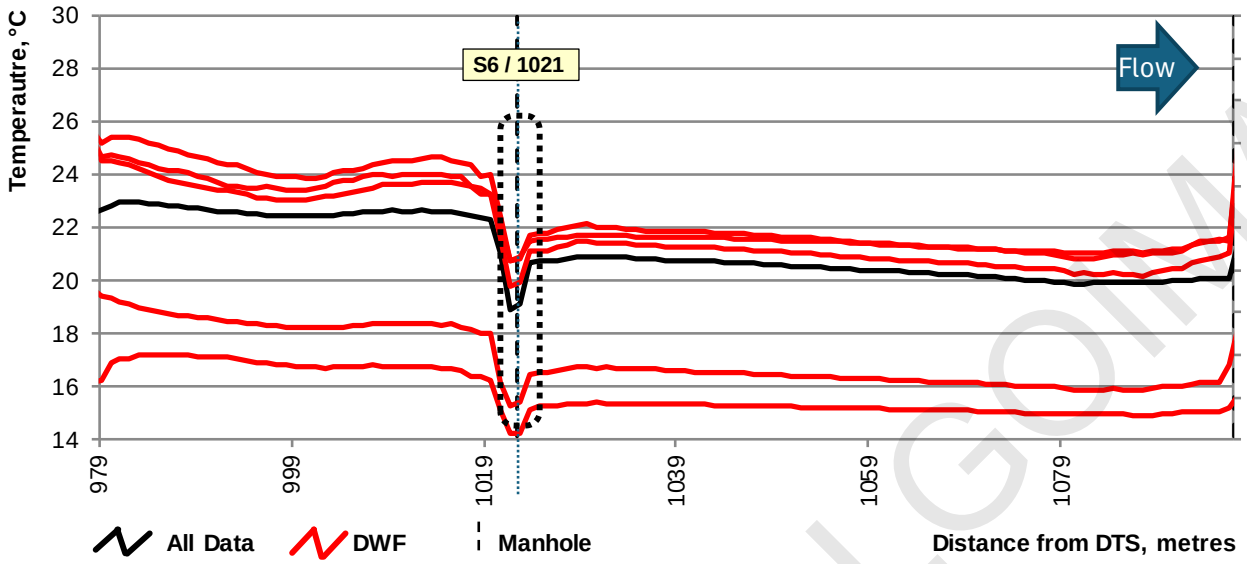
- Groundwater infiltration source S6 / 1021 in Manhole 15251 at 8 Hickmott Place. <new>

Source Identification Map

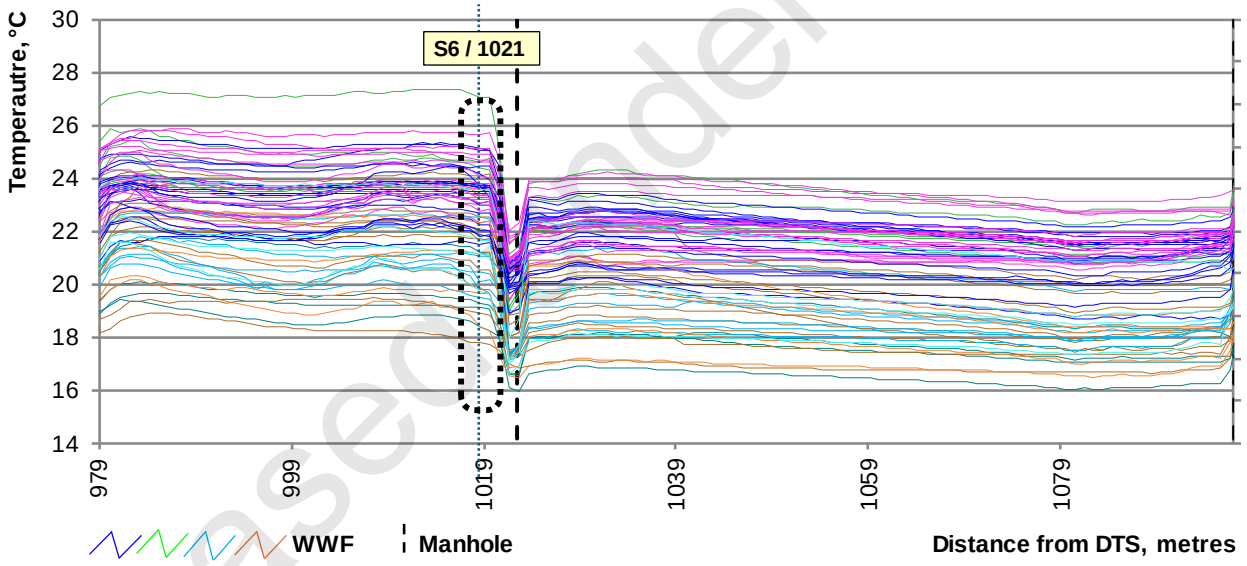


Notes:
1. Upstream manhole 15250 @ 8 Hickmott Place @ 978 m.
2. Downstream manhole 12008 @ 21 Tudor Street @ 1097 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

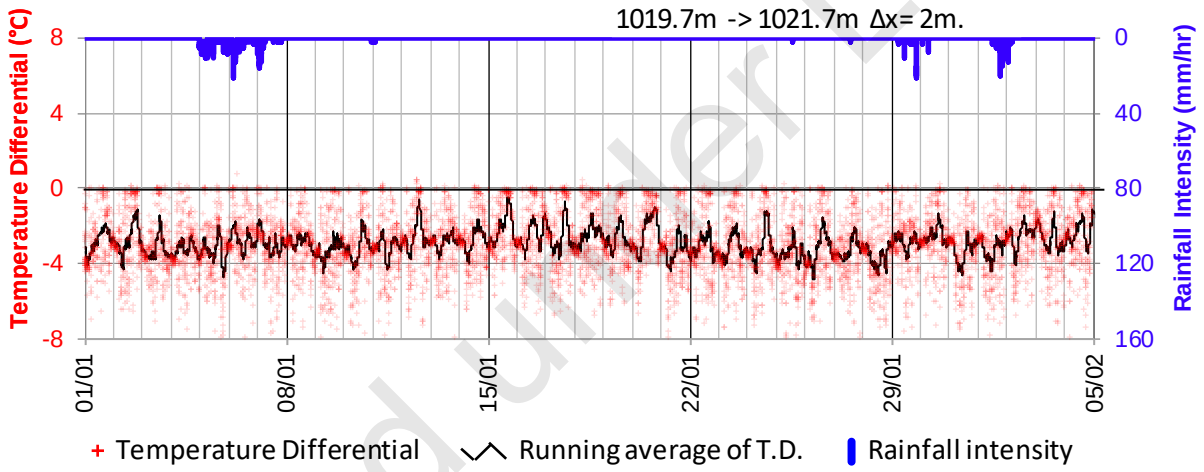


A.6.1 Source S6 / 1021<new>

Source Analysis Summary

Asset	Manhole 15251.
Address	8 Hickmott Place.
DTS signal	Strong, At manhole 15251.
Analysis	Temperature differential consistently below 0°C indicating GWI.
Recommendation	Inspection of manhole 15251 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (7 & 8 Hickmott Pl.) looking for deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.7 Section S7: Wallace Street

Four potential sources of I&I were identified in this section using the DTS data:

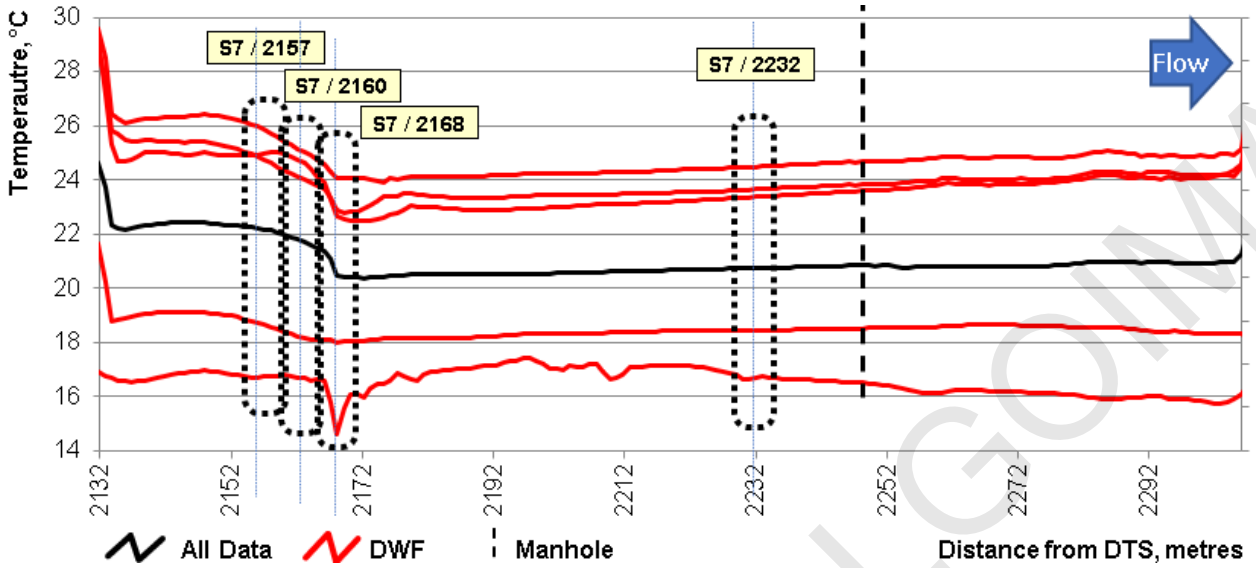
- Stormwater inflow source S7 / 2157 in pipe 31206 at 27 Wallace Street.
- Stormwater inflow source S7 / 2160** in pipe 31206 at 27 Wallace Street.
- Stormwater inflow and groundwater infiltration source S7 / 2168 in pipe 31206 at 27 Wallace Street.
- Stormwater inflow source S7 / 2232** in Pipe 31206 at 31 Wallace Street.

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

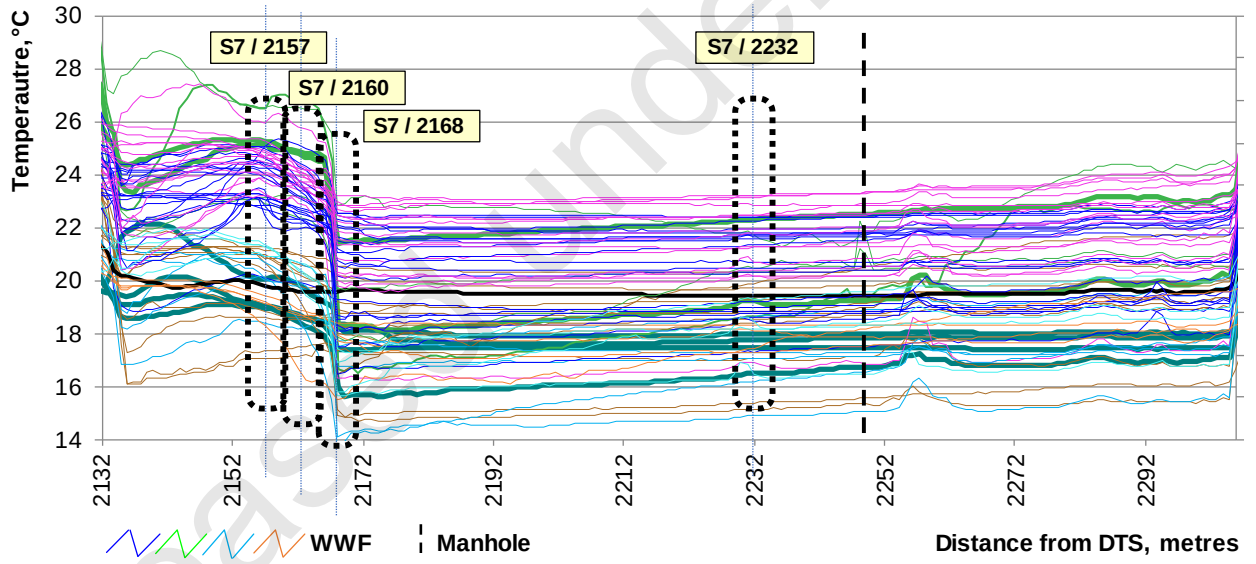
Source Identification Map

Notes:
1. Upstream manhole 18011 @ 23 Wallace Street @ 2132 m.
2. Downstream manhole 12323 @ 20 Wilkinson Street @ 2306 m

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

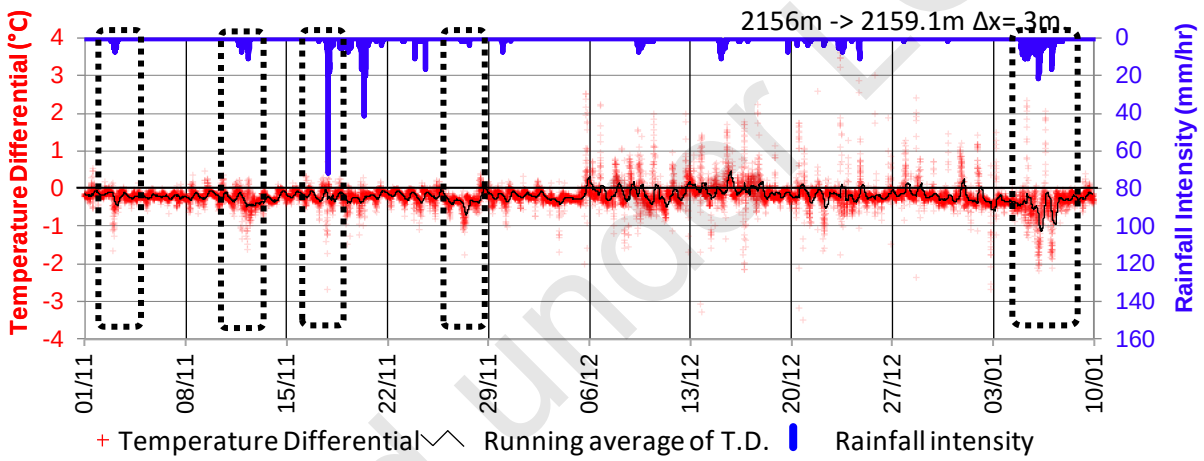


A.7.1 Source S7 / 2157

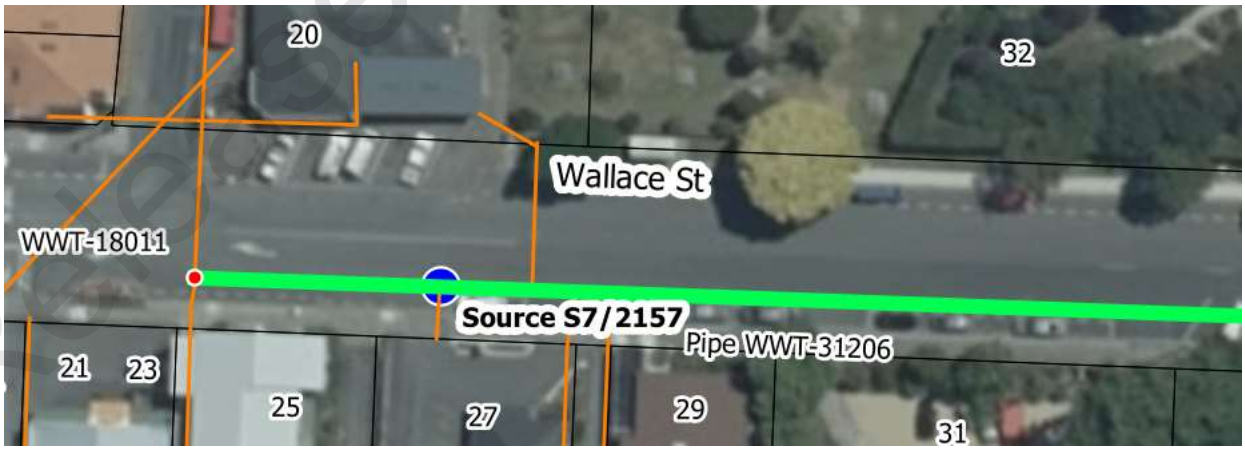
Source Analysis Summary

Asset	Pipe 31206 DN150, 114m, PVC, 1984.
Address	27 Wallace Street.
DTS signal	Strong, 25m ±3m downstream of manhole 18011.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (27 Wallace Street) looking for deterioration and/or stormwater connections.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map



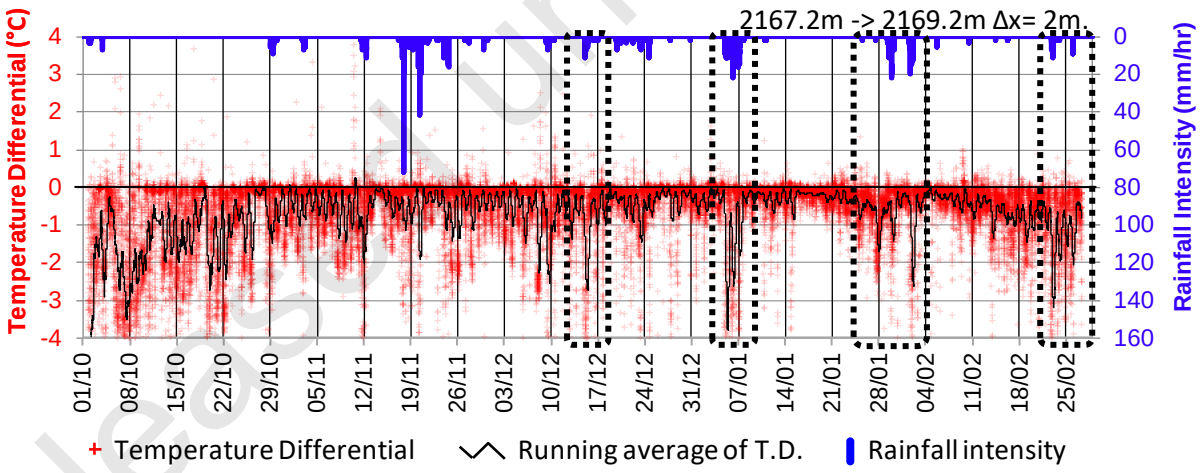
A.7.2 Source S7 / 2168

Source Analysis Summary

Asset	Pipe 31206 DN150, 114m, PVC, 1984.
Address	27 Wallace Street.
DTS signal	Strong, 36m ±3m downstream of manhole 18011.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow. Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	Inspection of nearby connected properties (20 and 27 Wallace Street) looking for deterioration and/or stormwater connections.
Note	The inspection of 27 Wallace Street is provided in the recommendations for S7 / 2157.

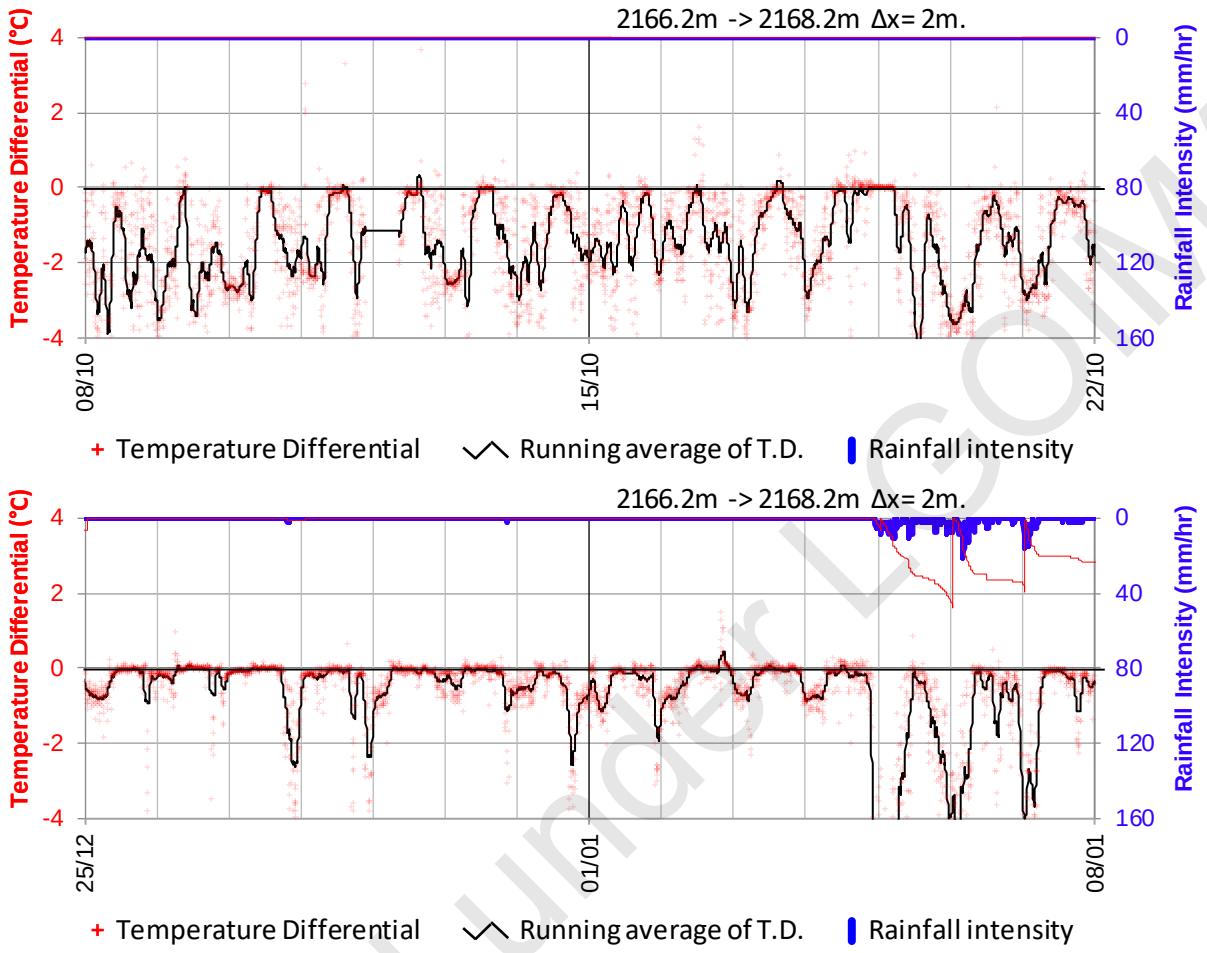
Source Analysis Plot – Temperature Difference vs Time

In the plot below temperature drops correlated with rain events (indicating SWI) are highlighted using black dashed rectangles.



In the plot **above**, during the first four weeks of monitoring, it appears that **during dry weather** there are temperature depressions of equivalent magnitude to what is observed during rain events. In the plot above the black trace is a rolling 12-hour average temperature differential. This long timespan for the rolling average was used to highlight the response to rain events.

The plots below present close-up views of the data from October and December 2022 using a 2-hour rolling average for the blank trace to highlight diurnal patterns. Close-up inspection of the data during this period indicates that the temperature depression during dry weather conditions is occurring in the late hours of the evening and the early hours of the morning. This is consistent with groundwater infiltration that is constantly occurring but is not significant enough to change the temperature of the wastewater during the hours of peak wastewater flow rates.



Source Location Map

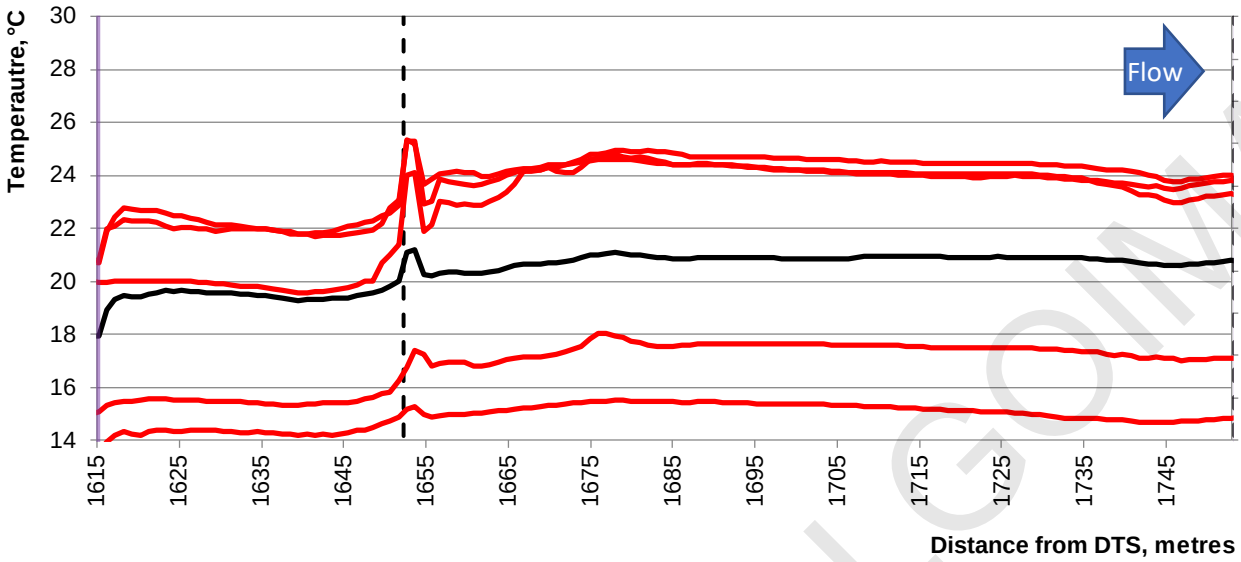
A.8 Section S8: 1 Taylor Ave to 9 Avalon Court

No potential sources of I&I were identified in this section using the DTS data.

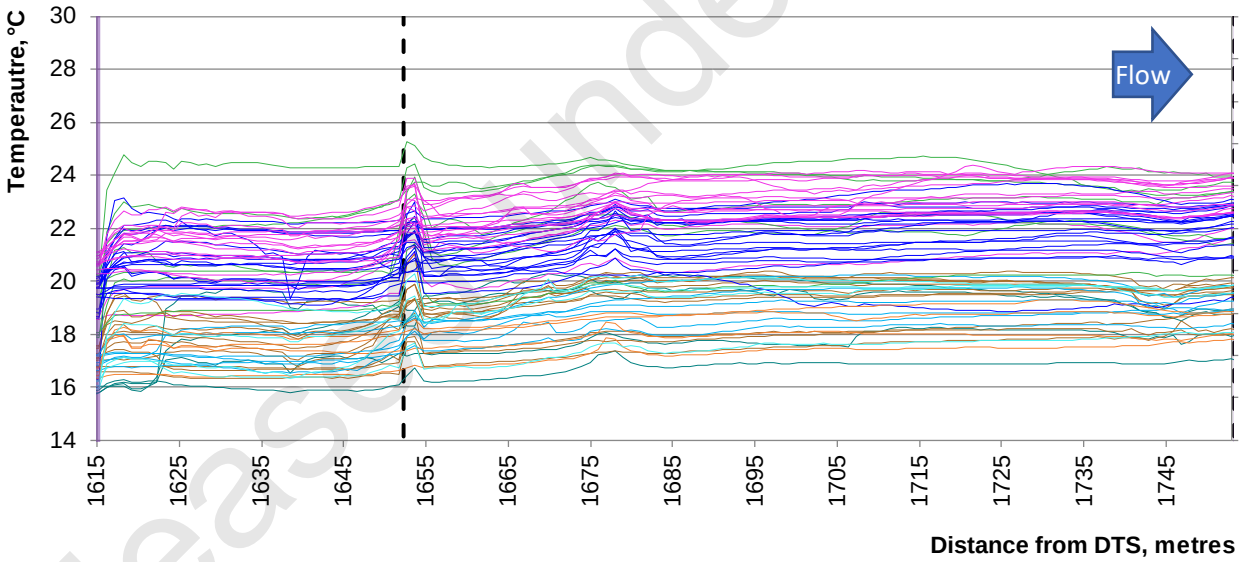
Source Identification Map

Notes:
1. Upstream manhole 13453 @ 2 Avalon Court @ 1617 m.
2. Downstream manhole 16126 @ 35 Tudor Street @ 1758 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

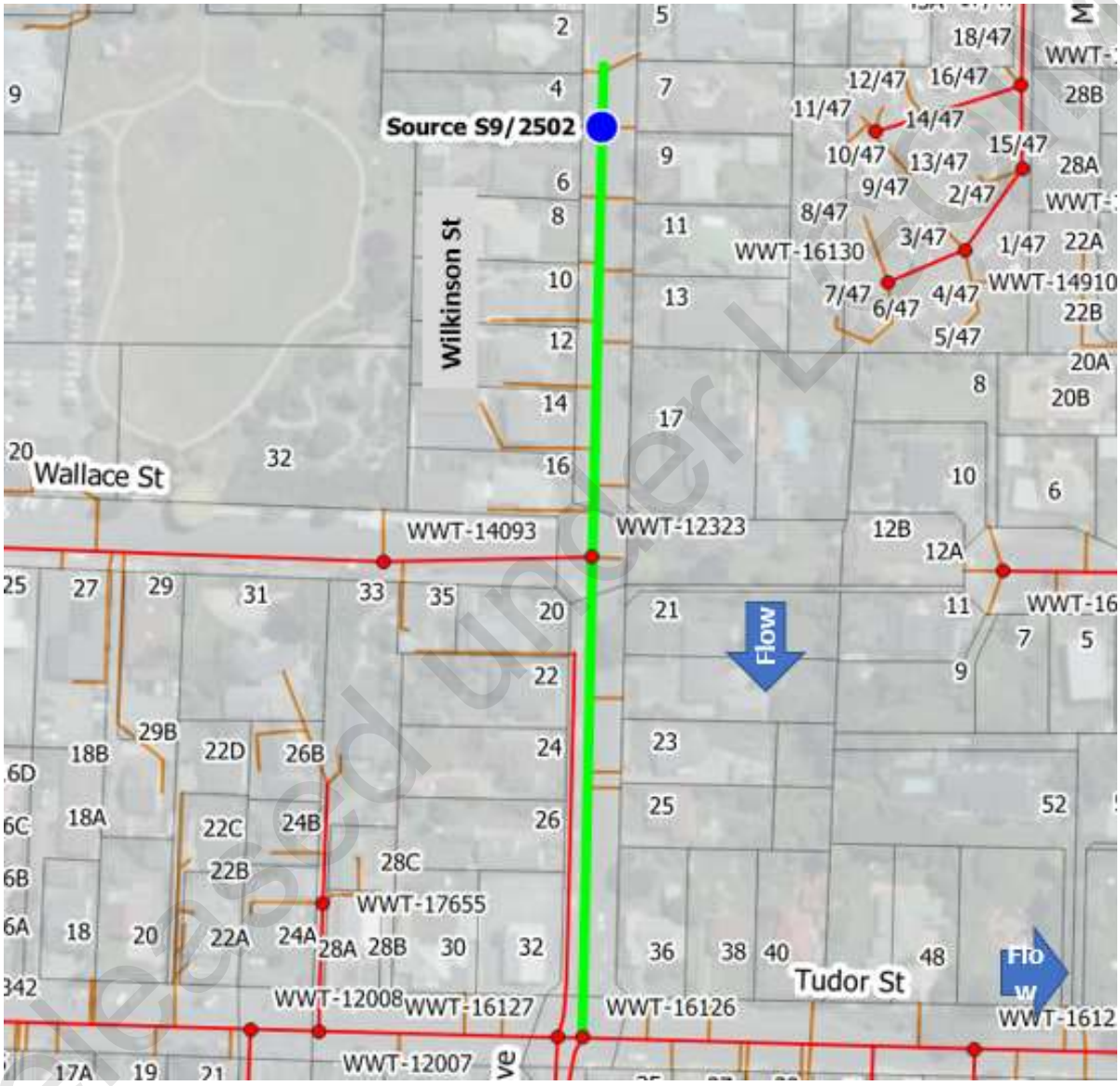


A.9 Section S9: Wilkinson Street

One potential source of I&I was identified in this section using the DTS data:

- S9 / 2502 Stormwater inflow source in pipe 41015 at 4 Wilkinson Street.

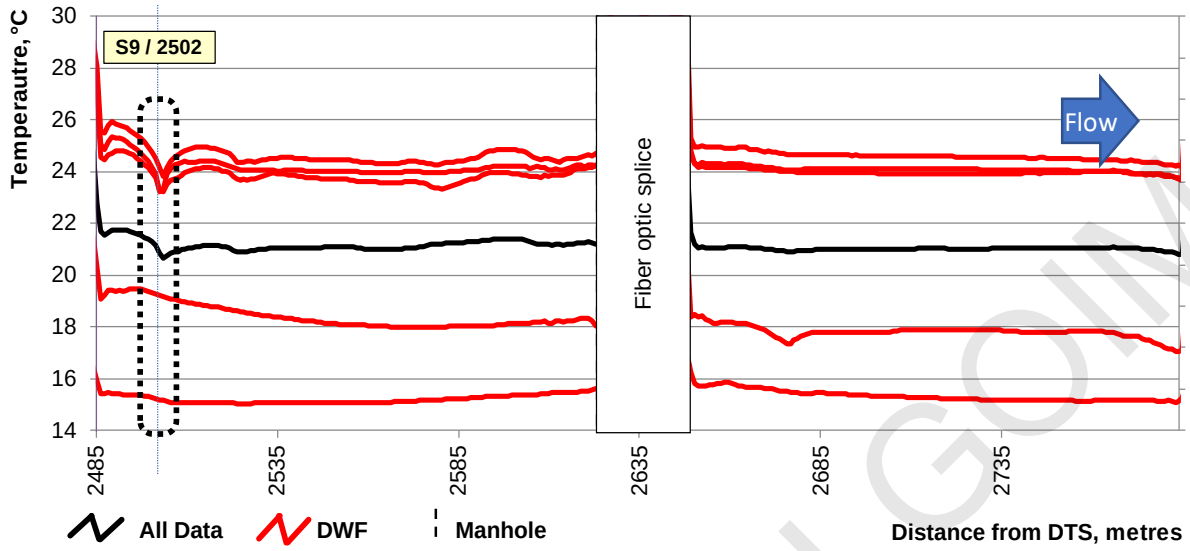
Source Identification Map



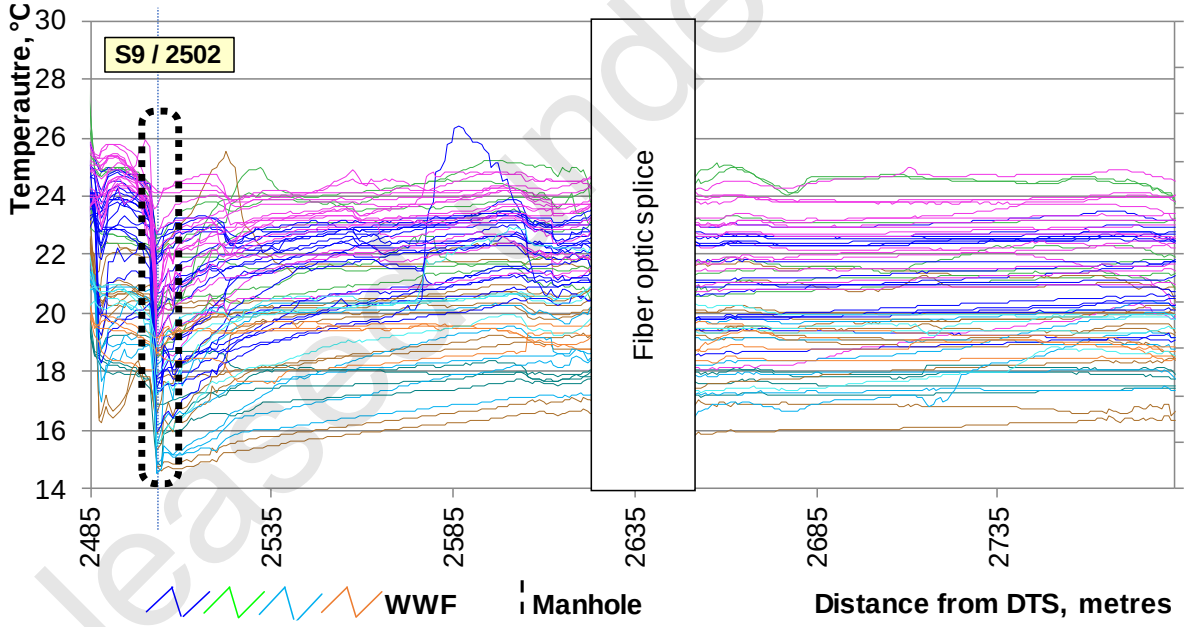
Notes:

1. Upstream manhole 12324 @ 2 Wilkinson Street @ 2486 m.
2. Downstream manhole 16126 @ 35 Tudor Street @ 2787 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

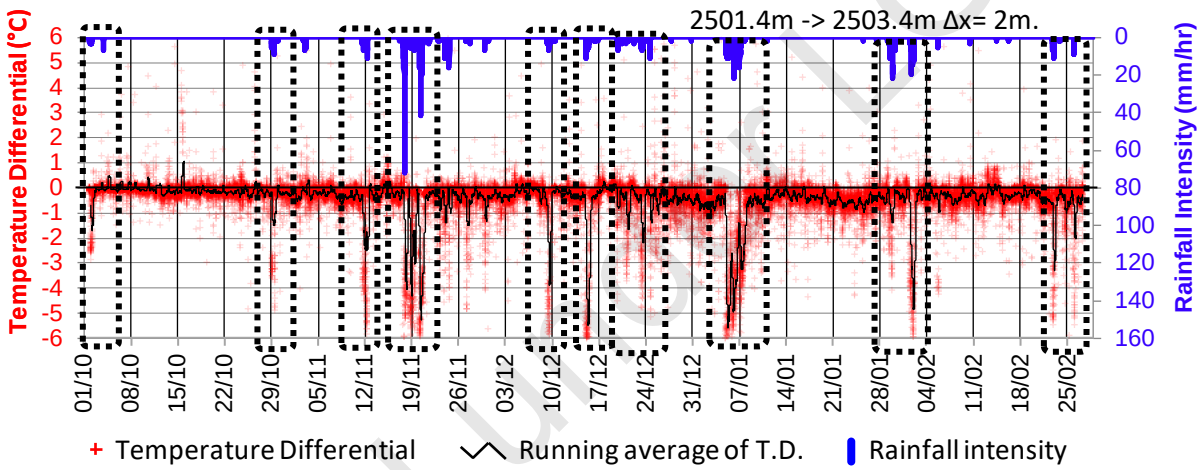


A.9.1 Source S9 / 2502

Source Analysis Summary

Asset	Pipe 41015 DN150, 138m, uPVC, 2010.
Address	4 Wilkinson Street.
DTS signal	Strong, 17m ±3m downstream of manhole 12324.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (4 and 7 Wilkinson Street) looking for deterioration and/or stormwater connections.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.10 Section S10: 95 - 67 Tudor Street

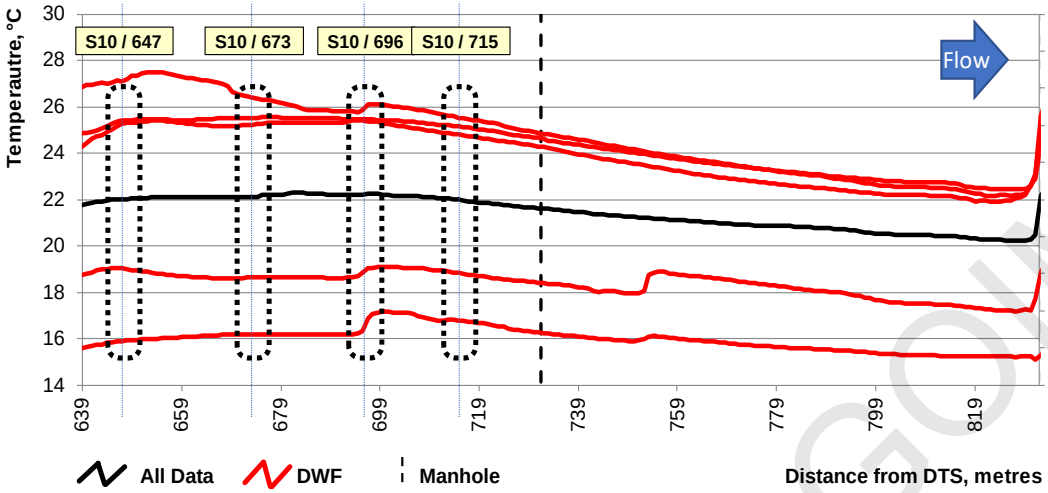
Four potential sources of I&I were identified in this section using the DTS data:

- Stormwater inflow source S10 / 647 in pipe 36229 at 88 Tudor Street.
- Stormwater inflow source S10 / 763 in pipe 36229 at 86 Tudor Street.
- Stormwater inflow source S10 / 696 in pipe 36229 at 84 Tudor Street.
- Stormwater inflow source S10 / 715 in pipe 36229 at 82 Tudor Street.

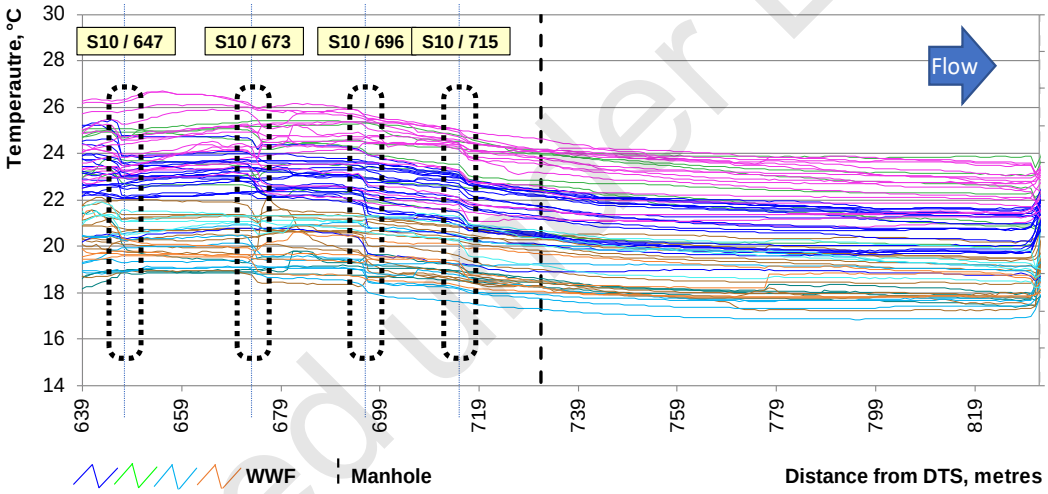
Source Identification Map

Notes:
1. Upstream manhole 12317 @ 91 Tudor Street @ 639 m.
2. Downstream manhole 14579 @ 67 Tudor Street @ 832 m.

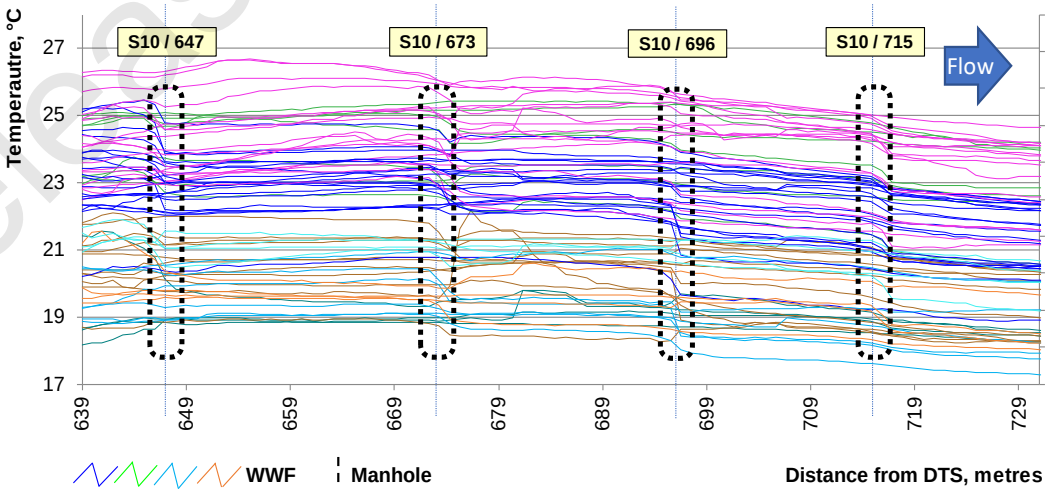
Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals – Close up

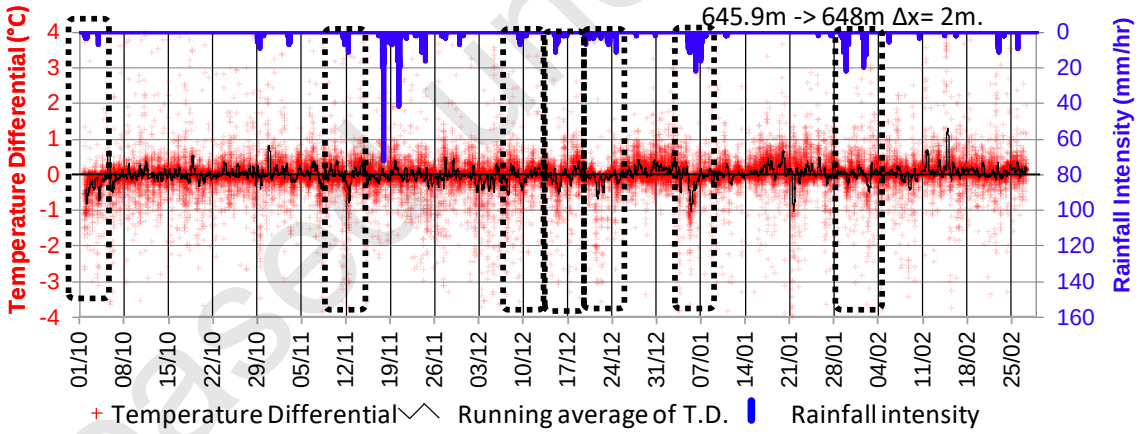


A.10.1 Source S10 / 647

Source Analysis Summary

Asset	Pipe 36229	DN150, 93m, Concrete, 1949.
Address	88 Tudor St.	
DTS signal	Strong, 8m ±3m downstream of manhole 12317.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	CCTV inspection of pipe checking for signs of deterioration and sources of inflow. Use CCTV records to identify where each property is connected to the wastewater main. This should be done for the full length of pipe 36229, not just near 88 Tudor Street. Inspection of nearby connected properties (88, 89, and 91 Tudor Street) looking for deterioration and/or stormwater connections.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Inspection of 91 Tudor Street has been included because it is not fully clear if 91 Tudor Steet is serviced by the lateral in the footpath in front of the driveway of 91 Tudor Street. CCTV records will show if the lateral for 91 Tudor Street connects to the wastewater main near source S10 / 647.	

