Infiltration Reduction Plan

Barnham

October 2021
Version 2.2

from
Southern
Water

Contents

Document Control

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Glossary

AMP – Asset Management Programme
CCTV - Closed-circuit television
EA - Environment Agency
GW – Ground Water
IRP - Infiltration Reduction Plans
l/s - litres per second
MH – Manhole
RPS - Regulatory Position Statement
SW – Southern Water
WaSC - Water and Sewerage Companies
WC – Water Closet
WPS - Wastewater Pumping Station
WTW - Wastewater Treatment Works

1. Background

This Infiltration Reduction Plan (IRP) for Barnham in the Lidsey catchment has been prepared in response to the Environment Agency's (EA) Regulatory Position Statement (RPS). SW has been carrying out work for many years to survey and repair sources of infiltration in the catchment for Lidsey Wastewater Treatment Works (WTW) in Sussex.

Flow gravitates to Lidsey WTW from two primary directions. From the north, the source of the flow is from the villages of Westergate and the western part of Eastergate. From the north-east, flow gravitates from Walberton and Eastergate to the centre of Barnham, where it is joined by flow from North End, Yapton WPS that is pumped along Lake Lane. Just south of the railway line in Barnham, the main sewer splits into a dual sewer and a combined storm overflow is provided at Marshall Close.

Flow from Yapton is pumped from Barnham Road WPS to join the dual sewer just south of Barnham. The resultant flow gravitates in a south-westerly direction to Lidsey WTW for treatment. Figure 1.1 shows a representation of the sewerage system in the Lidsey WTW catchment.

The repairs carried out by SW improve the integrity of the sewerage system. SW has been working with the following organisations and is dependent on their support to achieve the objective of reducing non-sewage flows into the sewers.

- Environment Agency,
- Arun District Council,
- West Sussex County Council,
- Barnham Parish Council.

Southern Water has consulted with representatives of these parties as part of meetings with the local councils.

