Groundwater Impacted System Management Plan

Little Marlow, River Thames

October 2021

Thames Water

It's everyone's water

Version control

Version	Date	Amendment	Author	Checked	Reviewed
1-d1	29/10/2021	Draft for EA	SS/NW	AJ	SE
1-V1	23/11/2021	Version 1	SS/NW	SE	DJ
Annual Update 2022	October 2022	Addition of Annual Update 2022	MB/JH	DJ	DJ
Annual Update 2023	October 2023	Addition of Annual Update 2023	MB	DJ	DJ

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Introduction

This document sets out Thames Water's approach to the management of groundwater infiltration in sewerage systems where the influence of groundwater infiltration is viewed as excessive and likely to be the source of uncontrolled escape of untreated or partially treated sewage.

All sewerage systems combined and separate will experience some groundwater infiltration[1] and a nominal allowance in design will be made for this. However, in some catchments the impact of groundwater infiltration can be considerable leading to impacts on service during periods of high groundwater, typically during the winter.

Groundwater can enter the sewerage system through the pipes and manholes, this may occur at a defect (crack, hole, displaced joint) or on a normal joint on the sewer or in the manhole. A key point to note is that where infiltration occurs it is not necessarily an indicator that the sewer is in poor structural state simply that jointing techniques used are not completely watertight.

Ingress of groundwater is not limited to the public system that Thames Water owns and maintains but potentially the private drains, manholes and sewers that connect to our system.

Preventing and reducing the impact of groundwater infiltration is predominately achieved through the lining of sewers and sealing of manholes. This entails the application of a synthetic liner within the pipe that creates a contiguous membrane for the length of the pipe or possibly section if the source of ingress can be narrowed down. For manholes it will typically entail sealing in a similar manner.

To line all sewers and manholes within most catchments would be prohibitively expensive to do so. Our approach to date has been centered on a 'find and fix' basis which has involved monitoring and investigating the networks in periods of high groundwater to identify sources of ingress and fix as we find them. This approach is constrained for the reason that investigations are typically limited to periods of high groundwater and when high groundwater occurs there are limited windows of time in which investigations can be successfully undertaken before flows either subside or the system is fully surcharged meaning CCTV surveys are not possible[2]. Once sections of sewers have been lined, it will be a case of waiting until high groundwater levels reoccur to assess the effectiveness of the work undertaken, which may not be the subsequent winter but several years later.

It is recognised that the approach to date lacks a degree of certainty of resolution and for this reason Thames Water has in 2020 undertaken a different approach for the medium to long-term management of groundwater, which is covered within this

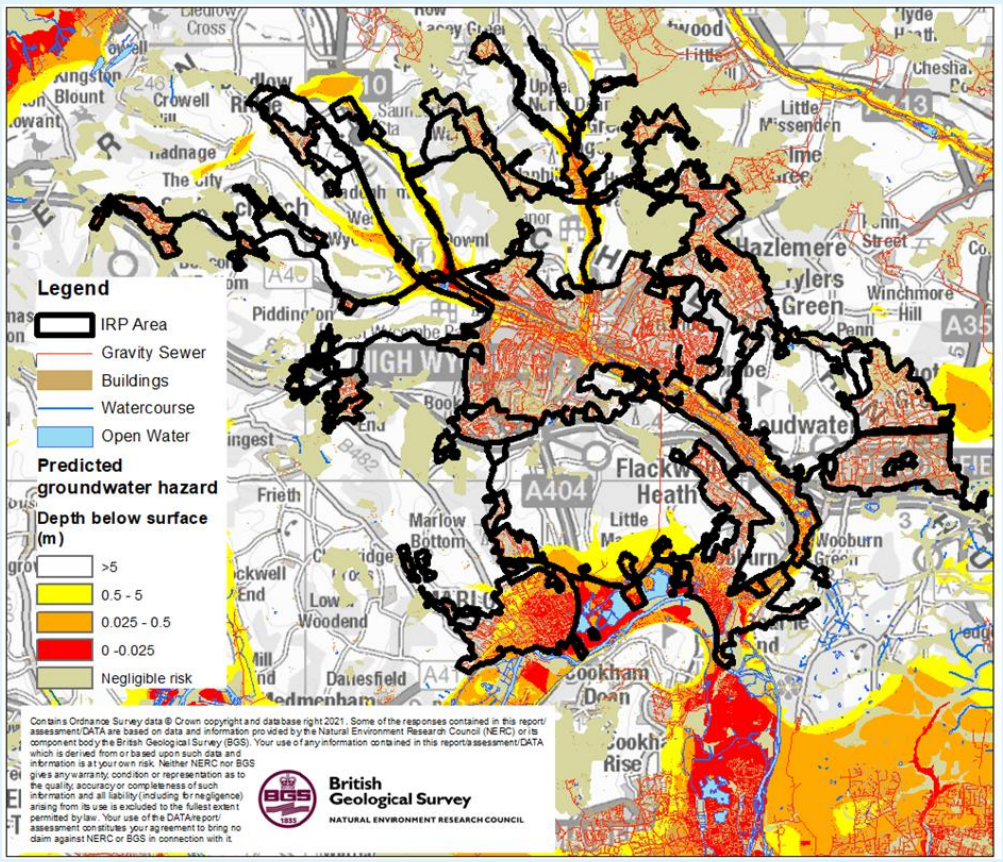
[1] Sewers for Adoption makes an allowance for 10% of normal wastewater flow to allow for unaccounted flows such as groundwater infiltration.

[2] On occasions it is possible to over-pump between manholes to isolate sections of sewer to survey, this is not always feasible when the flows involved are simply too great to over-pump or the location prohibits this approach.

document under the plan section. These plans require significant investment which Thames Water will seek to secure. In the meantime, we will continue to investigate sources of infiltration when it occurs and where feasible, undertake the work through our capital maintenance budgets. We refer to these as ‘minor works’ opportunities i.e. where we have high degree of certainty of reducing point sources of infiltration and can do so with reasonable costs and time.

The structure of this document has been created with input from the Environment Agency. Sections covered in this document include our ‘Outline Plan’ with timescales, Mitigation i.e. how we intend to manage the risk until our plan is fully implemented and when we will publish future updates on progress against this plan.

Brief description of Little Marlow catchment



1.0 – Little Marlow catchment

Little Marlow is located in Buckinghamshire, England, approximately 4 miles north of Maidenhead. Little Marlow serves a population equivalent[3] of 188,741 with a partially separate sewerage network totaling some 1,423 km in length excluding private drains and sewers. The extent of the catchment is shown in Figure 1.0 above.

Problem characterisation

Groundwater can enter our sewers when levels are high and a positive head above the soffit of the sewer is created. Significant groundwater ingress can impact sewer capacity and increase the risk of flooding.