Source Analysis Plot – Temperature Difference vs Time



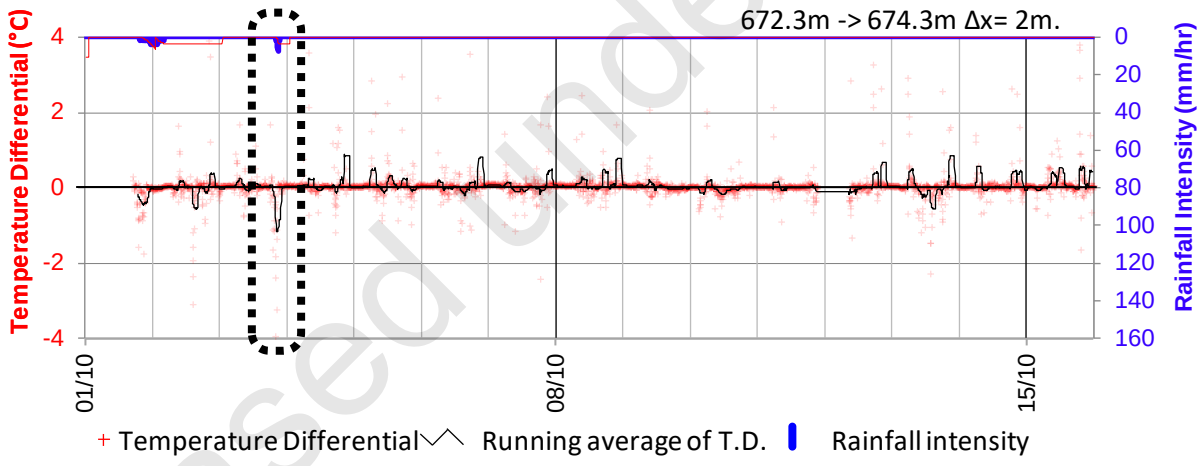
Source Location Map

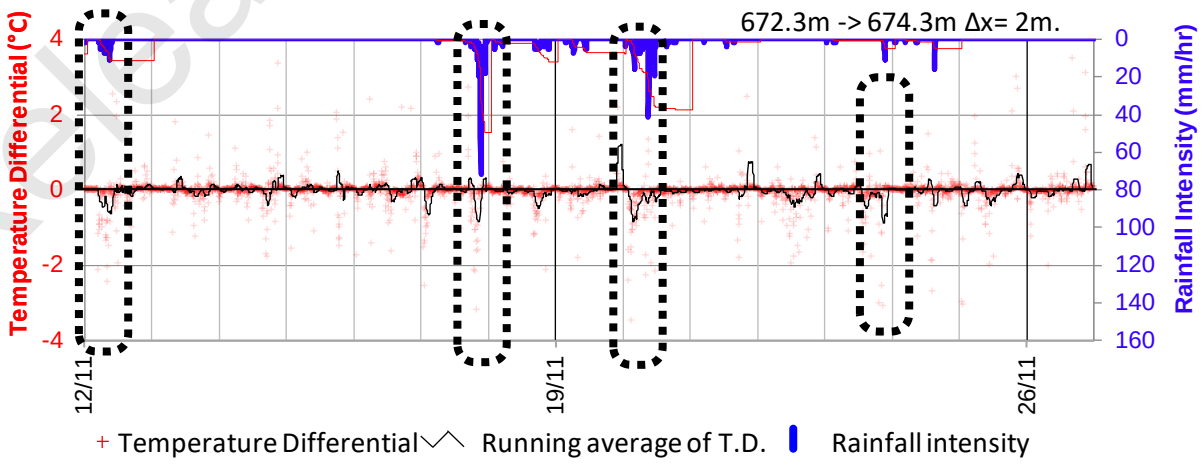
A.10.2 Source S10 / 673

Source Analysis Summary

Asset	Pipe 36229	DN150, 93m, Concrete, 1949.
Address	86 Tudor St.	
DTS signal	Medium, 34m ±3m downstream of manhole 12317.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	CCTV inspection of pipe 36229 to determine the connection point of laterals not shown on the GIS map (86 and 87 Tudor Street.). Inspection of nearby connected properties (86 and 87 Tudor Street) looking for deterioration and/or stormwater connections.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. CCTV inspection for pipe 36229 is included under the recommendations for I&I source S10 / 647. Include property inspections only if they are within five metres of the DTS signal.	

Source Analysis Plot – Temperature Difference vs Time





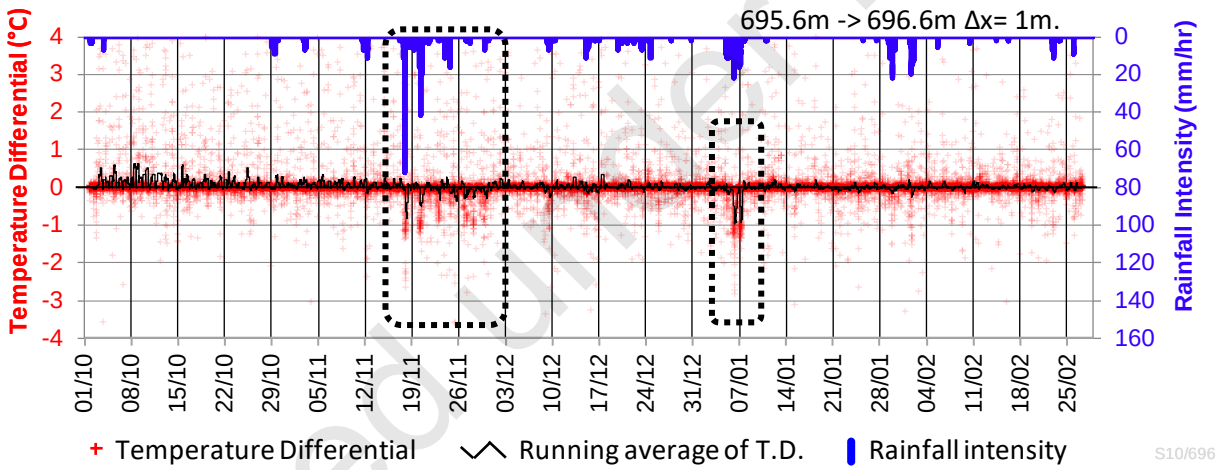
Source Location Map

A.10.3 Source S10 / 696

Source Analysis Summary

Asset	Pipe 36229	DN150, 93m, Concrete, 1949.
Address	84 Tudor Street	
DTS signal	Strong, 57m ±3m downstream of manhole 12317.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	Inspection of nearby connected properties (84 and 85A Tudor Street) looking for deterioration and/or stormwater connections.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.	

Source Analysis Plot – Temperature Difference vs Time



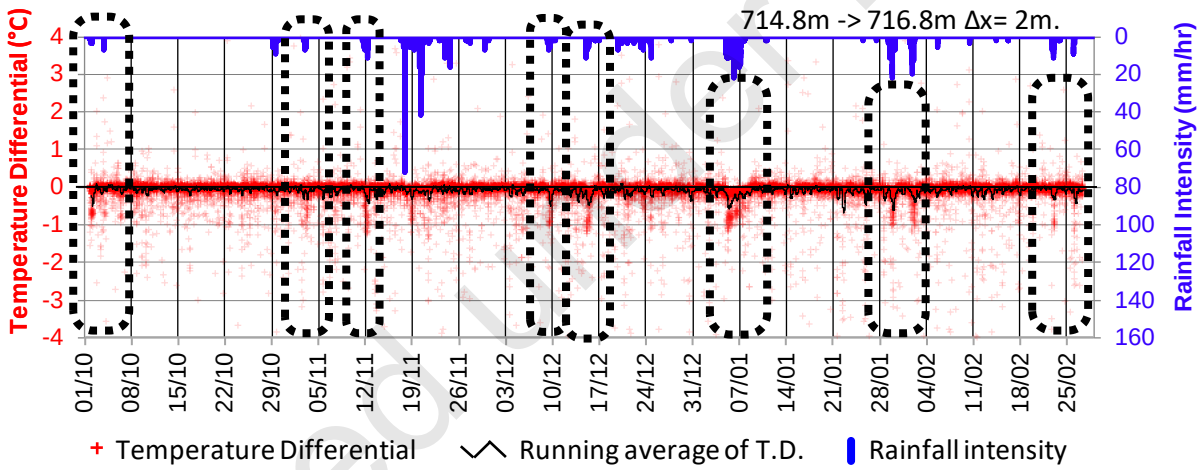
Source Location Map

A.10.4 Source S10 / 715

Source Analysis Summary

Asset	Pipe 36229	DN150, 93m, Concrete, 1949.
Address	82 Tudor Street.	
DTS signal	Strong, 17m ±3m upstream of manhole 14580.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	Inspection of nearby connected properties (81 and 82 Tudor Street) looking for deterioration and/or stormwater connections.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.	

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.11 Section S11: 20 Taylor Avenue to 47A Tudor Street

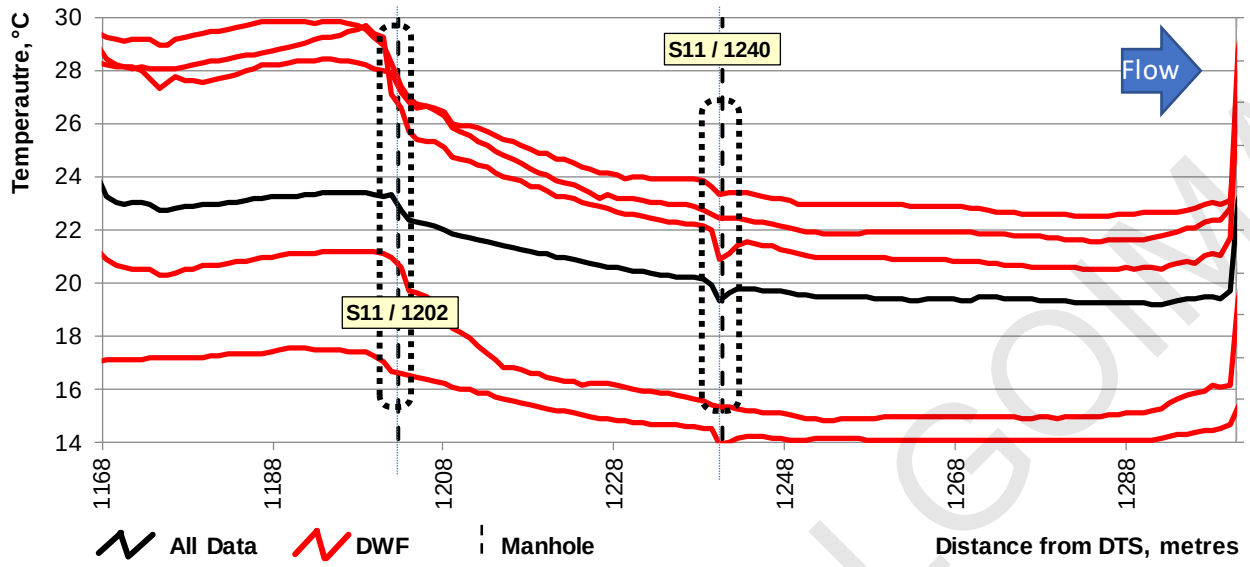
Two potential source of I&I was identified in this section using the DTS data:

- Groundwater infiltration source S11 / 1202 in Manhole 12321 at 12 Taylor Street.
- Stormwater inflow and groundwater infiltration source S11 / 1240 at manhole 13454 at 47B Tudor Street.

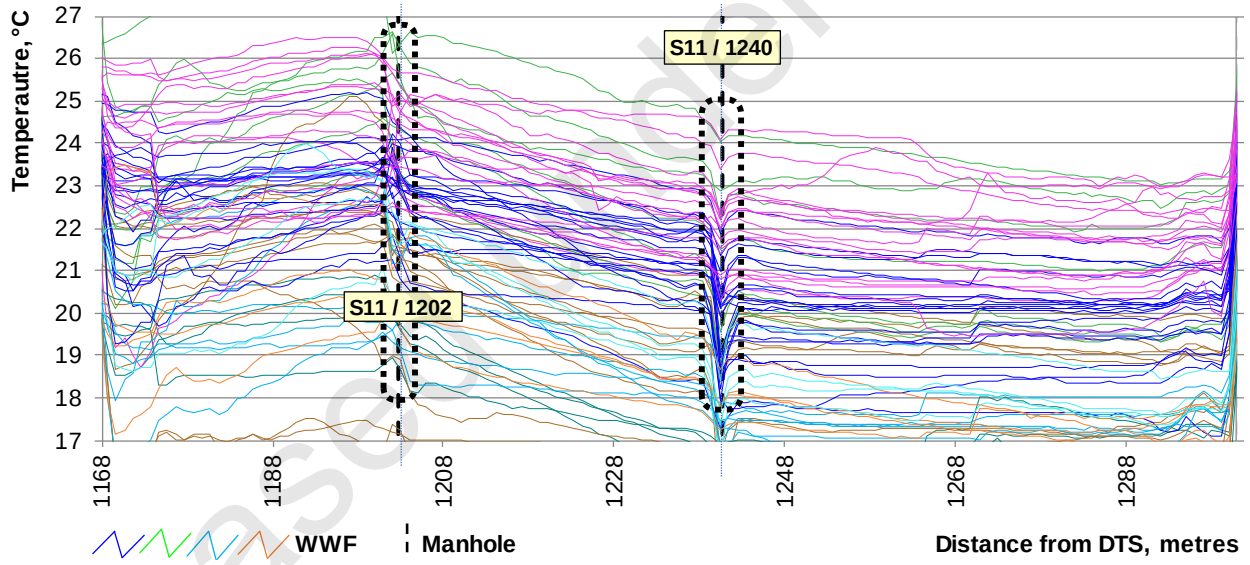
Source Identification Map

Notes:
1. Upstream manhole 12322 @ 16 Taylor Avenue @ 1169 m.
2. Downstream manhole 16125 @ 47A Tudor Street @ 1302 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

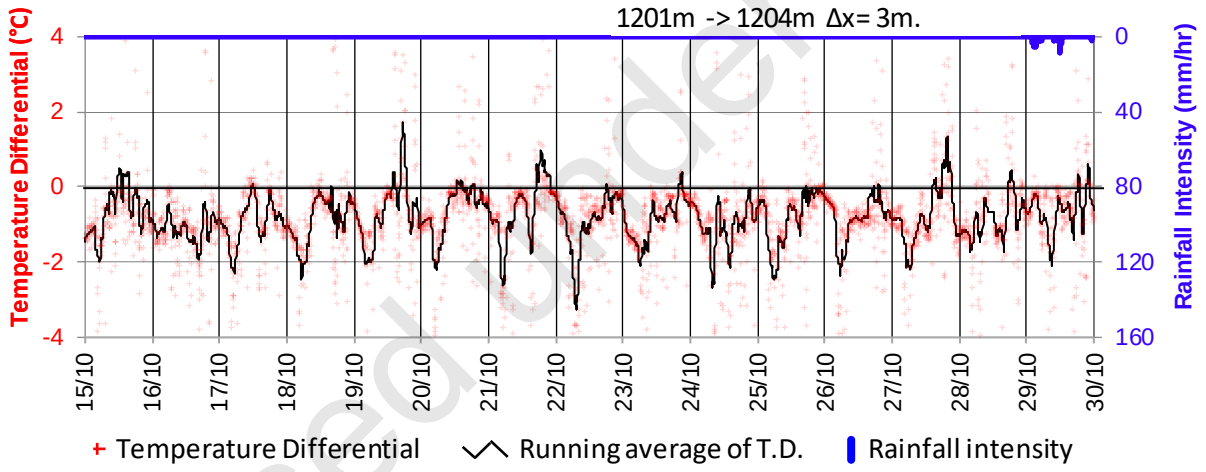


A.11.1 Source S11 / 1202

Source Analysis Summary

Asset	Manhole 12321.
Address	12 Taylor Street.
DTS signal	Strong, At manhole 12322.
Analysis	Temperature differential below 0°C during low wastewater flows in the early hours of the morning indicating ground water infiltration. The source is identified as infiltration so is expected to be a below ground fault or deterioration either in the public wastewater network or a private lateral.
Recommendation	Inspection of manhole 12321 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (12 and 14 Taylor Ave., 2 Avalon Court) looking for deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

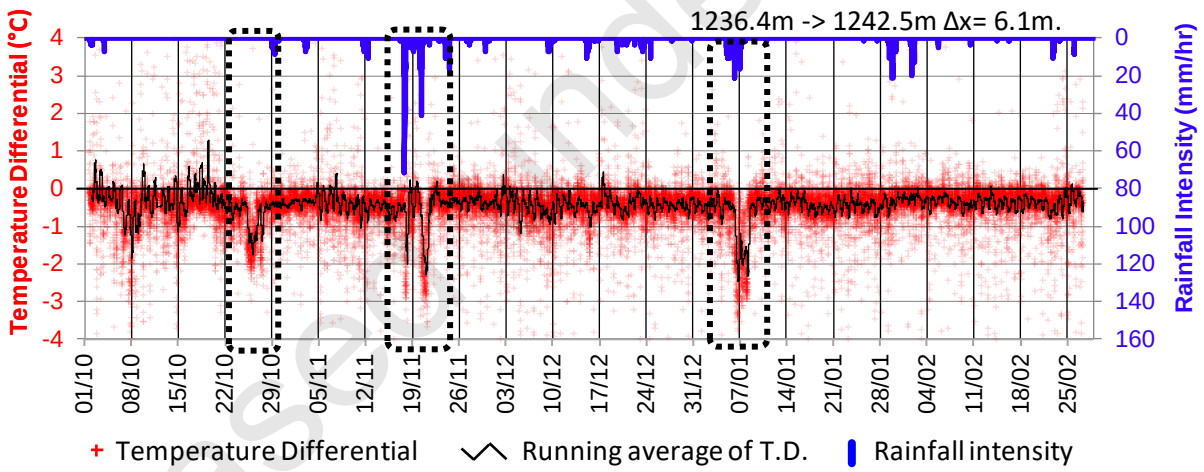
Larger Source Location Map showing lateral connection to 2 Avalon Court

A.11.2 Source S11 / 1240

Source Analysis Summary

Asset	Manhole 13454
Address	47B Tudor Street
DTS signal	Strong, At manhole 13454.
Analysis	Temperature differential generally below 0°C and correlated with rain indicating groundwater infiltration and stormwater inflow.
Recommendation	Inspection of manhole checking for signs of infiltration and inflow including poor construction, poor lid seal, and/or flow through lid keyholes. Inspection of connected properties (11, 13 Taylor Avenue, and 47B Tudor Street) looking for deterioration and/or stormwater connections.
Note	The location of the laterals for these three properties is not shown on the GIS map. A manhole inspection will confirm which properties connect at/near the manhole.

Source Analysis Plot – Temperature Difference vs Time



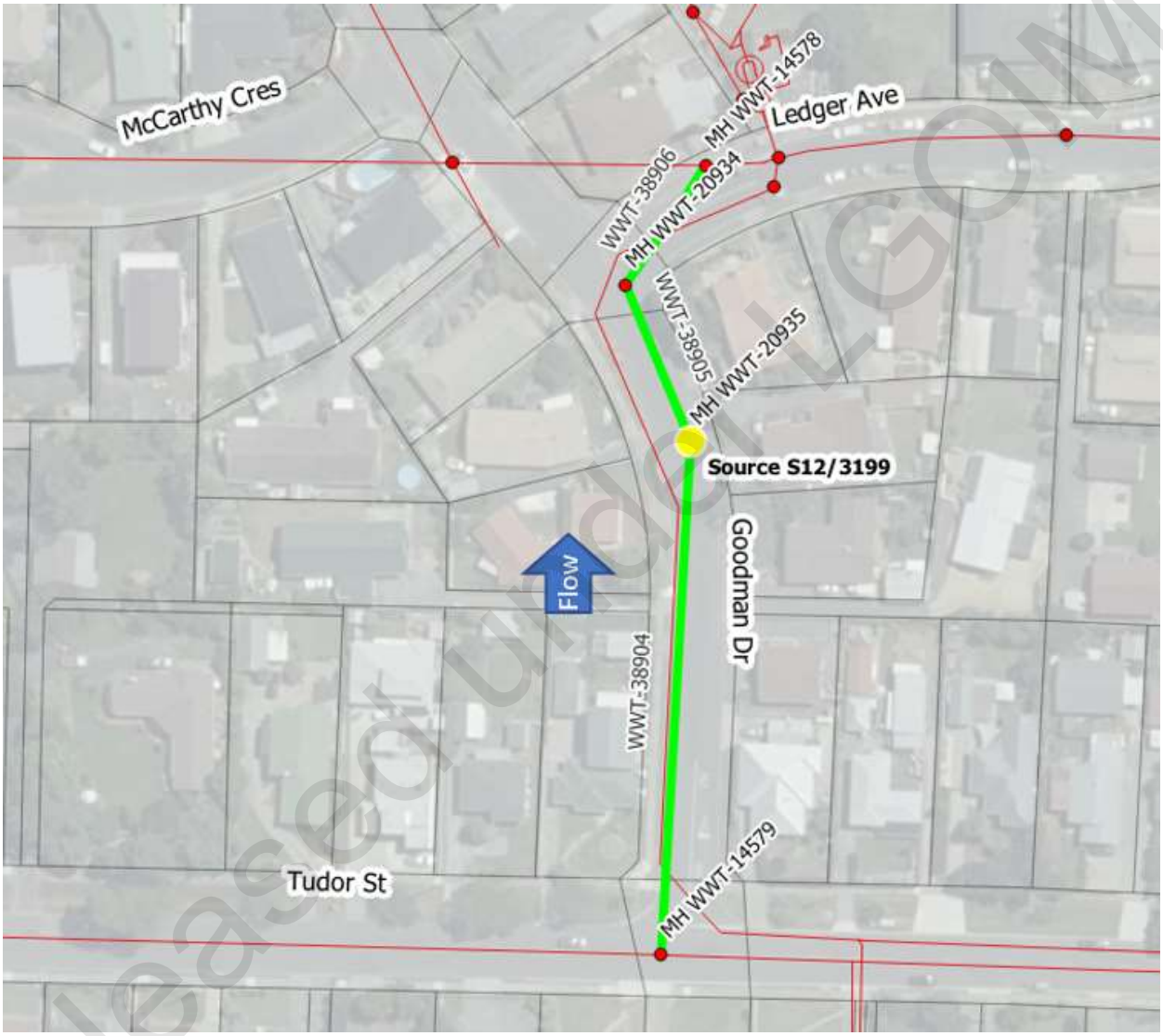
Source Location Map

A.12 Section S12: Goodman Drive between Tudor St. & Ledger Ave.

One potential source of I&I was identified in this section using the DTS data:

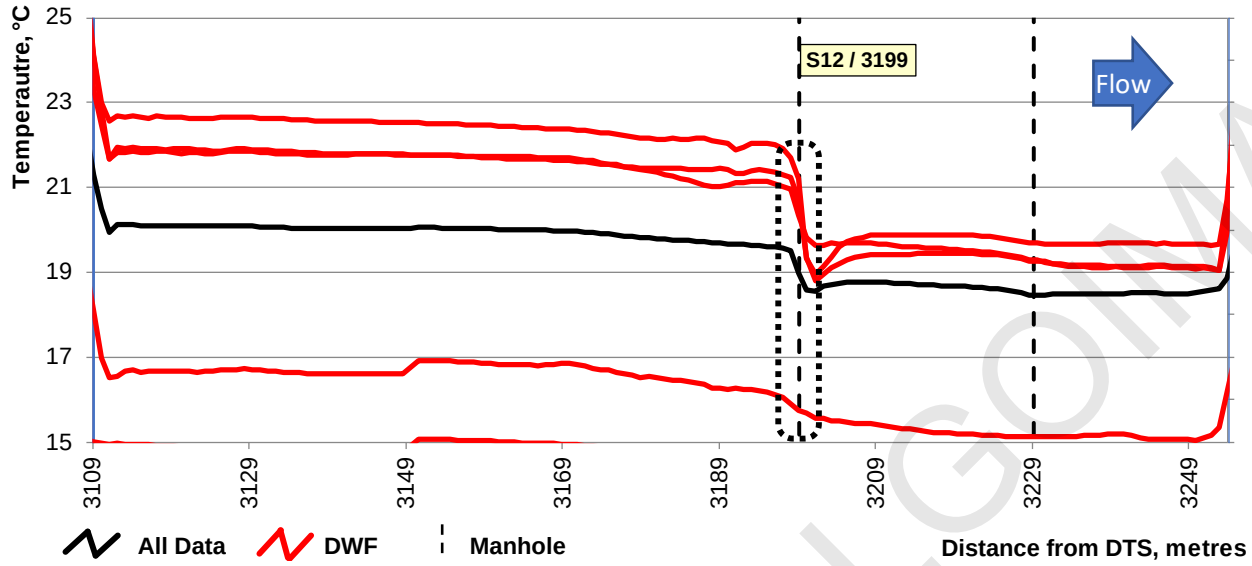
- SWI RDI Groundwater infiltration source S12 / 3199 at manhole 20935 at 6 Goodman Drive.

Source Identification Map

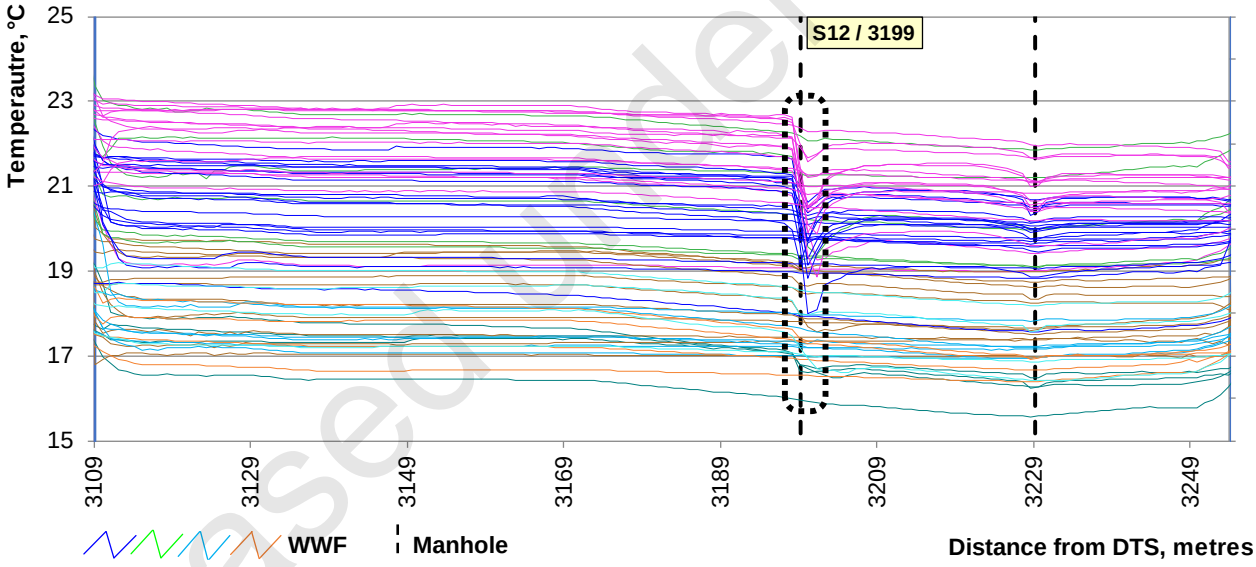


Notes:
1. Upstream manhole 14579 @ 67 Tudor Street @ 3109 m.
2. Downstream manhole 14578 @ 11 Goodman Drive @ 3254 m.

Source Identification Plot - Temperature vs Distance - 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

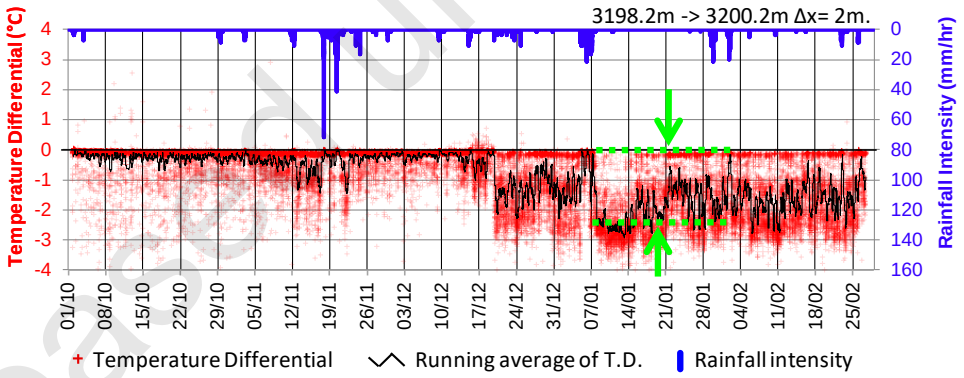


A.12.1 Source S12 / 3199

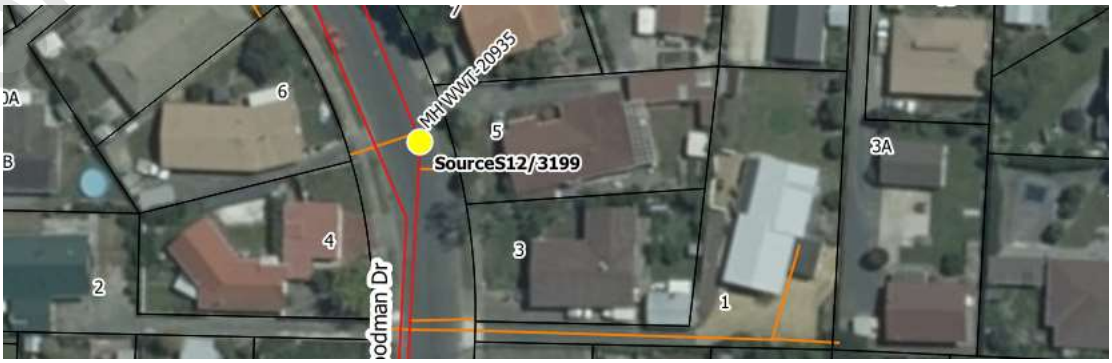
Source Analysis Summary

Asset	Manhole 20935
Address	6 Goodman Drive.
DTS signal	Strong, at Manhole 20935.
Analysis	Temperature differential generally below 0°C and correlated with rain indicating stormwater inflow, rainfall dependent infiltration, and groundwater infiltration.
Recommendation	Inspection of manhole checking for signs of infiltration and inflow including poor construction, poor lid seal, and/or flow through lid keyholes. Inspection of connected properties (4, 5 and 6 Goodman Drive) looking for deterioration, infiltration, and/or stormwater connections.
Note	The signal in the GIS data is centred on the manhole. The extent and magnitude of the temperature drop support assessing the wastewater main for five metres either side of the manhole (using a Push Camera or similar). Also, inspection of the adjacent properties connected within five meters from the manhole is warranted. It is not clear from the GIS map if the lateral for 4 Goodman Drive is combined with 2 Goodman Drive, or if the lateral for 4 Goodman Drive connects at or near manhole 20935.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map



A.13 Section S13: 32 – 11 Goodman Drive

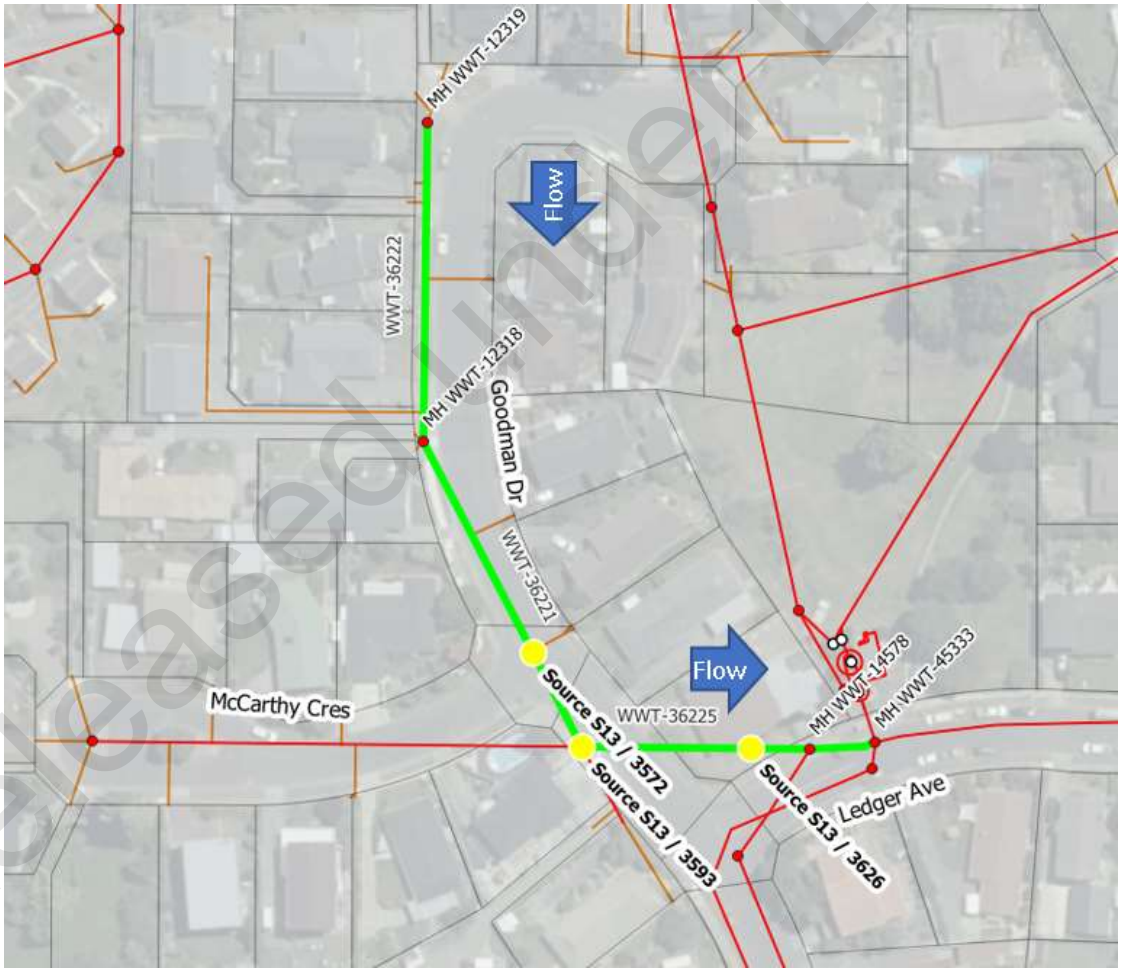
Three potential sources of I&I were identified in this section using the DTS data:

- Groundwater infiltration source S13 / 3572** in Pipe 36221 at 13A Goodman Drive
- Groundwater infiltration source S13 / 3593 in manhole 16123 at 12 Goodman Drive.
- Groundwater infiltration source S13 / 3626** in Pipe 36225 at 11 Goodman Drive.

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

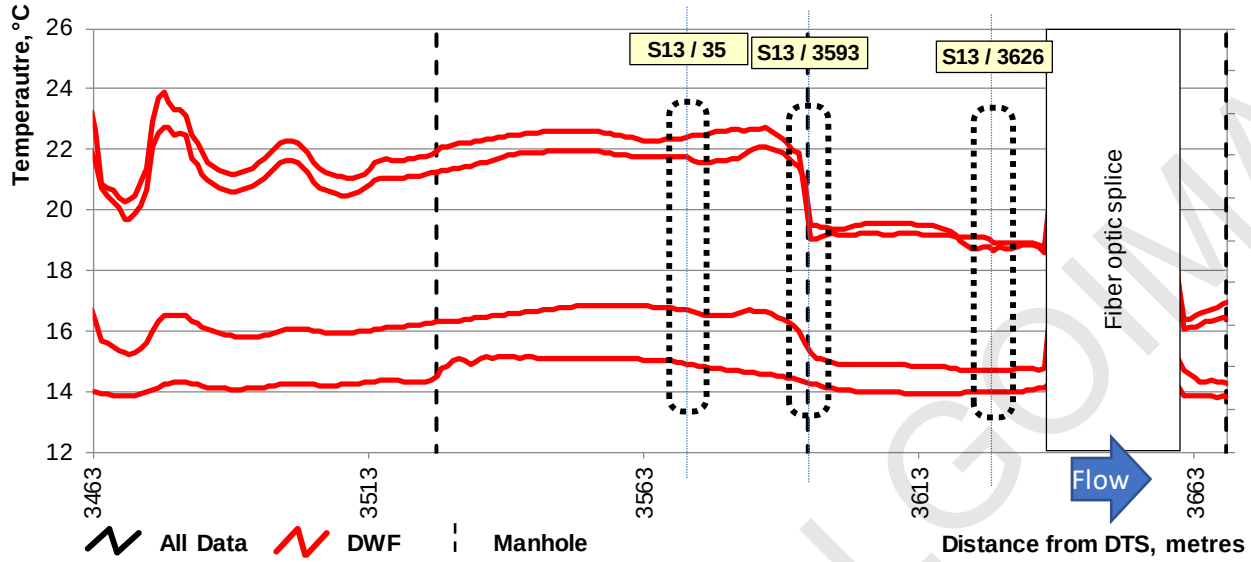
Source S13 / 3477 was identified as a groundwater infiltration source in the earlier interim reports. Further analysis indicates that the DTS data pattern was caused by differential solar heating of the ground rather than groundwater infiltration at this location. Source S13 / 3477 has been deleted from the list of locations recommended for further investigation.

Source Identification

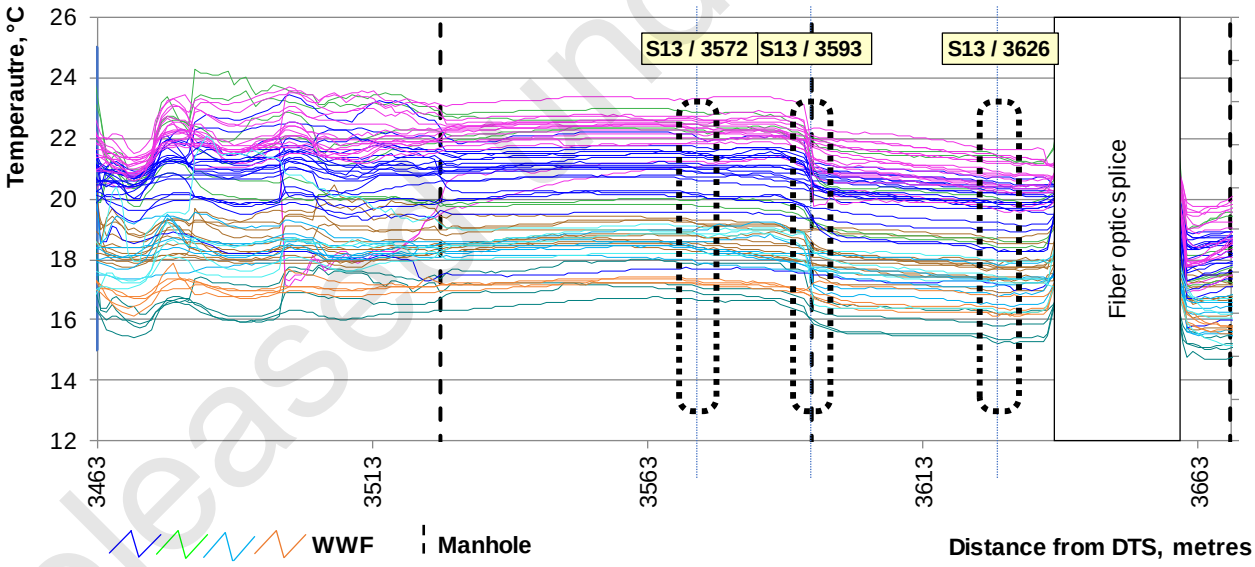


Notes:
1. Upstream manhole 12319 @ 30 Goodman Drive @ 3463 m.
2. Downstream manhole 45333 @ 2 Ledger Avenue @ 3673 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

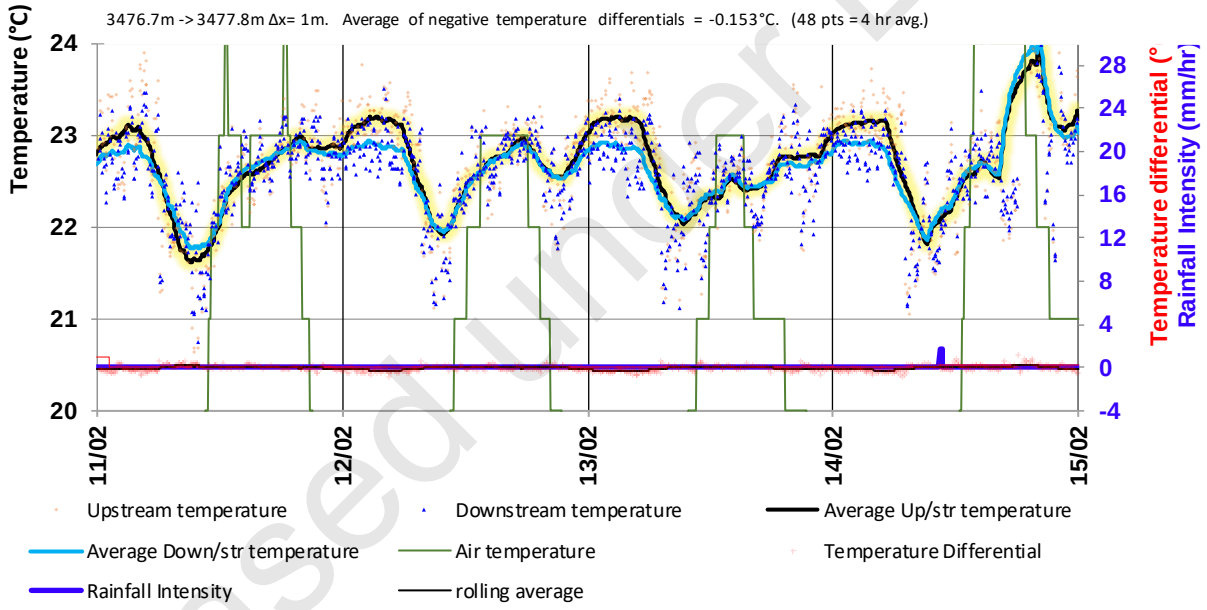


A.13.1 Source S13 / 3477 *** Deleted ***

This location was reported as a source of groundwater infiltration in the previous interim report. Further analysis has identified that the DTS data does not indicate a source of groundwater infiltration at this location.

The 'early morning temperature drop' between points upstream and downstream of this location that was previously reported as being caused by cool groundwater infiltration entering the pipe has been reassessed. The temperature difference appears to be caused by the cable at the upstream point warming during the low flow hours in the early morning, whereas the temperature of the downstream point did not warm to the same extent. This is indicated in the plot below by the temperature for the upstream point (black line) continuing to rise between midnight and early morning. The downstream temperature (light blue line) remained at a relatively constant temperature during the same time. This can occur in the early hours of the morning when and where there is negligible wastewater flow. The cable temperature can be dominated by ground temperatures rather than wastewater/groundwater inputs. The temperature of cable on the upstream side increases as it absorbs stored heat from the solar heated ground level paved surface. Less heat is absorbed and released to the wastewater pipe and cable that is located below vegetated ground cover.

Source Analysis Plot – Temperature Difference vs Time



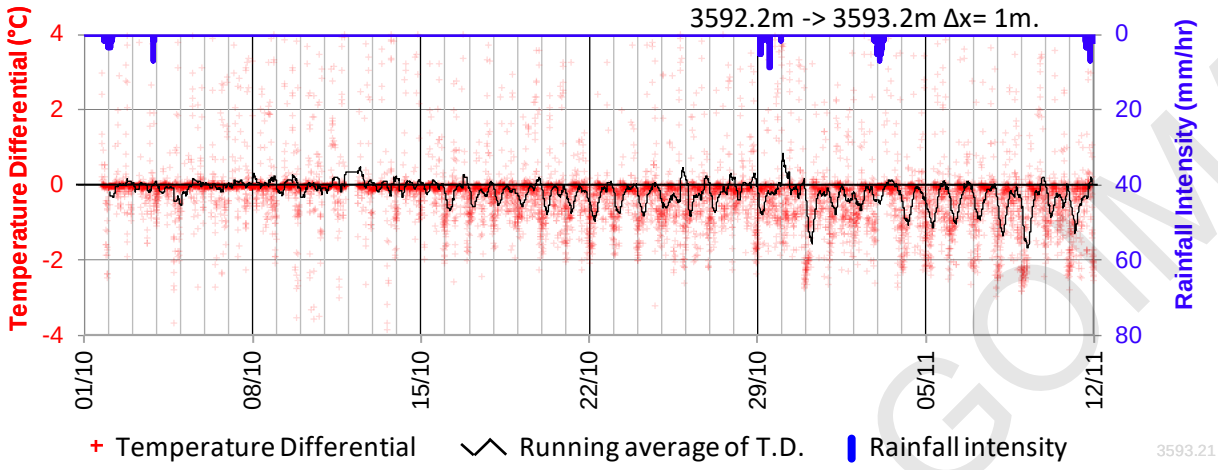
A.13.2 Source S13 / 3593

Source Analysis Summary

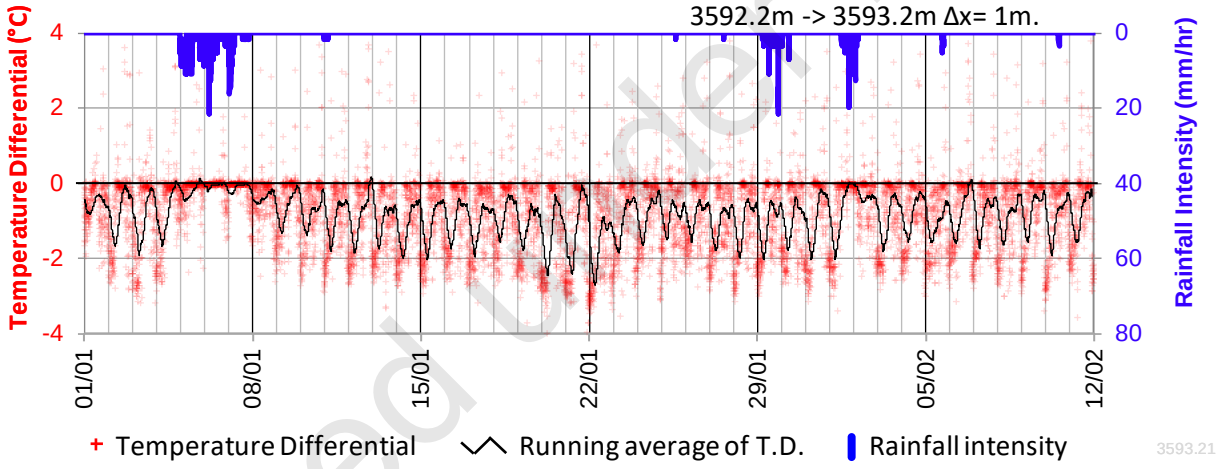
Asset	Manhole 16123
Address	12 Goodman Drive.
DTS signal	Strong, at Manhole 16123 and/or the unmonitored upstream catchment.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. The wastewater main in McCarthy Cresent was not directly monitored by DTS so the DTS data cannot be used to pinpoint where in McCarthy Crescent might the source(s) of I&I are located.
Recommendation	Inspection of manholes 16123 and 16124 checking for signs of deterioration and infiltration. CCTV inspection of pipe 36220 checking for signs of deterioration and infiltration. Any connection into this pipe should be inspected, including any properties (4, 6,10, 12A, 12B, 11, 9, 7, 5, 3, 1 McCarthy Cresent, and 8, 10A, 10B, 12, 16 Goodman Drive. As part of the property inspections, it is recommended to enquire if there were any construction works starting in October 2022 that may have led to discharges or groundwater infiltration into the wastewater network.
Note	There appears to be a discrete increase in the groundwater infiltration starting on the 16/10/2023 that is not related rainfall. This may have been caused by construction works affecting wastewater assets in the unmonitored catchment.

Source Location Map

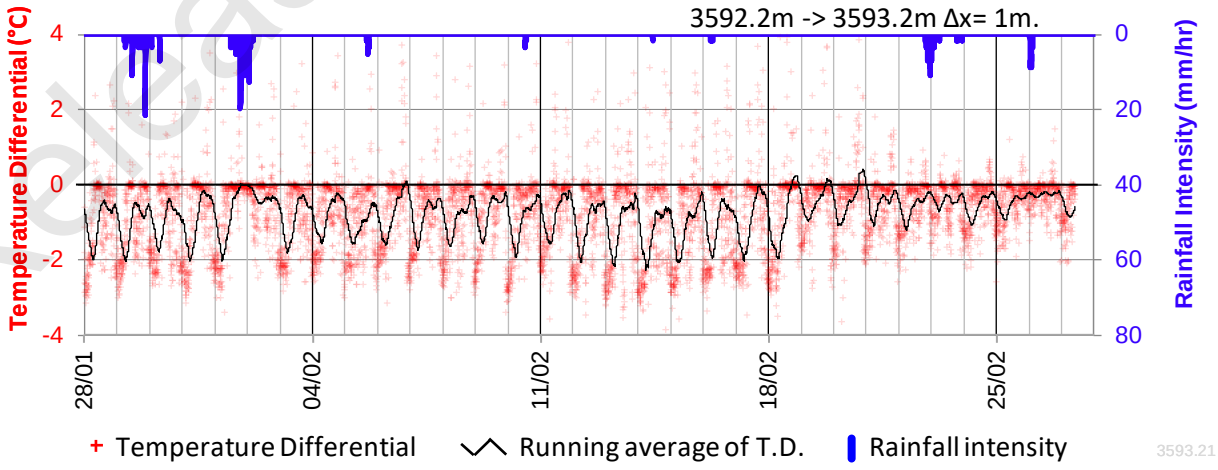
Source Analysis Plot – Temperature Difference vs Time – Groundwater infiltration starting on 16th October 2022.