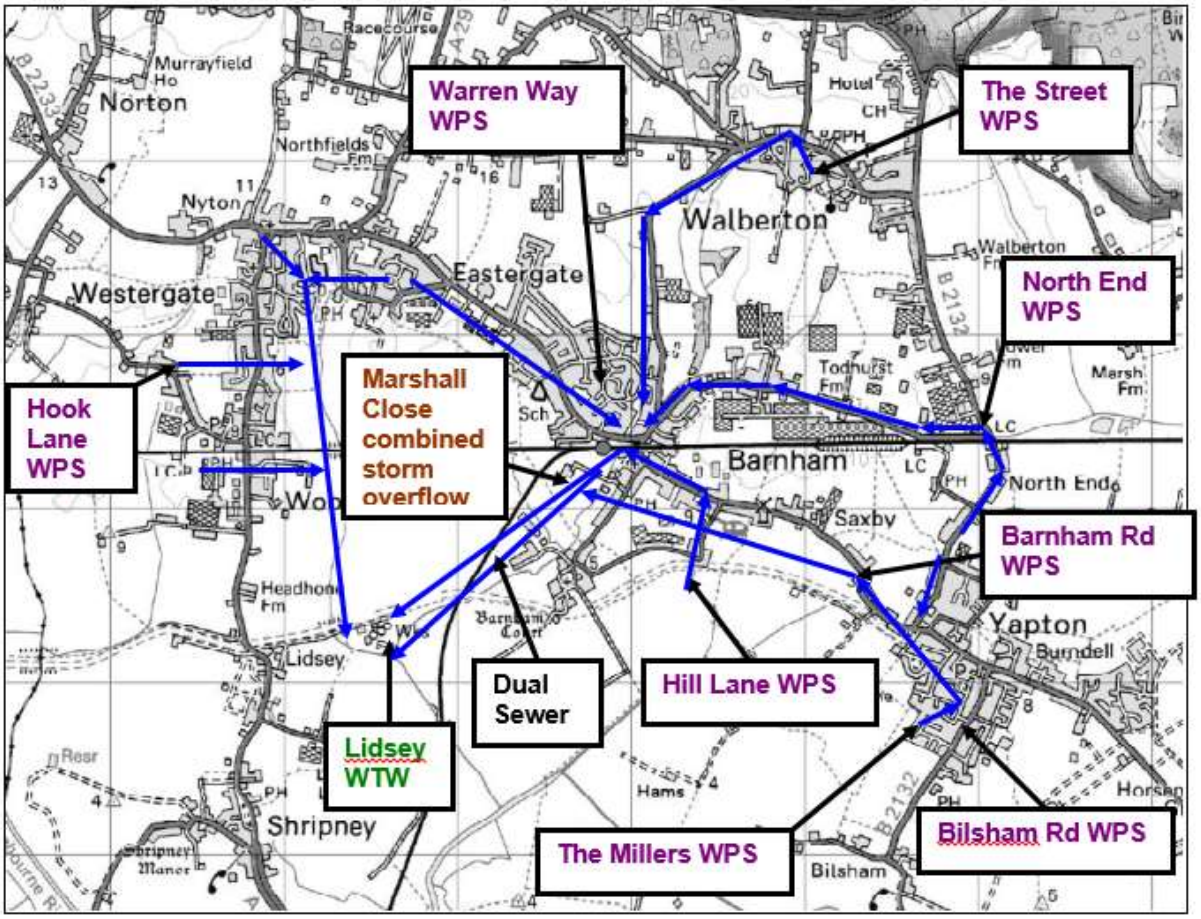

Figure 1.1 - Representation of the sewerage system for the Lidsey WTW Catchment

2. Groundwater Infiltration at Barnham

2.1. The significance of groundwater infiltration.

Barnham is one of a number of areas in Southern Water's operating area where, during excessively wet winters, customers have been inconvenienced by the effects of groundwater infiltration into sewers. Such effects can include flooding and restricted toilet use (RTU).

Southern Water strives to maintain services for customers by a programme of investigation, repair, maintenance and mitigation. Mitigation measures include the use of tankers and over-pumping. Such mitigation measures are not sustainable, so during the last three years SW has invested in carrying out major improvements to the integrity of the sewers and manholes in the vicinity of Barnham in order to minimise the occasions on which over-pumping is required.

2.2. What would happen if Southern Water did not take action?

Despite the significant groundwater flow through the valley during these conditions, incidents of sewer flooding have been relatively infrequent. Table 2.1 below shows reported incidents of sewer flooding since April 2010.

A hydraulic model of the Lidsey catchment is available, that can be used to understand the performance of the system and determine options to address risks. However, SW is aware from historical reports of which properties are likely to be the first to suffer from the effects of flooding.

It is noted that despite the groundwater levels in 2019/20 being comparable to those experienced in 2012/13 and 2013/14 (see Figure 4.1), the impact of this on the customers with respect to flooding and restricted toilet use is slightly lower. This suggests that the work undertaken in the catchment has had some impact.

Table 2.1- Reported Flooding Incidents by Category, in Lidsey Catchment.

Year	External Flooding	Restricted Toilet Use	Total
2010_2011	3	1	4
2011_2012	0	0	0
2012_2013	18	0	18
2013_2014	6	5	11
2014_2015	3	2	5
2015_2016	2	0	2
2016_2017	0	0	0
2017_2018	2	0	2
2018_2019	0	0	0
2019_2020	2	0	2
2020_2021	3	1	4
Totals	**39**	**9**	**48**

3. Investigation & repairs

3.1. Outline Plans to Investigate Sources of Infiltration

The Generic Plan describes Southern Water's Infiltration Reduction process. The specifics of the investigations and repairs at Barnham are captured in Section 3.2 below, and includes the following elements:

- Manhole Inspections and CCTV Surveys
- Flow Monitoring Surveys
- Manhole and Sewer Repairs
- Follow-Up Surveys and Repairs

3.2. Investigation and Repairs in the Barnham

Groundwater infiltration into sewers has been a long-running issue in Barnham. SW has been making significant investments over many years to minimise infiltration and the need for over-pumping though despite this the issue is not resolved and further monitoring and sewer sealing is required.