On occasion, prolonged, heavy rainfall and raised groundwater levels have resulted in extensive groundwater flooding to properties and highways, and the overwhelming of the local drainage systems; including the public foul sewer network in areas such as Hughenden Valley.

[3] Population equivalent or unit per capita loading, (PE), in waste-water treatment is the number expressing the ratio of the sum of the pollution load produced during 24 hours by industrial facilities and services to the individual pollution load in household sewage produced by one person in the same time.

The sewerage system is identified on the public sewer records as being a partially separate foul system, rather than a combined system. We believe that significant volumes of surface water runoff from surrounding saturated fields and built-up land have entered the foul sewerage network during recent wet winters.

The surveys we have carried out have detected that there is some evidence of groundwater infiltration into the foul sewer network when groundwater levels are high, and surface water inundation from highways, public spaces and properties and fluvial flooding from local watercourses. Causes of this include urban creep, climate change and population growth. Surface water misconnections (i.e. down pipes from roofs into the sewer network) are also suspected to be a contributing factor, hence further analysis is required to determine the extent to which this has contributed to sewer flooding. This also impacts the volume of flow from the upstream system reaching the High Wycombe transfer station which pumps directly to Little Marlow sewage treatment works.

A limited number of our sewerage systems include for overflows, these structures are there to protect against sewer flooding as a result of rainfall or equipment failure where appropriate. Discharges from these structures should not be impacted by excessive infiltration as detailed by the EA Regulatory Position Statement on groundwater impacted sewerage systems. The use of storm sewage overflows is accepted by our regulators, subject to conditions.

Our permit conditions for Little Marlow STW state:

"The discharge shall occur when and only for as long as the storm tank(s) are full. The discharge of storm sewage to the storm tank(s) shall only occur when the rate of flow at the storm sewage separating weir is in excess of 1442 litres per second due to rainfall and/or snowmelt. The storm tank(s) shall be emptied and their contents returned for full treatment as soon as practicable after cessation of the overflow to the storm tank(s)."

The Flood and Water Management Act 2010 places a responsibility on Lead Local Flood Authorities (LLFAs), to manage flood risk from surface and groundwater, plus a duty on all Risk Management Authorities (RMAs), to cooperate regarding flood risk. In our role as an RMA, Thames Water will work with Buckinghamshire Council as the Higher Tier Council, Lead Local Flood Authority and Planning Authority, in addition to the Environment Agency to ensure that a collaborative approach can be developed to address the problems.

Thames Water also has a statutory obligation to comply with environmental legislation. The Water Framework Directive establishes a strategic approach to managing the water environment, which the Environment Agency achieves through River Basin Management Plans and setting environmental objectives for groundwater and surface water. The environment is also protected from adverse effects of discharges of urban wastewater through the Urban Wastewater Treatment Directive, which requires us to improve and extend the sewerage system according to section 94 of the Water Industry Act (1991).

Anticipated unavoidable discharges

Within recent years there have been unplanned unconsented unavoidable discharges in the network as a result of surcharging manholes causing pollution. This has been as a direct result of the influence of groundwater infiltration.

We anticipate that this situation may continue until such time we are able to implement a long-term solution.

General outline plan & timescale

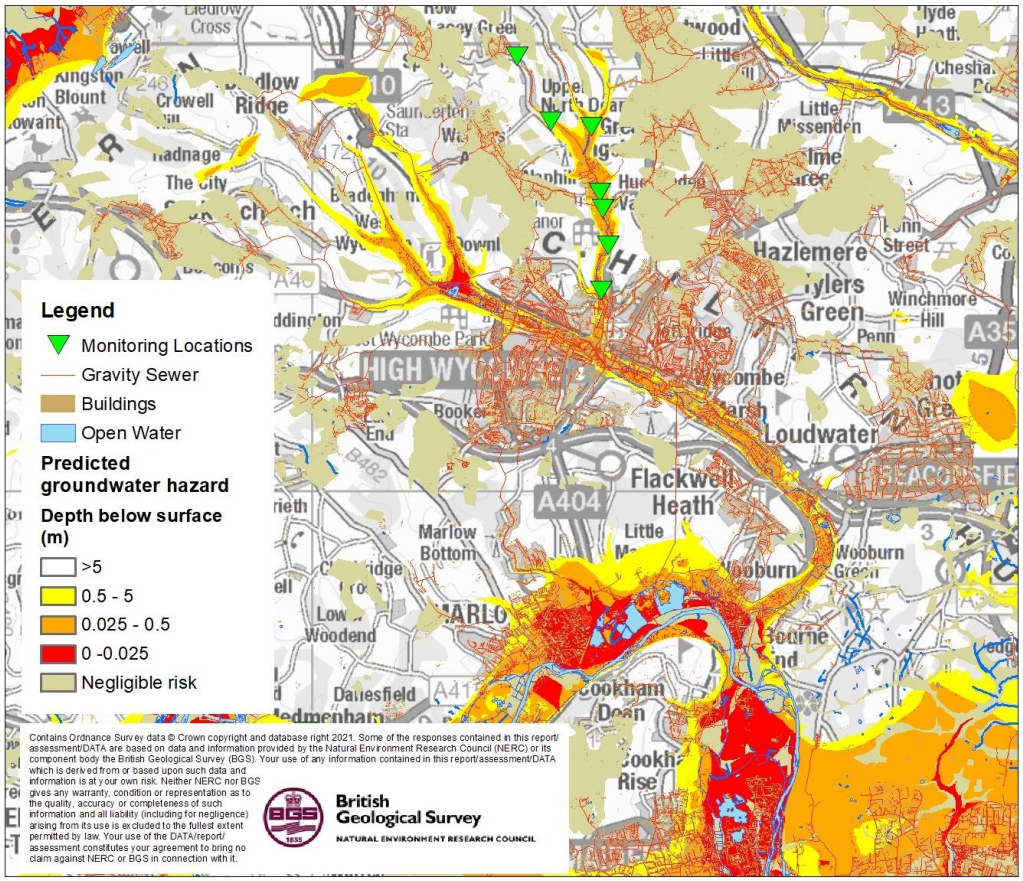


Figure 2.0 – Little Marlow monitoring and infiltration zones

Key to bringing the impact of groundwater infiltration under control is an enhanced monitoring regime. We have identified and have installed telemetered depth monitors in the Little Marlow system. Figure 2.0 presents a plan of current installation locations.

Complimenting the flow [at the treatment works] and depth measurement [in the sewer network] we will use pumping station run time data, rainfall data, river level data, and groundwater level data to create a full picture of movement and source of flows around the catchment.

Zones of Groundwater Risk

We engaged with JBA Consulting to develop plans for Little Marlow that identify zones of groundwater risk, see Figure 2.0. These zones are modelled areas where the groundwater has been determined to be above the sewer and hence pose a potential risk for groundwater ingress.