Source Analysis Plot – Temperature Difference vs Time – Typical throughout summer of 2022 / 2023.



Source Analysis Plot – Temperature Difference vs Time – Possible end or reduction of GWI in late February.



A.14 Section S14: 22 – 12 Ledger Avenue

Two potential source of I&I was identified in this section using the DTS data:

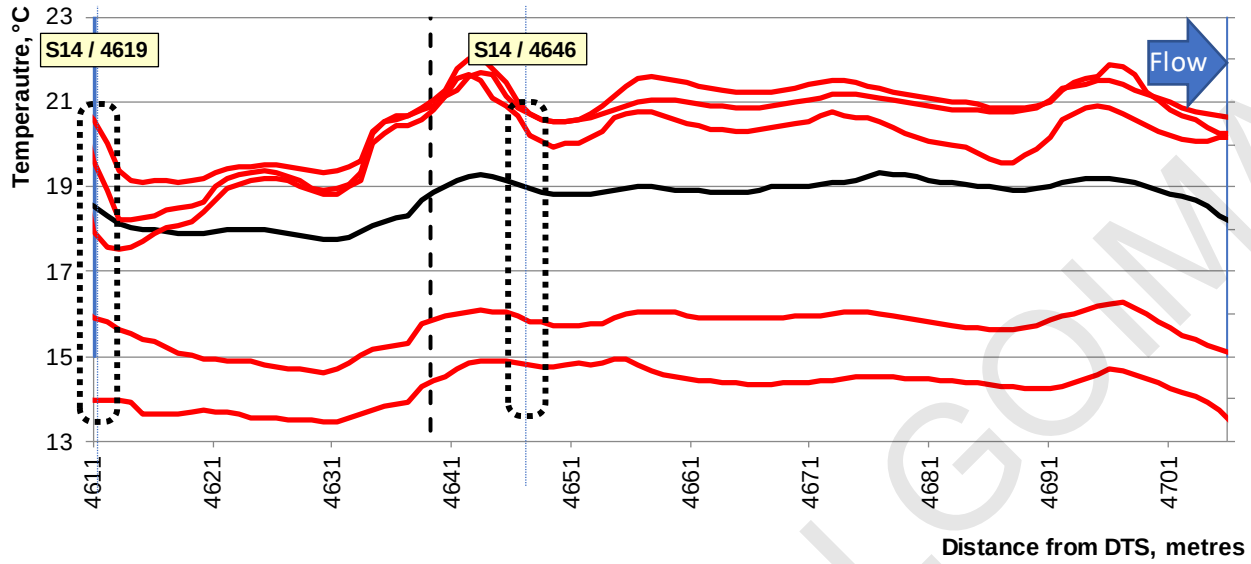
- Stormwater inflow source S14 / 4619** at Manhole 16871 at 20A Ledger Avenue.
- Groundwater infiltration source S14 / 4646 in Pipe 31114 at 18 Ledger Avenue.

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

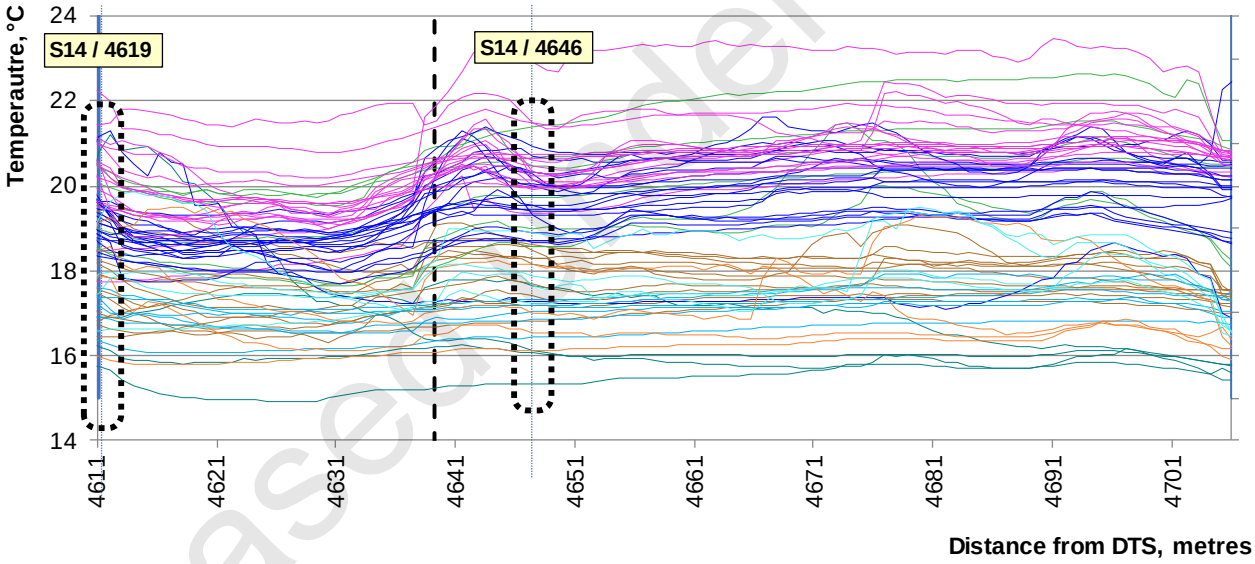
Source Identification Map

Notes:
1. Upstream manhole 16871 @ 20A Ledger Avenue @ 4611m.
2. Downstream 16870 @ 12 Ledger Avenue @ 4706m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

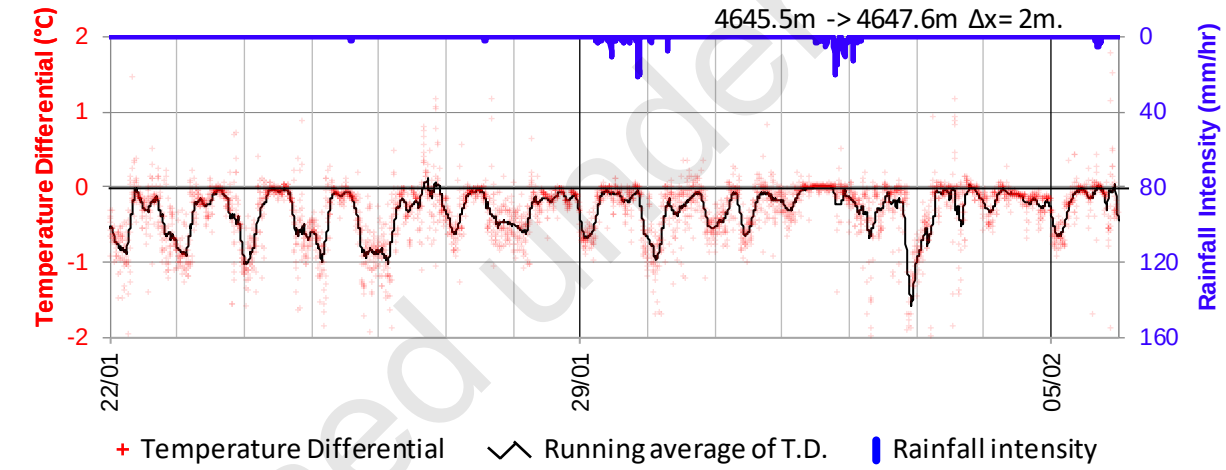


A.14.1 Source S14 / 4646

Source Analysis Summary

Asset	Pipe 31114 DN150, 67m, PVC, 1977.
Address	18 Ledger Avenue.
DTS signal	Strong, 7m ±3m downstream of manhole 16873.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 31114 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (18 Ledger Ave.). Inspection of nearby connected properties (18 Ledger Ave.) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.15 Section S15: 6 Ledger Avenue to Goodman Park Pump Station

Three potential source of I&I was identified in this section using the DTS data:

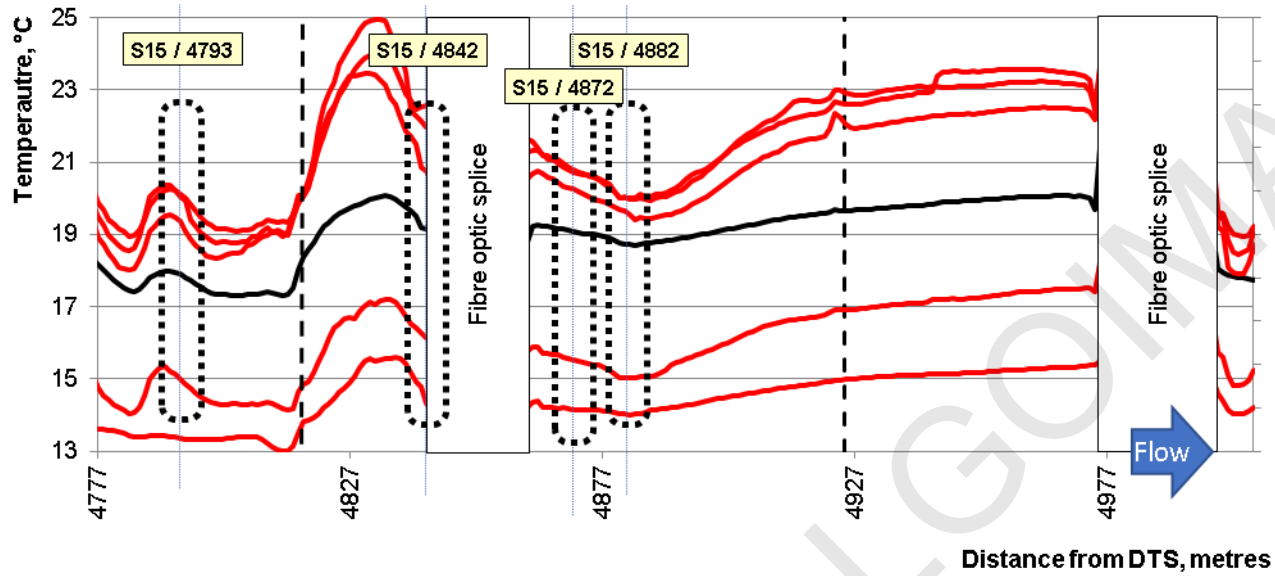
- Groundwater infiltration source S15 / 4792** in Pipe 28730 at 8 Ledger Avenue.
- Groundwater infiltration source S15 / 4842 in Manhole 13115 at 9 Ledger Avenue. <new>
- Stormwater inflow and groundwater infiltration sources S15 / 4872 and S15 / 4882 in Pipe 28745 at 9 Ledger Avenue. These two sources have been treated as a single source because they are close together, on the same property and on the same wastewater main.

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

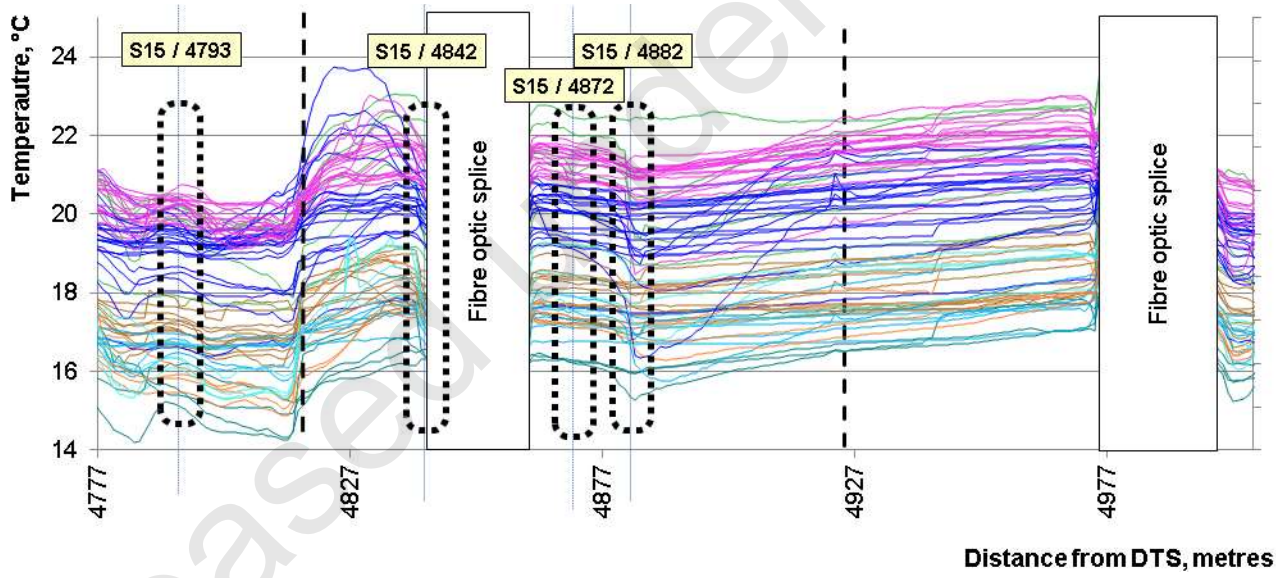
Source Identification Map

Notes:
1. Upstream manhole 14577 @ 6A Ledger Avenue @ 4777 m.
2. Downstream WWPSLEDGER-40569 (Pump station) @ 2 Ledger Avenue @ 5007 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

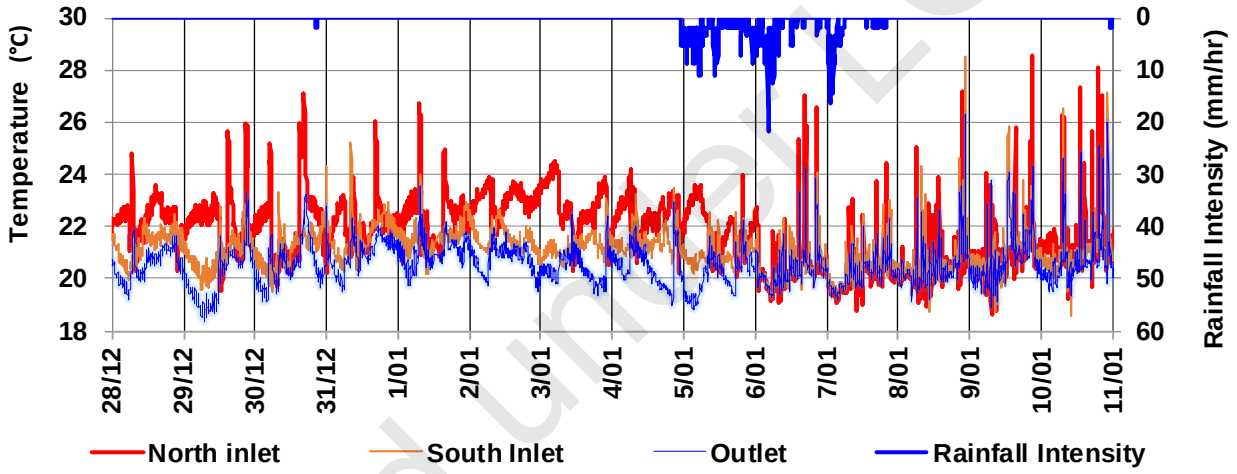


A.15.1 Source S15 / 4842 <new>

Source Analysis Summary

Asset	Manhole 13115.
Address	9 Ledger Avenue.
DTS signal	Strong. At manhole 16870.
Analysis	Temperature differential below 0°C during low wastewater flows in the early hours of the morning indicating ground water infiltration.
Recommendation	Inspection of manhole 13115 checking for signs of deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



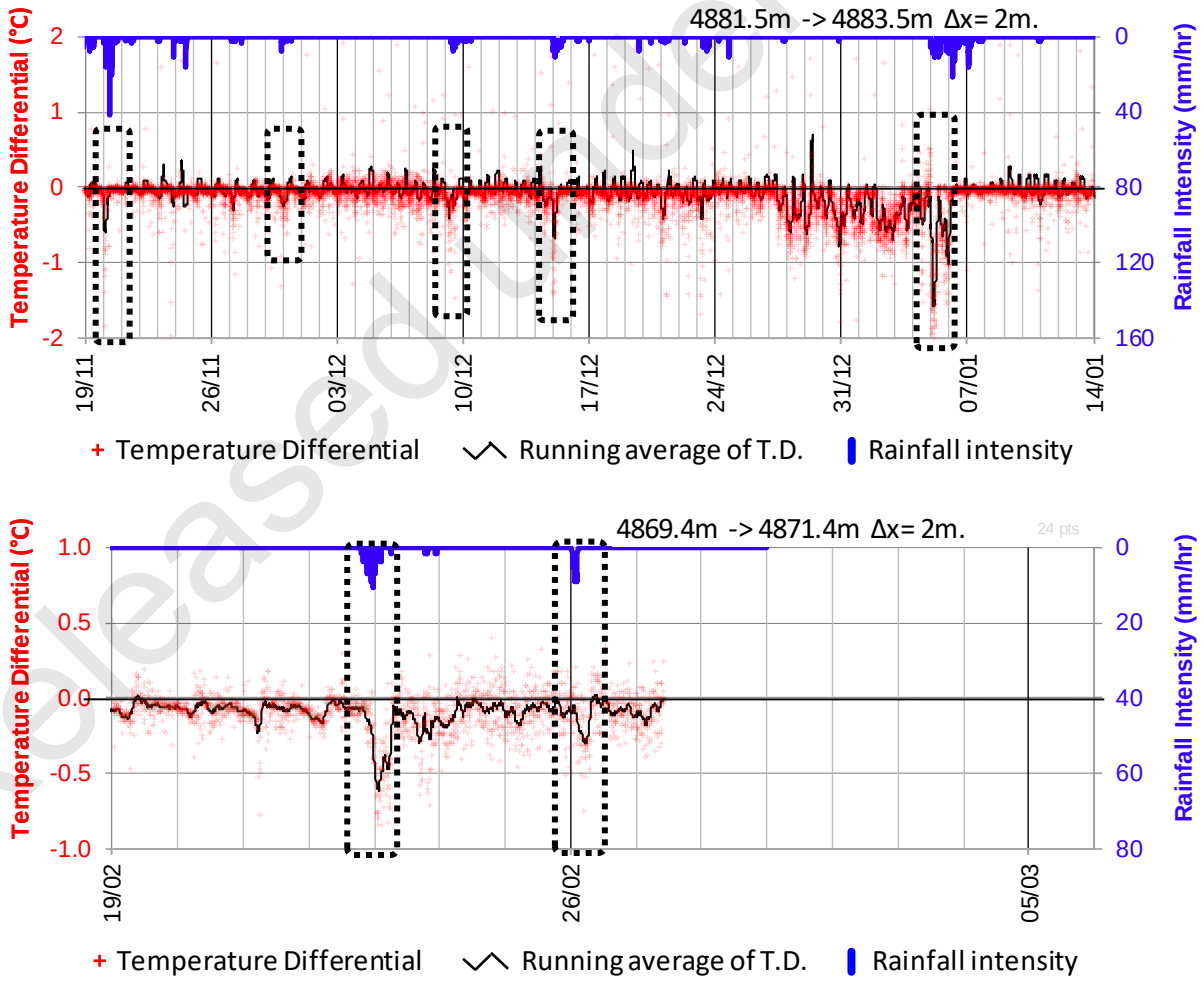
Source Location Map

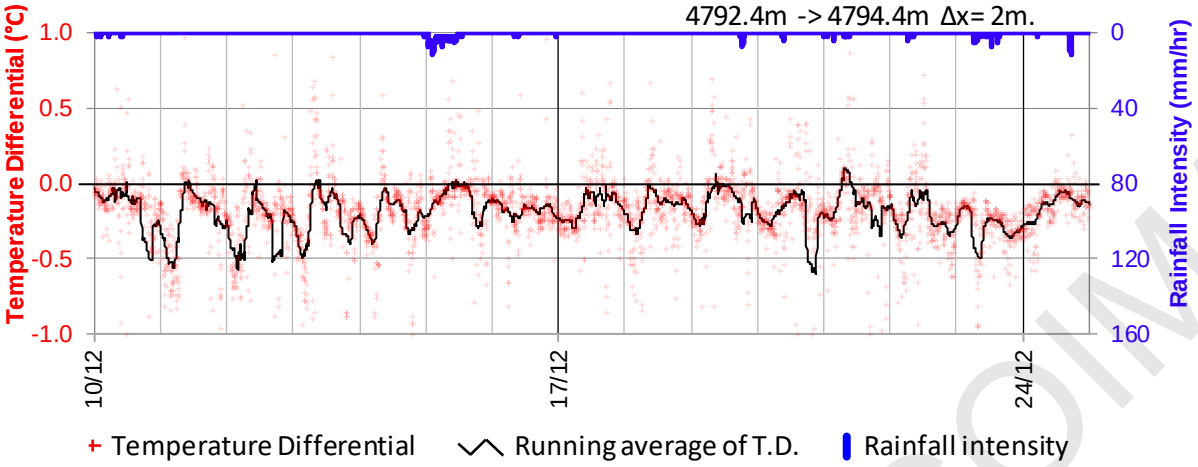
A.15.2 Source S15 / 4882 and S15 / 4872

Source Analysis Summary

Asset	Pipe 28745 DN150, 62m, PVC, 1977.
Address	9 Ledger Avenue.
DTS signal	Strong, 42m and 52m ±3m upstream of manhole 14576.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 28745 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (9 Ledger Ave.). Inspection of nearby connected properties (9 Ledger Ave.) looking for deterioration, infiltration, and inflow.
Note	Two separate signals were found within the boundaries of 9 Ledger Avenue.

Source Analysis Plot – Temperature Difference vs Time





Source Location Map

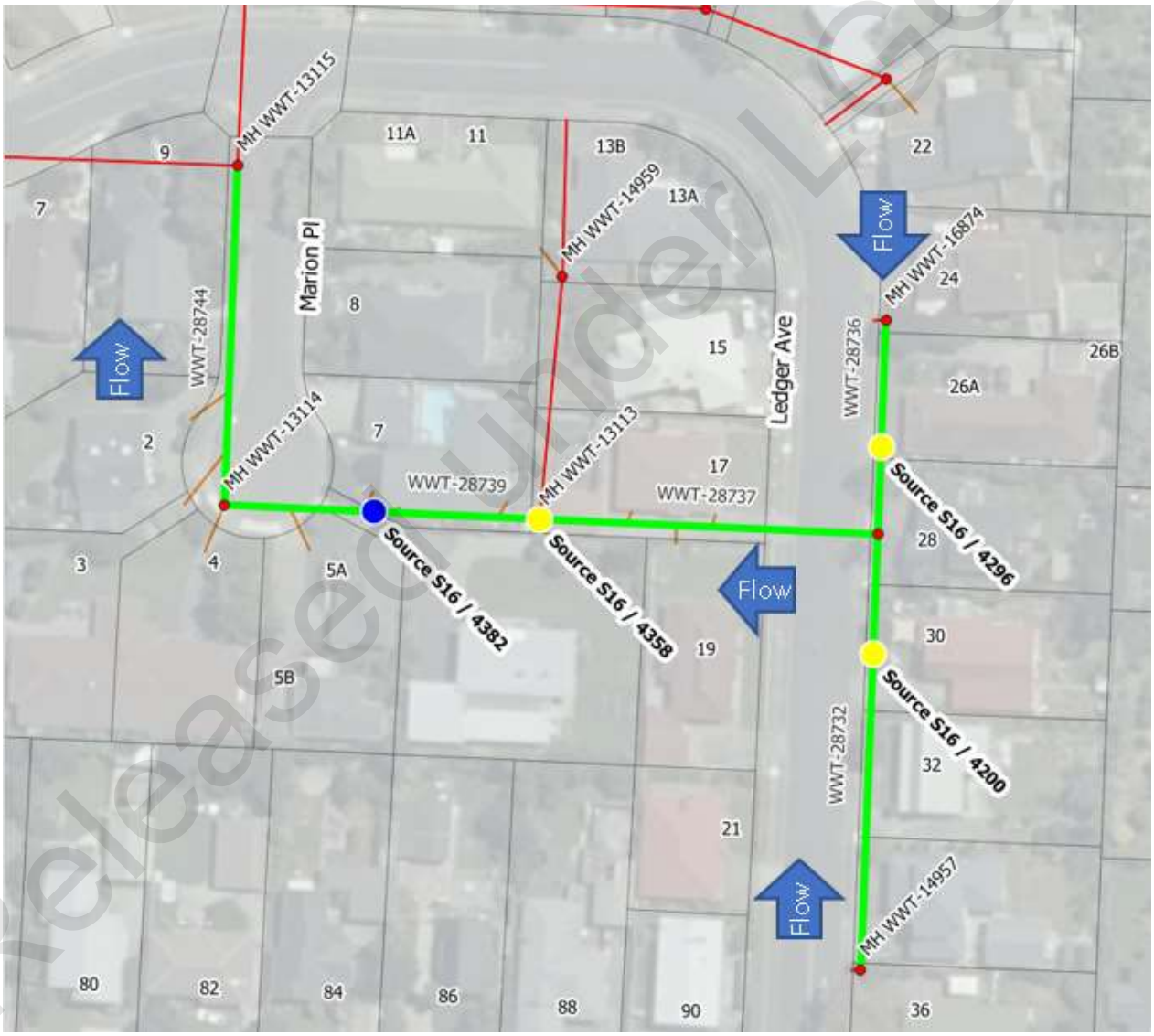
A.16 Section S16: 36 Ledger Avenue – 9 Marion Place

Four potential sources of I&I were identified in this section using the DTS data:

- Groundwater infiltration source S16 / 4200 in Pipe 28732 at 30 Ledger Avenue.
- SWI RDI Groundwater infiltration source S16 / 4296** in pipe 28736 at 26A Ledger Avenue.
- Stormwater inflow and groundwater infiltration source S16 / 4358 in manhole 13113 at 6 Marion Place.
- SWI RDI source S16 / 4382 in pipe 28739 at 6 Marion Place.

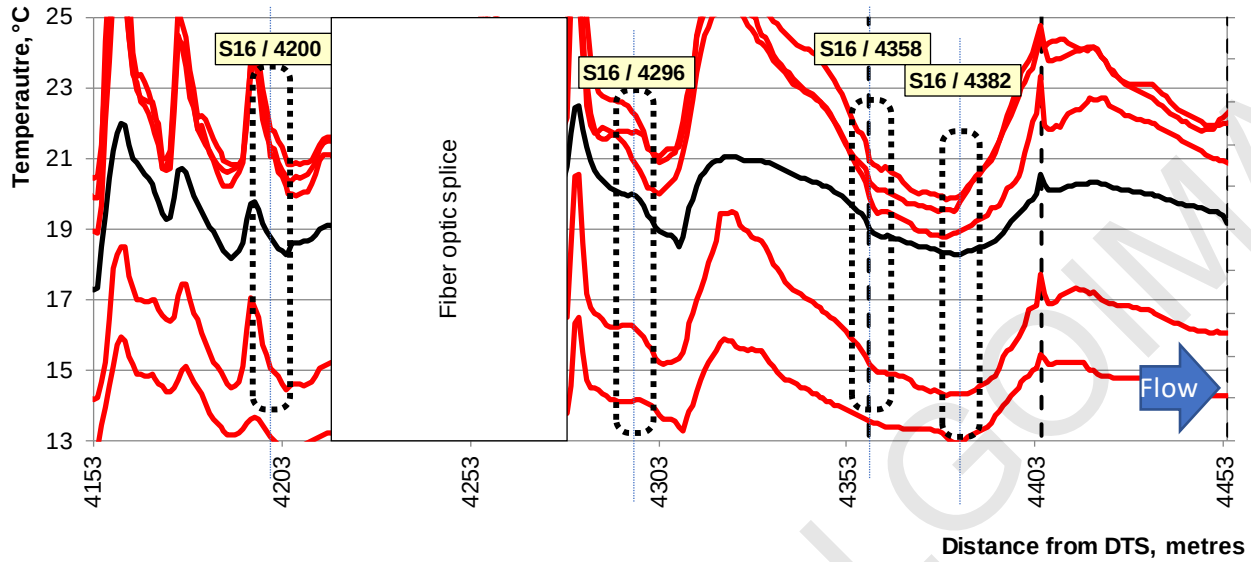
Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

Source Identification Map

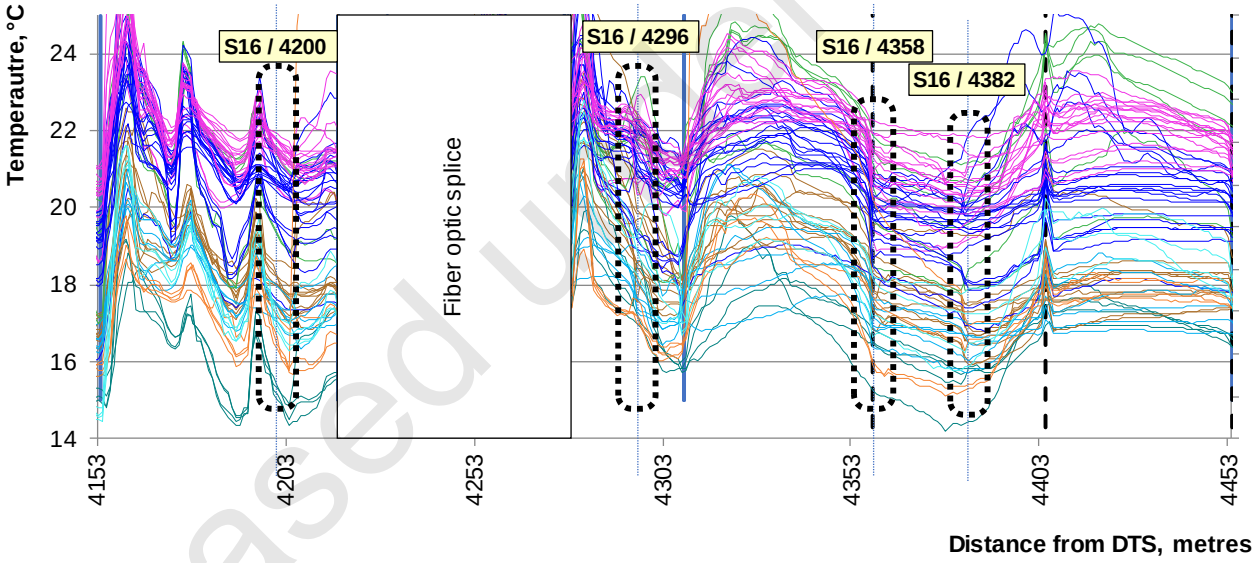


Notes:
1. Upstream manhole 14957 @ 36 Ledger Avenue @ 4154 m.
2. Downstream manhole 13115 @ 9 Ledger Avenue @ 4454 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals



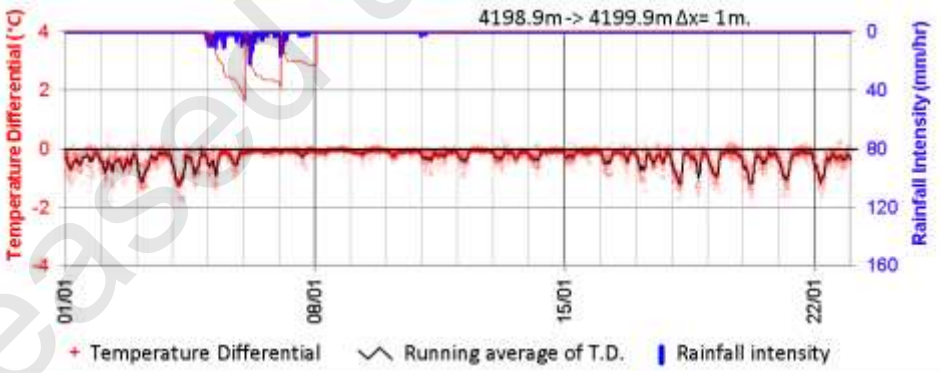
The temperature spikes between 4150 m and 4200 m are caused by solar heating of vehicle driveways transferring heat to the wastewater pipe. The cooler sections in-between have soil, grass, or vegetation above the wastewater pipe.

A.16.1 Source S16 / 4200

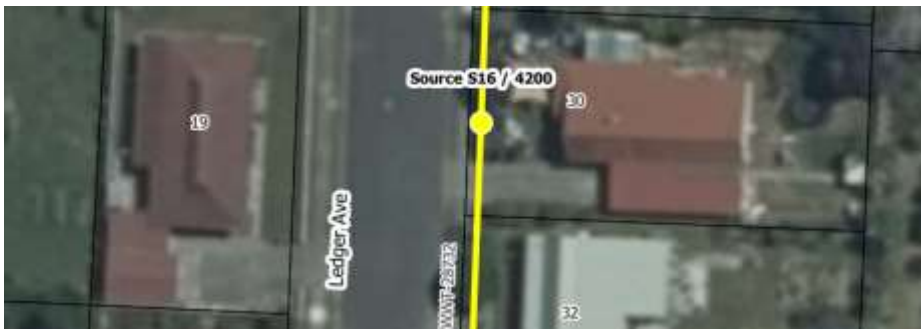
Source Analysis Summary

Asset	Pipe 28732 DN150, 64m, PVC, 1977.
Address	30 Ledger Avenue.
DTS signal	Strong, 17m ±3m upstream of manhole 14958.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 28732 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (30 Ledger Ave.). Inspection of nearby connected properties (30 Ledger Ave.) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Inspection of the private properties has been included to assess if the laterals are contributing infiltration. Include property inspections only if they are within five metres of the DTS signal. The masking of I&I during and following rain events indicates significant upstream I&I. No sources of I&I were clearly identified from the DTS data upstream of the point. This is due to the significant thermal gradients caused by solar heating of driveways impacting the DTS data. Given the age of the pipe, remediation of significant amounts of the upstream catchment may be required.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

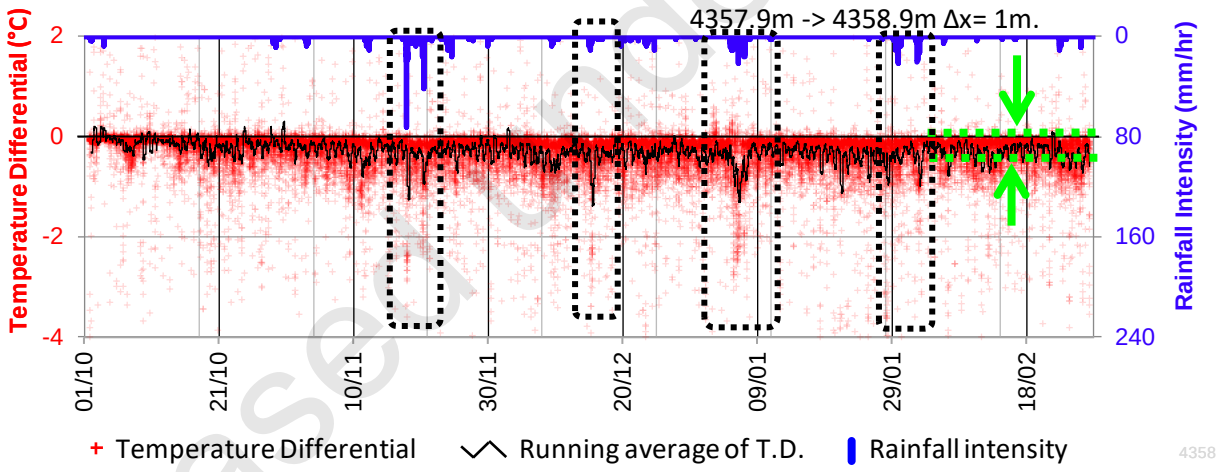


A.16.2 Source S16 / 4358

Source Analysis Summary

Asset	Manhole 13113.
Address	6 Marion Place.
DTS signal	Strong, at manhole 13113.
Analysis	Temperature differential generally below 0°C indicating groundwater infiltration. Temperature drop is correlated with rainfall indicating stormwater inflow.
Recommendation	Inspection of manholes 13113, 14959, and Flushing Point 41698 (at footpath boundary) checking for signs of deterioration and infiltration. CCTV inspection of pipes 28738 and 41534 checking for signs of deterioration and infiltration. Any connection into this pipe should be inspected, including any properties (8 Marion Place, 11, 11A, 13A, 13B, 15 Ledger Avenue).
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



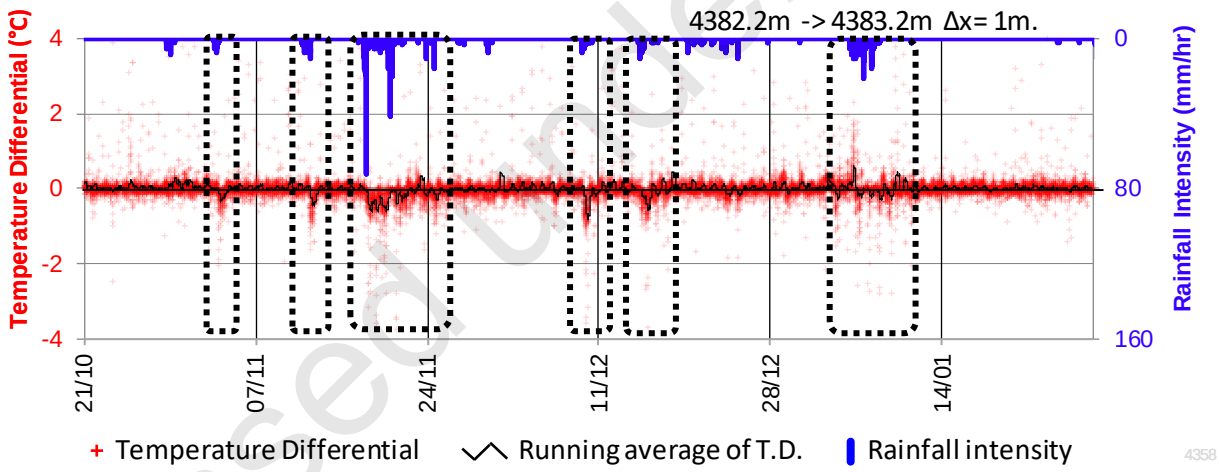
Source Location Map

A.16.3 Source S16 / 4382

Source Analysis Summary

Asset	Pipe 28739 DN150, 46m, PVC, 1977.
Address	6 Marion Place.
DTS signal	Strong, 22 m upstream of manhole 13114.
Analysis	Immediate and delayed reduction in temperature correlated with rainfall indicating stormwater inflow and rainfall dependent infiltration.
Recommendation	CCTV inspection of pipe 28739 to determine the connection point of laterals not shown on the GIS map. Inspection of nearby connected properties (6 and 7 Marion Place) looking for deterioration and/or stormwater connections.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.17 Section S17:

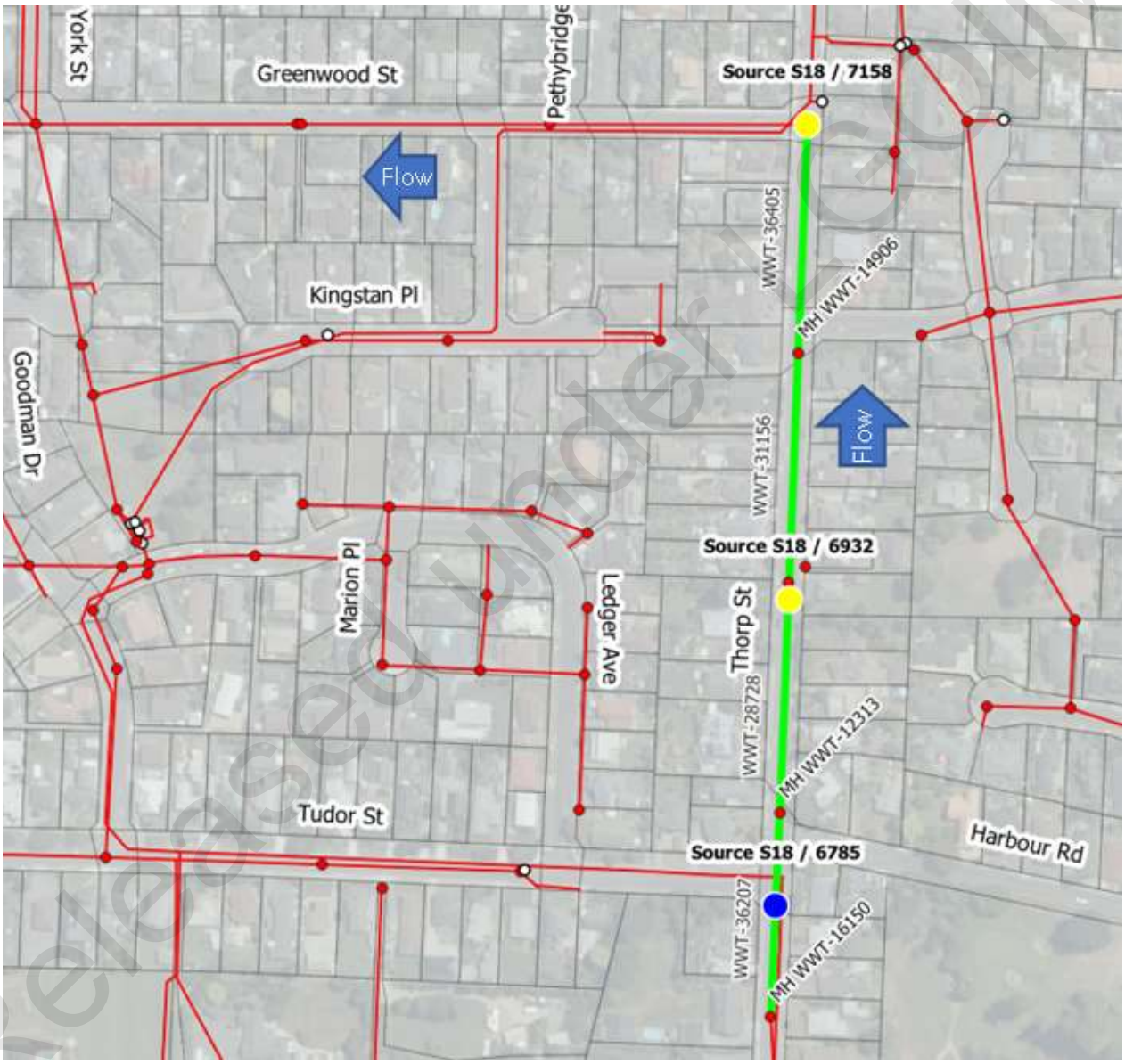
The original 'Section S17' has been incorporated into the current 'Section S16'. There is no reporting required for Section 17.

A.18 Section S18: 126 - 83 Thorp Street

Three potential sources of I&I were identified in this section using the DTS data:

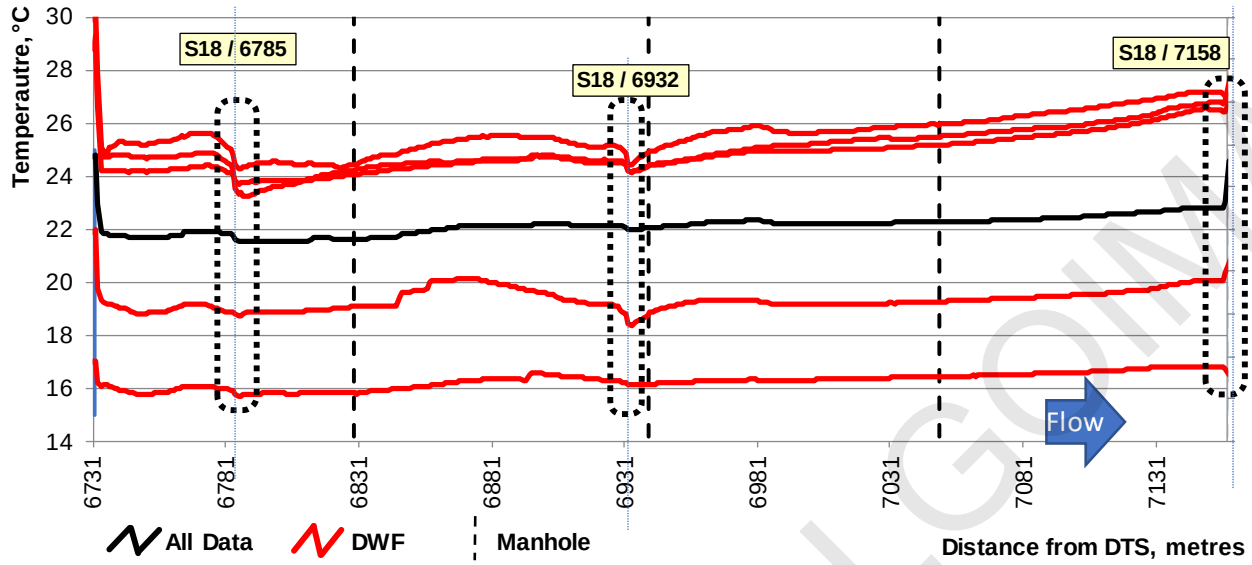
- Stormwater inflow source S18 / 6785 in pipe 36207 at 121 Thorp Street.
- Groundwater infiltration source S18 / 6932 in pipe 28728 at 107 Thorp Street.
- Groundwater infiltration source S18 / 7158 in manhole 14905 at 83A Thorp Street.