SW recently completed a major programme of survey and repairs to the sewers in the Barnham catchment. The investigations and repairs followed the process set out in the Generic Plan. The timing and status of each step is in Table 3.1 below.

Table 3.1 - Summary of Survey and Repairs

Step	Description	Approx. Date	Status
1a.	CCTV Surveys	Spring 2013	Completed.
2.	4 manholes and approx. 50m of sewers sealed.	Summer 2013	Completed.
5a.	Dry Weather flow Monitoring.	17th July to 2nd September 2013	Completed.
N/A	Tankering at Elm Grove, Barnham (100+ Tanker days)	Dec 2013 – March 2014	Completed.
5d	Lidsey Inflow and Infiltration Investigation	March 2014	Completed.
N/A	Over-pumping at Barnham Lane/ Lake Lane Junction	19 March – 24 April 2014	Completed.
5b.	Wet Weather Flow Monitoring	8th May to 19th June 2014.	Completed.
1b.	CCTV Surveys	Spring 2014	Completed.
3.	Review of Survey findings.	Spring 2014	Completed.
4.	Sewer Rehabilitation in Elm Grove and Lake Lane areas approx. 840m of sewers sealed.	Summer / Autumn 2014	Completed.

Step	Description	Approx. Date	Status
5c.	Two additional Sewer Level Monitors installed.	Autumn 2014	Completed.
6.	Targeted CCTV Survey	Summer 2015	Completed.
8.	Winter monitoring exercise commenced.	October 2015	Ongoing
7.	Scheduled repair near Barnham Station	January 2016	
8.	CCTV Investigation	March 2016 – April 2018	Completed.
9.	Sewer Rehabilitation	March 2016 – October 2018	Completed.
10.	Further Surveys	Post 2022	Planned

In 2013, surveys were carried out on 166 manholes and 1,226m of sewer which identified infiltration in 4 manhole structures but only 2 sources of infiltration in the sewers. In 2013/14 approximately 50m of sewers were rehabilitated.

Further CCTV was carried out in spring 2014 (73 manholes and 2,895m of sewers were surveyed). Significant infiltration was found. SW completed all of the identified repair work except for a repair near to the station. Appendix A shows where sealing work has been carried out. Table 3.2 summarises rehabilitation works that have been completed in 2013 and 2014. Most of these repairs at Barnham were carried out in the summer and autumn of 2014.

Table 3.2- Quantification of Repairs

Repair Type	Quantity
Manhole Sealing	4 no.
Sewer Repairs	890 m

In addition to the sewer repairs, SW has also carried out some other improvements in 2014. These include: modifications to the sewerage system in Marshall Close to improve the level of service for some properties in the area, redistribution of flows between the two sewers to Lidsey WTW and changes to the flow rate from one pumping station to reduce the peak flows. These interventions reduced external flooding incidents.

Further CCTV Investigations were carried out from March 2016 to April 2018, which led to Sewer rehabilitations from March 2016 to October 2018. A further package of surveys is planed post 2022.

4. Over-pumping

4.1. Circumstances that lead to over-pumping

Since 2013, SW has made significant investment to reduce infiltration and to protect specific properties at risk of flooding, with the objective of reducing the frequency of discharges to watercourses.

The circumstances under which over-pumping may be required, will be related to rainfall more than groundwater levels. As sewer levels rise, the Marshall Close combined storm overflow will operate. If flows continue to increase, measures (such as tankering and/ or over-pumping) will be required at other locations.

The Chilgrove House borehole is located on the south side of the South Downs, some 15km north west of Barnham. Figure 4.1 shows groundwater levels recorded at the borehole since 2005. (Note: The readings are water level elevations rather than depths below ground level.) Whilst there is no positive correlation between the groundwater level and full flow to treatment at Lidsey Works, a correlation between rainfall and flow to Lidsey Works has been identified (Bernard Poole, WaPUG Spring Meeting 2002, 'Estimation of Infiltration from Long Term Flow Records'). The correlation between rainfall and flow, but not between groundwater and flow, aligns with SW's experiences. The mechanism by which the effect of heavy rain results in rapid increases in sewer flows, is not entirely understood, but it appears that groundwater levels rise rapidly during rain because the ground is very permeable.