The sewer depth monitors referred to earlier are sited in and around these zones to verify and calibrate the risk in each of the zones.

If following the proposal to the sealing in part or wholly[4] of the high risk zones in AMP8[5], should it be required, the system is found to be still experiencing excessive infiltration we would then look to potentially seal 'private' laterals and/or drains along with starting to seal the medium to low risk zones. The decision on this will be based on information obtained from the monitors and depending on the scale of further work required this may need to form part of PR29[6] investment planning.

The monitors are also to be used to monitor change within the system hence even should we determine that infiltration has been brought under control, we will continue to monitor for potential trends in infiltration suggesting the need for further work. We also anticipate monitoring the response of the catchment to surface water and where appropriate will use the monitor data to address this source of storm flow.

With this plan we remain committed to minimising the impact of groundwater on the sewerage system in Little Marlow.

Our general medium to long term plan is therefore to apply a hierarchy to sealing the sewer as follows:

Activity	When	Description
Model Zones	2020/21	JBA have been engaged to undertake modelling activities to identify the areas (zones) to be targeted for sealing in the 56 systems identified as being impacted by infiltration in the Thames Water region.
Install monitors	2021-2023	Monitor plans have been developed to help calibrate and validate the zones. Each year completeness / coverage monitors will be reviewed and added to / or modified as necessary.
Calibrate zones	Refined each year	Following each winter, we intend to review the data from the monitors and if necessary, redefine the zones.
Look & Lift	Each winter	The look & lift surveys have two purposes, firstly to compliment the monitoring and secondly to identify 'quick fixes' that we would address through our normal capital maintenance.
CCTV	2020-2023	Required to confirm sewer condition and provide information to assist with costing any sewer lining.

[4] Decision of extent of sealing will be based on outcomes of works undertaken in AMP7, results of monitoring and successful submission of our plans for investment for AMP8.

[5] Asset Management Plan 8 – covering work between 2025-2030

[6] Price Review 2029

Activity	When	Description
Minor works	2020-2023	As mentioned, if we detect minor works being required, we will look to resolve these as and when we find them.
PR24	2023/24	Ideally through monitoring and on-going investigations work towards managing the infiltration risk, in AMP7, will be successful. However, in the absence of evidence justifying the need not to undertake sealing of the high-risk zone this is to be included as part of PR24 investment plan. This work will be subject to Cost Benefit Analysis and Best Technical Knowledge Not Entailing Excessive Cost (BTKNEEC assessments).
High risk zone sealing	2025-2030	Sealing of high-risk zone undertaken subject to need being demonstrated.

Little Marlow Infiltration Management Plan

As detailed above the impact of infiltration is largely experienced in the network.

Our approach to the resolution of infiltration impacting the Little Marlow sewerage system is outlined below.

High level approach statement

For Little Marlow our approach to tackling infiltration will be undertaken as follows:

1. We will investigate the network further with a view to identifying sources of ingress of infiltration that are cost effective[7] to address. To investigate the network, we have:

- Undertaken a desktop analysis to determine infiltration high to low risk zones (October 2020);

- Use installed monitoring to back up the analysis and to aid focusing of locations for identification of infiltration (2021 to 2023). Each year we will assess the completeness of monitoring and if required add to or modify the current locations.

To investigate the network, we will:

- Undertake sample CCTV in the high to low risk zones to assess the general asset health of the sewers and manholes (ongoing).

We will also review results of Winter 2019/20 and 2020/21 with historic data to build up evidence to support interventions in the network (Autumn 2021).

2. Where interventions can be undertaken as part of normal sewer maintenance activities these will be communicated and progressed.

3. If significant investment is identified as being required, then this will need to be considered in terms of relative need compared to other systems being investigated for infiltration reduction and need. Significant investment needs may need to be included in our next investment planning cycle at PR24.

[7] Assessment of cost effectiveness is based on assessment of the ratio of the cost of a solution to the monetised benefit gained from implementing the solution i.e. reduction in flood/pollution risk and/or reduced operating costs.

Investigations

As mentioned above we have commissioned JBA Consulting to undertake an exercise involving groundwater elevation data to determine which areas of the network are potentially below the groundwater table during high groundwater periods.

Site investigations, undertaken by Dene-Tech and our Customer Field Services (Thames Water Operations) will include 'look & lift' surveys, CCTV and where necessary dye tracing to confirm connectivity.

A table of the work undertaken is included in the appendix to this report.

Monitoring

Sewer Depth Monitors will be installed in the catchment in between 2021 and 2023. These devices are telemetered and provide real time data on the level of flow in the sewer.

The purpose of these units is to act as alerts for high groundwater impact in the sewer, calibration of the zones of infiltration risk and to demonstrate benefit gained from work undertaken to reduce infiltration. They will also provide evidence in the future of further need to manage the impact of infiltration.

Mitigation

On occasions to avoid flooding of properties or to manage the risk of damage to the environment we may undertake tankering from within the network, make use of pumps to contain flows or deploy settlement tanks to part treat sewage before release to the environment.

With regard to Little Marlow we do not envisage needing to undertake mitigation work beyond tankering within the network.

Updates

Work on the Groundwater infiltration management plan will continue, and we will aim to provide updates annually by the end of October each year.

Appendix

Groundwater infiltration potential analysis

The sewer network classified by the groundwater infiltration risk zones. The lengths of sewers within these zones are presented in the table below.

Risk category	Description	Length (km)	Percentage
High	Predicted groundwater extreme >1m above pipe invert	113.17	17.2
Medium	Predicted groundwater extreme 0-1m above pipe invert	21.54	3.3
Low	Predicted groundwater extreme 0-1m below pipe invert	28.99	4.4
Very Low	Predicted groundwater extreme >1m below pipe invert	492.81	75.1
Total		656.51	100.0

In addition, the table below presents the surface water flood risk classification for manholes within the catchment.

Manholes by Surface Water Inundation Risk Category

Risk category	Description	Number	Percentage
High	Inundation risk in 3.3% AEP fluvial or pluvial event	2767	11.9
Medium	Inundation risk in 1% AEP fluvial or pluvial event	1117	4.8
Low	Inundation risk in 0.1% AEP fluvial or pluvial event	3072	13.2
Very Low	All other manholes	16339	70.1
Total		23295	100.0

Investigations & remedial work undertaken since 2019/20 and future plans

Lift and Look and CCTV surveys have not yet commenced in the Little Marlow system. A summary of findings will be provided in the next update of this report.