Source Identification Map

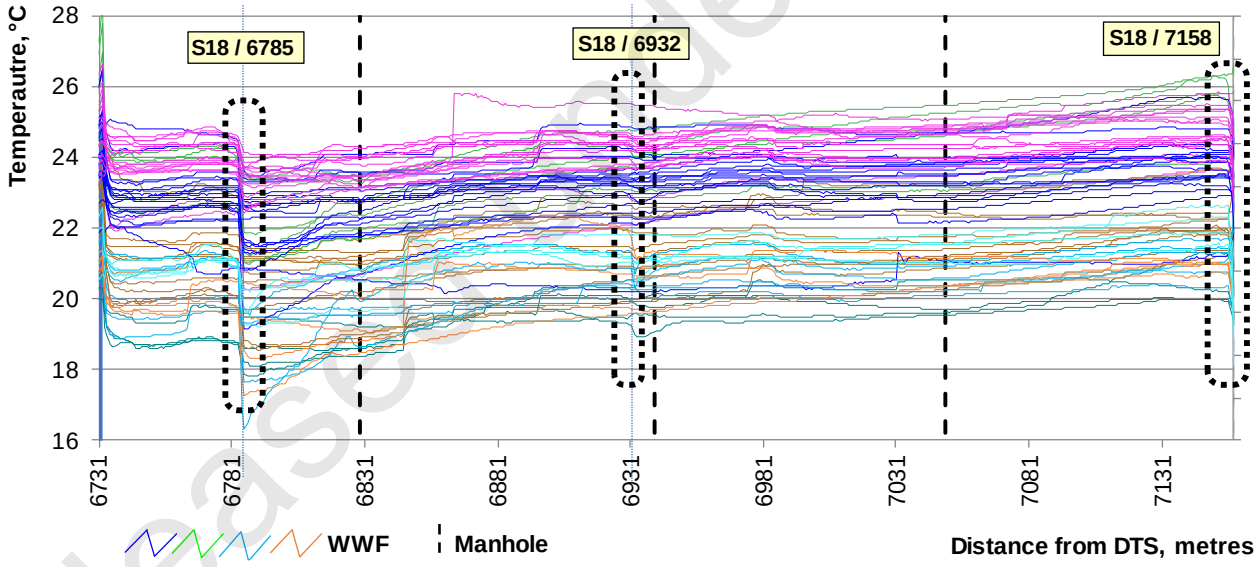


Notes:
1. Upstream manhole 16150 @ 126 Thorp Street @ 6731 m.
2. Downstream manhole 14905 @ 83A Thorp Street @ 7158 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

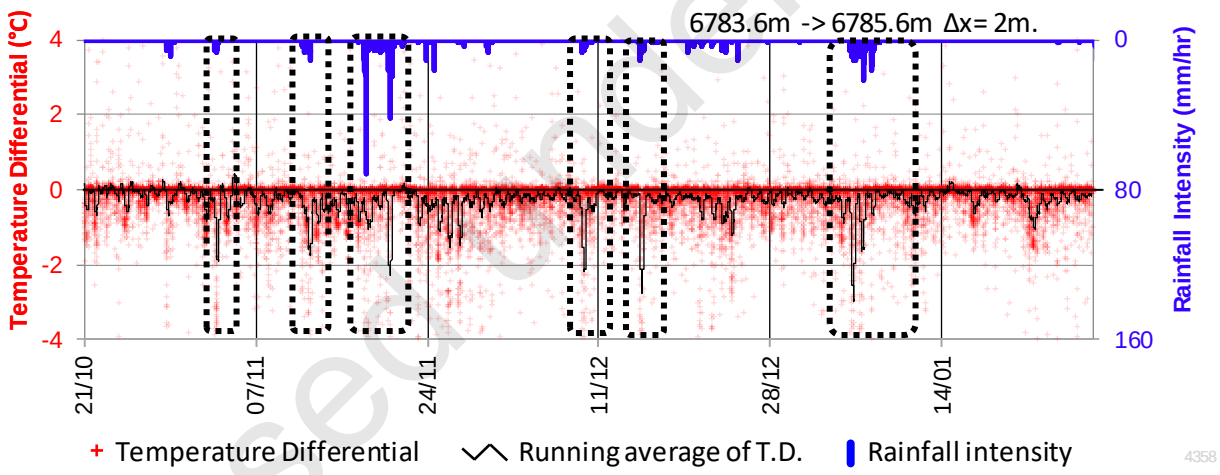


A.18.1 Source S18 / 6785

Source Analysis Summary

Asset	Pipe 36207 DN150, 96m, PVC Class B, 1954.
Address	121 Thorp Street.
DTS signal	Strong, 45m ±5m upstream of manhole 12313.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 36207 to determine the connection point of laterals not shown on the GIS map. Inspection of nearby connected properties (121 and 124 Thorp Street, 1 Harbour Road) looking for deterioration and/or stormwater connections.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



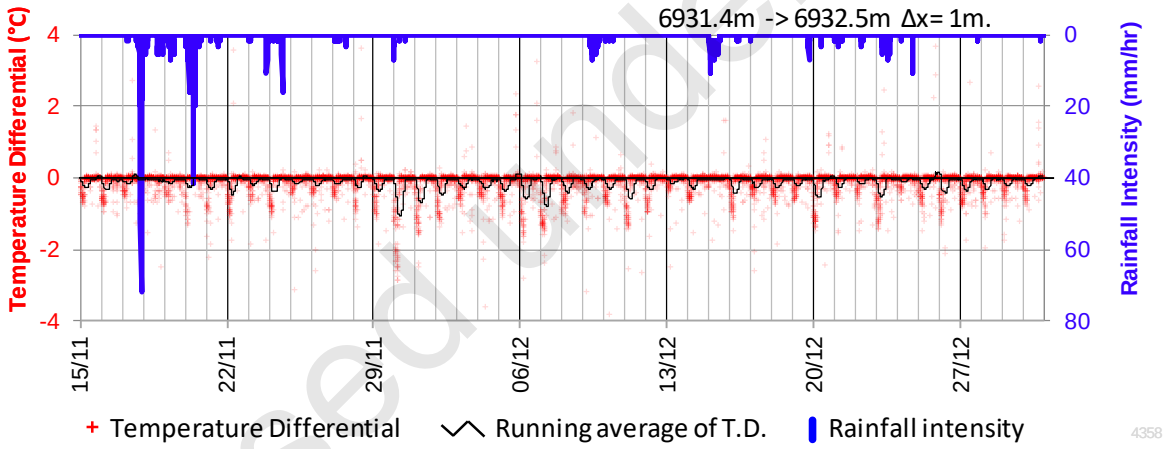
Source Location Map

A.18.2 Source S18 / 6932

Source Analysis Summary

Asset	Pipe 28728 DN150, 108m, Concrete, 1949.
Address	107 Thorp Street.
DTS signal	Strong, 8m ±5m upstream of manhole 12312.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 28728 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map. Inspection of nearby connected properties (107 and 110 Thorp Street) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



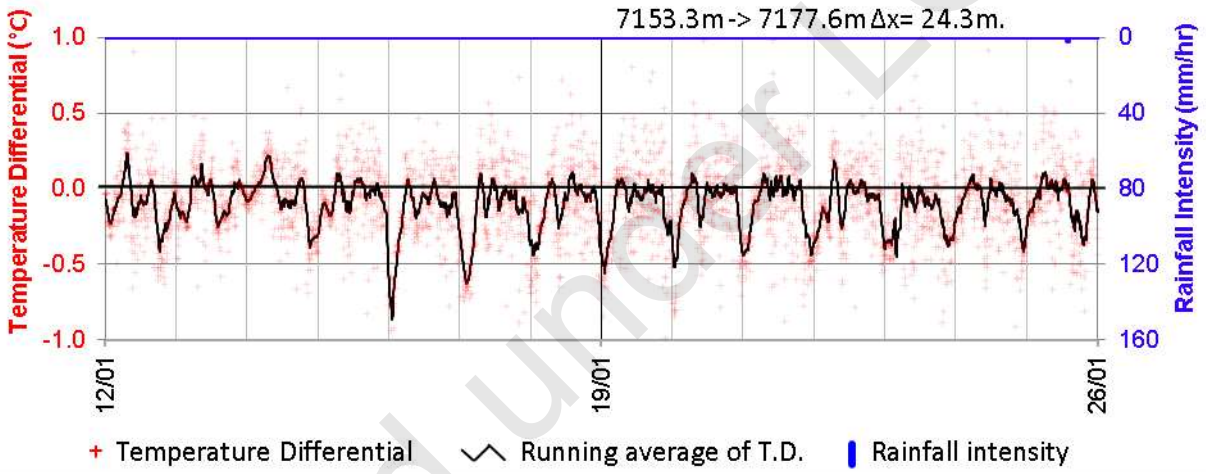
Source Location Map

A.18.3 Source S18 / 7158

Source Analysis Summary

Asset	Manhole 14905
Address	83A Thorp Street.
DTS signal	Medium. At manhole 14905.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	Inspection of manhole checking for signs of deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.19 Section S19: 61A to 86 Greenwood Street

Six potential sources of I&I were identified in this section using the DTS data:

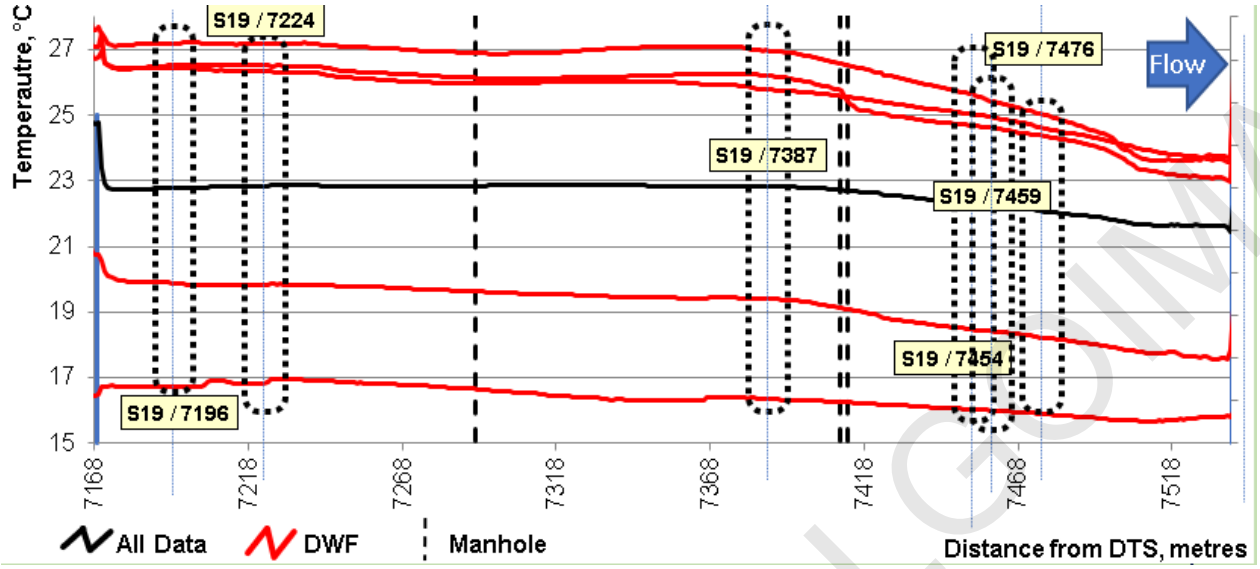
- Stormwater inflow source S19 / 7196 in pipe 36214 at 84 Thorp Street (on Greenwood Street frontage).
- Stormwater inflow source S19 / 7224 in pipe 36214 at 88 Greenwood Street.
- Stormwater inflow source S19 / 7386** in pipe 36215 at 75A Greenwood Street.
- Stormwater inflow source S19 / 7454 in Pipe 36219 at 67A Greenwood Street.
- Stormwater inflow source S19 / 7459** in Pipe 36219 at 67 Greenwood Street.
- Stormwater inflow source S19 / 7475 in pipe 36219 at 67 Greenwood Street.

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

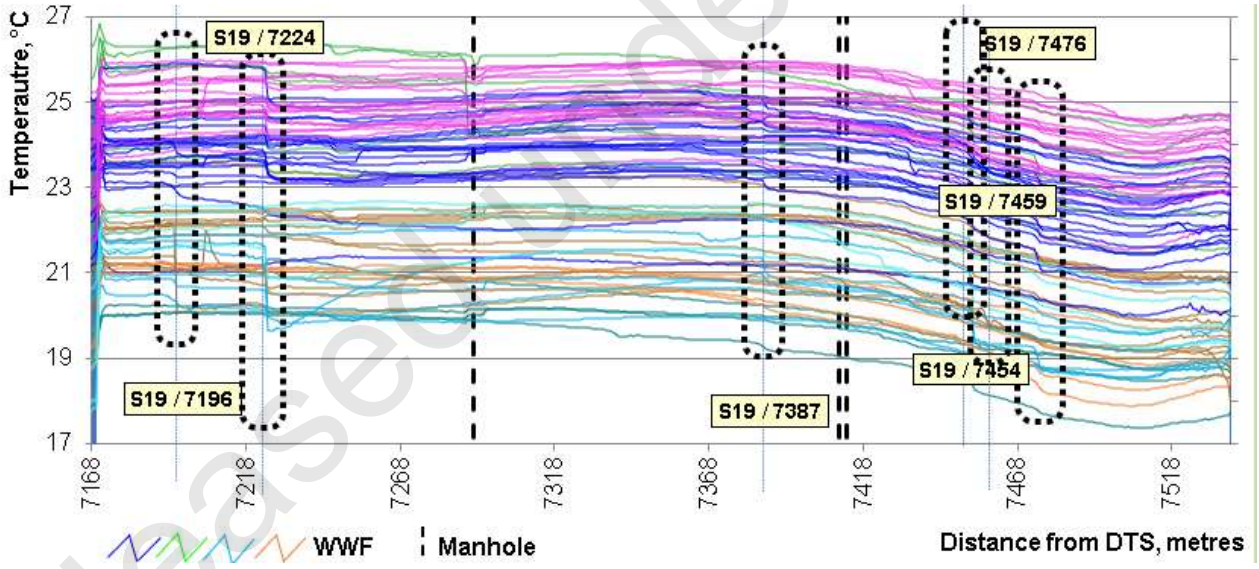
Source Identification Map

Notes:
1. Upstream manhole 14905 @ 83A Thorp Street @ 7169 m.
2. Downstream manhole 14912 @ 61A Greenwood Street @ 7538 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

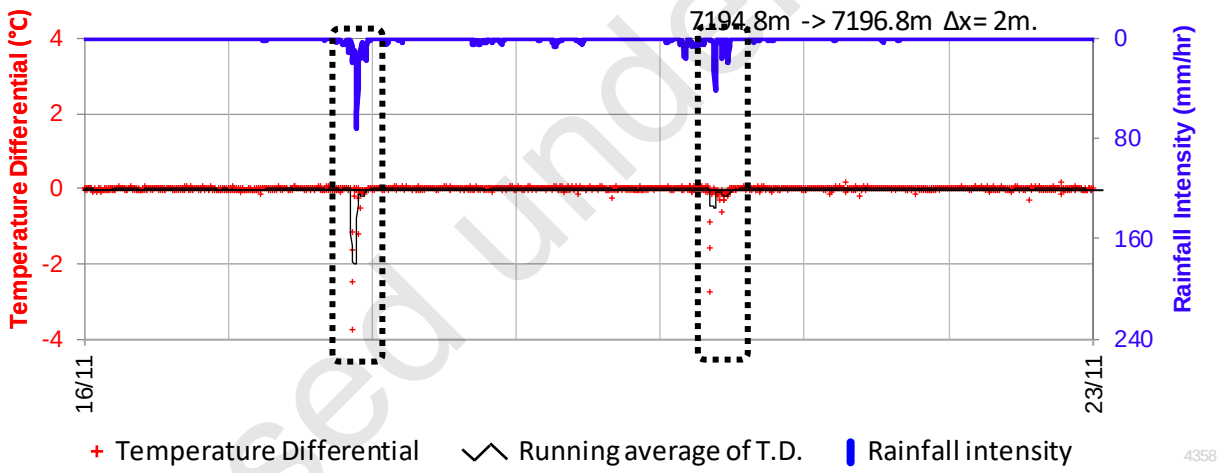


A.19.1 Source S19 / 7196

Source Analysis Summary

Asset	Pipe 36214 DN150, 121m, Concrete, 1949.
Address	84 Thorp Street (on Greenwood Street frontage).
DTS signal	Medium, 27m ±5m downstream of manhole 14905.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 36214 to determine the connection point of laterals not shown on the GIS map. Inspection of nearby connected properties (84 Thorp Street) looking for deterioration and/or stormwater connections.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

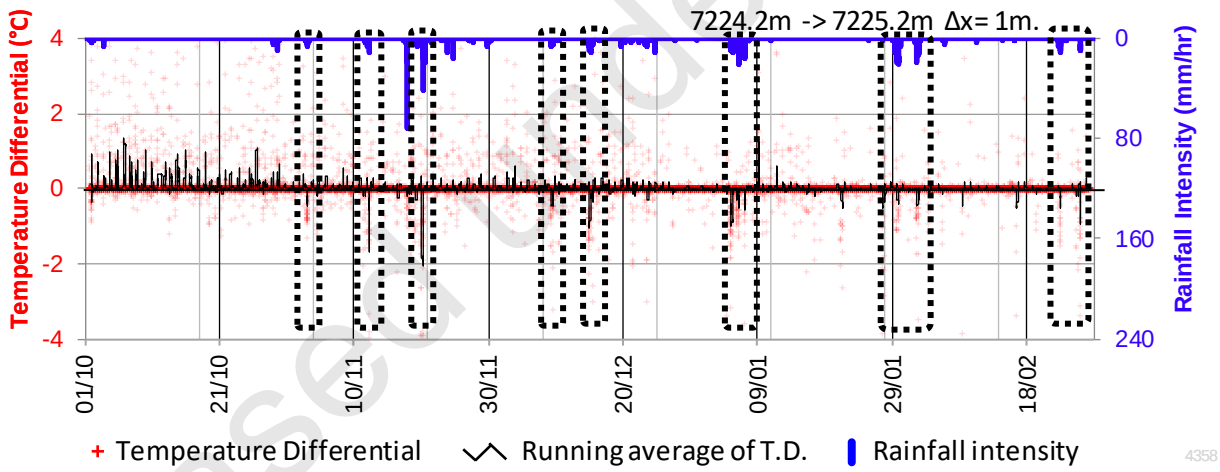
<Source label in map to be corrected to S19/7195 in final report>

A.19.2 Source S19 / 7224

Source Analysis Summary

Asset	Pipe 36214 DN150, 121m, Concrete, 1949.
Address	88 Greenwood Street.
DTS signal	Strong, 67m ±5m upstream of manhole 12329.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 36214 to determine the connection point of laterals not shown on the GIS map. Inspection of nearby connected properties (88 and 91 Greenwood Street) looking for deterioration and/or stormwater connections.
Note	CCTV inspection for this pipe is included under the recommendations for another I&I source. Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



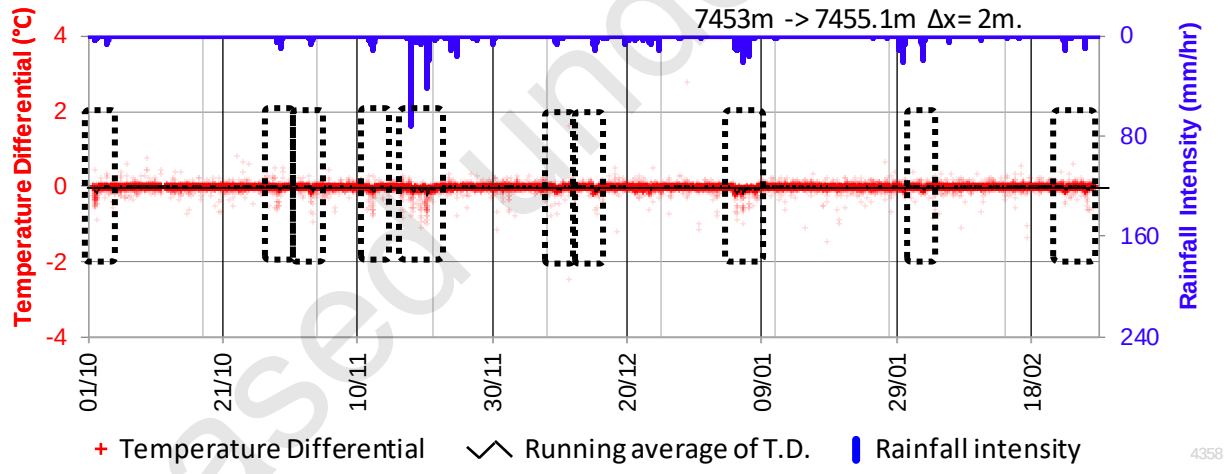
Source Location Map

A.19.3 Source S19 / 7454

Source Analysis Summary

Asset	Pipe 36219 DN150, 123m, Concrete, 1949.
Address	67A Greenwood Street.
DTS signal	Medium, 84m ±6m upstream of manhole 14912.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 36219 to determine the connection point of laterals not shown on the GIS map (66, 67,67A, 67B Greenwood St.). Inspection of nearby connected properties (66, 67, 67A, 67B, 69, 69A Greenwood St.) looking for deterioration and inflow.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within six metres of the DTS signal. CCTV inspection for pipe 36219 is included under the recommendations for I&I source S19 / 7475.

Source Analysis Plot – Temperature Difference vs Time



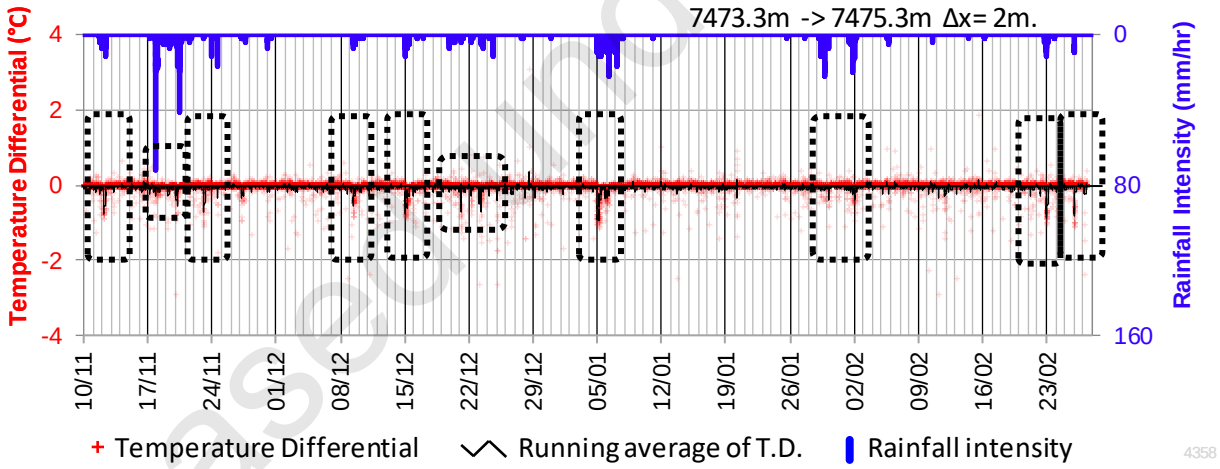
Source Location Map

A.19.4 Source S19 / 7475

Source Analysis Summary

Asset	Pipe 36219 DN150, 123m, Concrete, 1949.
Address	67 Greenwood Street.
DTS signal	Strong, 63m ±5m upstream of manhole 14912.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 36219 to determine the connection point of laterals not shown on the GIS map. Inspection of nearby connected properties (64 and 67 Greenwood Street) looking for deterioration and/or stormwater connections.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Property inspection of 67 Greenwood Street is listed under the recommendations for I&I source S19 / 7454.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

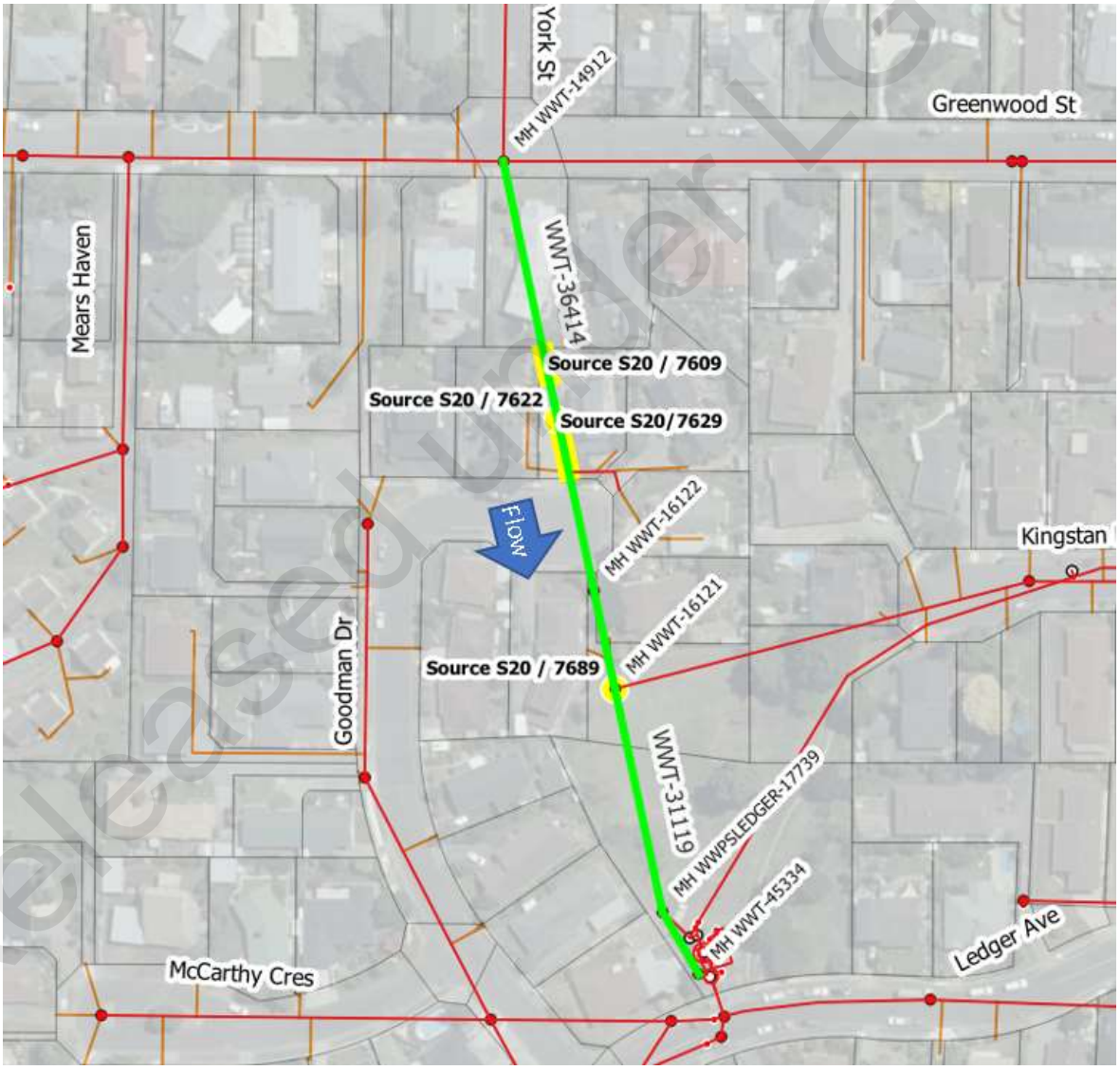
A.20 Section S20: 61A Greenwood Street to 2 Ledger Ave

Four potential sources of I&I were identified in this section using the DTS data:

- Groundwater infiltration source S20 / 7609** in Pipe 36414 at 31 Goldman Drive.
- RDI Groundwater infiltration source S20 / 7622 in pipe 36414 at 31 Goodman Drive.
- Groundwater infiltration source S20 / 7629 in pipe 36414 at 31 Goodman Drive.
- Stormwater inflow, rain dependent infiltration and groundwater infiltration source S20 / 7689 in Manhole 16121 at Ledger Goodman Park. <new>

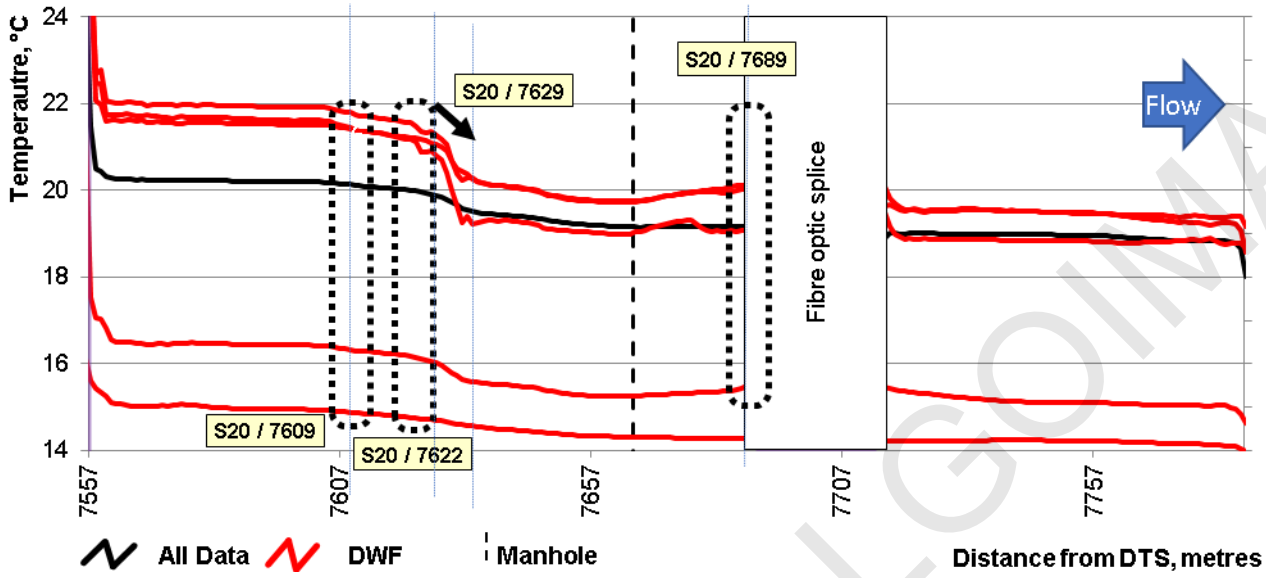
Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

Source Identification Map

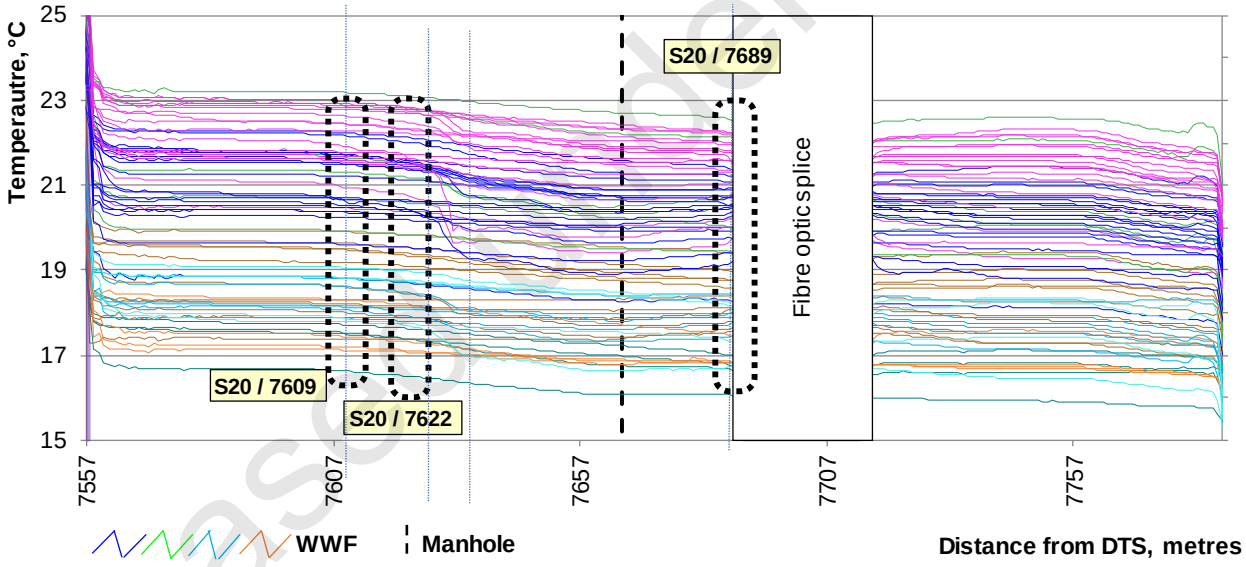


Notes:
1. Upstream manhole 14912 @ 61A Greenwood Street @ 7558 m.
2. Downstream manhole 45334 @ 2 Ledger Avenue @ 7787 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

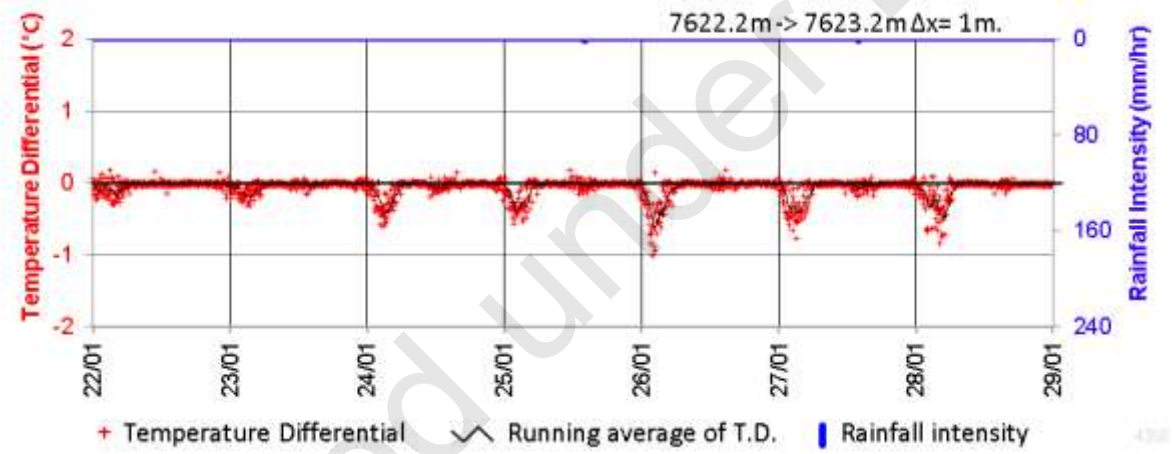


A.20.1 Source S20 / 7622

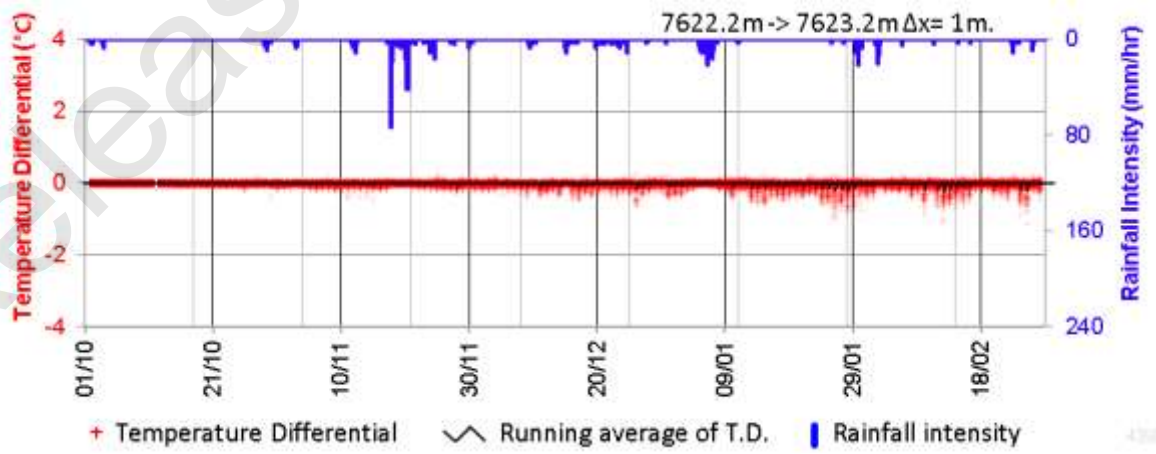
Source Analysis Summary

Asset	Pipe 36414 DN300, 106m, Concrete, 1949.
Address	31 Goodman Drive.
DTS signal	Strong, 43m ±4m upstream of manhole 16122.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. The infiltration signal varies from nothing during extended dry periods to a strong signal for multiple weeks after rain, indicating rainfall dependent infiltration.
Recommendation	CCTV inspection of pipe 36414 checking for signs of deterioration and infiltration. This CCTV inspection is listed under source S20 / 7629.

Source Analysis Plot – Temperature Difference vs Time – showing a clear temperature drop each morning.



Source Analysis Plot – Temperature Difference vs Time – showing variation during dry and wet conditions.



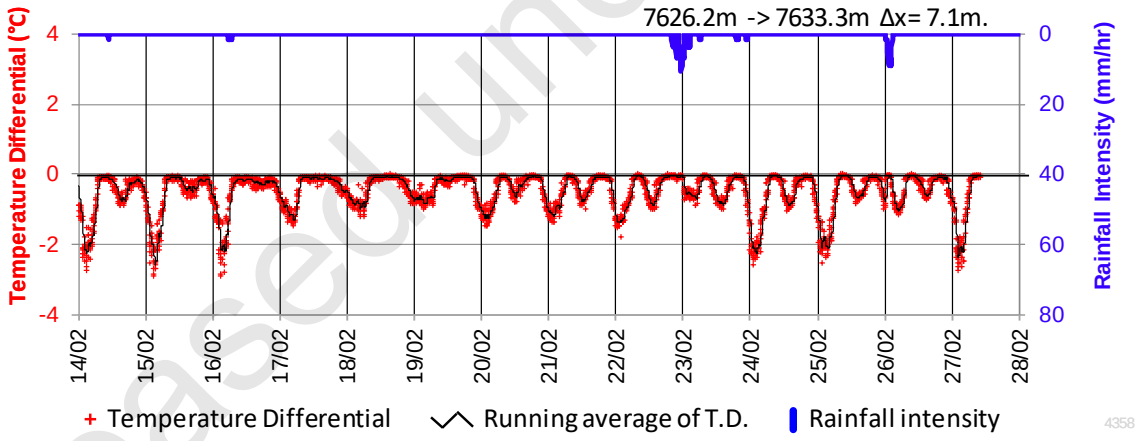
Source S20 / 7622 - Location Map

A.20.2 Source S20 / 7629

Source Analysis Summary

Asset	Pipe 36414 DN300, 106m, Concrete, 1949.
Address	31 Goodman Drive.
DTS signal	Strong, 32m to 39m ±4m upstream of manhole 16122. The temperature drop extends over a length of the pipe. Source S20/7622 may be a separate source of I&I or Sources S20/7622 and S20/7629 may be considered a single source spread over a longer length of the wastewater main.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. The infiltration signal varies from nothing during extended dry periods to a strong signal for multiple weeks after rain, indicating rainfall dependent infiltration.
Recommendation	CCTV inspection of pipe 36414 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (25, 27, 31, 33 Goodman Drive) looking for deterioration and infiltration.
Note	Inspection of the private properties has been included to assess if the laterals are contributing infiltration.

Source Analysis Plot – Temperature Difference vs Time



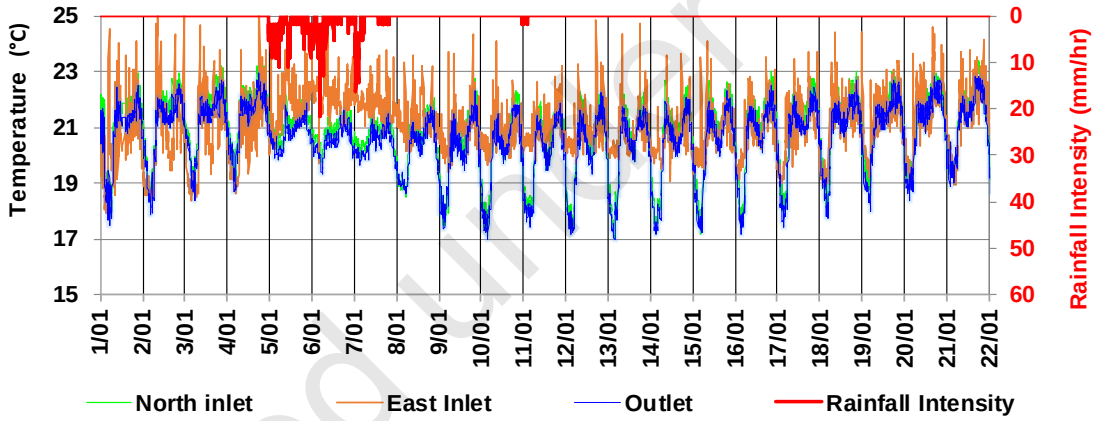
Source Location Map

A.20.3 Source S20 / 7689 <new>

Source Analysis Summary

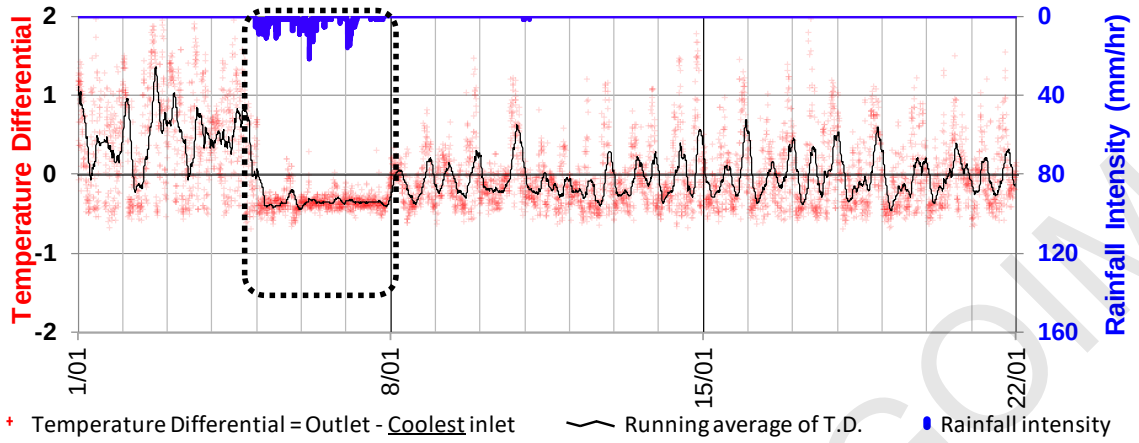
Asset	Manhole 16121.
Address	Ledger Goodman Park.
DTS signal	Strong. At manhole 16122.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Immediate and delayed reduction in temperature correlated with rainfall indicating stormwater inflow and rainfall derived infiltration.
Recommendation	Inspection of manhole 16121 checking for signs of poor construction, poor lid seal, surface inflow through cover keyholes, infiltration and/or inflow.

Source Analysis Plot – Temperature vs Time

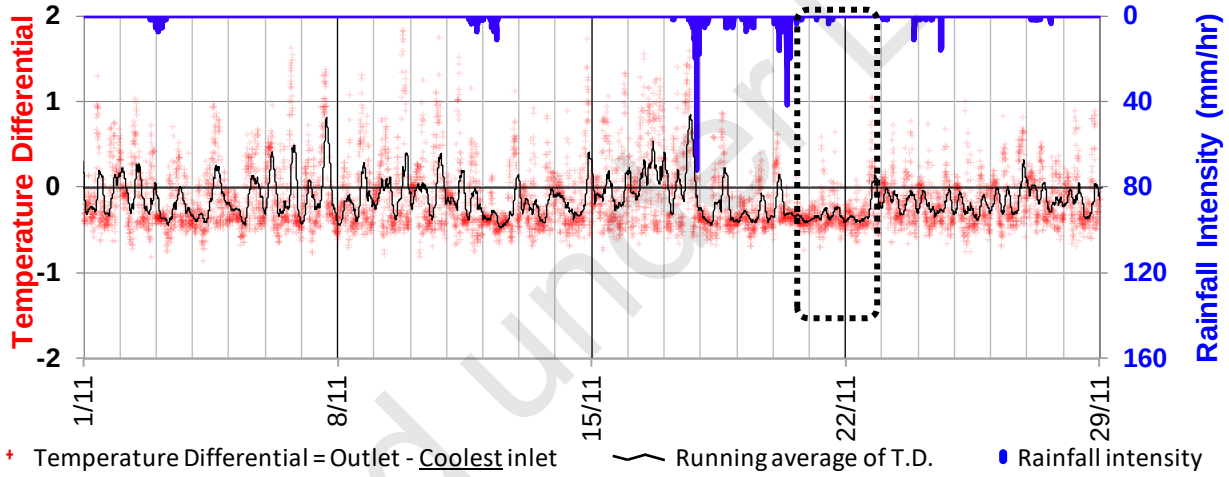


In the plot above it is difficult to visually observe the difference between the temperature of the northern inlet and the outlet. The difference between the temperature of the coolest inlet to the manhole and the outlet of the manhole is plotted below. This plot of temperature difference highlights when the outlet temperature is cooler than the inlet temperatures. The first plot below indicates stormwater inflow as the temperature difference ends when the rain stops. The second plot indicates rain dependent infiltration as the temperature difference continues for an extended period after the rain ends.

Source Analysis Plot – Temperature Difference vs Time showing stormwater inflow and GWI



Source Analysis Plot – Temperature Difference vs Time showing rain dependent infiltration



Source S20 / 7689 - Location Map

A.21 Section S21: Kingstan Place

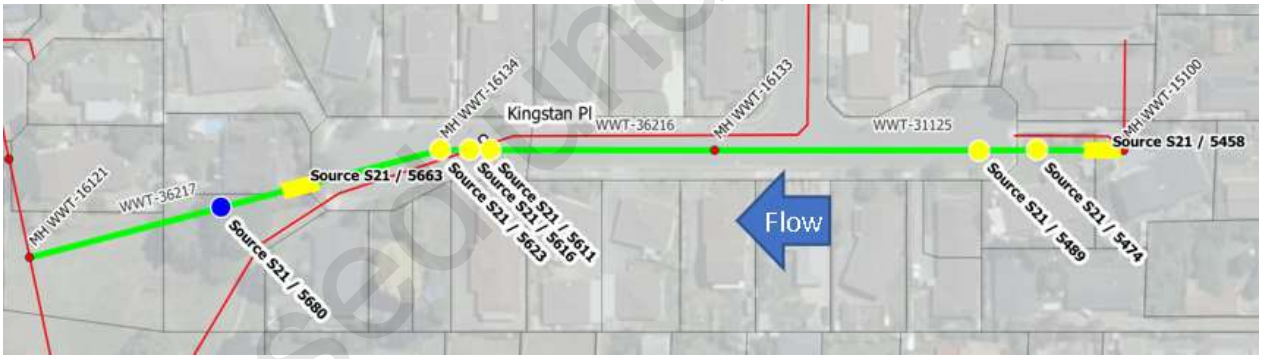
Six potential sources of I&I were identified in this section using the DTS data:

- Groundwater infiltration source S21 / 5458 in Pipe 31125 at 23 Kingstan Place.
- Groundwater infiltration source S21 / 5474 in pipe 31125 at 21 Kingstan Place.
- Groundwater infiltration source S21 / 5489 in Pipe 31125 at 19A Kingstan Place.
- Groundwater infiltration source S21 / 5611 in Pipe 36216 at 7 Kingstan Place.
- Rainfall dependent infiltration & Groundwater infiltration source S21 / 5616 in Pipe 36216 at 7 Kingstan Place.
- RDI Groundwater infiltration source S21 / 5623 in Manhole 16134 at 6 Kingstan Place.
- RDI Groundwater infiltration source S21 / 5663 in Pipe 36217 at 1 Kingstan Place.
- Stormwater inflow source S21 / 5680** in Pipe 36217 at Goodman Park.

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

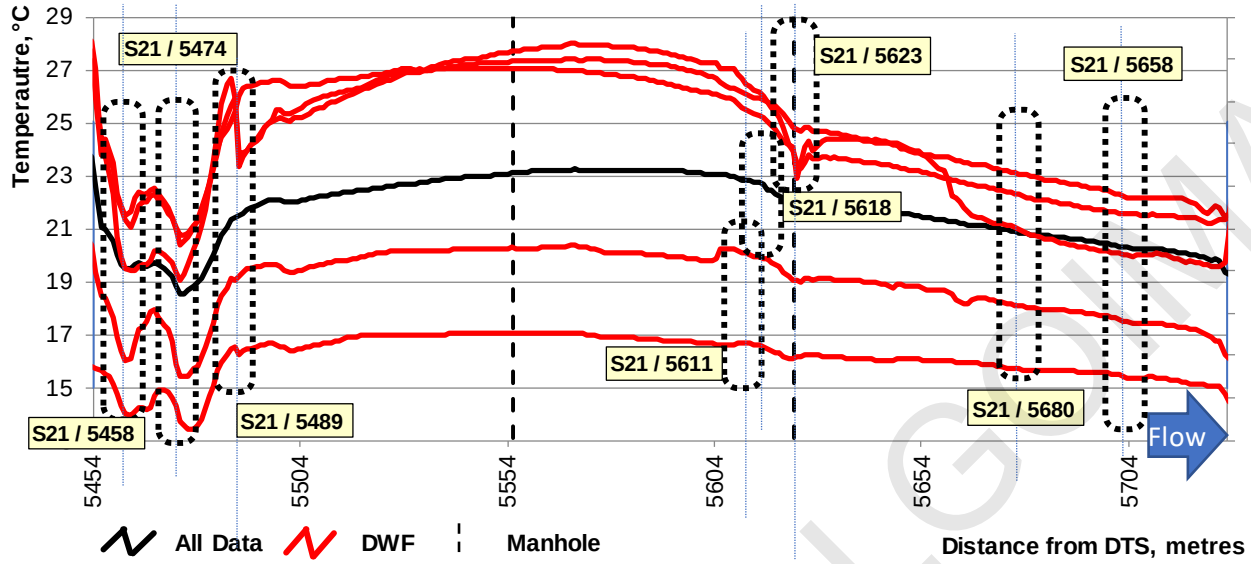
The masking of I&I patterns in the DTS data during rain events and for many days after rain indicates significant upstream I&I. Given the age and use of asbestos cement pipe material, it is anticipated that remediation of significant amounts of this section of wastewater main may be required.