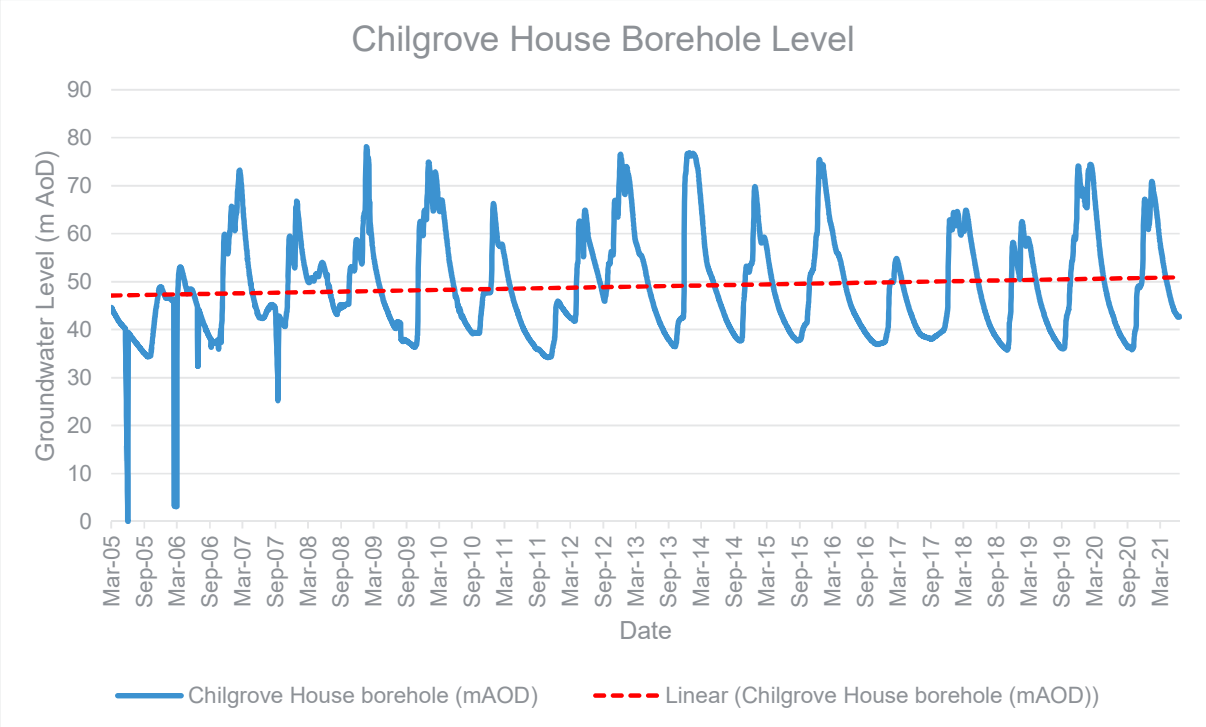

Figure 4.1 - Groundwater levels at Chilgrove House from 2005 to 2021

It is worth noting that there have been a number of very wet winters in recent years, which matches the trends of increasing flows and groundwater levels. Tankering was required from December 2013 to March 2014, 5 days in November 2014, 2 days in January 2015 and over-pumping was required from March 2014 to April 2014. Over-pumping was also required in spring 2016 but hasn't been undertaken in more recent years.

Sewer flooding which is a consequence of rainfall induced infiltration can result from short intense storms or longer periods of rain or a combination of both. Consequently it is difficult to predict the timing of measures that will need to be taken at Barnham to alleviate sewer flooding.

The operation of the Combined Sewer Overflow (CSO) at Marshall Close, Barnham is monitored. Also sewer level monitors have been added downstream of the CSO to give early warning of potential flooding. The sewer level monitors provide alarm signals to SW when the level rises to a pre-set value. SW will continue to respond to the alarms to assess the situation. Tankering will be organised as required and SW will discuss the provision of any over-pumping arrangement with the EA if tankers are not able to cope with the flow.