Glossary of terms

AEP – Annual Exceedance Potential

AMP – Asset Management Programme

CCTV – Closed Circuit Television

EA - Environment Agency

IRP – Infiltration Reduction Plans

MH – Manhole

STW – Sewage Treatment Works

WINEP – Water Industry National Environment Programme

Addendum – Annual Update 2022

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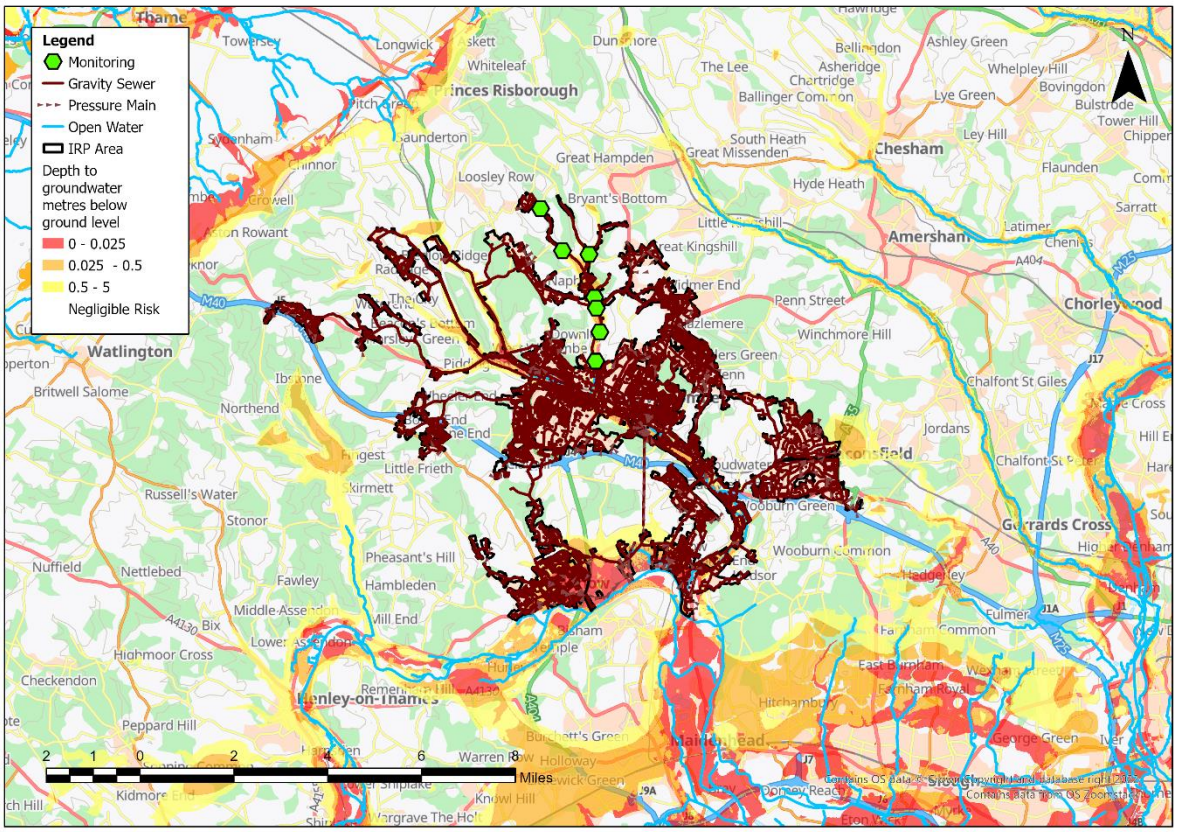
Overview

This addendum to the Little Marlow Groundwater Impacted System Management Plan 2021 (GISMP) provides an update on performance/work undertaken in the Hydrological Year October 2021 to September 2022. The key points covered include:

- Hydrological conditions
- How the sewerage system has performed over this period
- Mitigation / remedial measures progressed over the last year and being planned
- Summary and plan for 2022/23

Figure 1 – Little Marlow Monitoring Plan



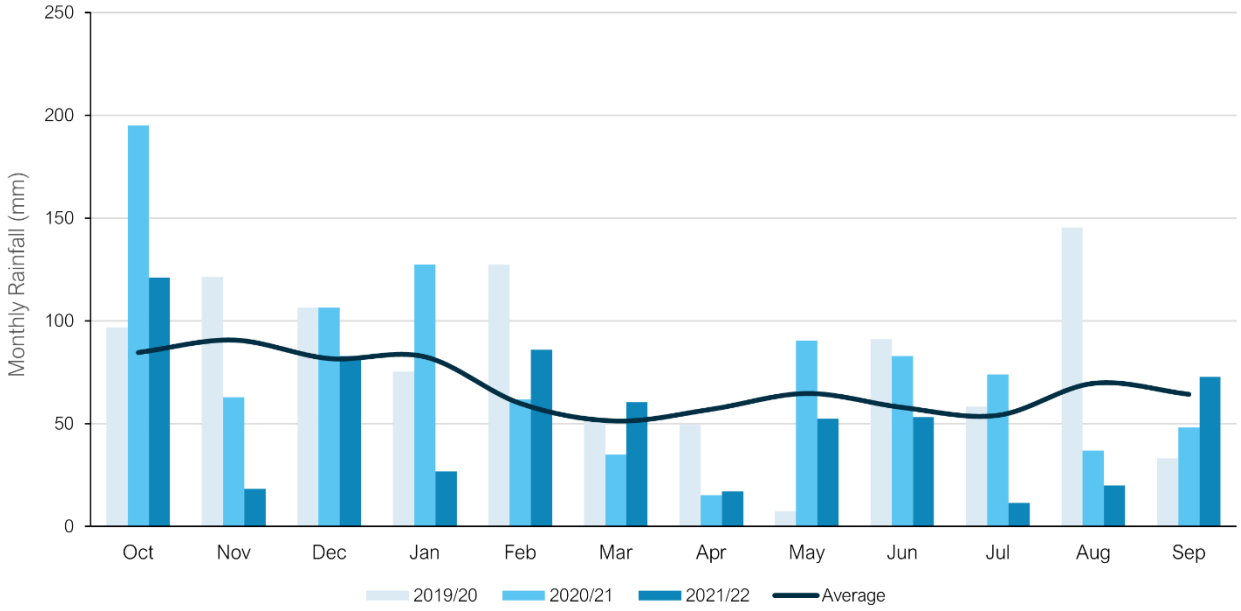
Hydrological Review – 2021-2022

This section summarises the hydrological conditions within the Little Marlow catchment within the period under investigation and provides comparison against previous year's performance to put the annual performance into context. The hydrological review has been undertaken based on the Hydrological Year which runs October 1st to September 30th.

Catchment Rainfall

Representative Radar rainfall has been used to generate monthly data at catchment level for comparison with average data generated by local Met Office Weather Station Records. Figure 2 presents the comparison of this data for the last three hydrological years to support longer term trends within the local system.

Figure 2 – Monthly Rainfall Performance



Average Values taken from Met Office Weather Station at High Wycombe based on the period 1991-2020

The total rainfall for the 2021/22 hydrological year is 22% below the annual average total. Total rainfall values are presented in Table 3 below.