Source Identification Map

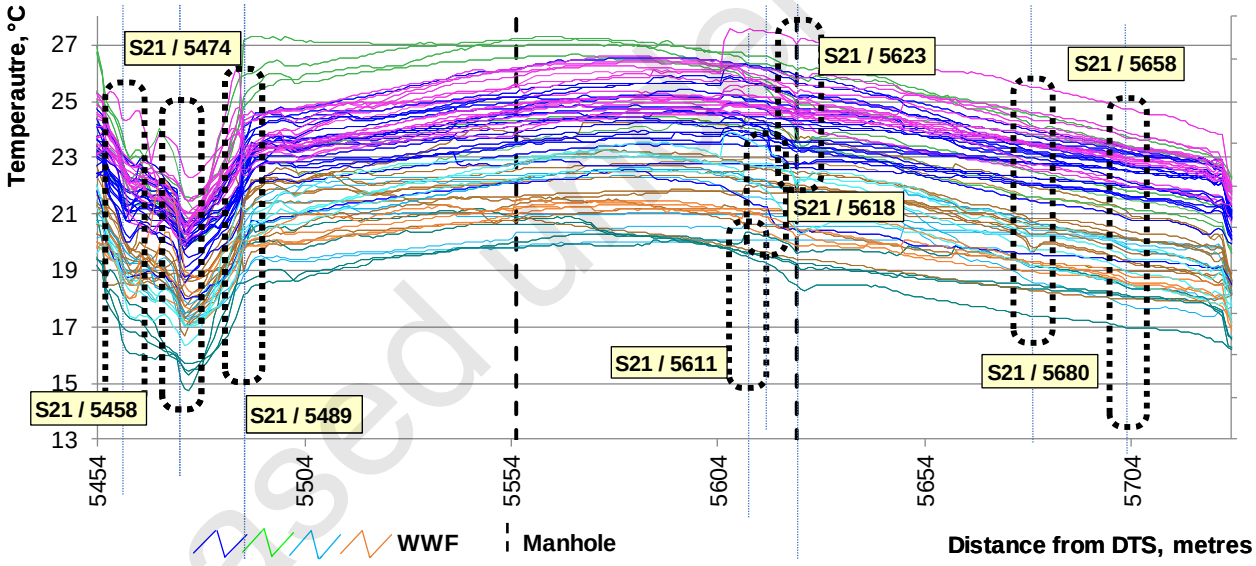


Notes:
1. Upstream manhole 15100 @ 23 Kingstan Place @ 5454 m.
2. Downstream manhole 16121 @ 23 Goodman Drive @ 5728 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

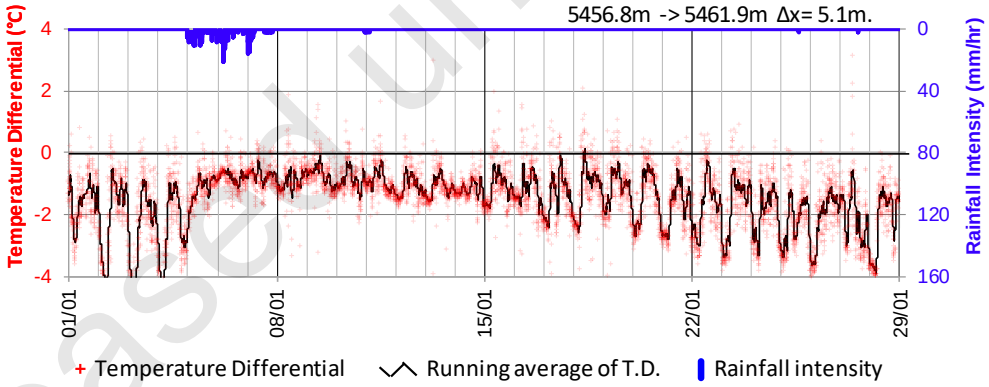


A.21.1 Source S21 / 5458

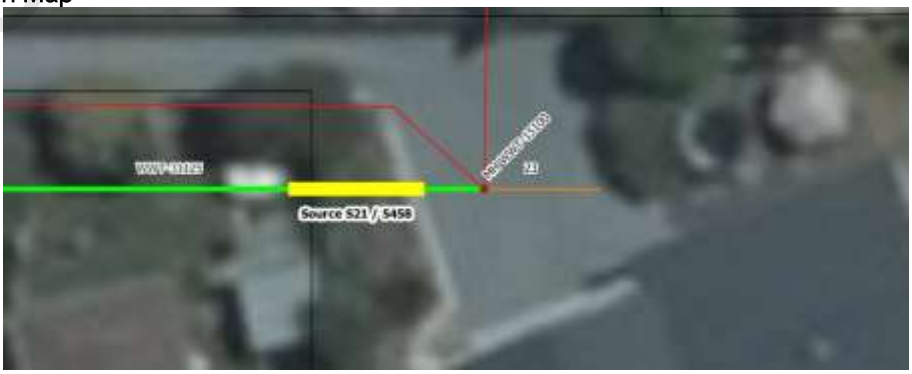
Source Analysis Summary

Asset	Pipe 31125 DN150, 100m, Asbestos Cement, 1978.
Address	23 Kingstan Place.
DTS signal	Medium, 3-8m ±5m downstream of manhole 15100.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipes checking for signs of deterioration and infiltration. Inspection of nearby connected properties (98A Thorp Street) looking for deterioration and infiltration.
Note	CCTV inspection for pipe 31125 is included under the recommendations for I&I source S21 / 5474. Use the CCTV data to update the connection points for the laterals not shown in the GIS map (98A Thorp Street). Include property inspections only if they are within five metres of the DTS signal. This analysis included assessment of the impacts of differential solar heating of ground surfaces. Solar differentials were assessed not to be the cause of the observed wastewater temperature differentials.

Source Analysis Plot – Temperature Difference vs Time - Over 5 m length of pipe



Source Location Map

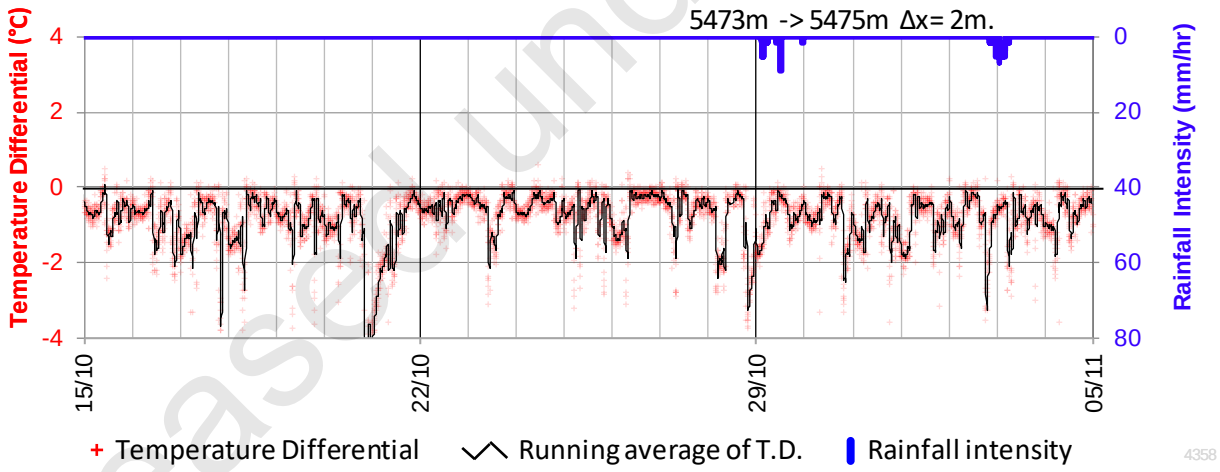


A.21.2 Source S21 / 5474

Source Analysis Summary

Asset	Pipe 31125 DN150, 100m, Asbestos Cement, 1978.
Address	21 Kingstan Place.
DTS signal	Medium, 20m ±5m downstream of manhole 15100.
Analysis	Temperature differential generally below 0°C indicating GWI. The source is identified as infiltration so is expected to be a below ground fault or deterioration either in the wastewater main or a private lateral.
Recommendation	CCTV inspection of pipe 31125 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (22A Kingstan Place). Inspection of nearby connected properties (21 and 22A Kingstan Place) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



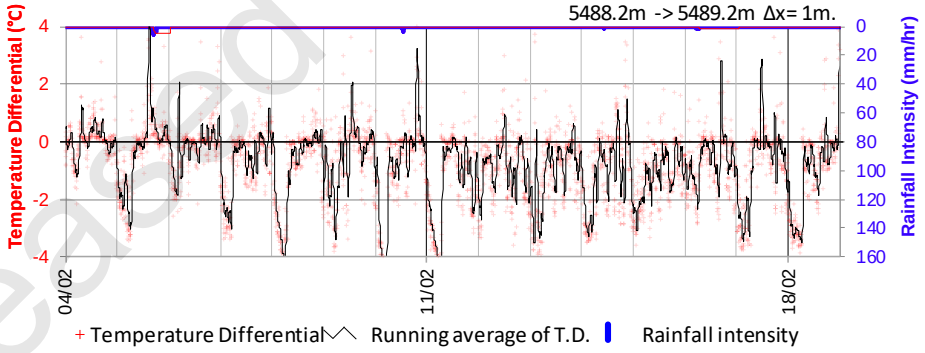
Source Location Map

A.21.3 Source S21 / 5489

Source Analysis Summary

Asset	Pipe 31125 DN150, 100m, Asbestos Cement, 1978.
Address	19A Kingstan Place.
DTS signal	Medium, 67m ±5m upstream of manhole 16133.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 31125 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (19A, 19B, 22A Kingstan Place, 98B Thorp Street) looking for deterioration and infiltration.
Note	These four lateral inspections are included due to uncertainty if the groundwater source is in the wastewater main, or the nearby laterals. CCTV inspection of pipe 31125 is included under the recommendations for source S21 / 5474. The groundwater intrusion signal was seasonal. The DTS data for same location did not exhibit any I&I patterns in October 2022. This DTS signal strength is assessed to be 'medium' rather than 'strong' despite the large temperature difference. The 'medium' rating is because the temperature difference is influenced more by the upstream temperature rising in the early hours of the morning rather than the downstream temperature reducing. It is expected that the downstream temperature is impacted by cool groundwater from a leak in a lateral at a location that is not affected by solar heating from the road pavement.

Source Analysis Plot – Temperature Difference vs Time



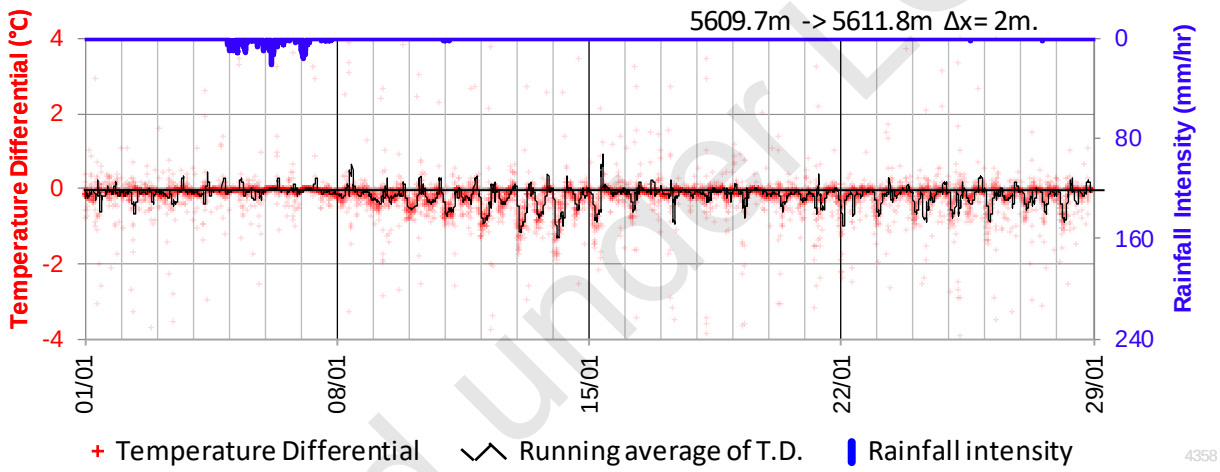
Source Location Map

A.21.4 Source S21 / 5611

Source Analysis Summary

Asset	Pipe 36216 DN150, 67m, Asbestos Cement, 1978.
Address	7 Kingstan Place.
DTS signal	Strong, 12m ±5m upstream of manhole 16134.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 36216 checking for signs of deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



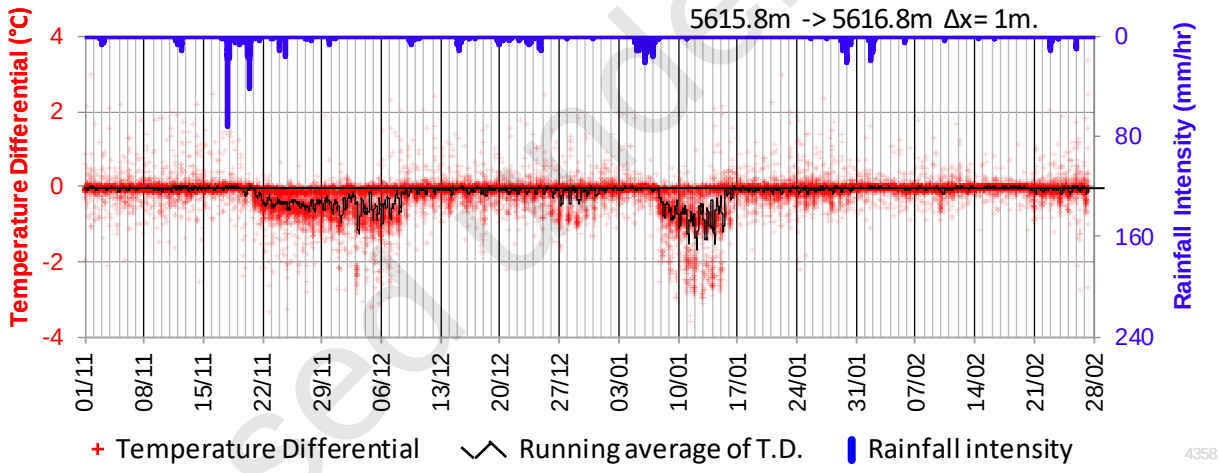
Source Location Map

A.21.5 Source S21 / 5616

Source Analysis Summary

Asset	Pipe 36216 DN150, 67m, Asbestos Cement, 1978.
Address	7 Kingstan Place.
DTS signal	Strong, 6m ±5m upstream of manhole 16134.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Reduction in temperature for an extended period after rain indicating rainfall dependent infiltration.
Recommendation	CCTV inspection of pipe 36216 checking for signs of deterioration and infiltration.
Note	CCTV inspection for pipe 36216 is included under the recommendations for I&I source S21 / 5611.

Source Analysis Plot – Temperature Difference vs Time



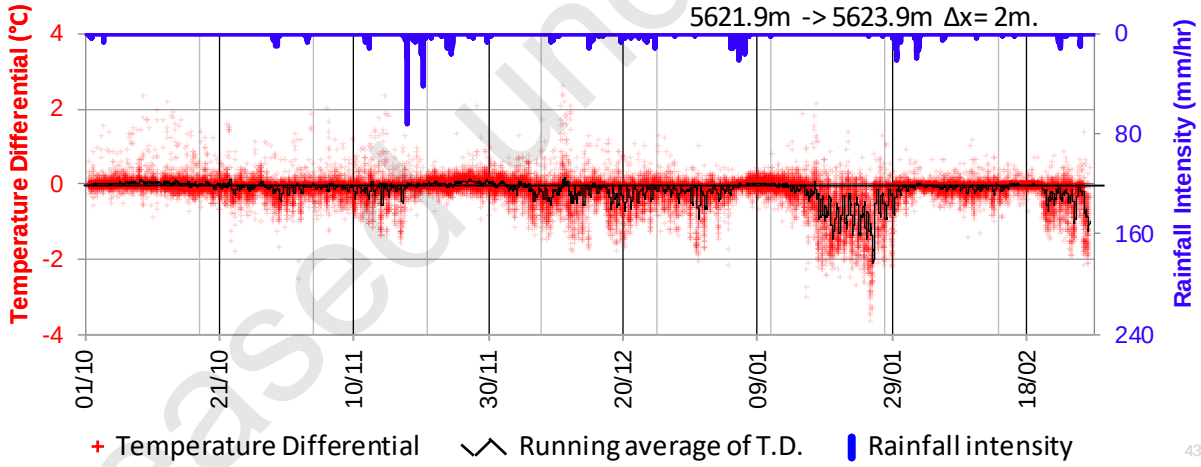
Source Location Map

A.21.6 Source S21 / 5623

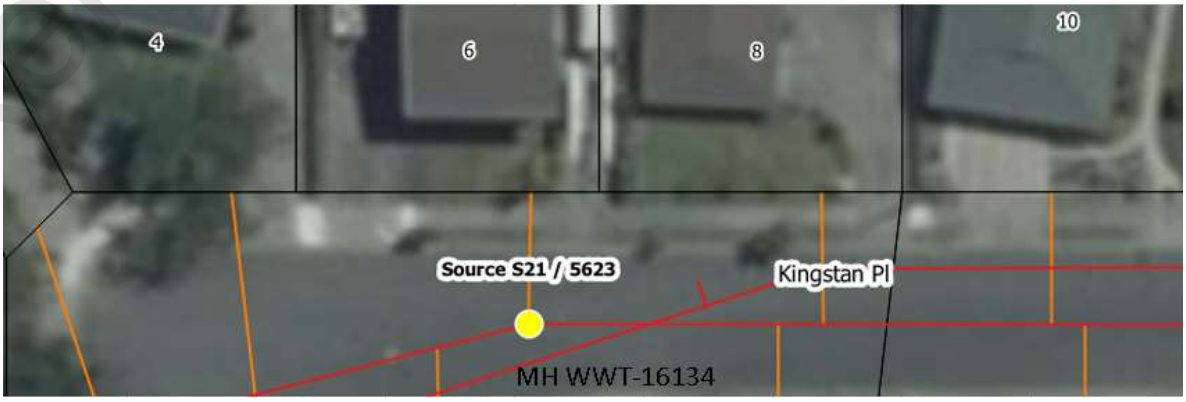
Source Analysis Summary

Asset	Manhole 16134.
Address	6 Kingstan Place.
DTS signal	Strong, At manhole 16134.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Reduction in temperature for an extended period after rain indicating rainfall dependent infiltration. The temperature drop observed during dry periods is reduced during rain events. This indicates infiltration is masked by upstream rainfall dependent inflow and infiltration.
Recommendation	Inspection of manhole 16134 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (6 Kingstan Pl.) looking for deterioration and infiltration.
Note	The masking of I&I during rain events indicates significant upstream I&I. Given the age and pipe materials, remediation of significant amounts of the upstream catchment may be required.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

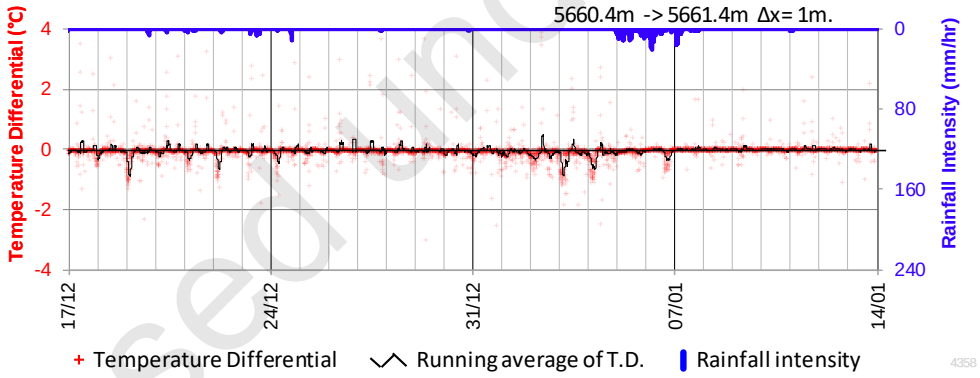


A.21.7 Source S21 / 5663

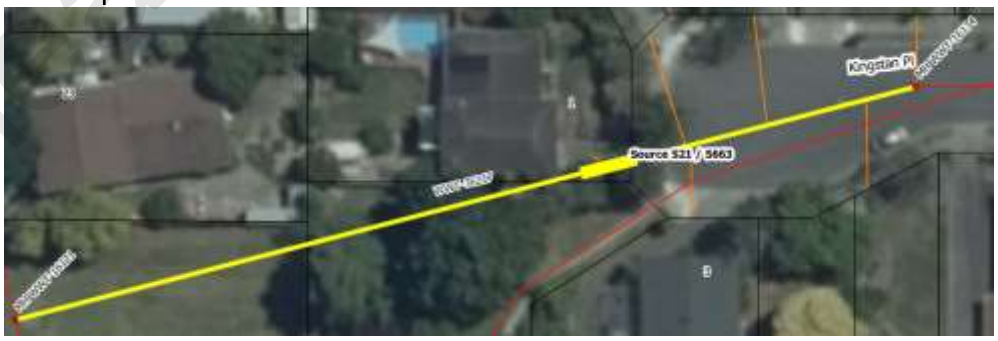
Source Analysis Summary

Asset	Pipe 36217 DN150, 103m, Asbestos Cement, 1978.
Address	1 Kingstan Place.
DTS signal	Medium, 65m to 71m±5m upstream of manhole 16121.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Reduction in temperature for an extended period after rain indicating rainfall dependent infiltration. The temperature drop observed during dry periods is reduced during rain events. This indicates infiltration is masked by upstream rainfall dependent inflow and infiltration.
Recommendation	Inspection of pipe 36217 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (1 Kingstan Pl.) looking for deterioration and infiltration.
Note	The masking of I&I during rain events indicates significant upstream I&I. Given the age and pipe materials, remediation of significant amounts of the upstream catchment may be required.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map



A.22 Section S22: Boyce Street. <new>

Four potential sources of I&I were identified in this section using the DTS data:

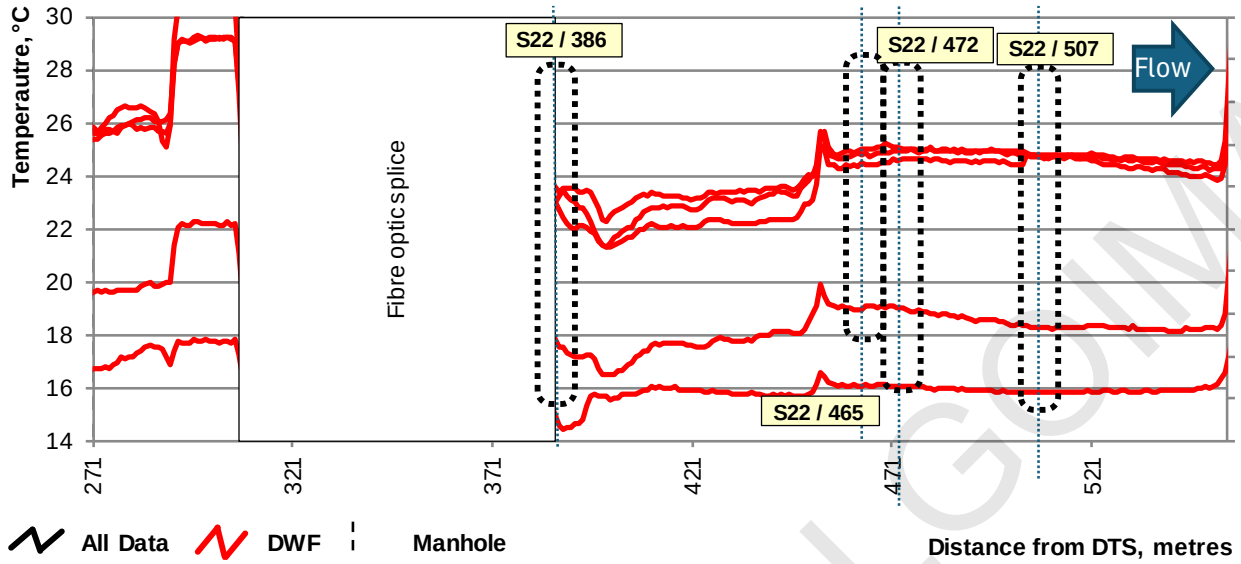
- Stormwater inflow source S22 / 386** in Manhole 14353 at 10 Boyce Street. <new>
- Stormwater inflow source S22 / 465** in Pipe 24459 at 6 Boyce Street. <new>
- Stormwater inflow source S22 / 472 in Pipe 24459 at 5 Boyce Street. <new>
- Stormwater inflow source S22 / 507 in Pipe 24459 at 1 Boyce Street. <new>

Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

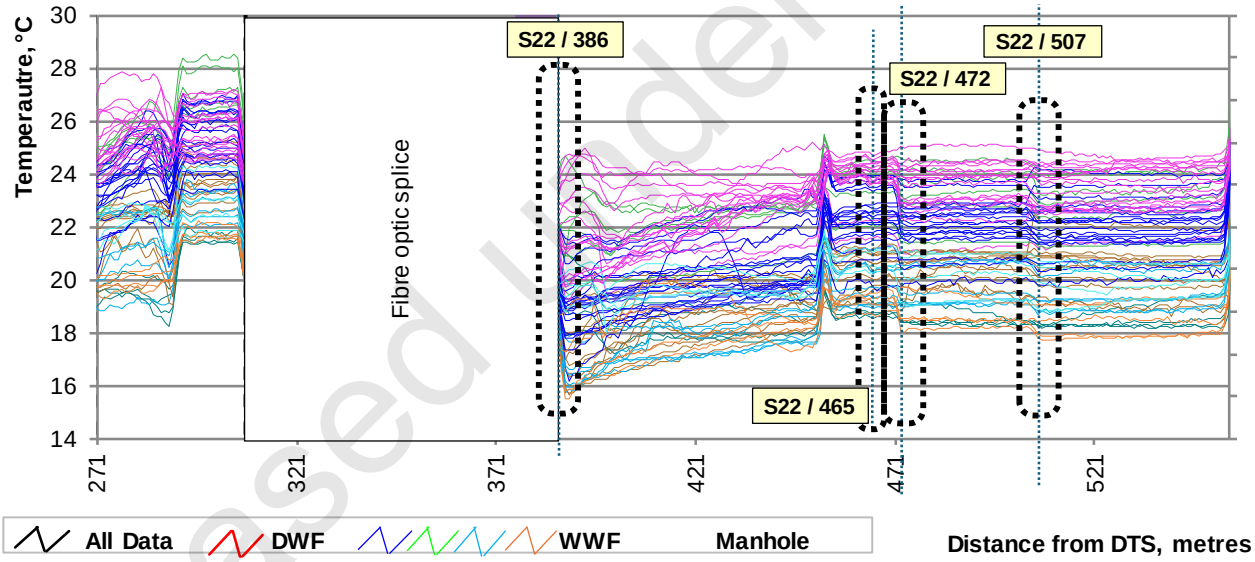
Source Identification Map

Notes:
1. Upstream manhole 24315 @ 13 Boyce Street @ 270 m.
2. Downstream manhole 24313 @ 9 York Street @ 555 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

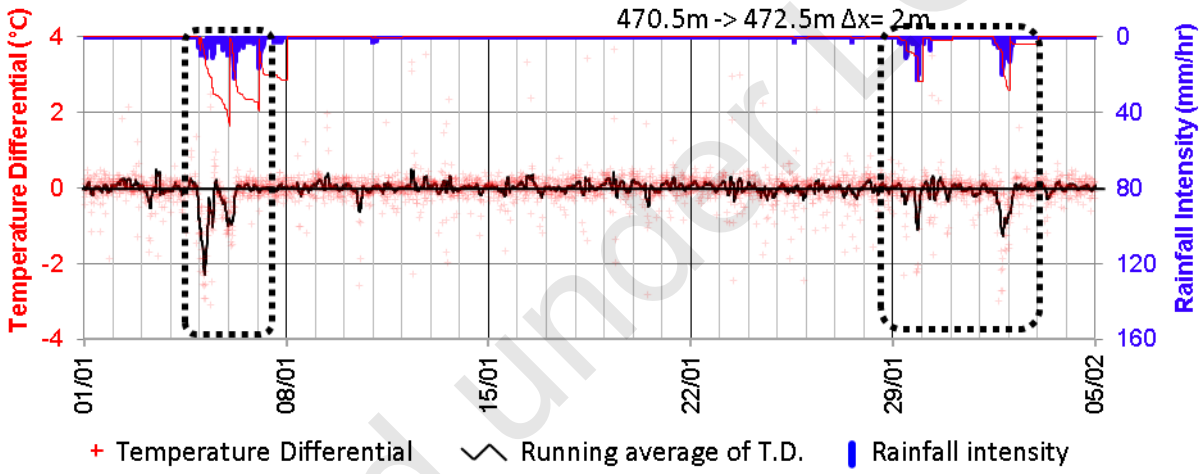


A.22.1 Source S22 / 472 <new>

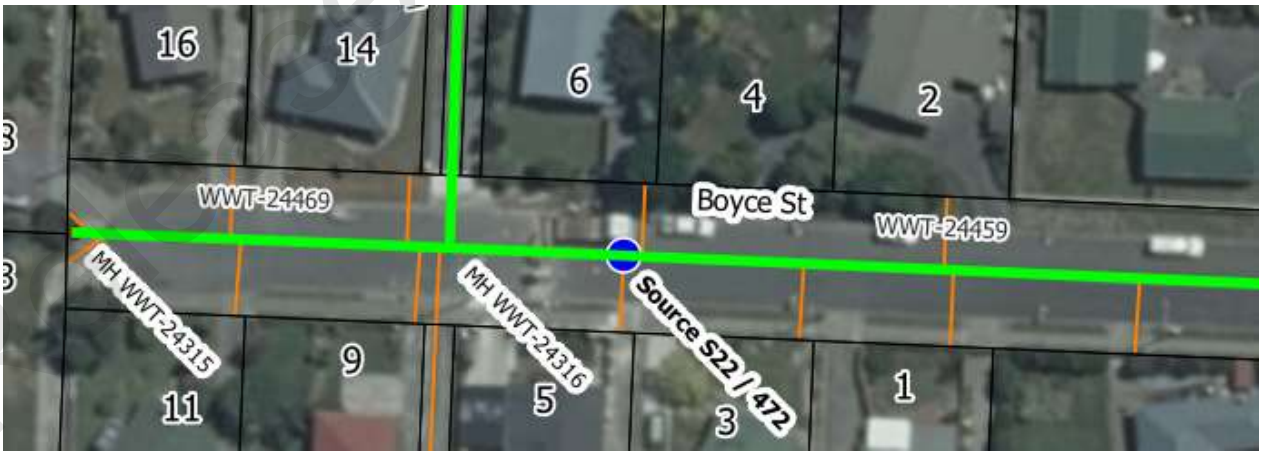
Source Analysis Summary

Asset	Pipe 24459	DN150, 101m, uPVC, 2012.
Address	5 Boyce Street.	
DTS signal	Strong. 18m ±3m downstream of manhole 24316.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	Inspection of nearby connected properties (5 & 6 Boyce St.) looking for deterioration and/or SW connections.	

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

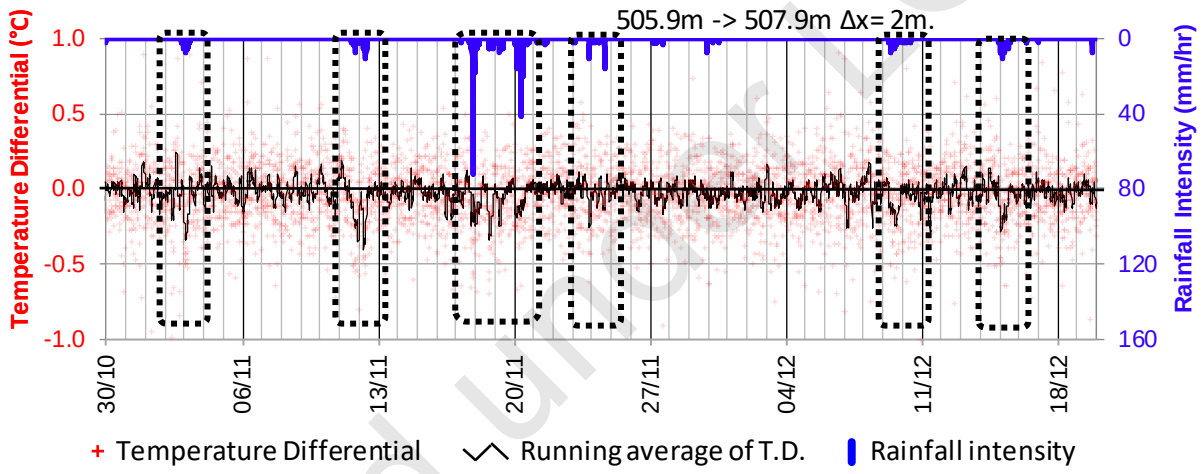


A.22.2 Source S22 / 507 <new>

Source Analysis Summary

Asset	Pipe 24459	DN150, 101m, uPVC, 2012.
Address	1 Boyce Street.	
DTS signal	Strong. 54m ±4m downstream of manhole 24316.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	Inspection of nearby connected properties (1 & 2 Boyce St.) looking for deterioration and/or SW connections.	

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

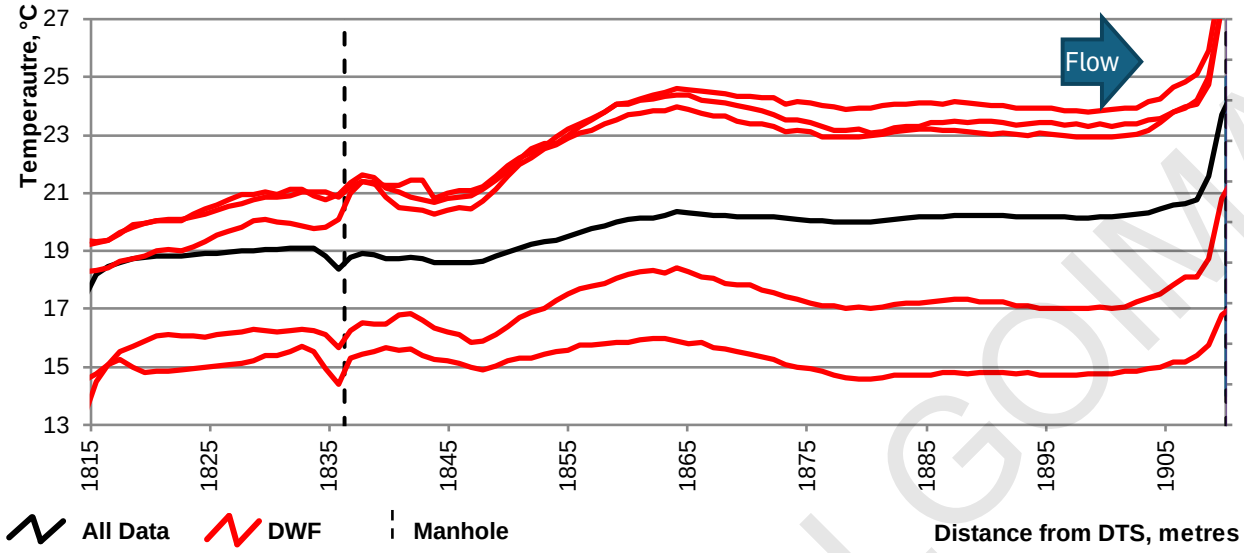
A.23 Section S23: 24 Moffatt Street to 23A York Street <new>

No potential sources of I&I were identified in this section using the DTS data.

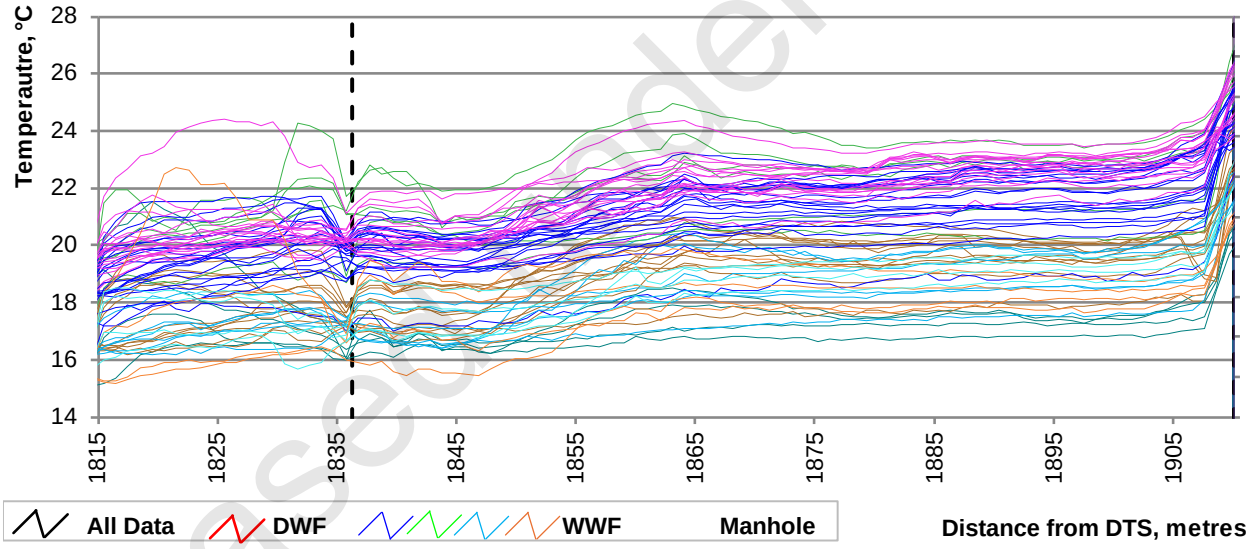
Source Identification Map

Notes:
1. Upstream manhole 40659 @ 24 Moffatt Street @ 1814 m.
2. Downstream manhole 14172 @ 23A York Street @ 1910 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals



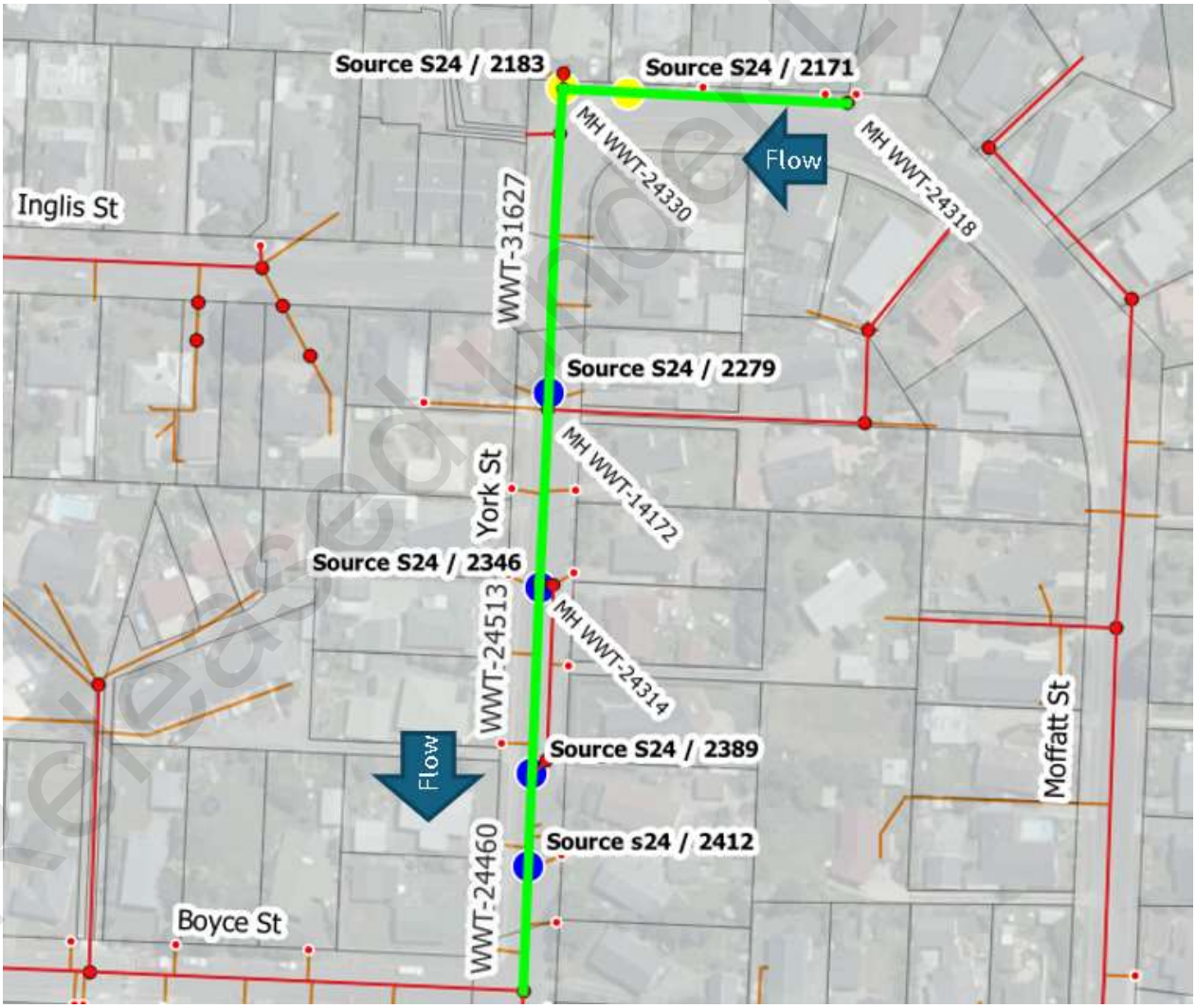
A.24 Section S24: 25 Moffatt Street to 9 York Street

Six potential sources of I&I were identified in this section using the DTS data:

- Groundwater infiltration source S24 / 2171 in Pipe 24520 at 31 Moffatt Street. <new>
- Groundwater infiltration source S24 / 2183 in Manhole 24330 at 33 Moffatt Street. <new>
- Stormwater inflow source S24 / 2279** in Pipe 31627 at 26 York Street. <new>
- Stormwater inflow source S24 / 2346 in or near Manhole 24314 at 22 Moffatt Street. <new>
- Stormwater inflow source S24 / 2389 in Pipe 24513 at 15 Moffatt Street. <new>
- Stormwater inflow source S24 / 2412** in Pipe 24460 at 11 York Street. <new>

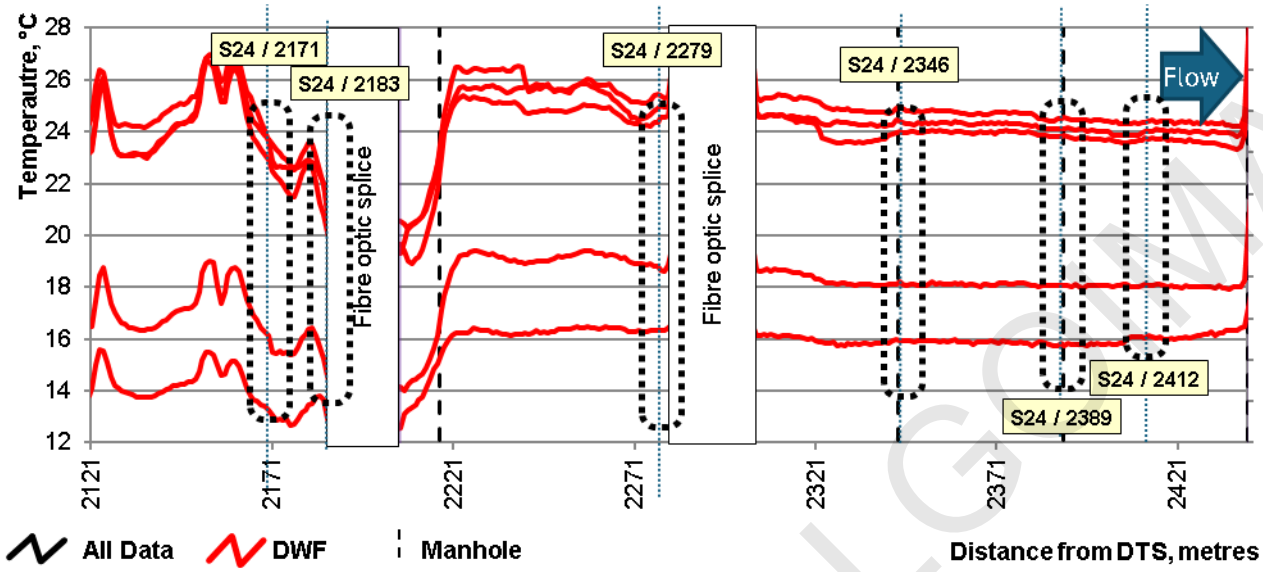
Sites noted with double asterisk ('**') are assessed to have a weak DTS I&I signal. The detailed analyses for these locations assessed are presented in Appendix B.