The details of where tankering and over-pumping has been necessary in the past are given in Appendix B. The repairs carried out, combined with the work noted above, and winter preparation checks, are expected to minimise the requirement for tankering and over-pumping. However, the effect of the repairs, and potentially other factors outside SW's control (such as the severity of the weather), may dictate that over-pumps or tankering are required at other locations either in place of, or in addition to, the sites described in Appendix B.

4.2. Steps to prevent discharges and alternatives to over-pumping

The Generic Plan details the typical activities that Southern Water undertakes to minimise the requirement for discharges to watercourses. Since 2013, SW has undertaken extensive surveys and repaired sewers and manholes where infiltration had been found (the extent of the work is shown in Appendix A). This built on the repairs that had been carried out in previous years (listed at the end of Appendix A).

4.3. Over-pumping arrangements (flow rates and minimisation of effect on watercourse)

A typical arrangement of an over-pumping setup is provided in the Generic Plan.

The locations where tankering and over-pumping has been used in recent years are shown in Appendix B. These locations were effective in restoring service to customers and are the default locations should the situation re-present itself. Dates of historic tankering and over-pumping are also provided in Appendix B.

SW invested in ten portable biological treatment units in January 2014 for use at flooded areas throughout its area. The units were trialled but found to be unreliable, it is now normal practice for UV units to be used when over-pumping is required.

4.4. Steps to minimise the volume and duration of over-pumping

The Generic Plan outlines a detailed rationale behind the use of tankers and over-pumping, and summarises the benefits and disadvantages. Some specific issues in relation to the Barnham catchment are captured below.

4.4.1. Tankering

Benefits:

- See Generic Plan.

Disadvantages

- The flow rate is low (approx. 2l/s per tanker over a 24 hour period).*Tankers operating at Barnham discharge at Ford WTW, - a round trip of approximately 2 hours including loading and discharging.
- See also Generic Plan.

4.4.2. Over-pumping

Benefits:

- Typical pump fuel consumption is 85% of the fuel that one tanker would use in a day.
- The discharge rate is significantly greater. A 4" pump will discharge typically 30 l/s; the equivalent of a fleet of 15 tankers.
- See also Generic Plan.

Disadvantages

- See Generic Plan.

Figure 4.2 shows the estimated carbon emission per m^3 of dilute effluent removed by tanker and by pump. Irrespective of the method of removing excess infiltration, it is clearly preferable to prevent it entering the system in the first place. Hence SW embarked on the programme of investigation and repair in Barnham, outlined in Section 3.2.

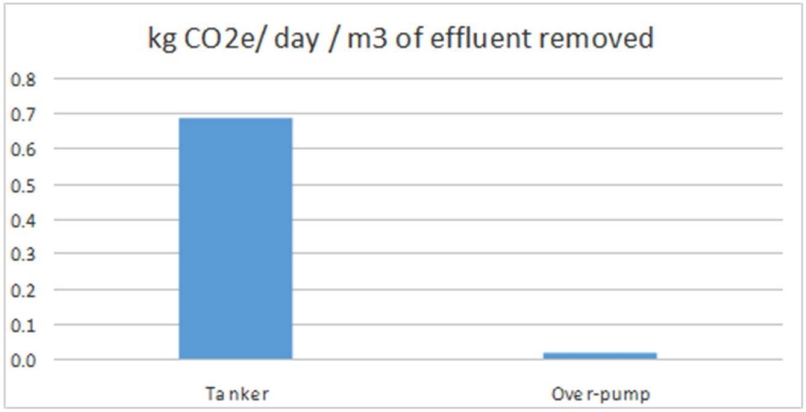

Figure 4.2 - Carbon Footprint figures for Tankers and Over-pumps per m^3 of effluent removed.

4.5. 3rd Party Communications about over-pumping

Since the start of the Infiltration Reduction Programme in 2013, Southern Water has been proactive in communicating with stakeholders and customers in the Barnham about planned and completed work to

improve the integrity of the sewerage system. Stakeholders have been kept informed of progress on survey and sealing work via emails and or face-to-face meetings.