Table 3 –Total Rainfall Based on Hydrological Year

Average (mm)	2019/20 (mm)	2020/21 (mm)	2021/22 (mm)
817	964	936	634

Groundwater / Local River Level

The Little Marlow catchment is situated in the Chilterns West, Chilterns East - Colne and North London water resources areas. It primarily sits in the Lewes Nodular Chalk Formation, Seaford Chalk and Newhaven Chalk Formation and the New Pit Chalk Formation. These are designated principal aquifers within the UK.

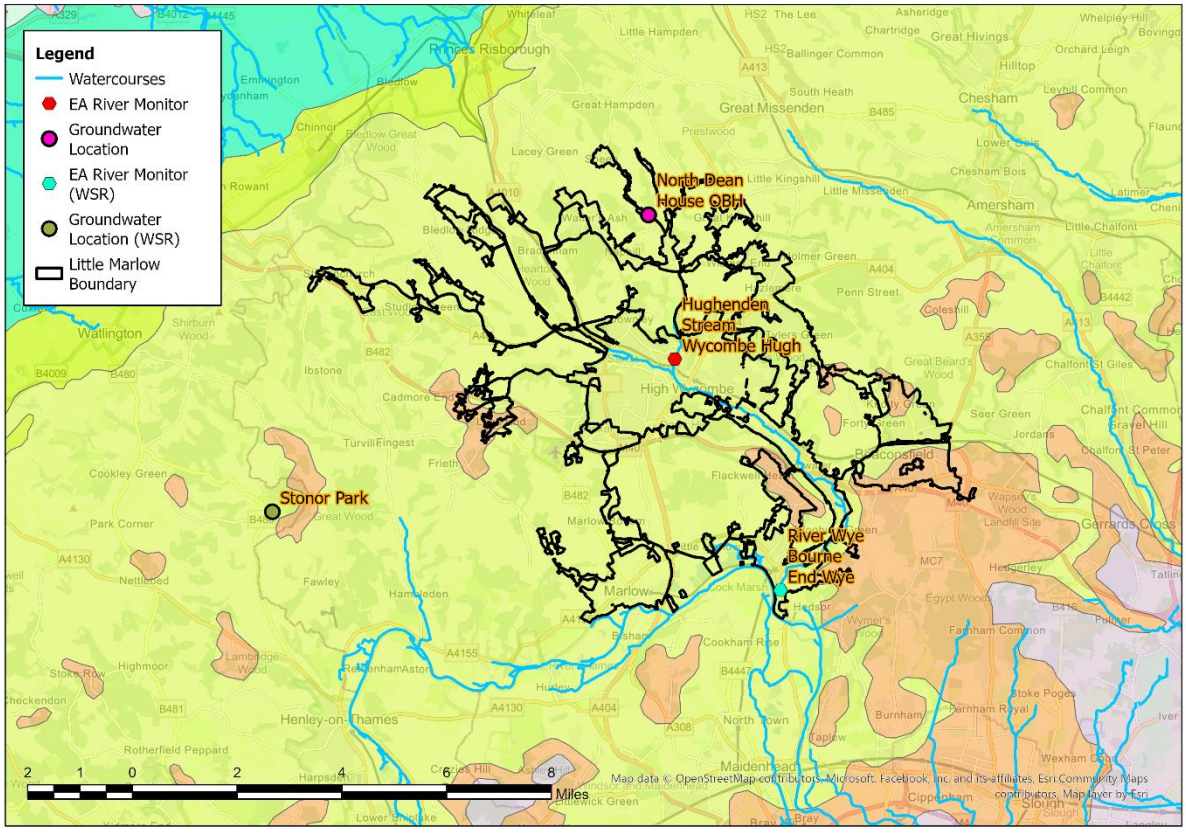
The Environment Agency has gauging stations on local watercourses measuring stage and observation boreholes measuring groundwater levels locally to the catchment which can be used to provide indicative local groundwater performance.

From previous investigations we have identified the following sites are good indicators of groundwater levels within the catchment.

- Hughenden Stream, Wycombe Hugh.
- North Dean House OBH.

These sites are illustrated in the figure below, alongside the closest groundwater reference station and closest gauging station from the Water Situation Report.

Figure 4 – Local Monitoring Stations



The following figures represent the last three hydrological years of level information at the indicator sites to build a picture of the relative conditions prevalent in the current year. It is presented against both the daily total rainfall values for the catchment and a rolling 15 day total rainfall.