Source Identification Map

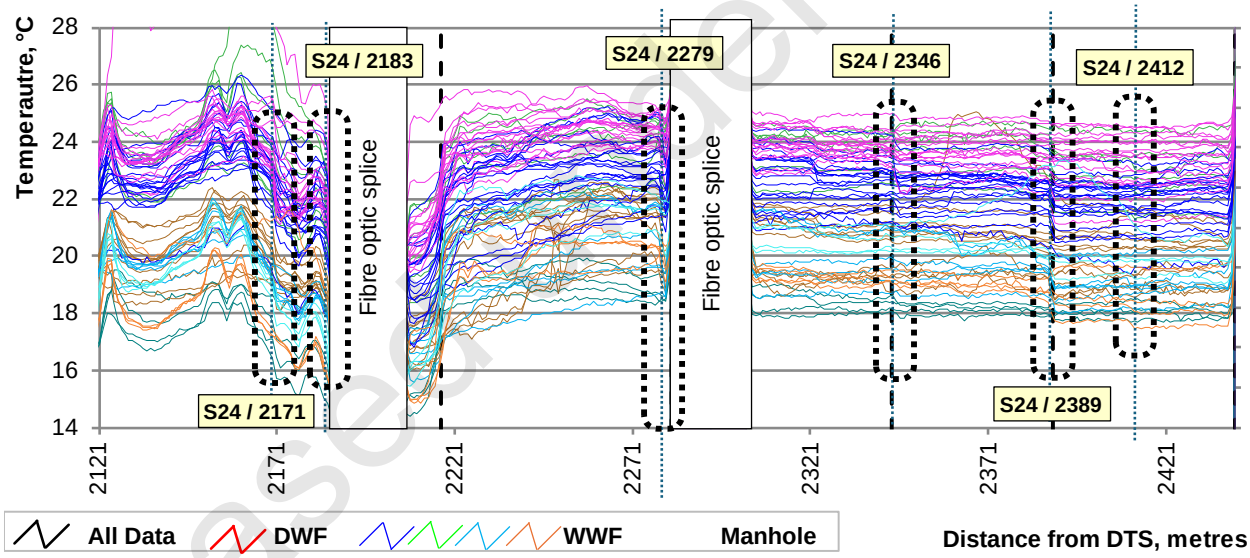


Notes:
1. Upstream manhole 24318 @ 27 Moffatt Street @ 2120 m.
2. Downstream manhole 24313 @ 9 York Street @ 2440 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

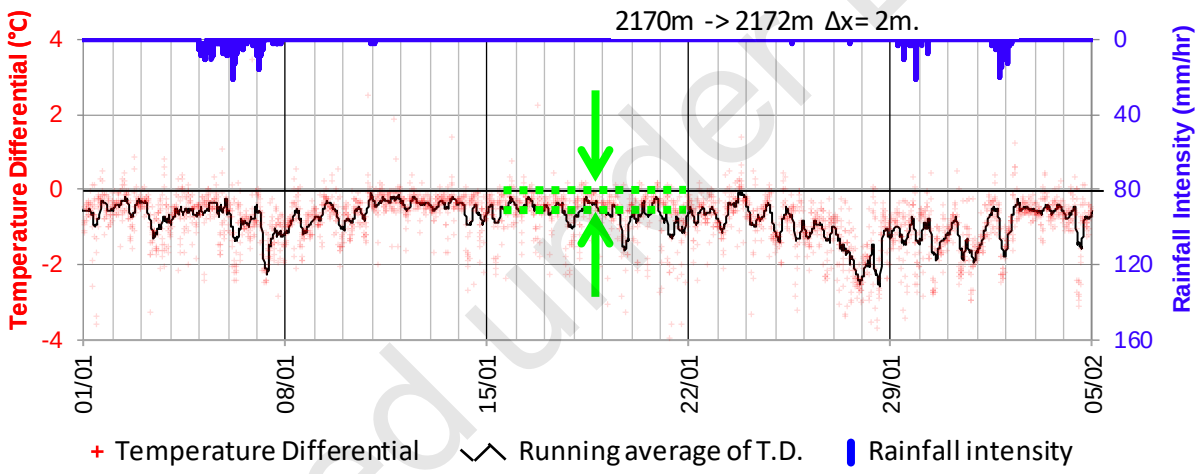


A.24.1 Source S24 / 2171 <new>

Source Analysis Summary

Asset	Pipe 24520 DN150, 66m, 2012
Address	31 Moffatt Street.
DTS signal	Strong. 15m ±3m upstream of manhole 24330.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 24520 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (31 Moffatt St.) looking for deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



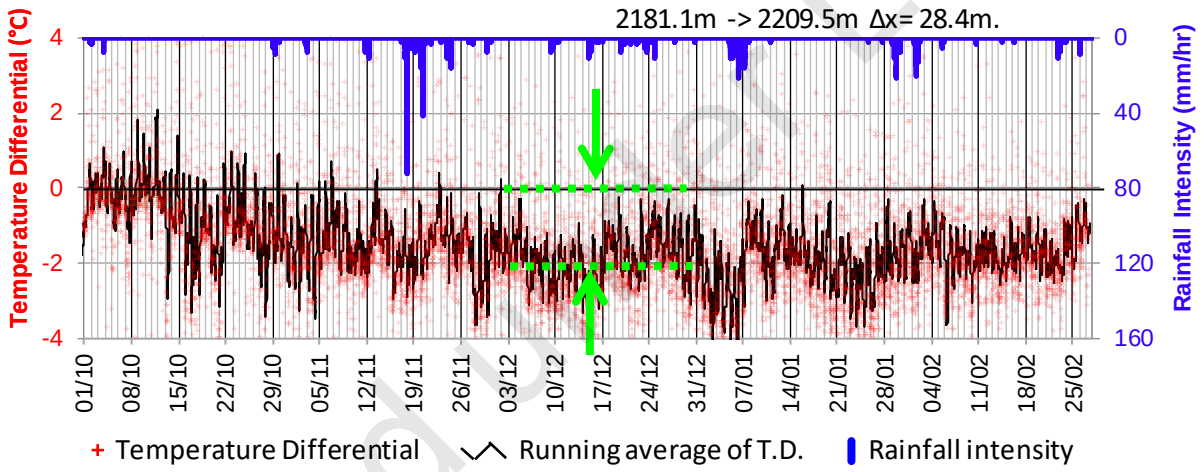
Source Location Map

A.24.2 Source S24 / 2183 <new>

Source Analysis Summary

Asset	Manhole 24330.
Address	33 Moffatt Street.
DTS signal	Strong. At manhole 24330.
Analysis	Temperature differential consistently below 0°C indicating GWI.
Recommendation	Inspection of manhole 24330 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (33 & 30A Moffatt St.) looking for deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



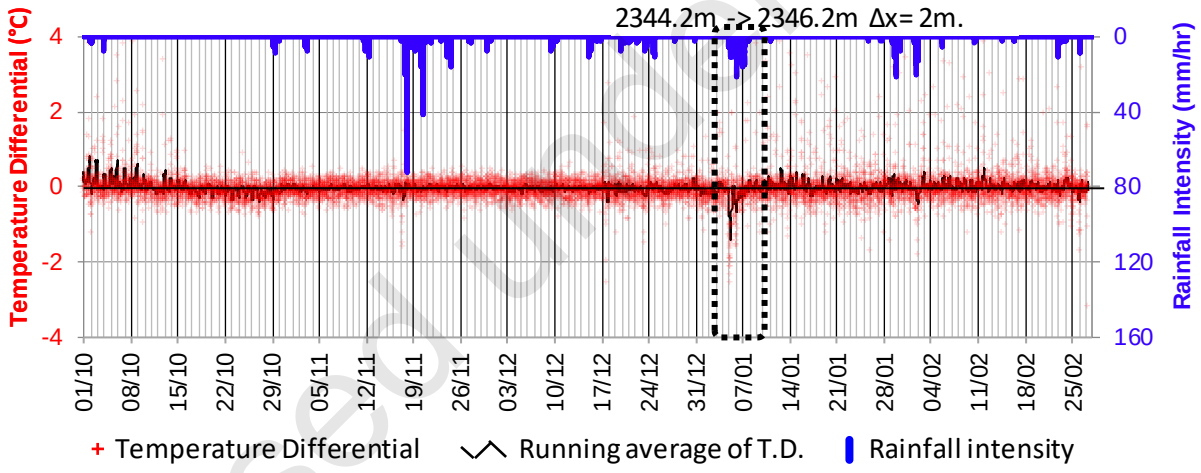
Source Location Map

A.24.3 Source S24 / 2346 <new>

Source Analysis Summary

Asset	Manhole 24314.
Address	22 Moffatt Street.
DTS signal	Medium. 1m ±3m downstream of manhole 24314.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of manhole 24314 checking for signs of poor construction, poor lid seal, surface inflow through cover keyholes, and/or inflow. Inspection of nearby connected properties (22 Moffatt St.) looking for deterioration and infiltration.
Note	This DTS signal is assessed as 'medium' rather than 'strong' because although the pattern characteristic of stormwater inflow was very clear for 5th-7th January 2023, it was not observed for most other rain events.

Source Analysis Plot – Temperature Difference vs Time



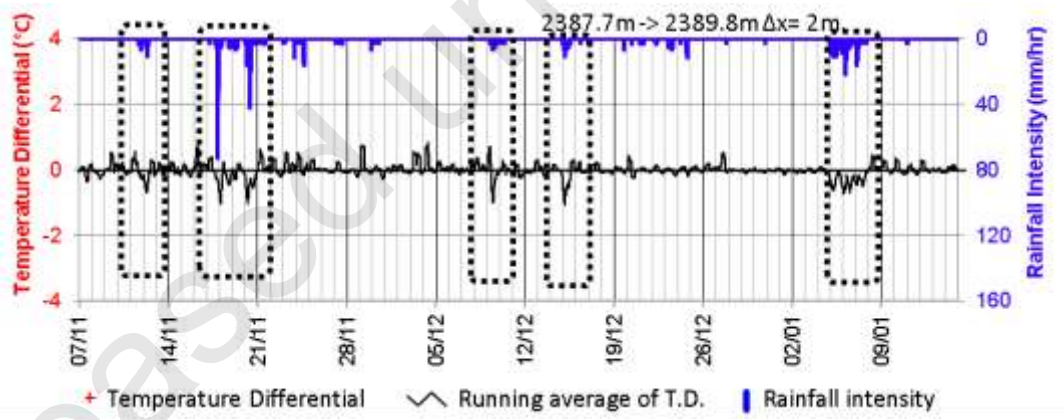
Source Location Map

A.24.4 Source S24 / 2389 <new>

Source Analysis Summary

Asset	Pipe 24513 DN150, 45m, uPVC, 2012
Address	15 Moffatt Street.
DTS signal	Strong. 45m ±3m downstream of manhole 24314.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of manholes 24327 and 24328 checking for signs of poor construction, poor lid seal, surface inflow through cover keyholes, and/or inflow. Inspection of nearby connected properties (15, 17, 19, 21 York St.) looking for deterioration and infiltration.
Note	The DST signal location is a buried node with connection to an unmonitored part of the catchment. DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. Therefore, inspection of the unmonitored connected catchment is recommended. The GIS map indicates there is a lateral to the driveway of 17 York Street. It also shows a lateral from the east side of the 17 York Street house connected to the wastewater main in Moffatt Street. Inspect the lateral entering the driveway of 17 York Street.

Source Analysis Plot – Temperature Difference vs Time



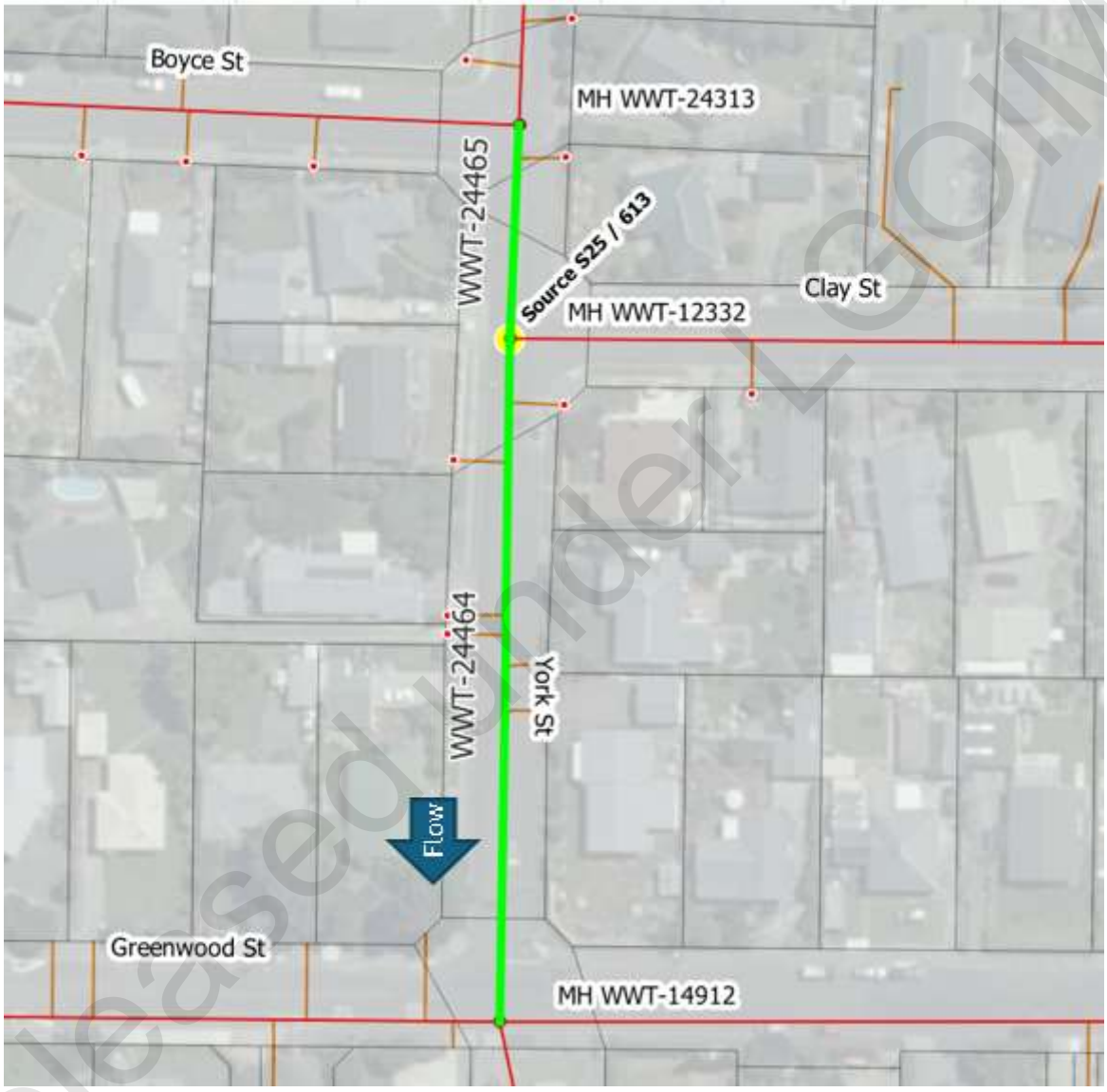
Source Location Map

A.25 Section S25: 9 to 1 York Street <new>

One potential source of I&I was identified in this section using the DTS data:

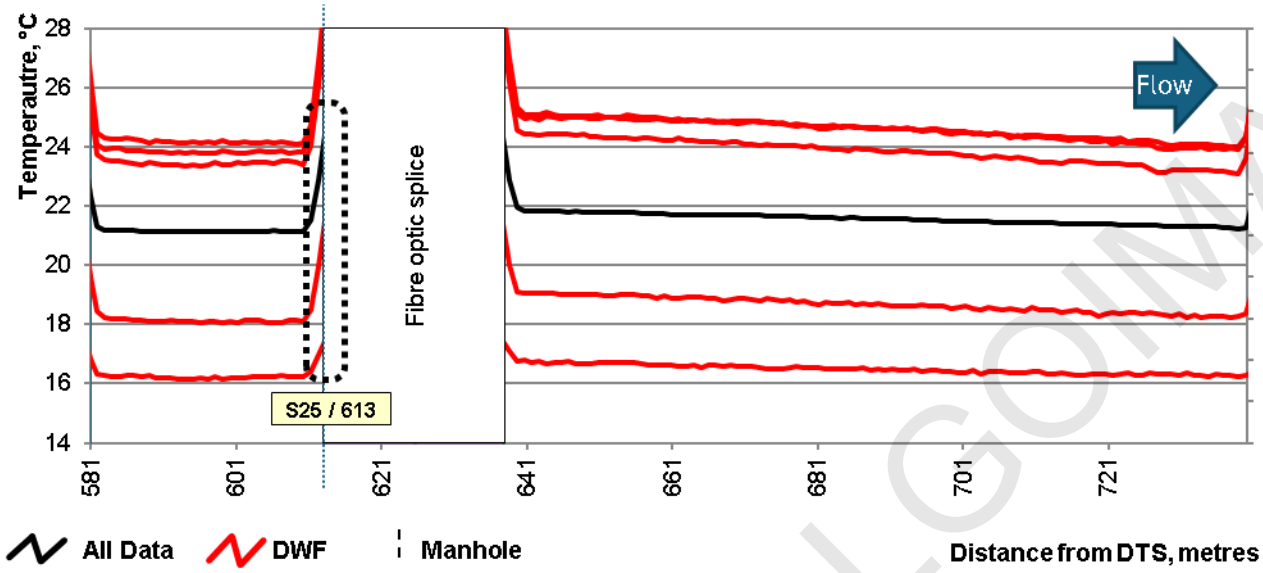
- Groundwater infiltration source S25 / 613 in Manhole 24313 at 6 York Street.

Source Identification Map

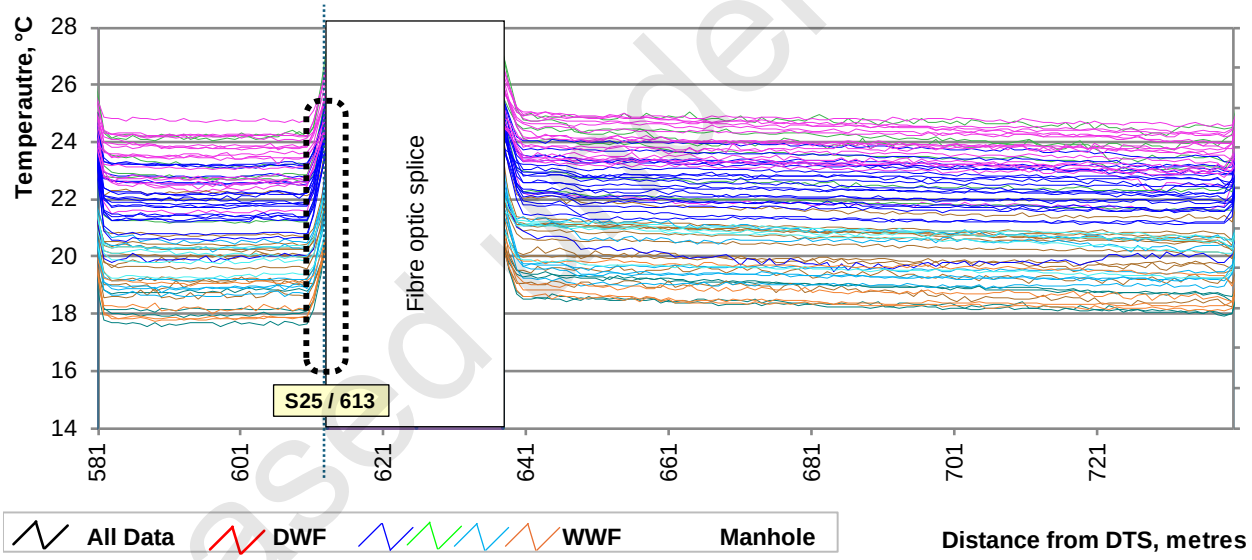


Notes:
1. Upstream manhole 24313 @ 9 York Street @ 581 m.
2. Downstream manhole 14912 @ 61A Greenwood Street @ 740 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

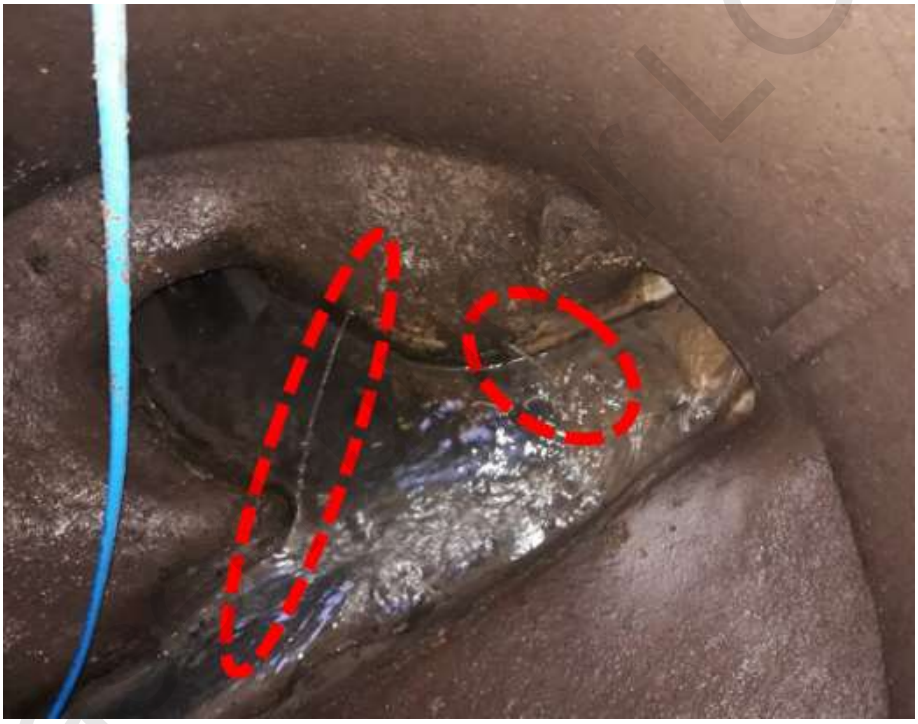


A.25.1 Source S25 / 613 <new>

Source Analysis Summary

Asset	Manhole 12332.
Address	6 York Street.
DTS signal	Strong. At manhole 12332.
Analysis	Groundwater infiltration leak observed during installation of DTS cable. Refer to photo.
Recommendation	Inspection of manhole 12332 checking for signs of deterioration and infiltration.

Photo of visible groundwater infiltration leaks



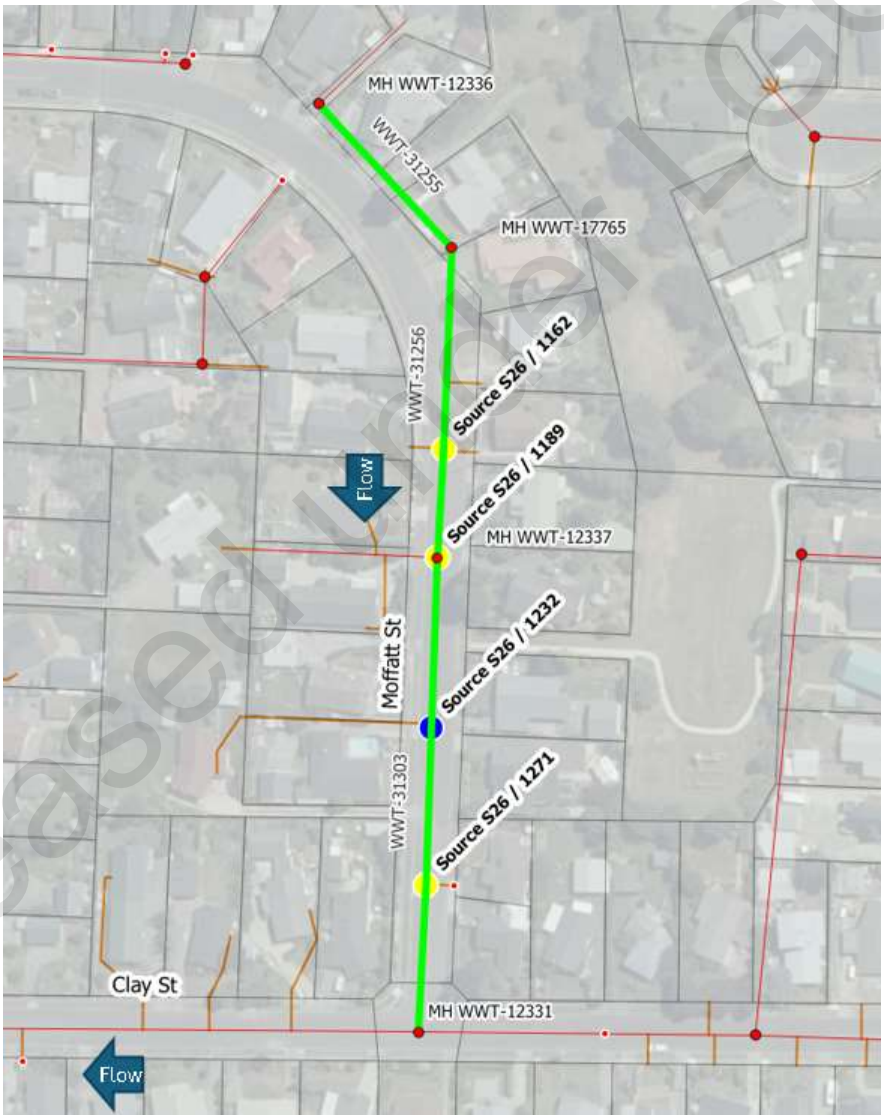
Source Location Map

A.26 Section S26: 23 Moffatt Street to 9 Clay Street <new>

Four potential sources of I&I were identified in this section using the DTS data:

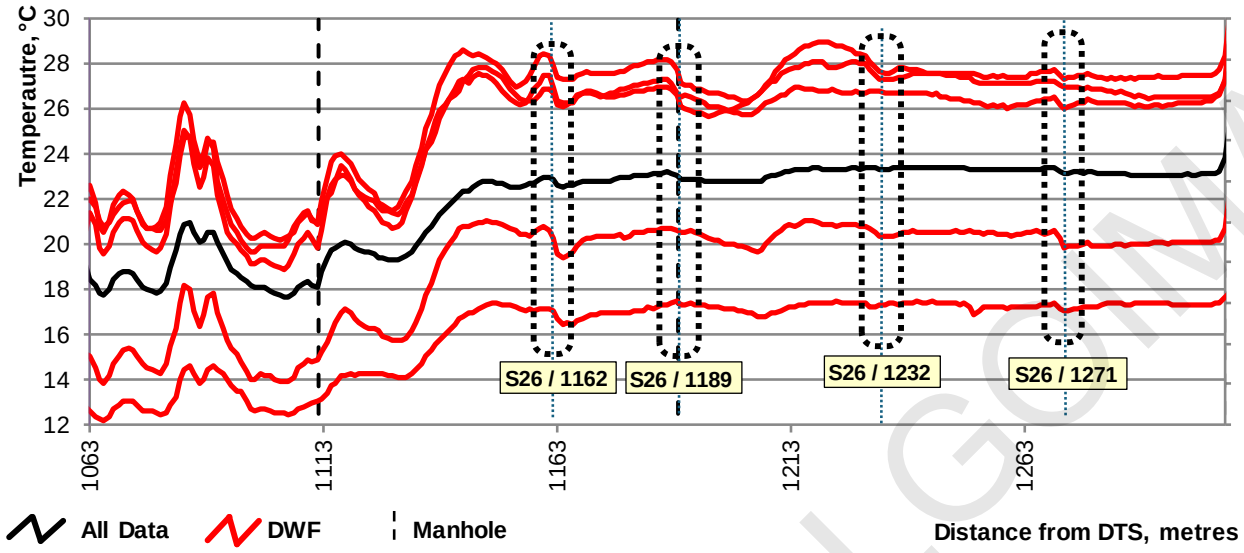
- Groundwater infiltration source S26 / 1162 in Pipe 31256 at 12 Moffatt Street. <new>
- Stormwater inflow and groundwater infiltration source S26 / 1189 in Manhole 12337 at 12 Moffatt Street. <new>
- Stormwater inflow source S26 / 1232 in Pipe 31303 at 2 Moffatt Street. <new>
- Stormwater inflow and groundwater infiltration source S26 / 1271 in Pipe 31303 at 1A Moffatt Street. <new>

Source Identification Map

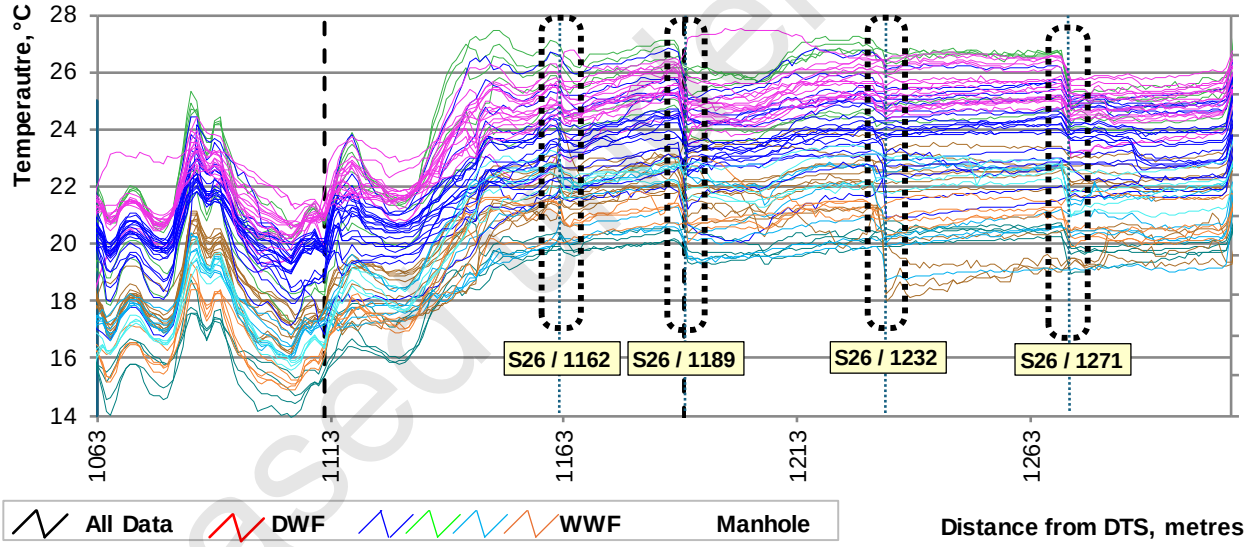


Notes:
1. Upstream manhole 12336 @ 23 Moffatt Street @ 1062 m.
2. Downstream manhole 12331 @ 9 Clay Street @ 1306 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

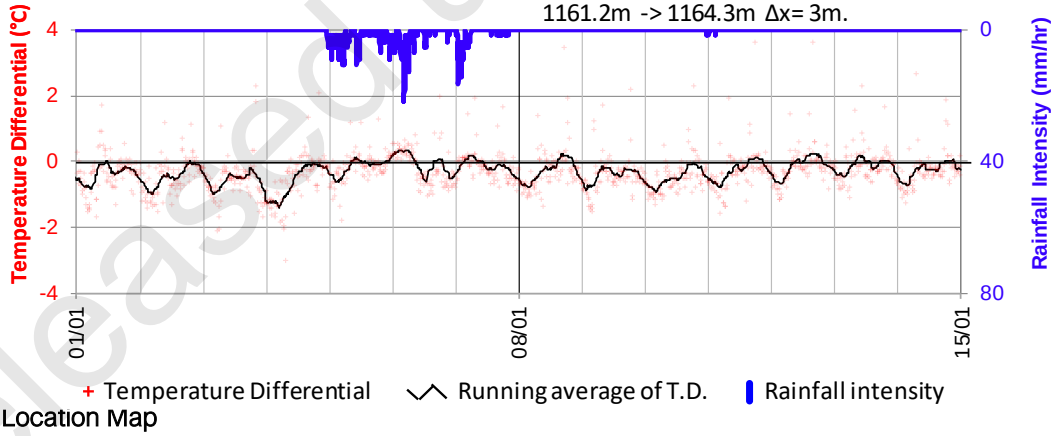


A.26.1 Source S26 / 1162 <new>

Source Analysis Summary

Asset	Pipe 31256 DN150, 76m, Asbestos Cement, 1977.
Address	12 Moffatt Street.
DTS signal	Medium. 32m ±3m upstream of manhole 12337.
Analysis	During summer, this section of pipe absorbs heat from the ground due to solar heating of the road. This is especially noticeable in early morning low-flow hours when the DTS-measured temperature can be dominated by ground heat transfer. A temperature comparison spanning 3 m at the point of interest (1162m), is shown on the next page in the 'Source Analysis Plot – Temperature vs Time at 1162m'. A source of cooler groundwater infiltration at the point of interest is indicated by the downstream temperature increasing significantly less during the early hours of the morning compared to the point 3m upstream. Additional temperature comparisons at pairs of points 3m apart, located four metres upstream and five metres downstream of the point of interest are provided in the plots on the next page. These temperatures rise and fall together during early morning hours. The existence of a temperature differential at the point of interest, but not 4-5 metres either side of the point of interest further supports the assessment that groundwater infiltration is occurring at the point of interest.
Recommendation	CCTV inspection of pipe 31256 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (12 and 13 Moffatt St.) looking for deterioration and infiltration.

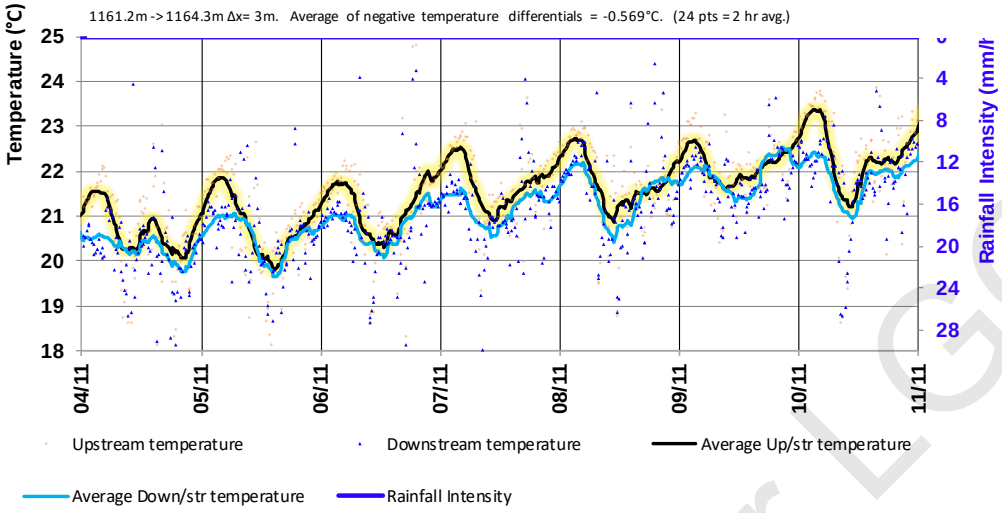
Source Analysis Plot – Temperature Difference vs Time



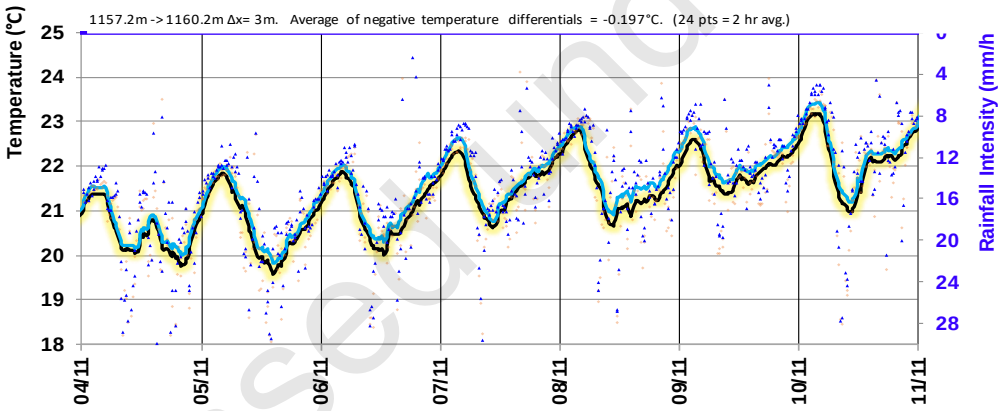
Source Location Map

Source Analysis Plot – Temperature vs Time at 1162m (the point of interest)

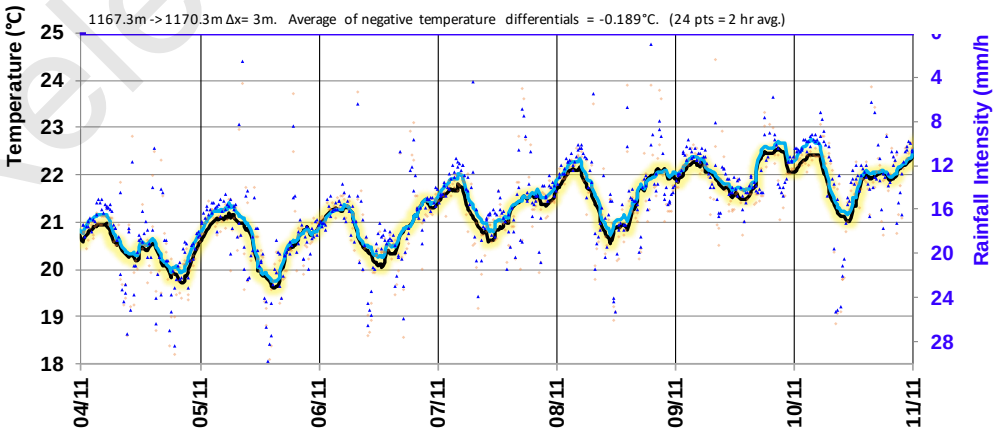
Ground water temperature in the early hours of the morning appears to be moderated by groundwater infiltration. The point 3m upstream more is significantly heated by the ground which stores solar heat absorbed by from the road.



Source Analysis Plot – Temperature vs Time – Four metres upstream of the point of interest.



Source Analysis Plot – Temperature vs Time – Five metres downstream of the point of interest.

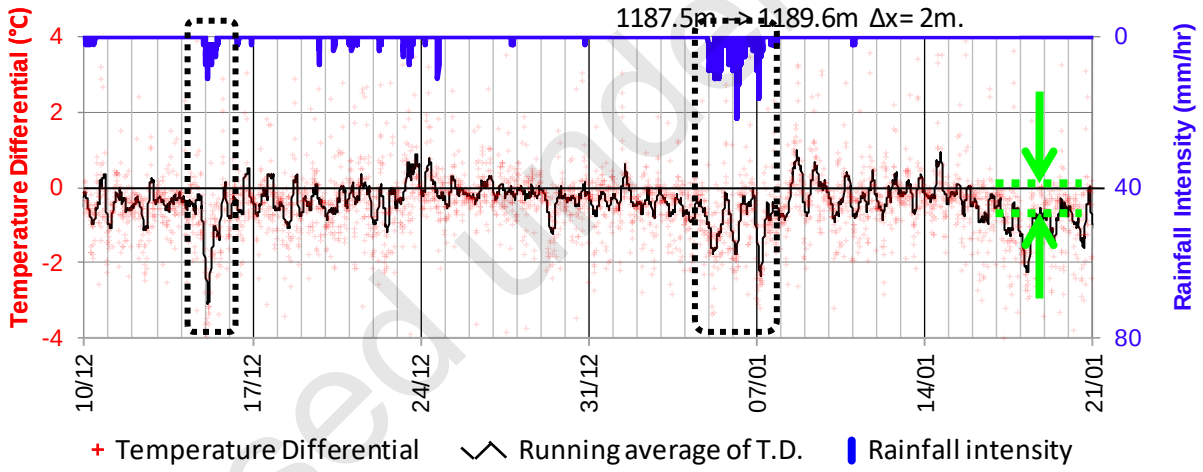


A.26.2 Source S26 / 1189 <new>

Source Analysis Summary

Asset	Manhole 12337.
Address	12 Moffatt Street.
DTS signal	Medium. At manhole 12337.
Analysis	Temperature differential correlated with rain indicating stormwater inflow. Temperature differential often below 0°C during the early morning and/or for periods of multiple days indicating groundwater infiltration.
Recommendation	Inspection of manhole 12337 checking for signs of poor construction, poor lid seal, surface inflow through cover keyholes, infiltration and/or inflow. Inspection of nearby connected properties (8 & 10 Moffatt St., 17 York St.) looking for deterioration, stormwater connections, infiltration and/or inflow.

Source Analysis Plot – Temperature Difference vs Time



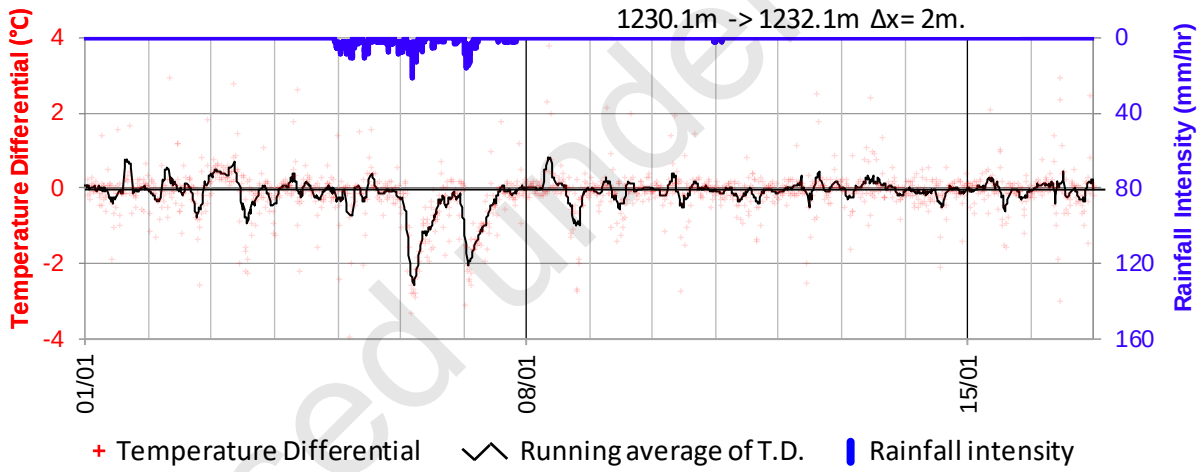
Source Location Map

A.26.3 Source S26 / 1232 <new>

Source Analysis Summary

Asset	Pipe 31303	DN150, 117m, Asbestos Cement, 1971.
Address	2 Moffatt Street.	
DTS signal	Strong. 42m ±3m downstream of manhole 12337.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	CCTV inspection of pipe 31303 to determine the connection point of laterals not shown on the GIS map (3 & 6 Moffatt St.). Inspection of nearby connected properties (2, 3, 6 Moffatt St.) looking for deterioration, stormwater connections, and/or inflow.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.	

Source Analysis Plot – Temperature Difference vs Time



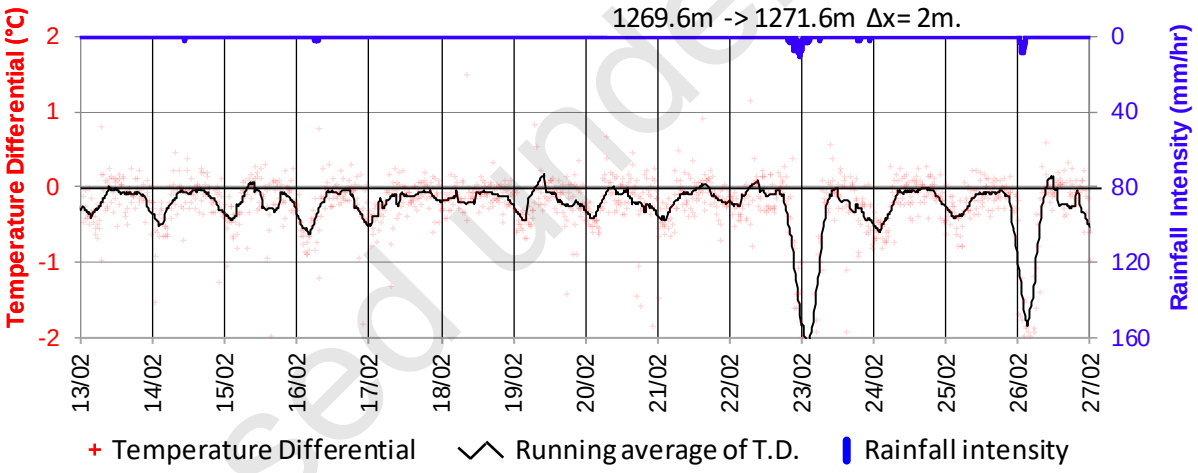
Source Location Map

A.26.4 Source S26 / 1271 <new>

Source Analysis Summary

Asset	Pipe 31303 DN150, 117m, Asbestos Cement, 1971.
Address	1A Moffatt Street.
DTS signal	Strong. 36m ±3m upstream of manhole 12331.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (1A Moffatt St.) looking for deterioration, stormwater connections, infiltration and/or inflow.
Note	CCTV inspection for pipe 31303 is included under the recommendations for I&I source S26 / 1232.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

A.27 Section S27: 22 Pethybridge Street to 20 Clay Street <new>

One potential source of I&I was identified in this section using the DTS data:

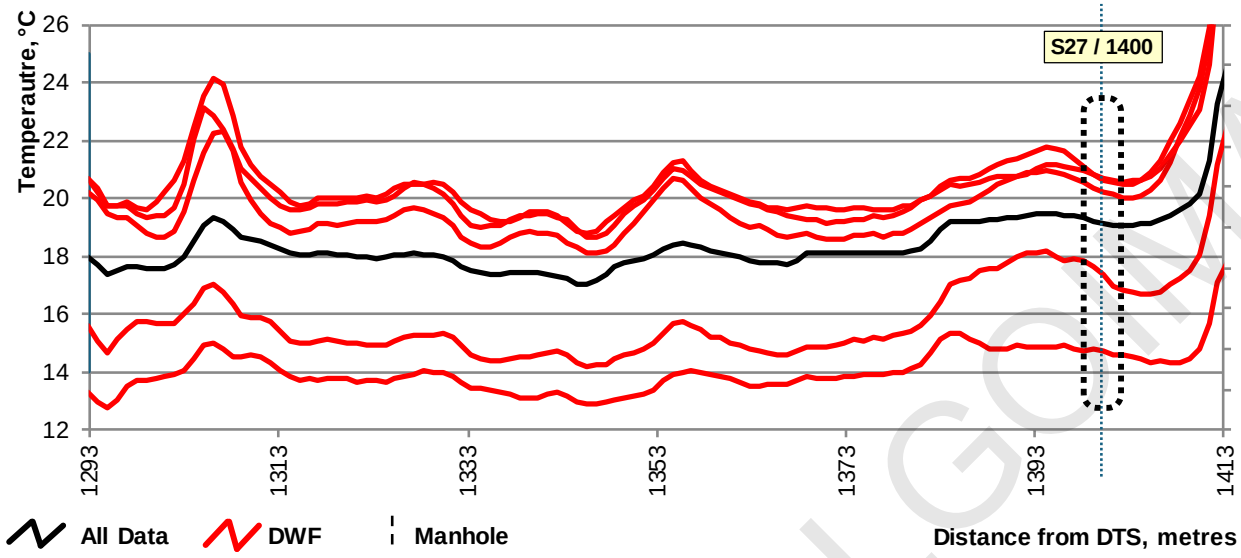
- Groundwater infiltration source S27 / 1400** in Pipe 31260 at 20 Clay Street. <new>

This site, as noted with double asterisk ('**'), is assessed to have a weak DTS I&I signal. The detailed analysis for this location is presented in Appendix B.