SW attends and convenes meetings with a number of local groups. In particular the meetings with local council representatives have been influential in helping to shape the IRP. The latest version of the IRP approved by the EA, will be published on SW's website.

Despite the work being undertaken, if over-pumping is required, the location is provided in Appendix B. The Generic Plan provides more detailed arrangements around over-pumping.

From time to time, SW updates stakeholders about completed and planned work, as part of stakeholder meetings with the local councils.

4.6. Monitoring quality of the downstream watercourse

The Generic Plan provides details of water quality monitoring that will be undertaken, should over-pumping be required.

5. Options to Reduce Infiltration

5.1. Sewer Rehabilitation Programme

SW acknowledges that infiltration reduction is on-going process. Since 2013, SW has undertaken surveys and repairs at Barnham. The major repair work was completed in 2013. In the Spring of 2014 further CCTV investigations were carried out. SW completed all the identified repair work except for a repair near to the station; modifications to the sewerage system in Marshall Close were made to improve the level of service for some properties in the area; redistribution of flows was carried out between the two sewers to Lidsey Works; and changes to the flow rate from one pumping station were made to reduce the peak flow. Further CCTV Investigations were carried out from March 2016 to April 2018, which led to Sewer rehabilitations from March 2016 to October 2018.

5.2. Property Level Protection

There are various measures that can be used to protect a property from internal flooding. There are two aspects to protecting properties: flooding from sewers and flooding from surface water.

To restrict sewer flooding for vulnerable properties, SW can install Non-Return Valves (NRVs) on private drains. These prevent effluent from the main sewer flowing back up into peoples' homes where their properties are low-lying relative to the sewer. Despite this benefit, there are a number of potential disadvantages; for example - sealing off a property from the main sewer can cause flooding due to the residents own domestic use - this is particularly relevant if there is a short private drain. Also protecting one property, or a group of properties, can simply pass the problem to other customers. Consequently, each potential property would need to be assessed on a case by case basis.

Whilst in some cases non-return valves can be effective in providing property level protection, in Barnham there does not appear to be a great opportunity for their use. However SW will continue to evaluate properties, if they regularly suffer from loss of sanitation when sewers are surcharged.

To restrict surface water flooding, homeowners can fit flood-proof doors, airbrick shutters, and seal ductwork etc.).

5.3. Local Flow Control

As noted in Section 4.1, tankering was required from December 2013 to March 2014, 5 days in November 2014, 2 days in January 2015. Over-pumping was required from March 2014 to April 2014, and in spring 2016.

5.4. Monitoring

In addition to monitoring groundwater levels at Chilgrove House, SW also monitors the levels in sewers. Four monitors are installed in sewers in the Barnham area. Sewer flows increase rapidly after rainfall, so sewer levels are helpful to provide back-up information to assess the proposed response to flooding.

6. Action Plans

A significant amount has been achieved in the Barnham catchment in the last eight years. Some actions are ongoing which reflects the continuous improvement process for dealing with infiltration due to groundwater. To make it easy to track progress, the following tables set out the actions to reduce infiltration and also to mitigate the effects of it, if the infiltration cannot be controlled at economic cost. Tables 6.1 and 6.2 cover the actions by SW and by other parties, respectively, to reduce infiltration. Tables 6.3 and 6.4 cover mitigation of the effects of flooding (Communication and other activities).

SW is committed to continuing to pursue infiltration to reduce the frequency of over-pumping. This IRP describes the work that has been done by SW to improve the situation. In addition, it also describes what is being done to monitor flows, the 'winter preparation' work to be carried out to ensure assets are operating correctly, and the work to be developed with other agencies to improve an integrated plan to address flooding.

Colour coding of actions in tables:

- Green – completed
- Orange – imminent action required
- Red – overdue
- White – on-going actions with no specific end dates.