Figure 5A – Hughenden Stream, Wycombe Hugh

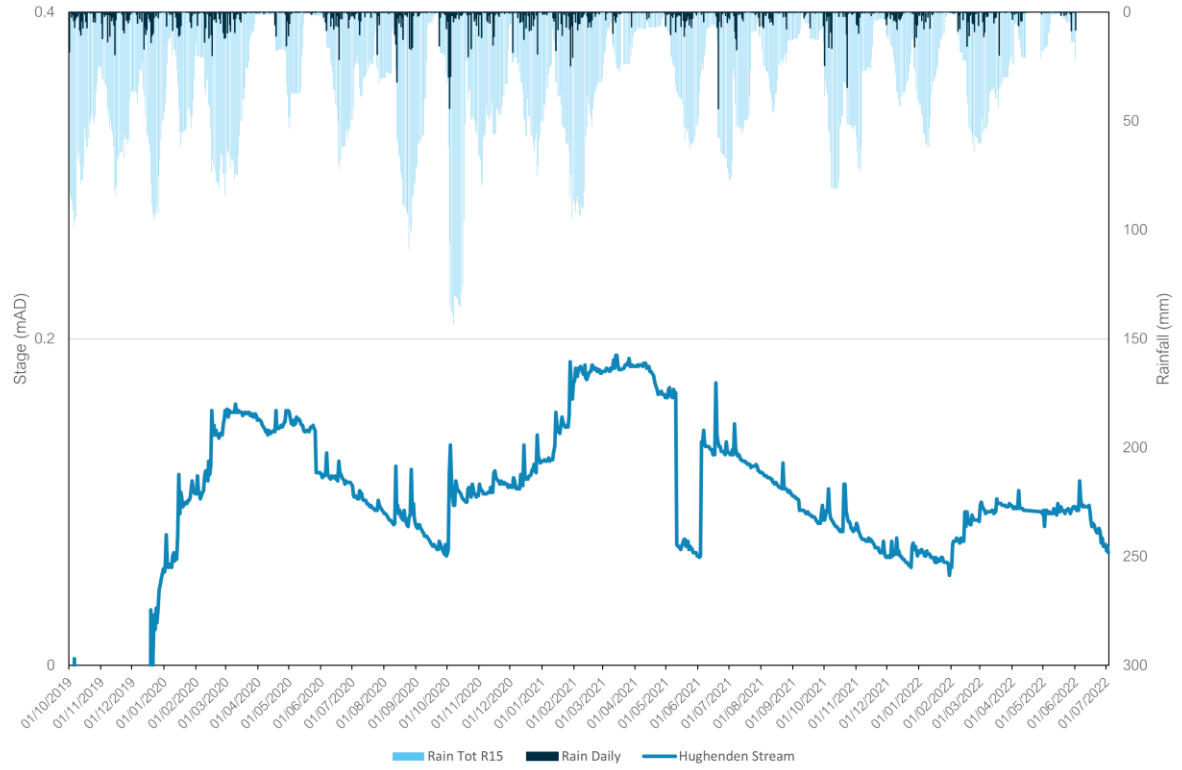
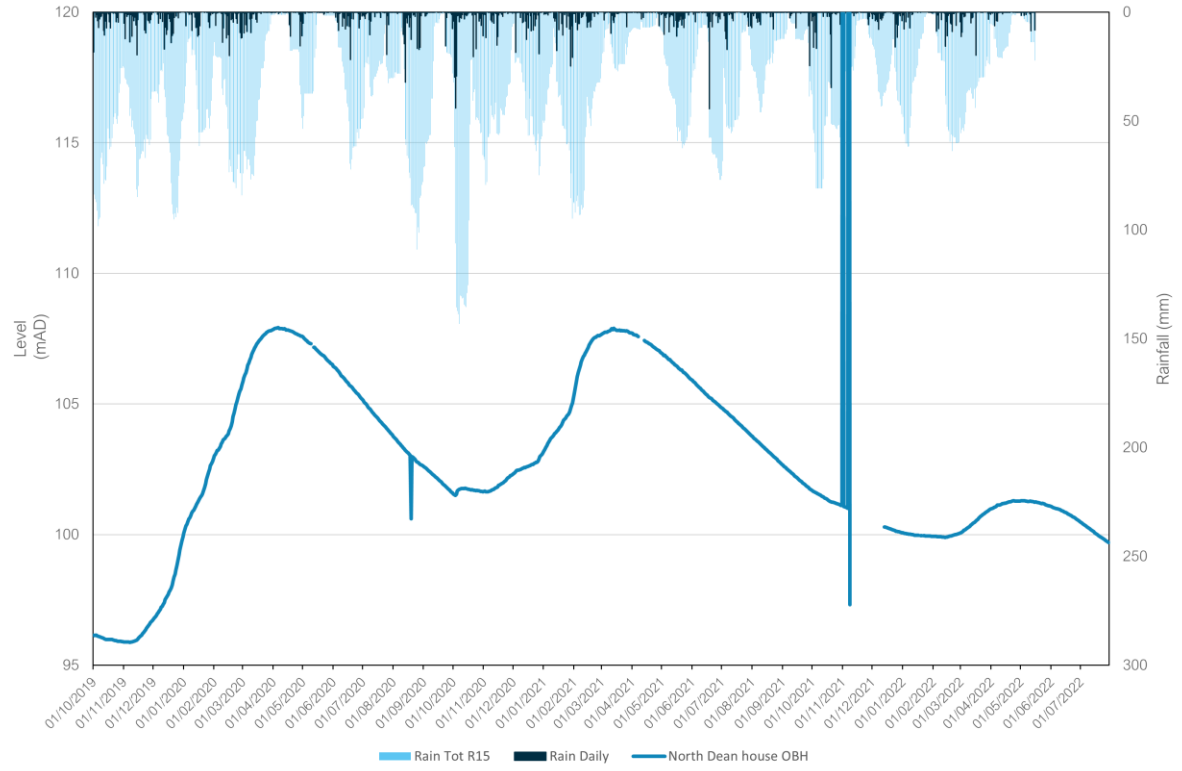
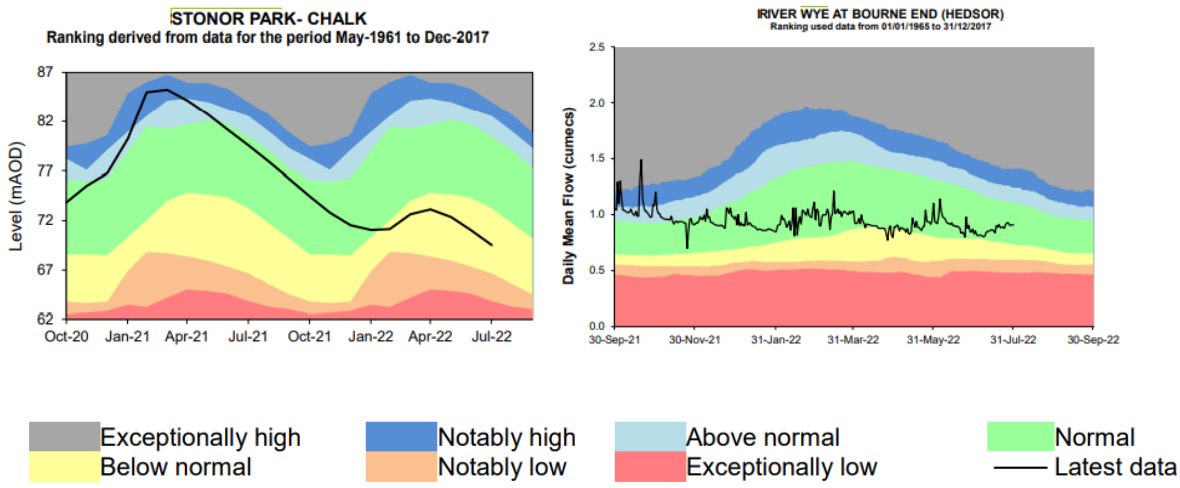


Figure 5B – North Dean House OBH



In addition to these specific stations, the wider groundwater context is illustrated in the Water Situation Report for Chilterns West. The nearest groundwater reference station is Stonor Park. This site shows significantly lower overall groundwater than the previous year. This can be seen in the figure below alongside the river indicator location at Bourne End on the River Wye.

Figure 6 – Water Situation Report



Extract from - [Water Situation Report (publishing.service.gov.uk)]

Network Performance

Within the Little Marlow catchment there is one site detailed within the Environment Agency Consents Database which has an Event Duration Monitor (EDM) fitted.