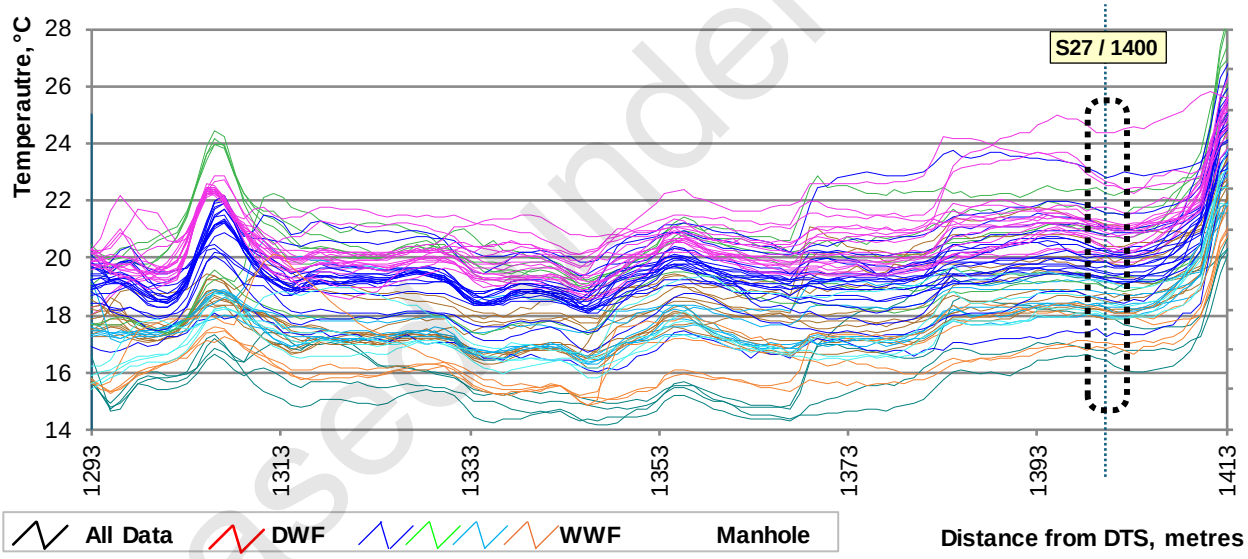
Source Identification Map

Notes:
1. Upstream manhole 17767 @ 22 Pethybridge Street @ 1292 m.
2. Downstream manhole 12330 @ 17 Clay Street @ 1413 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals



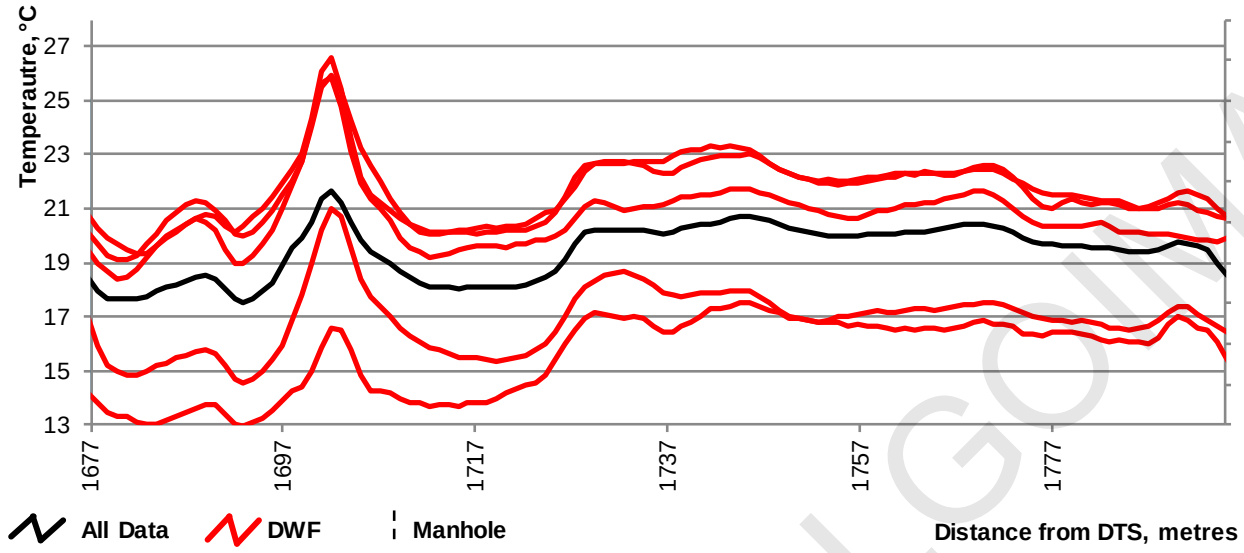
A.28 Section S28: 23 to 9 Pethybridge Street <new>

No potential sources of I&I were identified in this section using the DTS data:

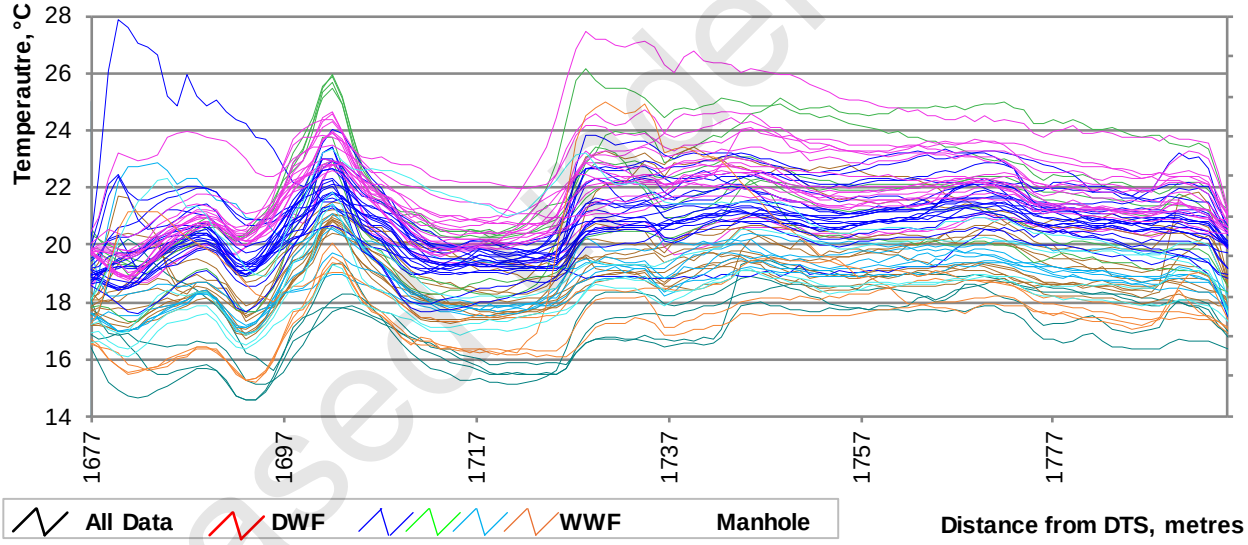
Source Identification Map

Notes:
1. Upstream manhole 14654 @ 19 Pethybridge Street @ 1676 m.
2. Downstream manhole 13713 @ 7 Pethybridge Street @ 1795 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals



A.29 Section S29: 66 to 78 Thorp Street <new>

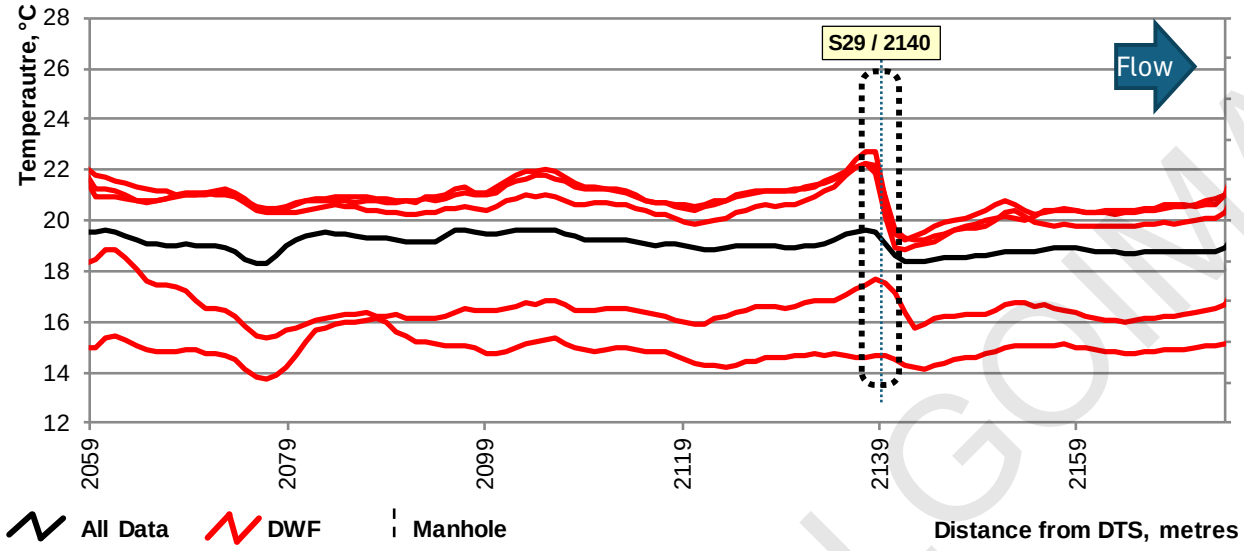
One potential source of I&I was identified in this section using the DTS data:

- SWI RDI Groundwater infiltration source S29 / 2140 in Pipe 31262 at 74 Thorp Street. <new>

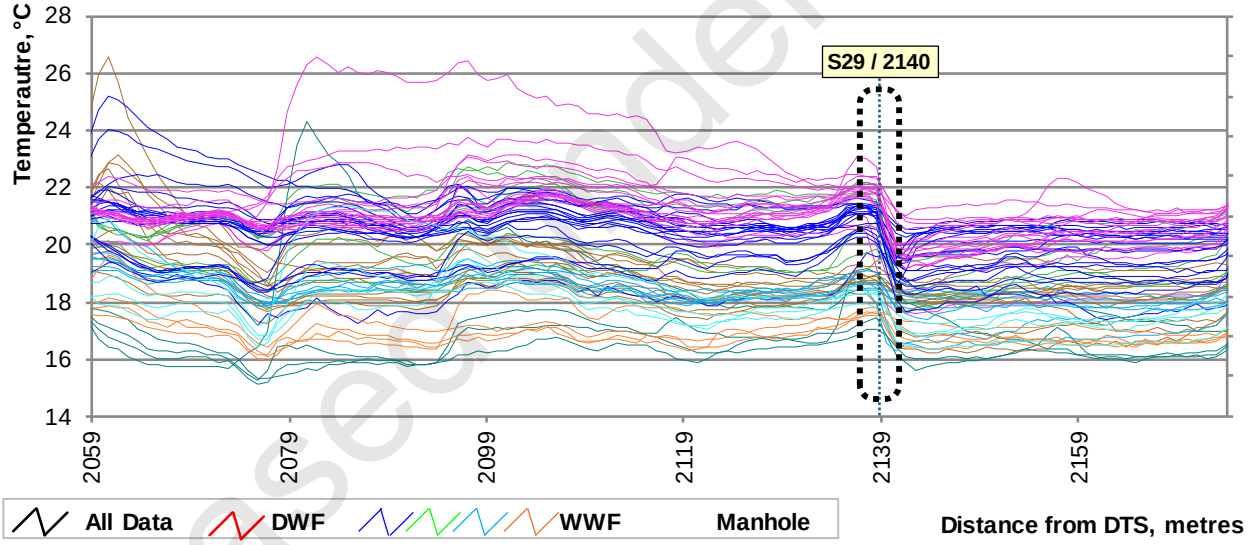
Source Identification Map

Notes:
1. Upstream manhole 17768 @ 66 Thorp Street @ 2058 m.
2. Downstream manhole 13712 @ 78 Thorp Street @ 2174 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

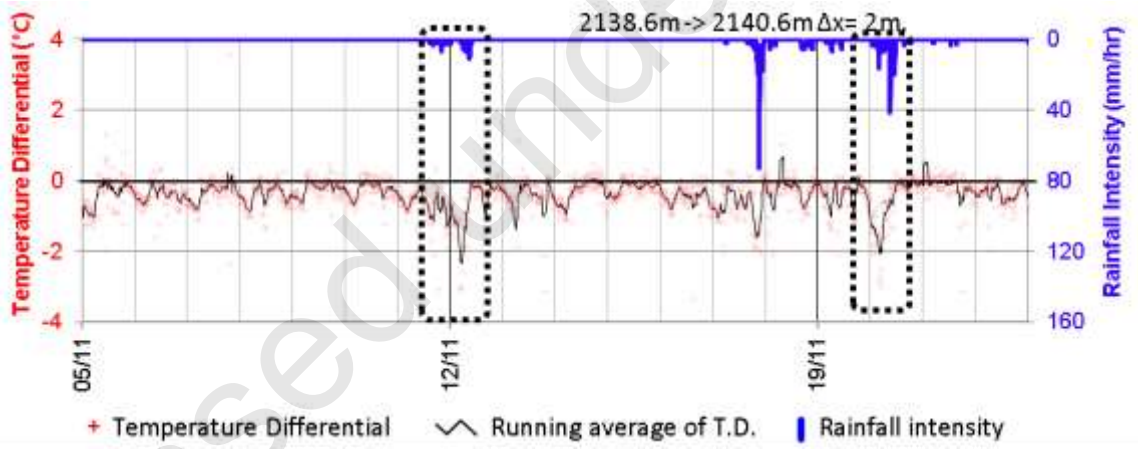


A.29.1 Source S29 / 2140 <new>

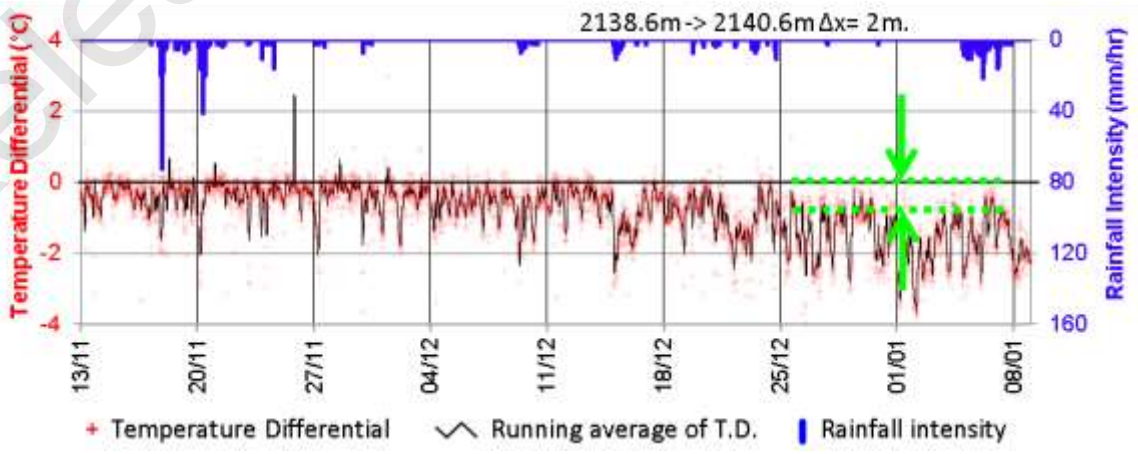
Source Analysis Summary

Asset	Pipe 31262	DN225, 117m, Concrete, 1973.
Address	74 Thorp Street.	
DTS signal	Strong. 35m ±3m upstream of manhole 13712.	
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration. Reduction in temperature for an extended period after rain indicating rain derived infiltration.	
Recommendation	CCTV inspection of pipe 31262 checking for signs of deterioration and infiltration. Inspection of nearby connected properties (74 Thorp St.) looking for deterioration, infiltration, stormwater connections, and/or inflow.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.	

Source Analysis Plot – Temperature Difference vs Time – Indicating stormwater inflow



Source Analysis Plot – Temperature Difference vs Time – Indicating rain derived infiltration



Source Location Map

A.30 Section S30: 82 to 78 Thorp Street <new>

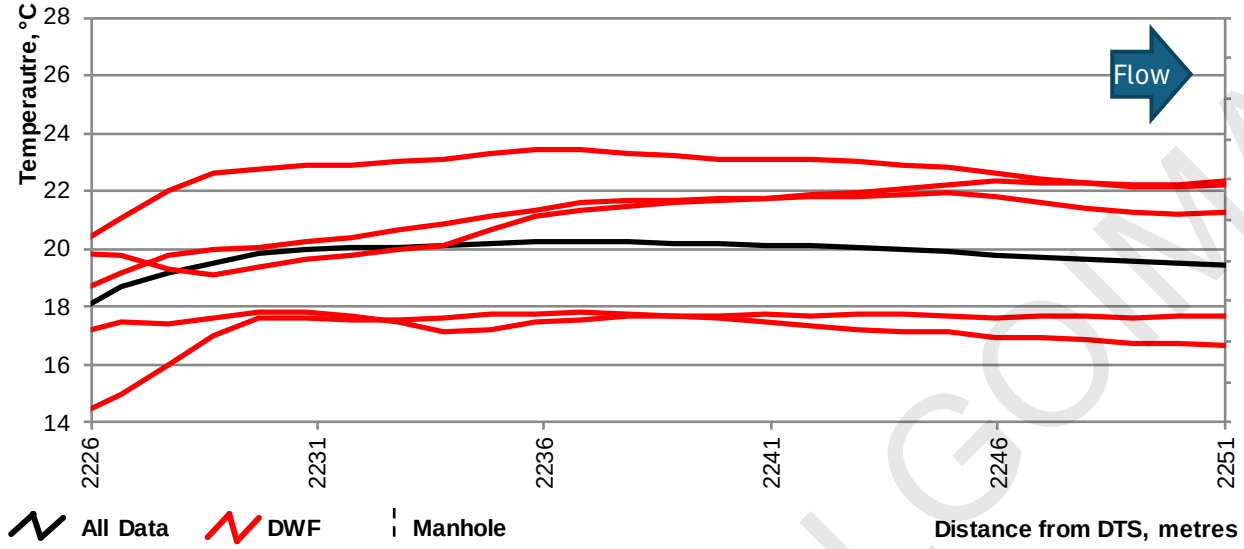
No potential sources of I&I were identified in this section using the DTS data:

Source Identification Map

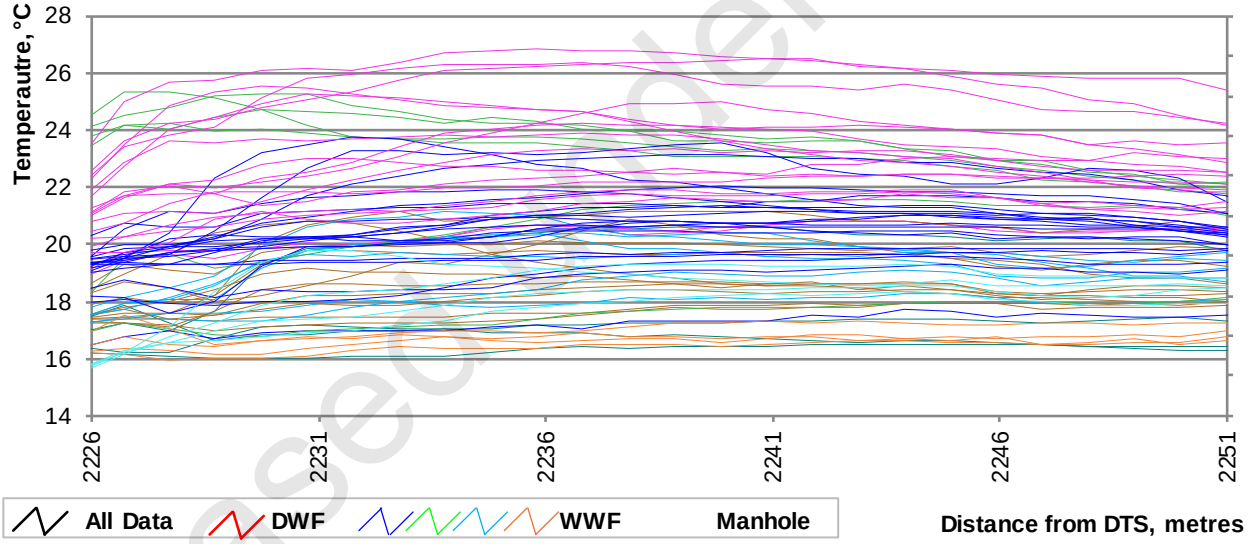
Notes:

1. Upstream manhole 13714 @ 5 Pethybridge Street @ 2225 m.
2. Downstream manhole 13712 @ 7 Pethybridge Street @ 2251 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals



A.31 Section S31: Clay Street <new>

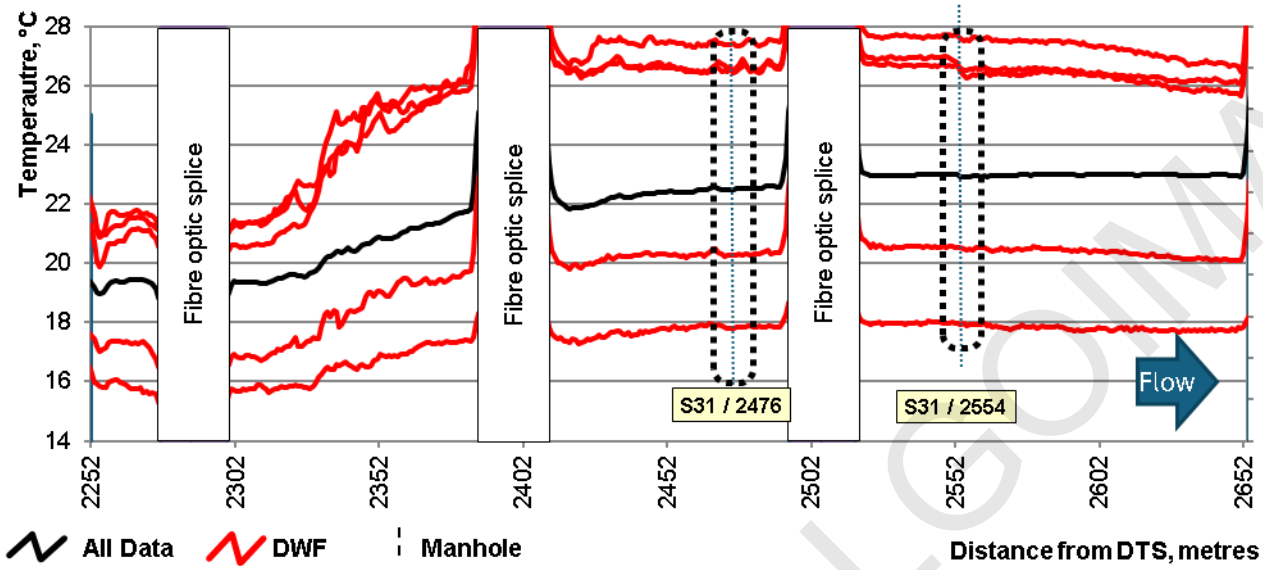
Two potential sources of I&I were identified in this section using the DTS data:

- Stormwater inflow source S31 / 2476 in Pipe 31302 at 11 Clay Street. <new>
- Stormwater inflow source S31 / 2554 in Pipe 31301 at 5 Clay Street. <new>

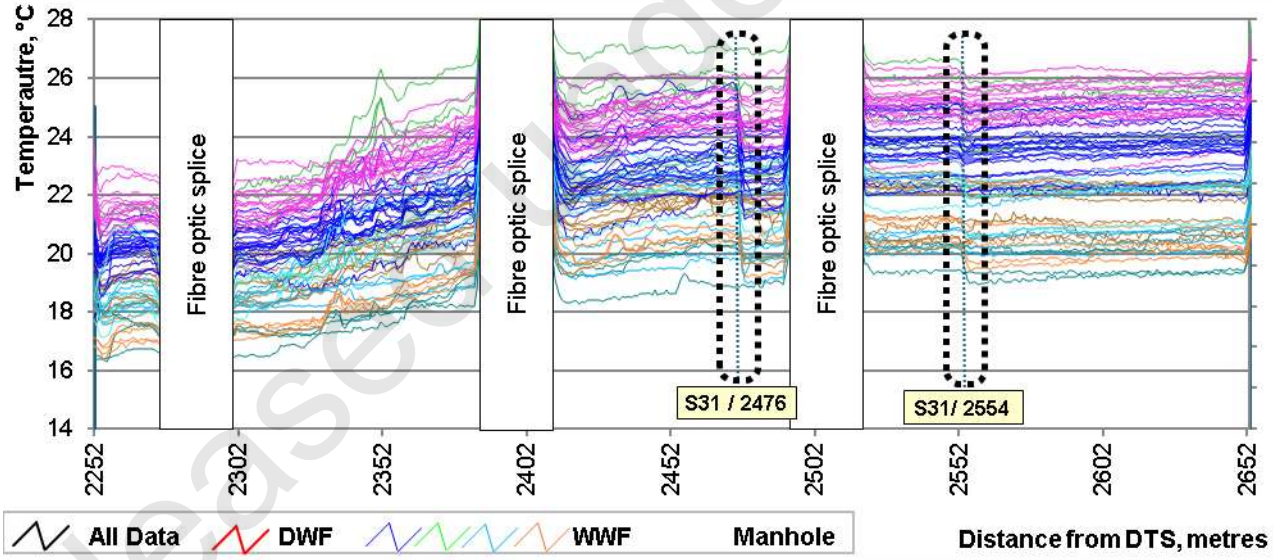
Source Identification Map

Notes:
1. Upstream manhole 13712 @ 7 Pethybridge Street @ 2251 m.
2. Downstream manhole 12332 @ 6 York Street @ 2653 m.

Source Identification Plot - Temperature vs Distance – 'All time' and dry weather flow intervals



Source Identification Plot - Temperature vs Distance – Wet weather flow intervals

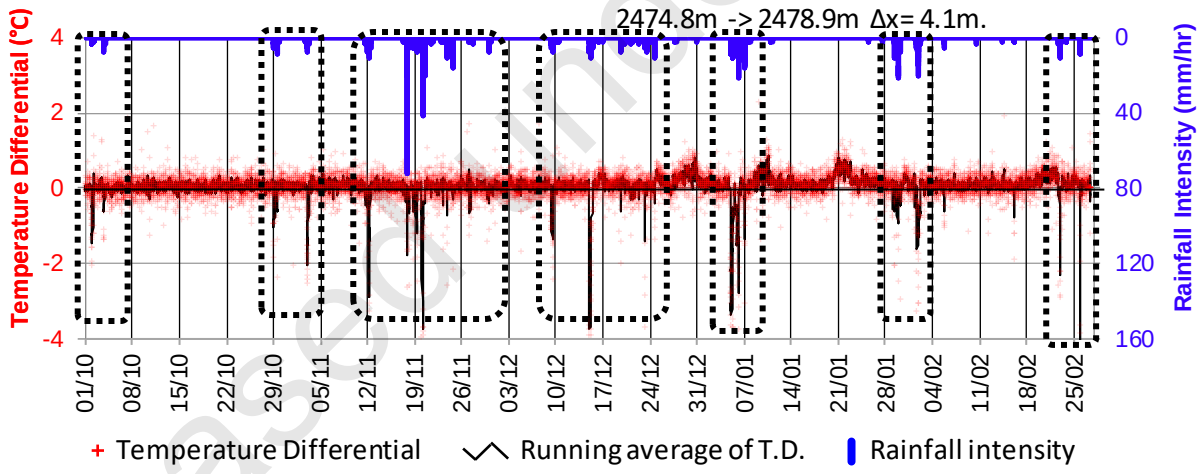


A.31.1 Source S31 / 2476 <new>

Source Analysis Summary

Asset	Pipe 31302 Pipe 31304	DN225, 47m, Concrete, 1971. DN225, 38m, Concrete, 1973.
Address	11 Clay Street.	
DTS signal	Strong. 18m ±5m upstream of manhole 12331.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	CCTV inspection of pipes 31302, 31304 to determine the connection point of laterals not shown on the GIS map (11 & 12 Clay St.). Inspection of nearby connected properties (11 & 12 Clay St.) looking for deterioration, stormwater connections, and/or inflow.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Pipes 31302 and 31304 are joined by a buried node rather than a manhole.	

Source Analysis Plot – Temperature Difference vs Time



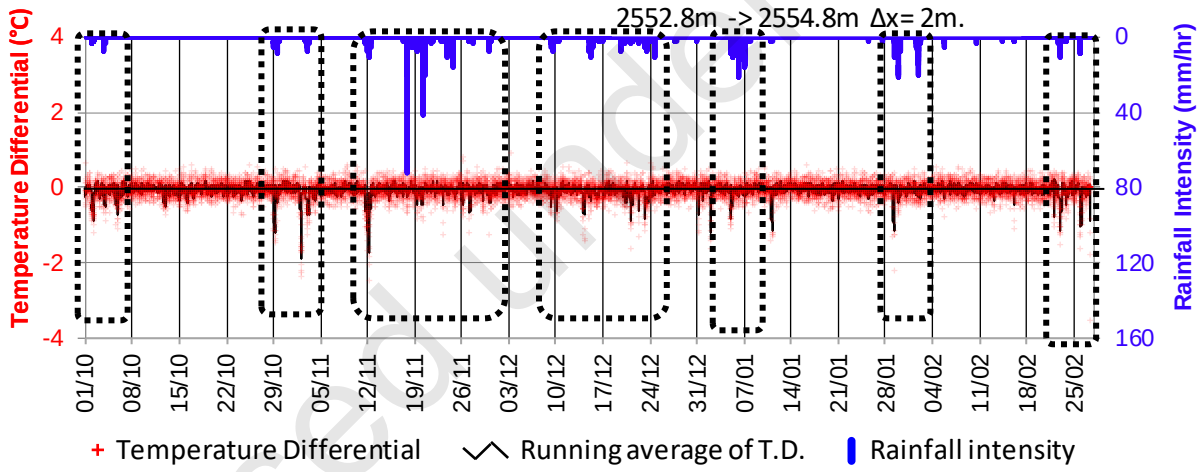
Source Location Map

A.31.2 Source S31 / 2554 <new>

Source Analysis Summary

Asset	Pipe 31301	DN225, 134m, Concrete, 2000.
Address	5 Clay Street.	
DTS signal	Strong. 36m ±5m downstream of manhole 12331.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	CCTV inspection of pipe 31301 to determine the connection point of laterals not shown on the GIS map (5 Clay St.). Inspection of nearby connected properties (5 Clay St.) looking for deterioration, stormwater connections, and/or inflow.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. Inspect 6 Clay Street if a source of stormwater inflow is not found at 5 Clay Street.	

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

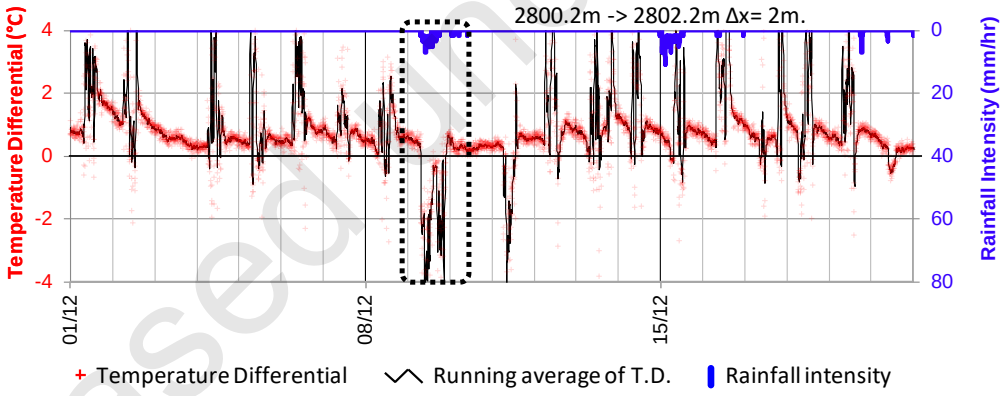
Appendix B DTS Data Analysis
Individual Sources (for weak DTS signals)

B.1.1 Source S1 / 2802 <new>

Source Analysis Summary

Asset	Pipe 36281 DN150, 98m, Concrete, 1949.
Address	140 High Street.
DTS signal	Weak. 42m ±5m downstream of manhole 12357.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (140 High St.) looking for deterioration and/or SW connections.
Note	When checking the lateral, look for connection or leakage from the stormwater assets in the footpath that are very close to the alignment of the lateral. The daily heat spike during office/school hours indicates there are significant hot water discharges during those hours. It may be worth the owner checking for unintended sources of hot water discharges. This DTS signal is assessed as 'weak' rather than 'strong' because the pattern characteristic of stormwater inflow was not observed for other rain events.

Source Analysis Plot – Temperature Difference vs Time



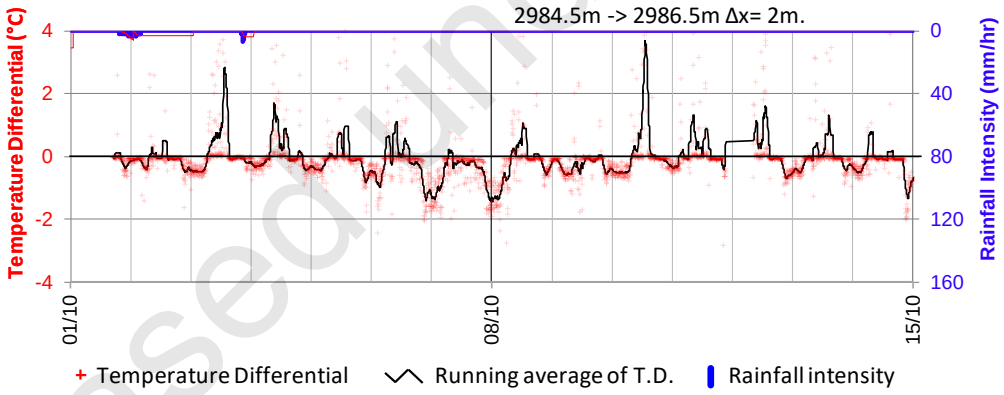
Source Location Map

B.1.2 Source S1 / 2986 <new>

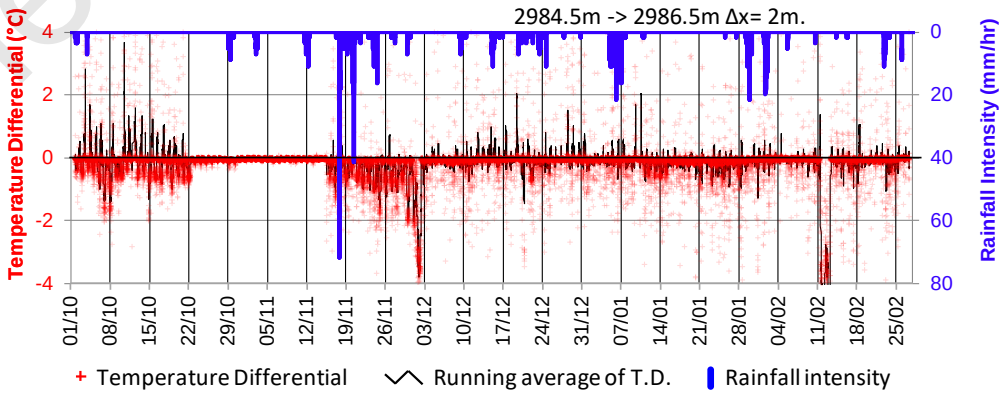
Source Analysis Summary

Asset	Pipe 36283 DN150, 88m, Concrete, 1949.
Address	196 High Street.
DTS signal	Weak. 21m ±5m downstream of manhole 12355.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 36283 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (196 High St.). Inspection of nearby connected properties (196 High St.) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. This DTS signal is assessed as 'weak' because the pattern characteristic of early morning groundwater infiltrations was inconsistent and entirely absent for some periods.

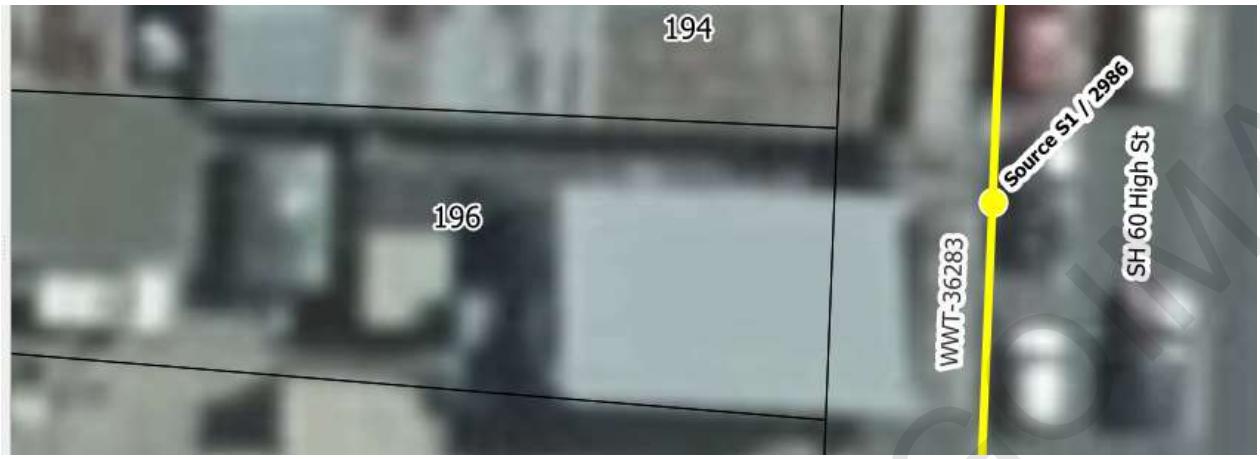
Source Analysis Plot – Temperature Difference vs Time – showing early morning groundwater infiltration signals



Source Analysis Plot – Temperature Difference vs Time – showing inconsistency with a period without signals



Source Location Map - Source S1 / 2986

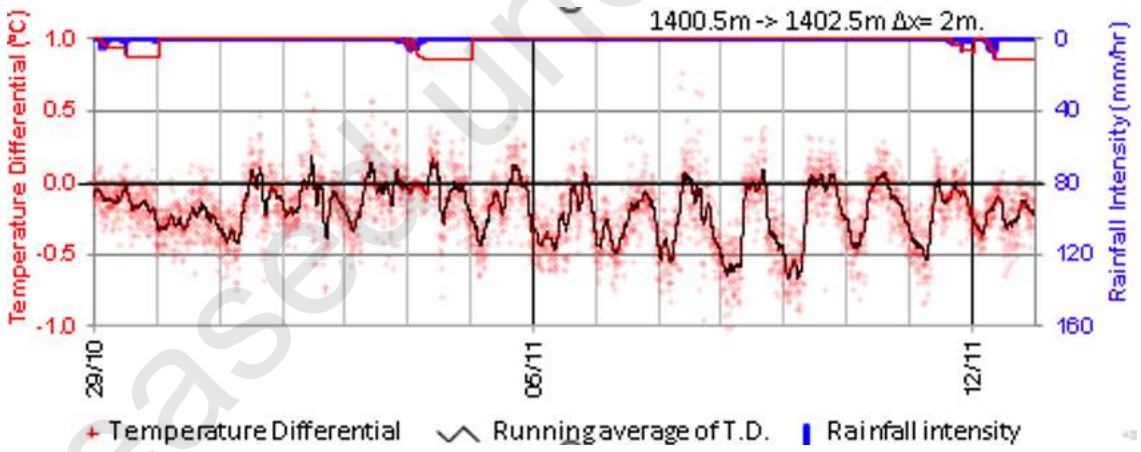


B.1.3 Source S4 / 1402 <new>

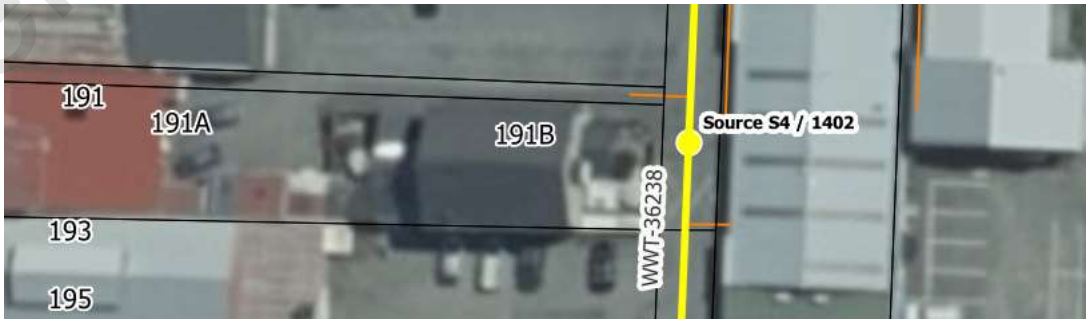
Source Analysis Summary

Asset	Pipe 36238 DN150, 122m, Concrete, 1996.
Address	191B High Street (on Hart Lane frontage)
DTS signal	Weak. 16m ±3m downstream of Manhole 12006.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	CCTV inspection of pipe 36238 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (191A, 191B High St.). Inspection of nearby connected properties (191A, 191B High St.) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. CCTV inspection for pipe 36238 is included under the recommendations for I&I source S4 / 1477.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

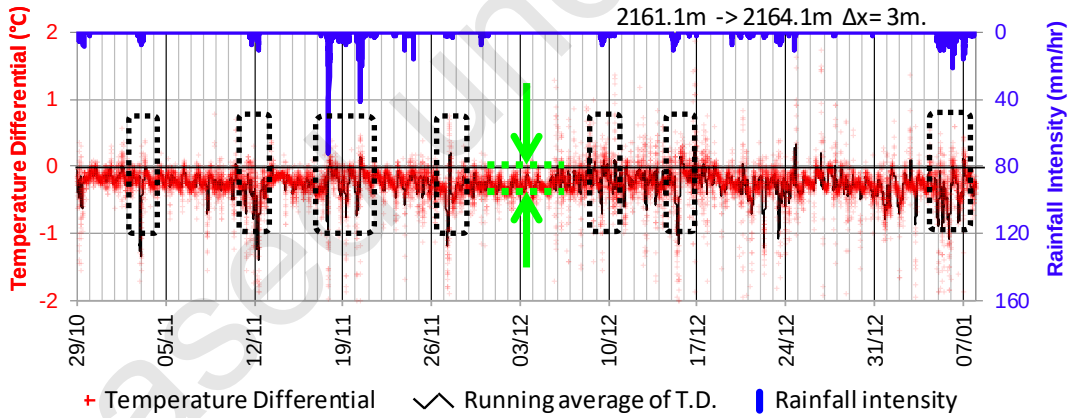


B.1.4 Source S7 / 2160

Source Analysis Summary

Asset	Pipe 31206 DN150, 114m, PVC, 1984.
Address	27 Wallace Street.
DTS signal	Weak, 25m to 34m±3m downstream of manhole 14093.
Analysis	Temperature differential generally below 0°C indicating groundwater infiltration. Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Consider CCTV inspection of pipe 31206 checking for signs of deterioration, infiltration, and inflow.
Note	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface. Signal strength rating is weak because it is difficult to ascertain if the reduction in temperature along this section of pipe is a separate source of I&I, or is it related to the sources at 2157m and 2168m or is it 'natural' cooling along the length of the pipe.

Source Analysis Plot – Temperature Difference vs Time



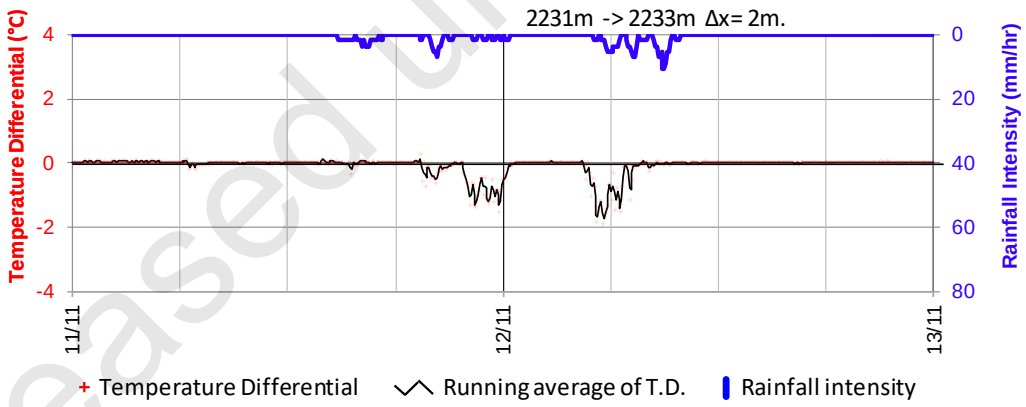
Source Location Map

B.1.5 Source S7 / 2232

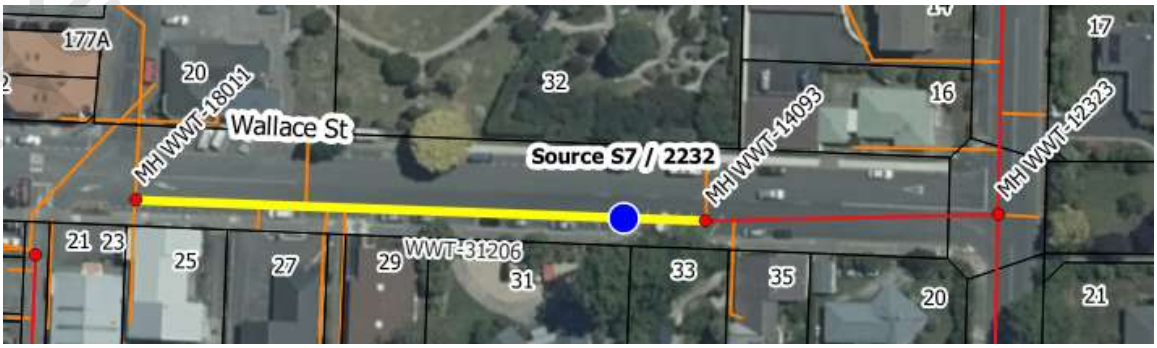
Source Analysis Summary

Asset	Pipe 31206 DN150, 114m, PVC, 1984.
Address	31 Wallace Street.
DTS signal	Weak, 17m ±3m upstream of manhole 14093.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow. This is a weak DTS signal because it is observed briefly at the start of some (but not all) rain events.
Recommendation	Consider CCTV inspection of pipe 31206. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface. Consider inspection of nearby connected properties looking for deterioration and inflow.
Note	CCTV inspection for pipe 31206 is included under the recommendations for I&I source S7 / 2160. DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

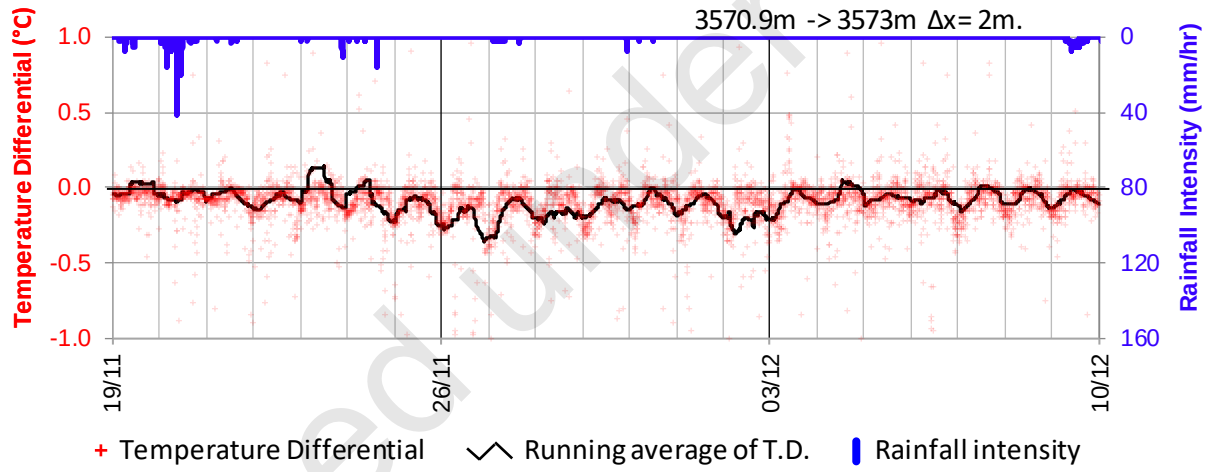


B.1.6 Source S13 / 3572

Source Analysis Summary

Asset	Pipe 36221 DN150, 66m, Asbestos Cement, 1974.
Address	13A Goodman Drive.
DTS signal	Very weak, 21m ±3m upstream of manhole 16123.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	Consider CCTV inspection of pipe 36221 checking for signs of deterioration and infiltration. Consider inspection of nearby connected properties (13A, 13B, 15 Goodman Drive) looking for deterioration and infiltration.