Table 6.1 - Southern Water Current Activities to Reduce Groundwater Infiltration

Ref.	Item	Actions	Timescale and Status	Outcomes
1.1	Develop an approach for reduction of infiltration and maintenance of reduced levels of infiltration.	Refer to Section 3 above and the report in Appendix A.	Summer 2013 - Complete	The steps are being followed to deliver results.
1.2	'Dry weather' flow surveys (to measure background levels of infiltration during low groundwater periods)	Identify suitable measurement points, carry out survey over four week period in Summer, match rainfall records with flow data.	July - September 2013 – Complete	Groundwater infiltration is greater than would be expected for summer conditions.
1.3	'Wet weather' flow surveys (to identify remaining areas of infiltration following initial sewer rehabilitation/repair).	Identify suitable measurement points, carry out survey over four week period, match rainfall records with flow data.	May/June 2014 - Complete	The wet and dry weather flow survey results were compared to identify potential areas of infiltration.
1.4	CCTV etc. survey of sewers	Identify Strategic Manholes, survey manholes to identify clear flow and infiltration. Carry out CCTV survey where clear flow was identified.	Spring 2013 and Spring 2014 - Complete March 2016 – April 2018 – Completed.	Sources of infiltration were identified to determine scope of rehabilitation work.

Ref.	Item	Actions	Timescale and Status	Outcomes
1.5	Carry out sewer rehabilitation work	Use various techniques to seal infiltration points in manholes and sewers	Summer/Autumn 2014: - Completed in 2014/15, April 2016 – October 2018: Completed	Rehabilitation will restore structural integrity of sewers restored
1.6	Further sewer rehabilitation work, if required, in areas where surveys carried out.	As above, use various techniques to seal infiltration points in manholes and sewers	As required dependent on survey results; none currently scheduled.	Rehabilitation will restore structural integrity of sewers restored
1.7A	Maintain IRP as a live document	Update IRP as appropriate to describe work carried out and/or developments	Annually – on anniversary of submission to EA for approval	Up to date IRP
1.7B	Quarterly progress reports	A progress report on infiltration reduction work related to this catchment will be submitted to the Environment Agency	Quarterly (December, March, June, September)	Keep the Environment Agency informed of progress on a regular basis
1.8	Strategy for inflows via private drains	Southern Water to propose a strategy for dealing with infiltration via private drains*	SW 2014. Complete	Southern Water's objective is to improve awareness of the significance of infiltration into private drains and the importance for customers to ensure infiltration is repaired when it is discovered.

Ref.	Item	Actions	Timescale and Status	Outcomes
1.9	Long-term monitoring	SW will monitor sewer flow to identify significant increases in inflows.	SW, Autumn 2014 onwards	Early identification of areas where infiltration has increased.
1.10	Over-pumping Sites: improve effluent quality	Investigate potential for improved screening and biological treatment at points of discharge into watercourse.	SW, 2014, Complete	Improved arrangements for discharges when required.
1.11	Over-pumping Sites: minimise flow	Add level control to pumps to reduce durations for pumping	SW, 2014, Complete	Establish whether seasonal discharge (s) will be necessary in order to maintain use of sewerage services for customers during periods of very high groundwater levels.
1.12	Standards for emergency discharges	SW to discuss with EA about best practice set up for over-pumping arrangements.	SW, 2014, Complete	Agree with EA acceptable standards for discharges and acceptable flow rates.
1.13	Action Plans	Develop SW action plans documenting set up of pumps, tankers, etc. for emergency situations.	SW, Summer 2014 - Complete	Action Plan available for planning sessions with other authorities in preparation for repeat flooding events. Engagement with the local community about the potential arrangements for dealing with excess flows into sewers to mitigate disruption to customers.
1.14	Consider alternative solutions that involve some risk	Investigate unconventional options such as vacuum sewers or consider conventional combined sewer overflows	2020	Ongoing.
1.15	Identification of lengths of sewer to survey or resurvey in the period 2021-25	Review sewer records with available ground water profile date	Post 2022	Planned

Ref.	Item	Actions	Timescale and Status	Outcomes
1.16	Surveys by CCTV or electroscan lengths of sewer potentially at risk	Compare historical survey coverage with results of 1.15 and produce a survey schedule.	Post 2022	Planned
1.17	Survey result review	Review results of surveys undertaken in 1.16 to determine sewer sealing work.	Post 2022	Planned
1.18	Undertake required sewer sealing	Seal sewers and manholes by most appropriate technique	Post 2022	Planned
1.19	Review effectiveness of any sealing work	Analyse monitoring data and groundwater data to determine benefit of investment	Post 2022	Planned
1.20	Review further options for property protection and alternative tanker points	Consider other improvements	Post 2022	Planned