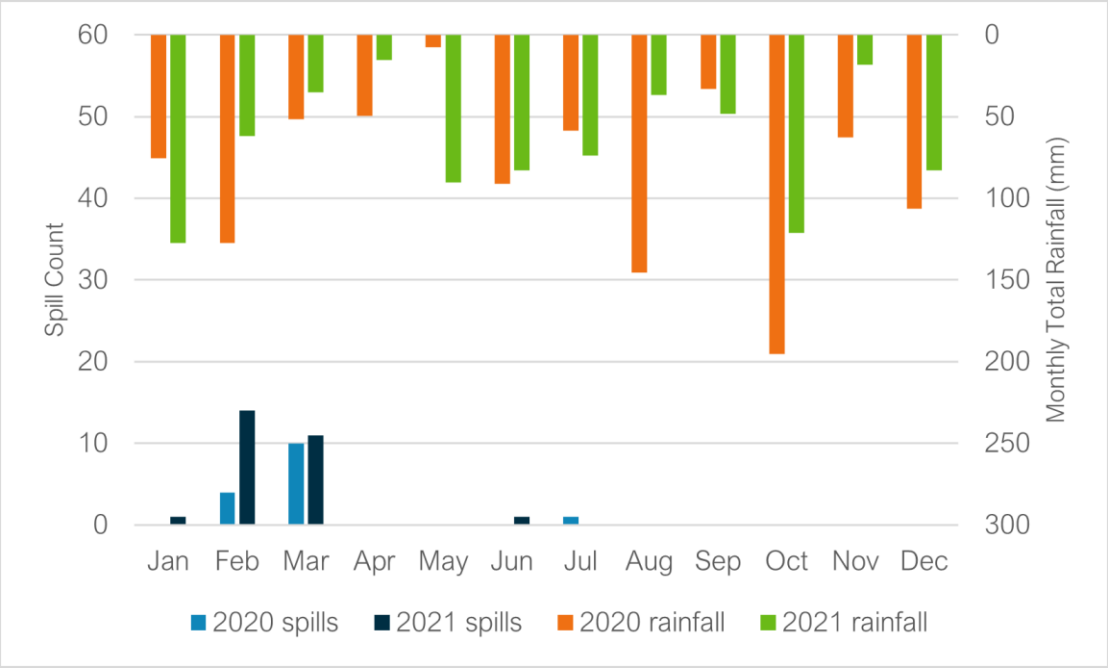
Table 7 below details the last 2 years performance of overflows within the catchment.

Table 7 – Event Duration Monitoring

Overflow	2020		2021	
	Spills	Duration (hours)	Spills	Duration (hours)
Little Marlow STW	15	150.94	27	464.69

A critical part of the assessment of EDM performance and its relation to groundwater inundation is to review the month-on-month spill performance, against previous years and the monthly total rainfall values to give context to the performance. Figure 8 below presents the EDM performance trend and rainfall for recent years. Note that the EDM monitor was only operational for 84% of the time in 2020. Note also that one of the Final Settlement Tanks at Little Marlow STW was not in operation during 2021. Therefore, 2021 spills were likely impacted by asset availability, as well as resilience at Little Marlow STW for wet weather periods.

Figure 8 – EDM Monthly Performance



The trend in spill performance across the two recorded years does show variation in spills, with an overall focus on spills during the winter months. The data suggests a wider relationship between rainfall, elevated groundwater levels and spill frequency. Despite significantly less rainfall in February 2021 compared to in January 2021, the spill count in February 2021 was significantly higher than in January 2021. The indicator sites suggest groundwater levels in the catchment were higher in February 2021.

Investigations & Interventions

This section details the activities that have been undertaken within the catchment within the Hydrological Year 2021-22.

Monitor Installations

The sewer depth monitor (SDM) programme supports long term groundwater understanding within GISMP catchments. Currently, there are a total of 7 monitors installed within the Little Marlow catchment. There are currently no further monitor installs planned.

The data from these will be cross-referenced with other long-term records (where available) within the catchment.

Remediation Works Undertaken this Hydrological Year

Table 9 below provides a summary of the investigations and remediation works undertaken or planned within the Little Marlow catchment in the 2021-22 Hydrological Year.

Table 9 – Works Undertaken in the 2021/22 Hydrological Year

Investigation/ remediation type	Number/ length undertaken
CCTV survey	432 metres
Look and lift survey	N/A
Sewer lining	139 metres*
Patch lining	10
Manhole sealing	N/A
Manhole sealing plates	N/A
Manhole covers and frames replaced	N/A

*Lining undertaken in response to findings of CCTV surveys

Although the seasonal trends in groundwater have been low in comparison with previous years and the SDM installations are generally not showing significant groundwater presence, targeted surveys and appropriate remedial action have been undertaken where groundwater levels have allowed.

Summary

Rainfall in the Little Marlow catchment over the 2021/22 hydrological year has been below average, with groundwater levels in the aquifer beneath Little Marlow not reaching the levels seen in previous years which triggered groundwater ingress into the sewerage network and elevated flow/depth readings at monitoring sites.

Lift and look and CCTV surveys will continue throughout the remaining wet winter periods within this AMP7 period (2020- 2025) with the aim of finding further priority locations for remediation and investigating/justifying the need for future larger scale lining as part of our 2024 Price Review (PR) process if required.

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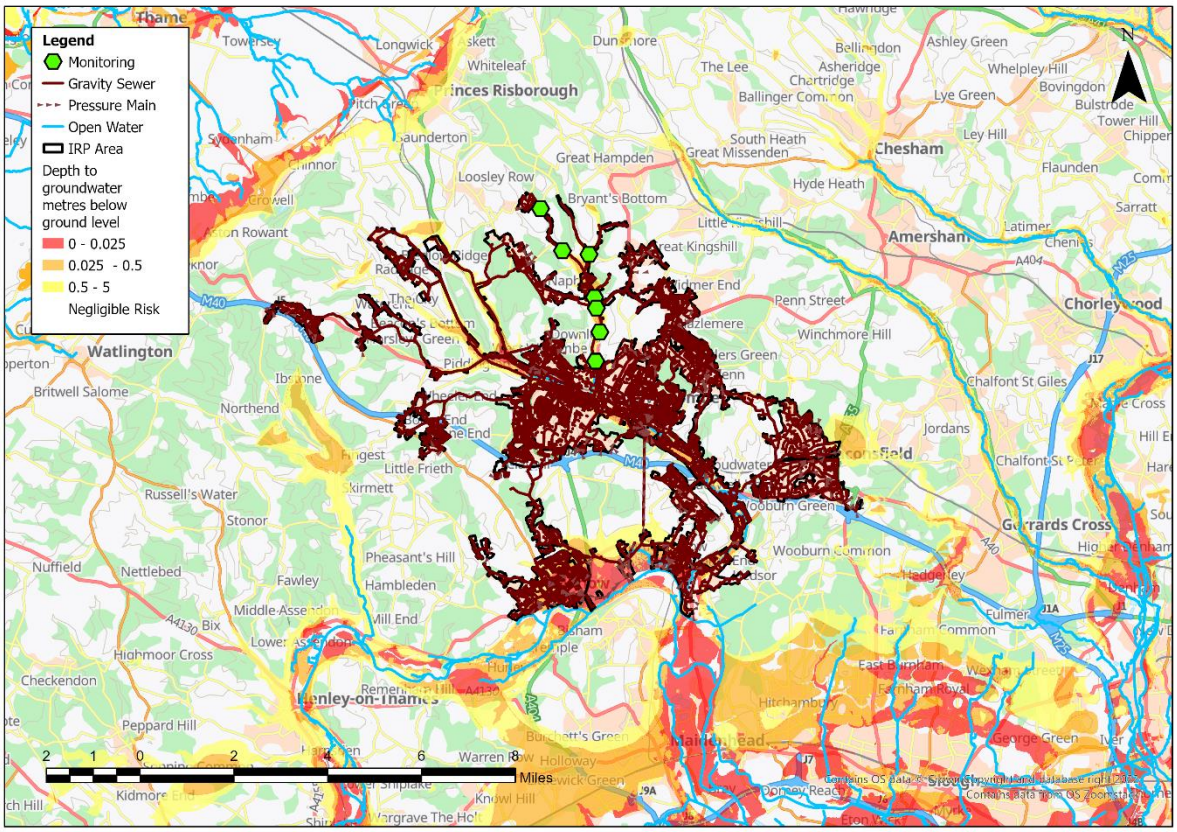