Source Analysis Plot – Temperature Difference vs Time



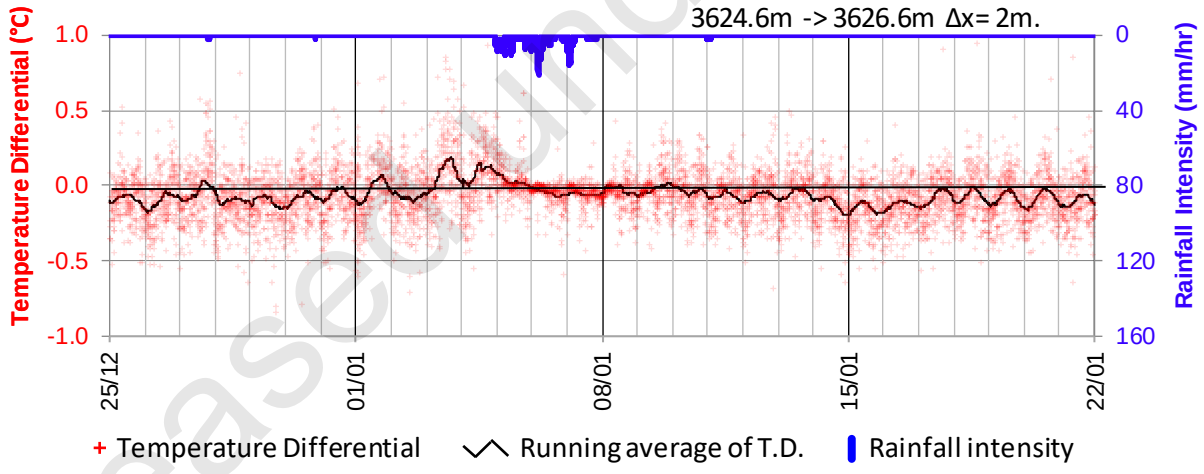
Source Location Map

B.1.7 Source S13 / 3626

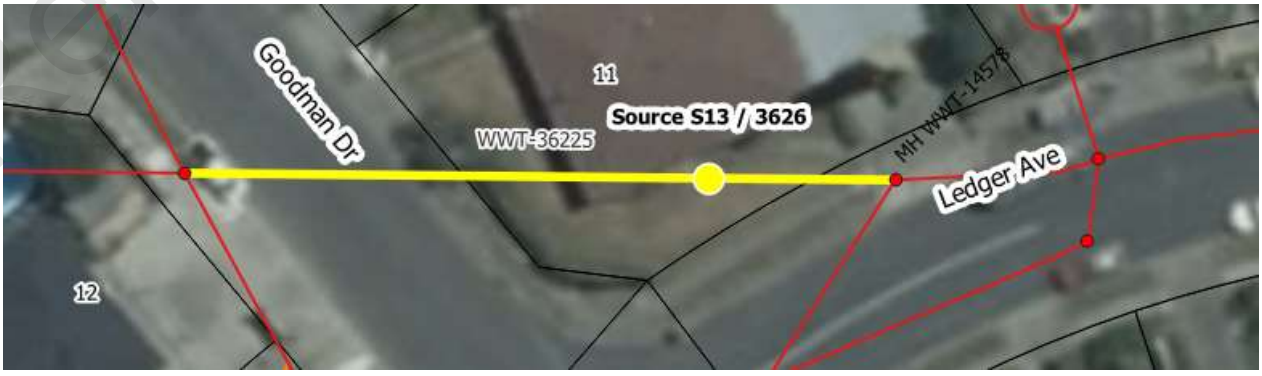
Source Analysis Summary

Asset	Pipe 36225 DN150, 44m, PVC, 1974.
Address	11 Goodman Drive.
DTS signal	Weak, 12m ±3m upstream of manhole 14578.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	Consider CCTV inspection of pipe 36225 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (11 Goodman Drive). Consider inspection of nearby connected properties (11 Goodman Drive) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal. The masking of I&I during rain events indicates significant upstream I&I.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

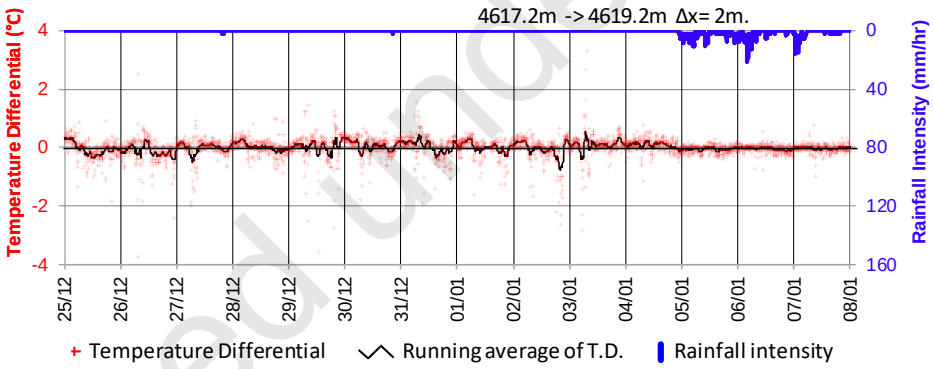


B.1.8 Source S14 / 4619

Source Analysis Summary

Asset	Manhole 16871.
Address	20A Ledger Avenue.
DTS signal	Weak, At manhole 16871.
Analysis	The normal temperature variations between two points analysed downstream of the manhole disappear during rain events. This indicates there is at least one source of stormwater inflow in the upstream catchment.
Recommendation	Consider inspection of manhole 16871 checking for signs of poor construction, poor lid seal, surface inflow through cover keyholes, and/or inflow. Consider inspection of nearby connected properties (20A, 20B, 22 Ledger Ave.) looking for deterioration or stormwater connections.
Note	Inspect the 80mm PVC flushing pipe 41533 looking for deterioration or stormwater connections.

Source Analysis Plot – Temperature Difference vs Time



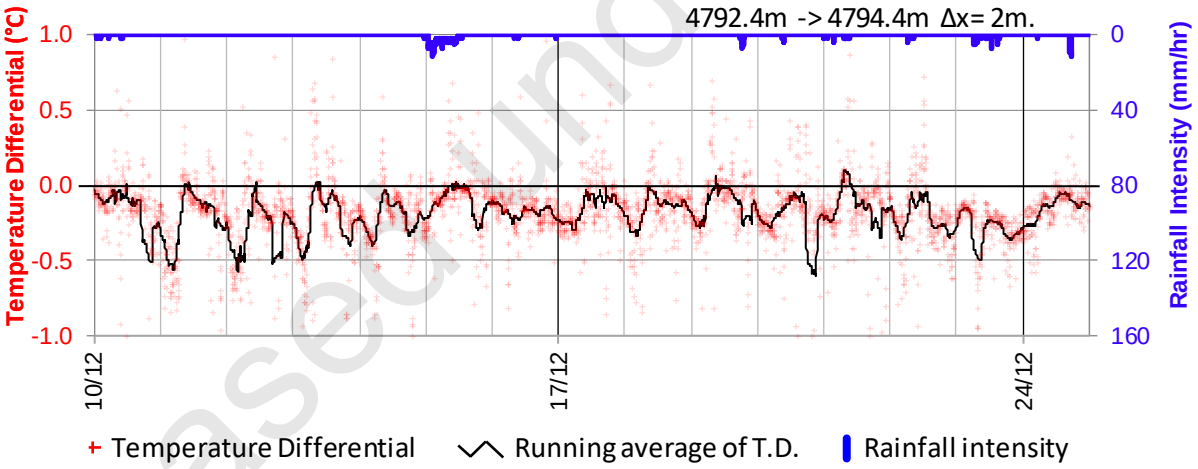
Source Location Map

B.1.9 Source S15 / 4792

Source Analysis Summary

Asset	Pipe 28730 DN150, 41m, PVC, 1977.
Address	8 Ledger Avenue.
DTS signal	Weak, 24m ±3m upstream of manhole 16870.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	Consider CCTV inspection of pipe 28730 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (8 Ledger Ave.). Consider inspection of nearby connected properties (8 Ledger Ave.) looking for deterioration and infiltration.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



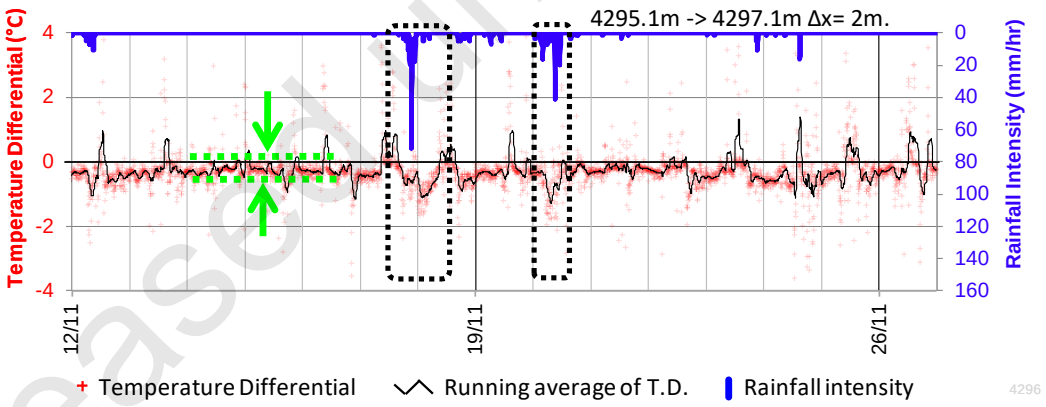
Source Location Map

B.1.10 Source S16 / 4296

Source Analysis Summary

Asset	Pipe 28736 DN150, 32m, PVC, 08 / 06 / 1977.
Address	26A / 26B Ledger Avenue.
DTS signal	Weak, 13±3m upstream of manhole 14958.
Analysis	Temperature differential is generally below 0°C indicating groundwater infiltration. Temperature drop is correlated with rainfall indicating rainfall dependent infiltration and/or stormwater inflow. There are also temperature drops over the next 5-10m downstream of this point indicating groundwater infiltration in November 2022 but not in the months before or after.
Recommendation	Consider CCTV inspection of pipe checking for signs of deterioration and infiltration. Consider inspection of connected properties (26A and 26B Ledger Avenue) looking for signs of deterioration, infiltration, and/or stormwater connections. When reviewing CCTV footage pay close attention to the section of pipe 8m either side of the boundary between 26A and 28 Ledger Avenue.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



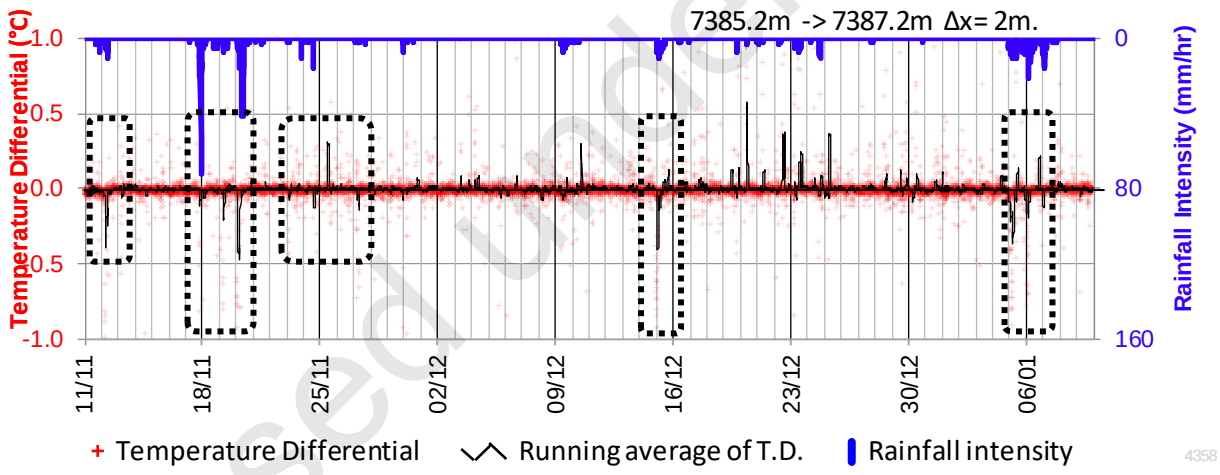
Source Location Map

B.1.11 Source S19 / 7386

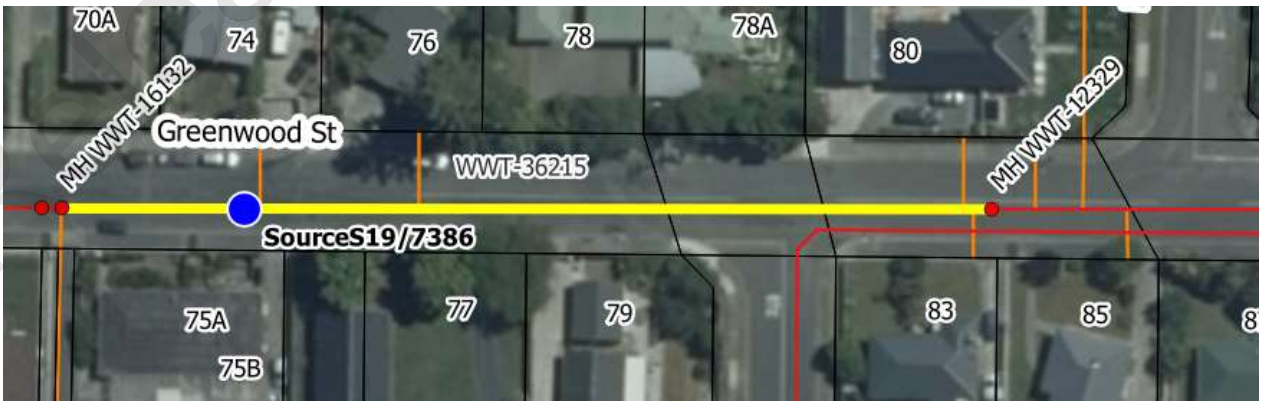
Source Analysis Summary

Asset	Pipe 36215 DN150, 116m, Concrete, 1949.
Address	75A Greenwood Street.
DTS signal	Weak, 24m ±6m upstream of manhole 16132.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Consider CCTV inspection of pipe 36215 to determine the connection point of laterals not shown on the GIS map. Consider inspection of nearby connected properties (74, 75A and 75B Greenwood Street) looking for deterioration and/or stormwater connections.
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

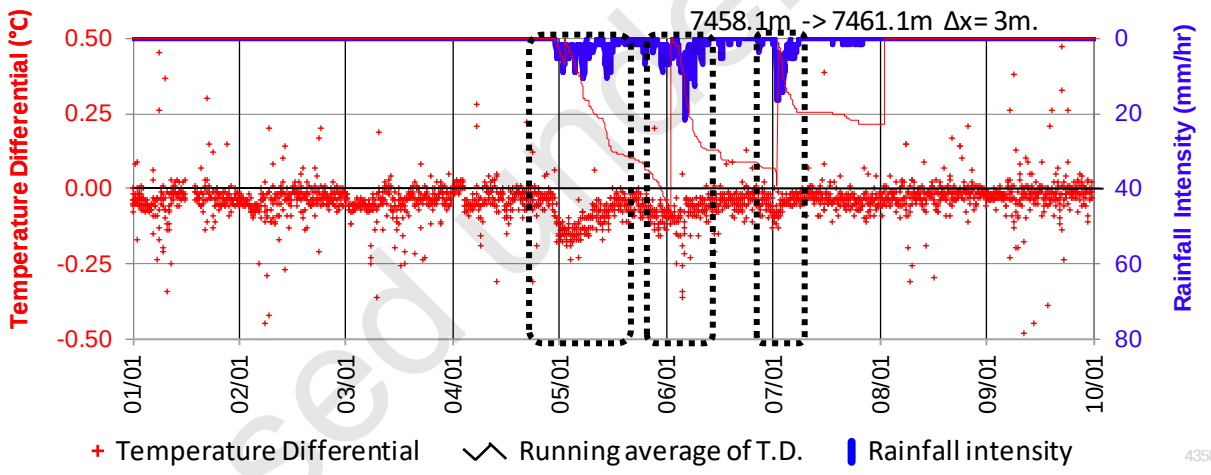


B.1.12 Source S19 / 7459

Source Analysis Summary

Asset	Pipe 36219 DN150, 123m, Concrete, 1949.
Address	67 Greenwood Street.
DTS signal	Weak, 79m ±6m upstream of manhole 14912.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe to determine the connection point of laterals not shown on the GIS map (66, 67 Greenwood St.). Inspection of nearby connected properties (66, 67 Greenwood St.) looking for deterioration and inflow.
Note	CCTV inspection of pipe and property inspection of 66 and 67 Greenwood Street are listed under the recommendations for I&I source S19 / 7454 and S19 / 7475.

Source Analysis Plot – Temperature Difference vs Time



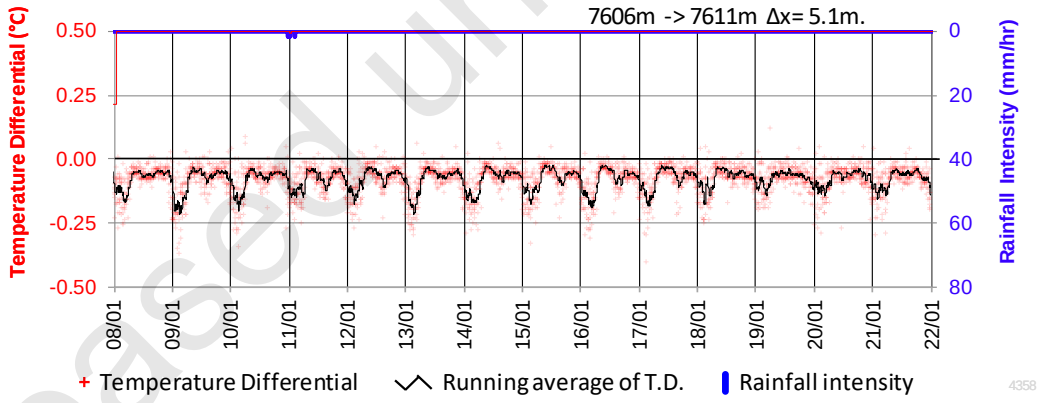
Source Location Map

B.1.13 Source S20 / 7609

Source Analysis Summary

Asset	Pipe 36414 DN300, 106m, Concrete, 1949.
Address	31 Goodman Drive.
DTS signal	Weak. 47m to 53m ±4m upstream of manhole 16122.
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.
Recommendation	Consider CCTV inspection of pipe 36414 checking for signs of deterioration and infiltration. This CCTV inspection is listed under source S20 / 7629.
Note	This is a very weak signal. It is weaker than would normally be reported. It has been included because it is in a part of the catchment that would be expected to have a significant wastewater flow, even during the early hours of the morning. Therefore, a very small temperature drop may indicate a significant leak. It is rated as a weak signal, because the temperature drop is very small of a magnitude that may only be caused by ground temperature differences due to changes in ground cover and sun exposure along the pipe.

Source Analysis Plot – Temperature Difference vs Time



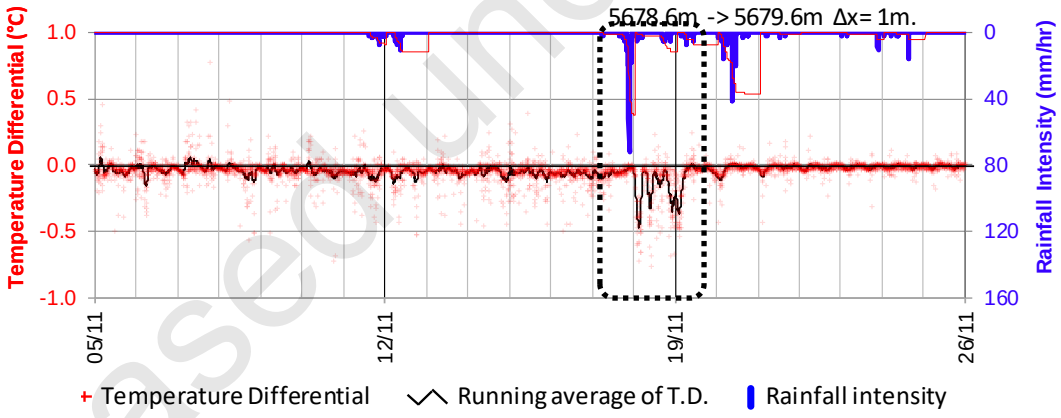
Source Location Map

B.1.14 Source S21 / 5680

Source Analysis Summary

Asset	Pipe 36217 DN150, 103m, Asbestos Cement, 1978.
Address	Goodman Park.
DTS signal	Weak, 48m ±5m upstream of manhole 16121.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Consider CCTV inspection of pipe to identify if there are any connection points or faults that could result in stormwater inflow. CCTV inspection for pipe 36217 is included under the recommendations for I&I source S21 / 5663.
Note	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have surface connections. Use CCTV data to check for surface connections, including pipe faults, and disconnected or terminated lateral connections that could be hydraulically connected to the surface. This signal is described as a weak signal. This is because the location exhibited what appears to be a DTS stormwater inflow signal for the rain event of the19th November 2022 but not for any other rain events.

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

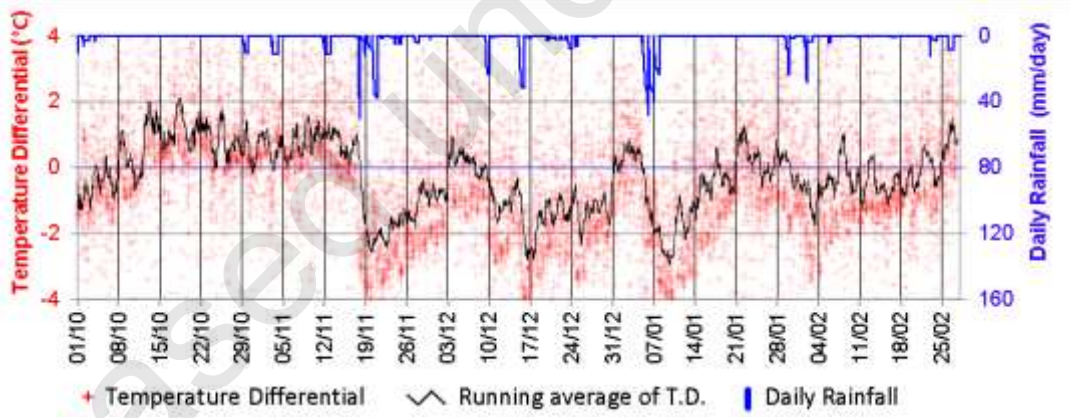
B.1.1 Source S22 / 386 <new>

Source Analysis Summary

Asset	Manhole 14353.
Address	10 Boyce Street.
DTS signal	Weak. At manhole 14353.
Analysis	Comparing the wastewater temperature at the upstream manhole to the temperature of the wastewater near the bottom of Boyce Street shows that the temperature at the upstream manhole reduces much more during rainfall than does the wastewater in the downstream network. Based on this it is assessed there is rainfall dependent infiltration and inflow at the upstream manhole or from the connected laterals.
Recommendation	Inspection of manhole 14353 checking for signs of poor construction, poor lid seal, surface inflow through cover keyholes, infiltration and/or inflow. Inspection of nearby connected properties (8A, 8B, 8C, 8D, 10 Boyce St., and 29A York St.) looking for deterioration, stormwater connections, infiltration and/or inflow.

Source Analysis Plot – Temperature Difference vs Time

This plot suppresses the noise of short-term variations by using a rolling 24-hour average temperature difference. This also supresses diurnal variations. The result is that the impact of rain derived infiltration is more obvious.



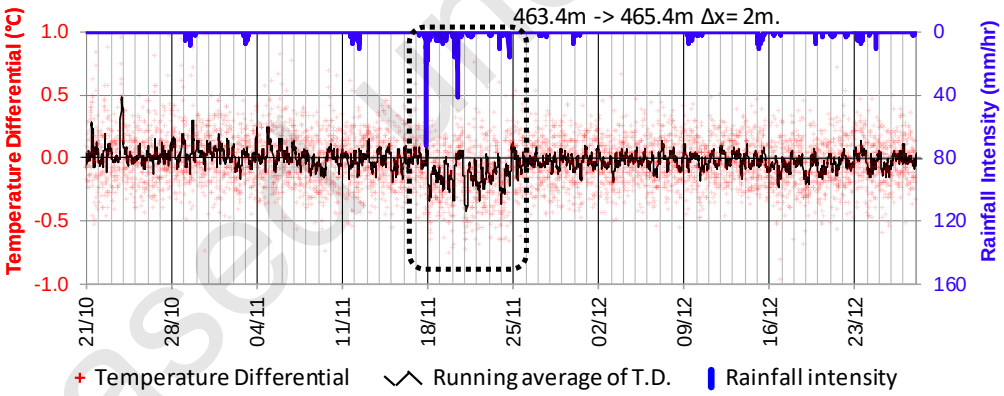
Source Location Map

B.1.2 Source S22 / 465 <new>

Source Analysis Summary

Asset	Pipe 24459 DN150, 101m, uPVC, 2012.
Address	6 Boyce Street.
DTS signal	Weak. 11m ±4m downstream of manhole 24316.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	CCTV inspection of pipe 24459 to identify any possible hydraulic connections to the surface.
Note	DTS signal indicates stormwater inflow which would require a hydraulic connection to ground level features. The GIS data set does not indicate any assets or connections at this location that have intentional surface connections. Check for any unintended hydraulic connection to the stormwater pipe that crosses the wastewater pipe at this point. The connection could be via exfiltration of stormwater to pipe bedding and infiltration from the pipe bedding to the wastewater main. This DTS signal is assessed as 'weak' rather than 'strong' because the pattern characteristic of stormwater inflow was not observed for other rain events. This DTS signal is also assessed as 'weak' because the magnitude of the signal is small.

Source Analysis Plot – Temperature Difference vs Time



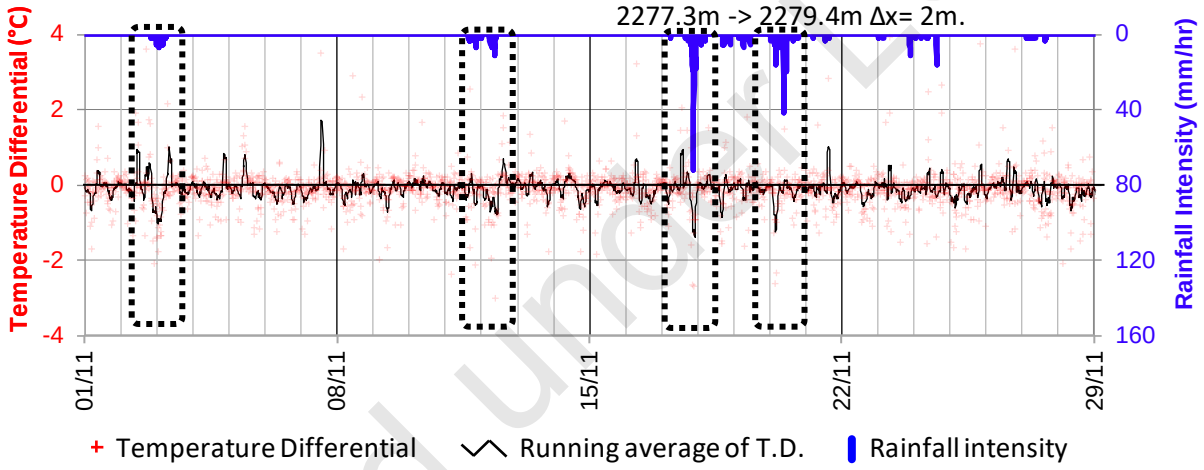
Source Location Map

B.1.3 Source S24 / 2279 <new>

Source Analysis Summary

Asset	Pipe 31627 DN150, 64m, Concrete, 1977.
Address	26 York Street.
DTS signal	Weak. 4m ±4m upstream of manhole 14172.
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.
Recommendation	Inspection of nearby connected properties (26 and 27 York St.) looking for deterioration and/or SW connections.
Note	This signal is assessed as weak because there are similar but larger temperature differentials on some dry days.

Source Analysis Plot – Temperature Difference vs Time



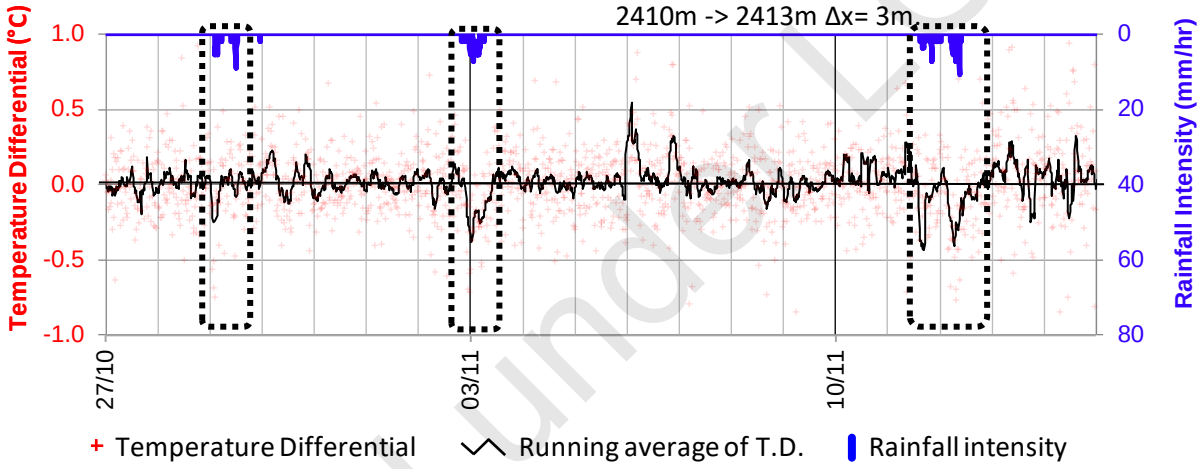
Source Location Map

B.1.4 Source S24 / 2412 <new>

Source Analysis Summary

Asset	Pipe 24460	DN150, 50m, uPVC, 2012.
Address	11 York Street.	
DTS signal	Weak. 29m ±4m upstream of manhole 24313.	
Analysis	Reduction in temperature during rainfall indicating stormwater inflow.	
Recommendation	Inspection of nearby connected properties (11 York St.) looking for deterioration and/or SW connections.	
Note	This DTS signal is assess as 'weak' because the magnitude of the signal is small.	

Source Analysis Plot – Temperature Difference vs Time



Source Location Map

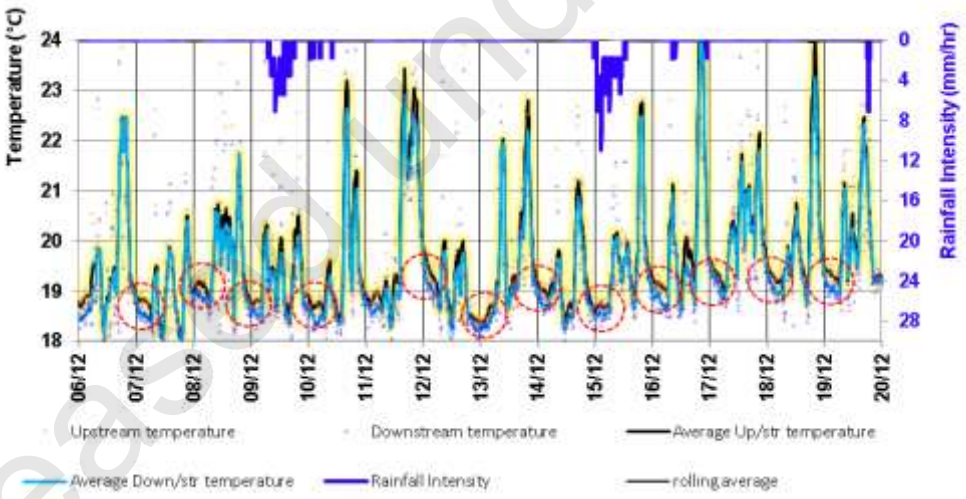
B.1.5 Source S27 / 1400 <new>

Source Analysis Summary

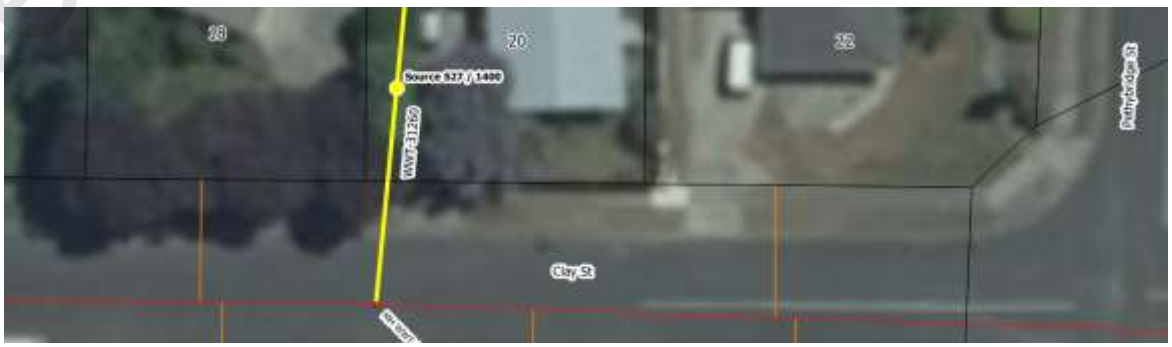
Asset	Pipe 31260	DN225, 119m, Asbestos Cement, 1973.
Address	20 Clay Street.	
DTS signal	Weak. 15m ±5m upstream of manhole 12330.	
Analysis	Reduction in temperature in the early hours of the morning indicating ground water infiltration.	
Recommendation	CCTV inspection of pipe 31260 checking for signs of deterioration and infiltration and to determine the connection point of laterals not shown on the GIS map (20 Clay St.). Inspection of nearby connected properties (20 Clay St.) looking for deterioration and infiltration.	
Note	Use the CCTV data to update the connection points for the laterals not shown in the GIS map. Include property inspections only if they are within five metres of the DTS signal.	

Source Analysis Plot – Temperature vs Time

For this location, a plot showing the upstream and downstream temperatures reveals the temperature differences indicating groundwater infiltration better than the default type of plot. The cooler downstream temperatures in the early hours of the morning are highlighted using the red circles.



Source Location Map



Appendix C Common Features in Temperature versus Time Analyses

Common Features in Temperature versus Time Analyses

Some features of the temperature versus time plots may raise questions in the reader's mind that might distract from the main observations of the data if no explanation was provided. Selected features are described below to minimise the amount of description required in the main text and the detailed analyses presented in this report. The example graphs provided below are intended to be generic and are selected from various projects around New Zealand.

Red and black temperature differentials

In the temperature versus time plots, the red data points and black trace are calculated by subtracting the upstream temperature from the downstream temperature. If the differential is negative (below zero) then the downstream point is cooler than the upstream point. This indicates a source of cooler water may have entered between the two points of the wastewater main. Hence the location may be a source of I&I. If the temperature differential is zero, then there is no change in temperature between the two points. If the differential is positive (above zero) then warm water has entered the wastewater main between the two points.

The blue line is the rainfall intensity with the scale (mm/hr) on the right side of the graph. If the temperature reduction only occurs during and/or following rain, then stormwater inflow and/or rain dependent inflow is indicated (refer to Figure C-1). If the temperature reduction occurs independently of rain fall events and is ongoing, then the groundwater infiltration is indicated (refer to Figure C-2).

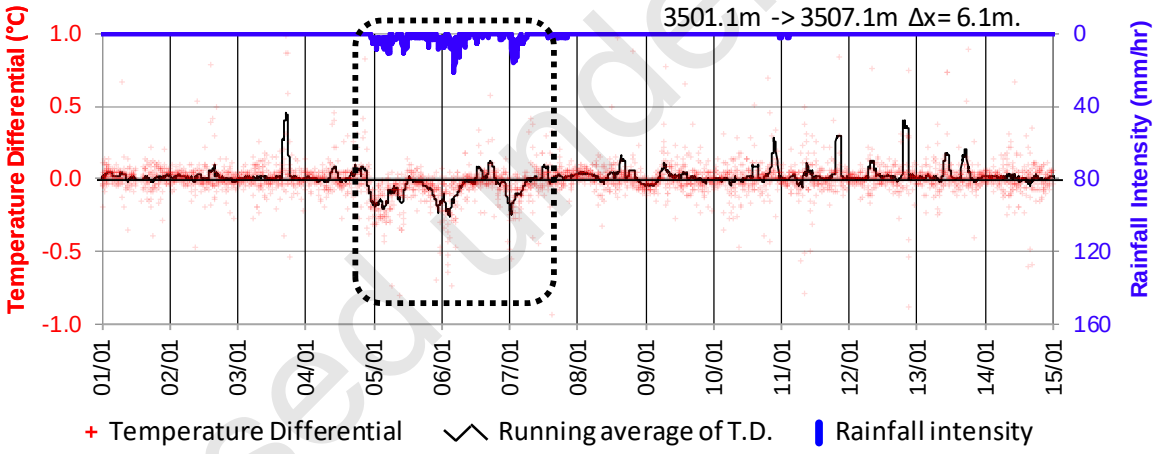


Figure C-1 Example source analysis plot of temperature vs time for stormwater inflow

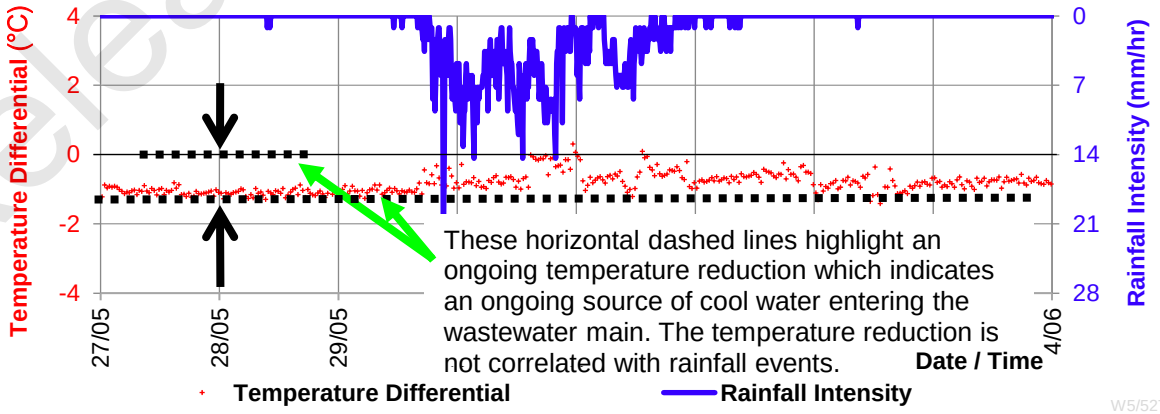


Figure C-2 Example source analysis plot of temperature vs time for groundwater infiltration

Supressed temperature differences due to rain events or extensive seasonal infiltration

In some cases, a temperature differential indicating groundwater infiltration decreases or is suppressed during or following rain events.

To illustrate the issue, assume an upstream point ('U') and downstream point ('D') are being compared. In dry weather, the downstream point is the cooler of the two indicating groundwater infiltration between the two points. This is shown in the left side of Figure C-3. A **suppression** of the temperature differential during or following rain can be caused by the temperature of the upstream point ('U') being temporarily reduced by inflow or significant infiltration entering wastewater system higher up in the wastewater network. This results in a smaller temperature drop between the points 'U' and 'D'. Figure C-3 shows an example of this phenomenon lasting for five days between 24th to 28th March.

In some catchments, the suppression of DTS I&I signals can be seasonal lasting the duration of the wet season. In extreme cases, if groundwater infiltration is significant year-round, then DTS detection of I&I below the points of extreme year-round infiltration will be compromised and of limited effectiveness year-round.

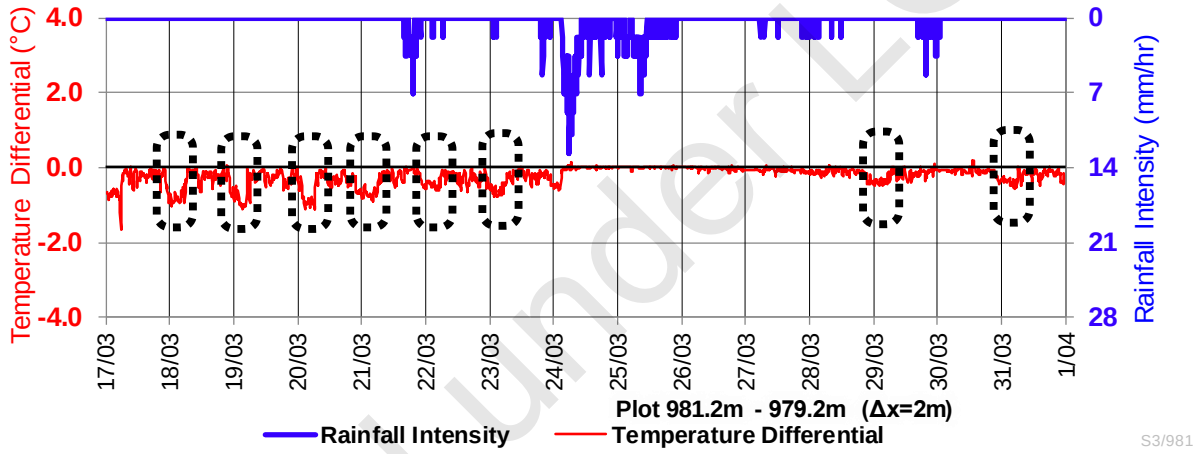


Figure C-3 Example of groundwater infiltration temperature differential being reduced by rain dependent infiltration and inflow.

Positive spikes

Positive spikes indicate the downstream temperature is temporarily warmer than the upstream point. This indicates a short-term discharge of hot water such as baths, spa baths, or commercial washing processes. This feature is irrelevant to DTS I&I source identification.

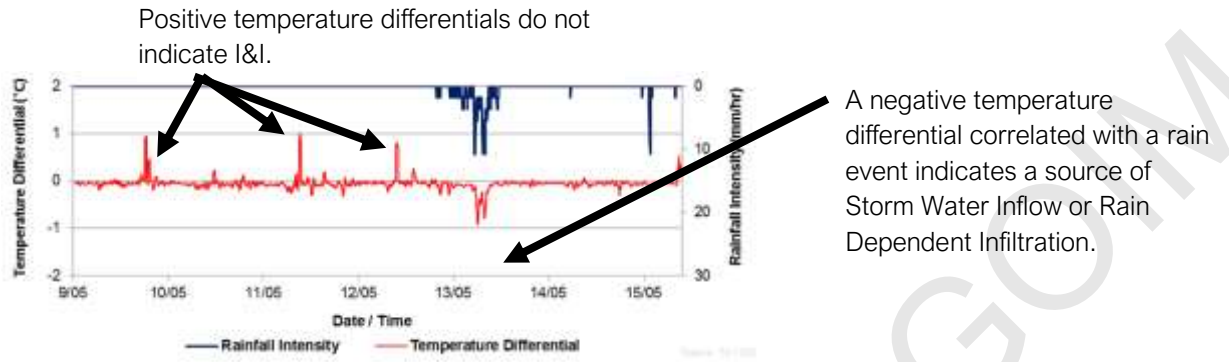


Figure C-4 Example of positive spikes in temperature versus time analyses

Repeated peaks and troughs

Often the temperature difference will vary several degrees within a single day. The pattern may approximate a single rise and fall each day. This might be caused by domestic sewage transferring heat to the pipe material and soils surrounding the wastewater mains until late at night with subsequent cooling as sewage volumes reduce in the late evening.

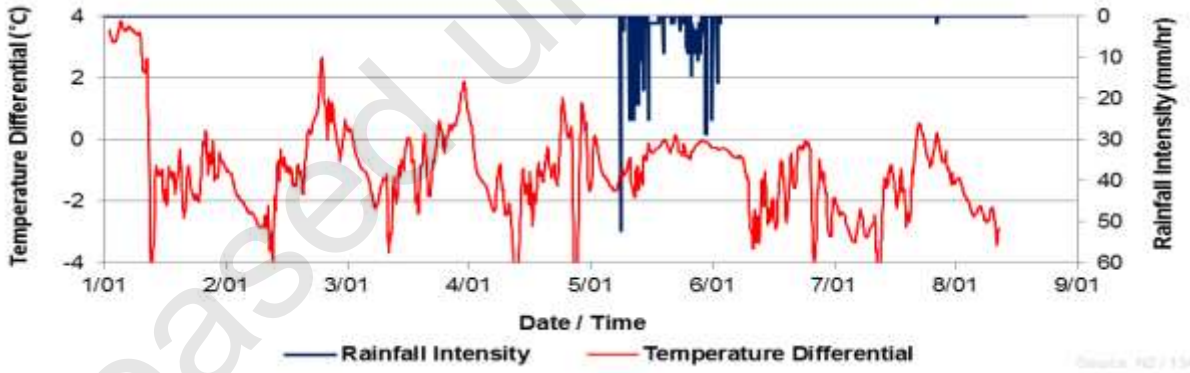


Figure C-5 Example of daily variations in temperature versus time analyses

Multiple peaks and troughs within a day might indicate morning and evening flushes following the diurnal profile of domestic wastewater flows. Depending on the nature of the catchment there can be lunch time peaks or very distinct peaks at regular time intervals indicating discharges from commercial or industrial sources.

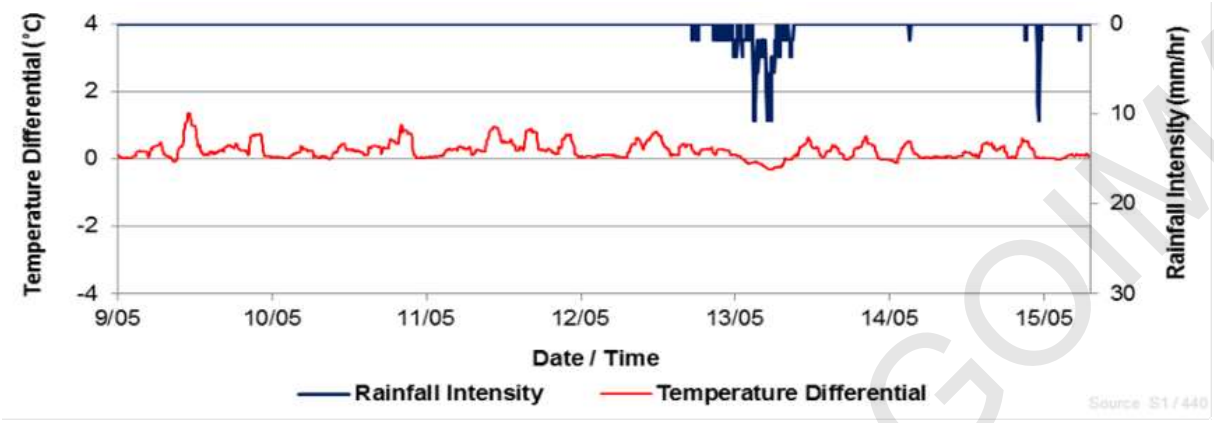


Figure C-6 Example of multiple peaks each day due to human activities

Negative spikes during business hours can be associated with dumping of cool water from commercial/industrial sources or pools. If there is a repeating pattern of a negative temperature differential but it is reduced or non-existent in the low flow hours of early morning, then it is not expected to be caused by I&I.

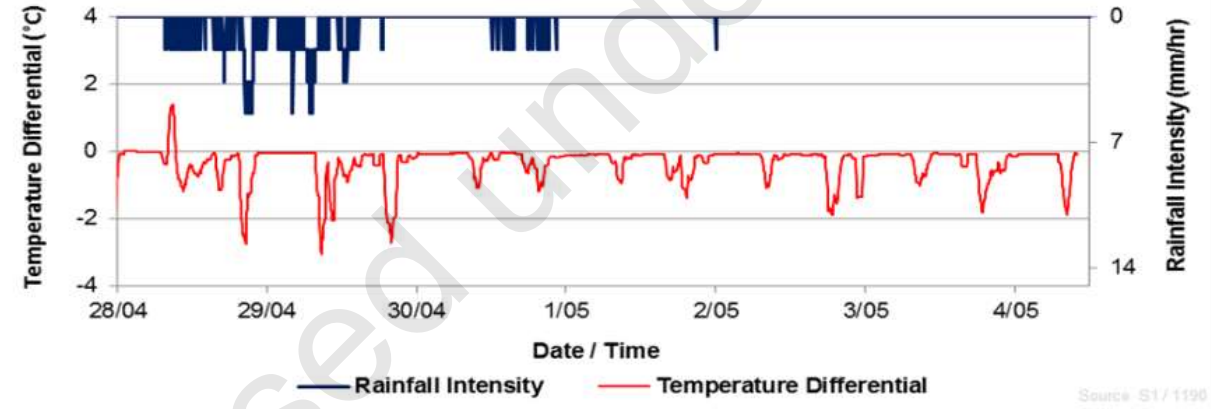


Figure C-7 Example of regular cold discharges due to human activities

Appendix D Inspection Definitions

Manhole Inspection (including inspection chambers and flushing points)

The manhole inspection is a visual inspection of a manhole.

Photographs / video are to be recorded using pole cam.

Manhole inspection check sheet to be completed, this includes:

- Performance of asset.
- Visual condition.
- Location (checks for potential inflow from runoff and ponding).
- State all connections into manhole.
- Push Cam inspection approximately 5 m upstream and downstream of manhole.

Property Inspection

The property inspection is a visual inspection of a private property and their wastewater and stormwater connections.

Visual property inspection check sheet to be completed, this includes:

- Inspection for direct inflow from stormwater cross-connections.
- Inspection for direct inflow of stormwater surface water (i.e. low-lying gulley traps).
- Inspection for inflow of stormwater due to defects and/or damage to drainage (i.e. poorly sealed gully traps).

Property inspections are to include a camera inspection of the private lateral checking for signs of non-compliant construction, deterioration, connections to the surface, inflow, and infiltration. Any cross-connection with foundation drains, stormwater collectors and catchpit drainage must be identified.

CCTV Inspection

A CCTV inspection shall be of the highlighted area of an asset to be inspected by an experienced CCTV operator. The inspection shall be conducted with a pan and tilt camera to record footage. The footage should be reviewed to the New Zealand Pipe Inspection Manual standards.