Table 6.2 - Multi-Agency Activities to Reduce Groundwater Infiltration

Ref.	Item	Actions	Owner, Timescale and Status	Outcomes
2.1a	Long-term Monitoring	SW will monitor sewer flow to identify significant increases in inflows.	Ongoing	Early identification of areas where infiltration has increased
2.2a	Investigate highway 'mis-connections'	Where non-sewage flow is identified, check highway drainage relative to sewers to ensure road drainage is not a source of flow into the SW sewers	Local councils with support from SW, 2014 onwards. To be pursued as and when required.	Reduced flow of surface water (if connections are found).
2.2b	Investigate groundwater infiltration on domestic drains	Where non-sewage flow is identified from domestic properties, investigate to identify source of flow into SW sewers	SW, with assistance from local councils, 2014 onwards. To be pursued as and when required.	Reduced flow of surface water (if connections are found).
2.3	Consider effects of proposed new developments on infiltration.	District Council to continue to consult with SW on development applications.	District Council, Ongoing.	Developments in areas which would be detrimental to sewer flooding, to have conditions recommended by SW and applied, as appropriate, by the City and District Councils.
		SW to determine threshold above which they require to be consulted.	District Council, Ongoing. SW wish to be consulted on all proposed development.	
		Sewerage materials for new developments	SW & District Council, when developments are at planning approval stage. Ongoing.	

*Note: Southern Water does not have powers to require residents to repair private drains. Hence the support of the other agencies is required. It is acknowledged that customers may not be aware of infiltration in their private drains, so SW will consider ways of obtaining information to

demonstrate the presence of infiltration. District Councils would only be able to instigate action under Section 59 of the Building Act where proof/evidence is provided of the defect.

Table 6.3 - Publicity / Communication Activities to Reduce / Mitigate the Effects of Groundwater Infiltration.

Ref.	Item	Actions	Owner, Timescale and Status	Outcomes
3.1	Public meetings about reducing groundwater infiltration into sewerage system	Attend public meetings with other agencies as appropriate.	Regular meetings are not planned, but SW will attend with other agencies as required.	Inform the local population of progress and planned activities and receive feedback.
3.2	Liaise with other agencies as appropriate.	Discuss and agree actions to reduce requirements for tankering and emergency discharges to watercourses.	On-going – further liaison as required	Improved understanding of issues and appreciation of issues. Agreement to actions to help reduce the need for tankering and emergency discharges to watercourses

** SW can provide base information to councils to include in articles publicising the role that everyone can play in minimising non-sewage flows into sewers, and the importance of doing so to reduce the incidence of restricted toilet use during periods of high groundwater.

Table 6.4 - Activities to Mitigate the Effects of Groundwater Infiltration/ Other Flood Protection Mechanisms

Ref.	Item	Actions	Owner, Timescale and Status	Outcomes
4.1	Early Warning system	Joint continuous monitoring of groundwater levels and sewer levels/flows.	SW, EA, 2014, Commenced and on-going. [SW use EA borehole data.]	Develop trigger levels by comparing historic customer complaints and tankering with BH levels (or other reference). Note trigger levels should vary as a consequence of rehabilitation. Also they will need to reflect groundwater reaction times.
4.2	Tankering arrangements	Investigate options for improving location of tankers and over-pump units for future events. e.g. by use of longer hoses/ pumping	SW, Spring/Summer 2014, done	Potentially less disruption to residents when tankering / pumping is essential.
4.3	Integrated Flood Risk Management	Develop a multi-agency approach to the management of flood risk within catchments as it relates to the impact on public sewers.	West Sussex County Council/Arun District Council, with inputs from SW, EA, Parish Councils and local flood action groups.	Actions for participating authorities that in unison will reduce the extent of flooding and the impact of flooding.

Appendix

A Survey Findings and Rehabilitation Scope

B Emergency Discharge Sites