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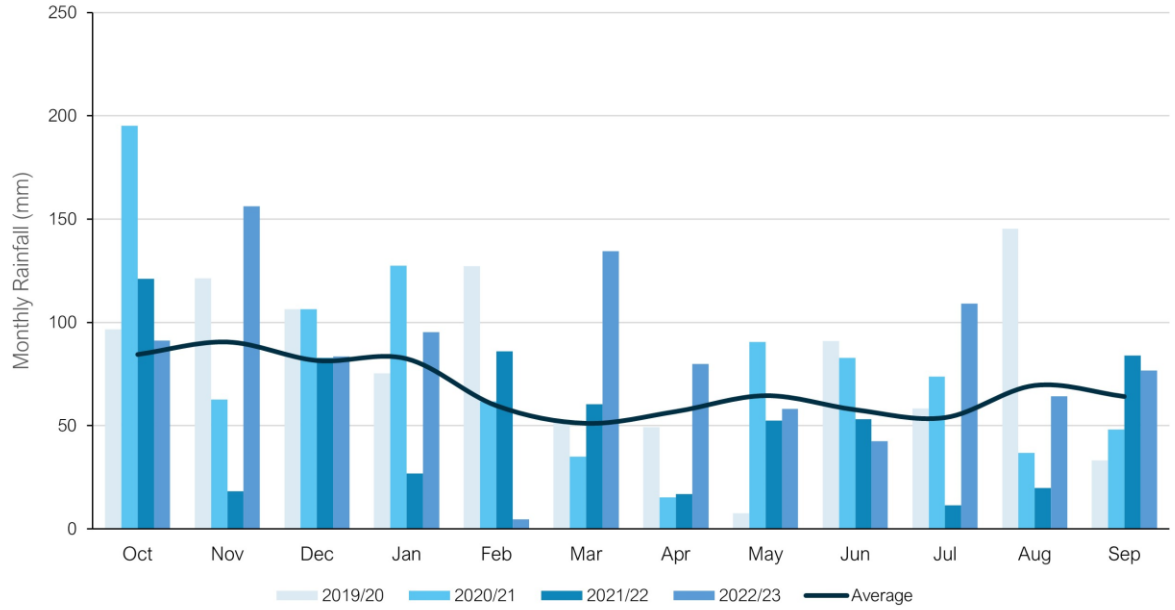

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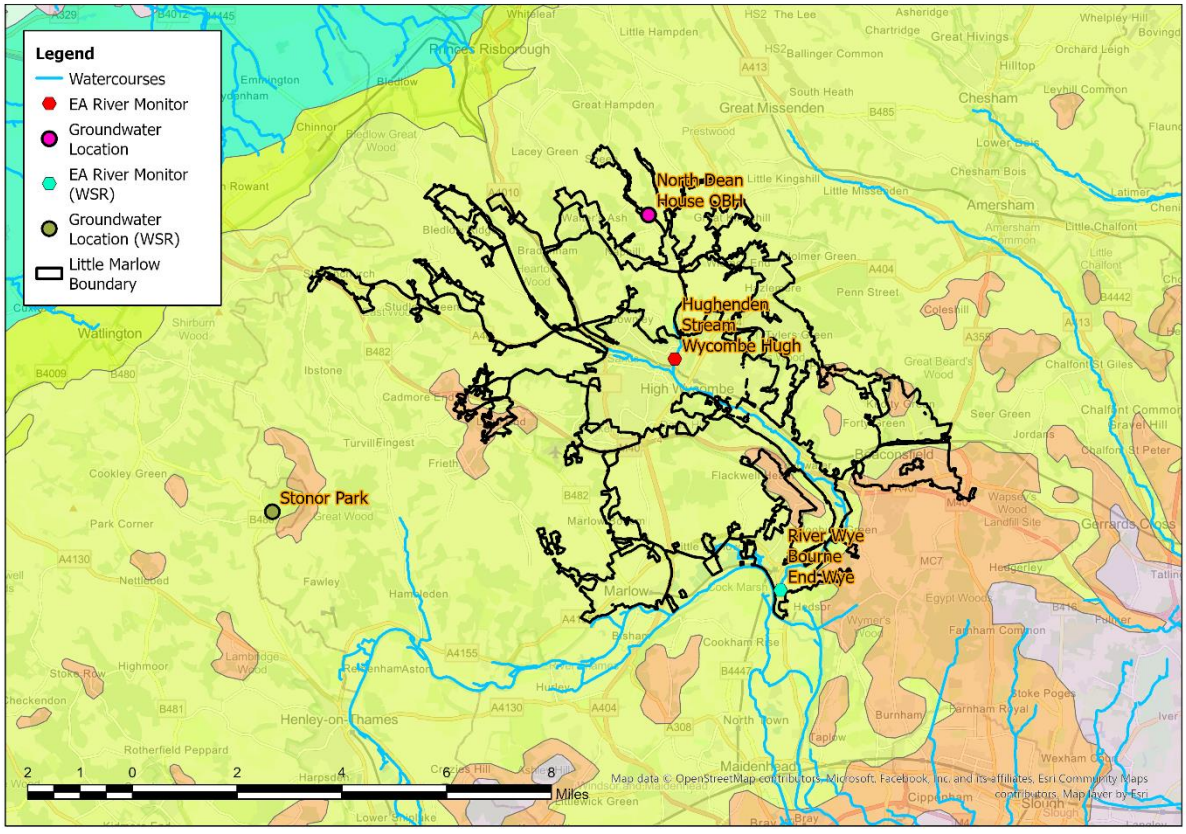

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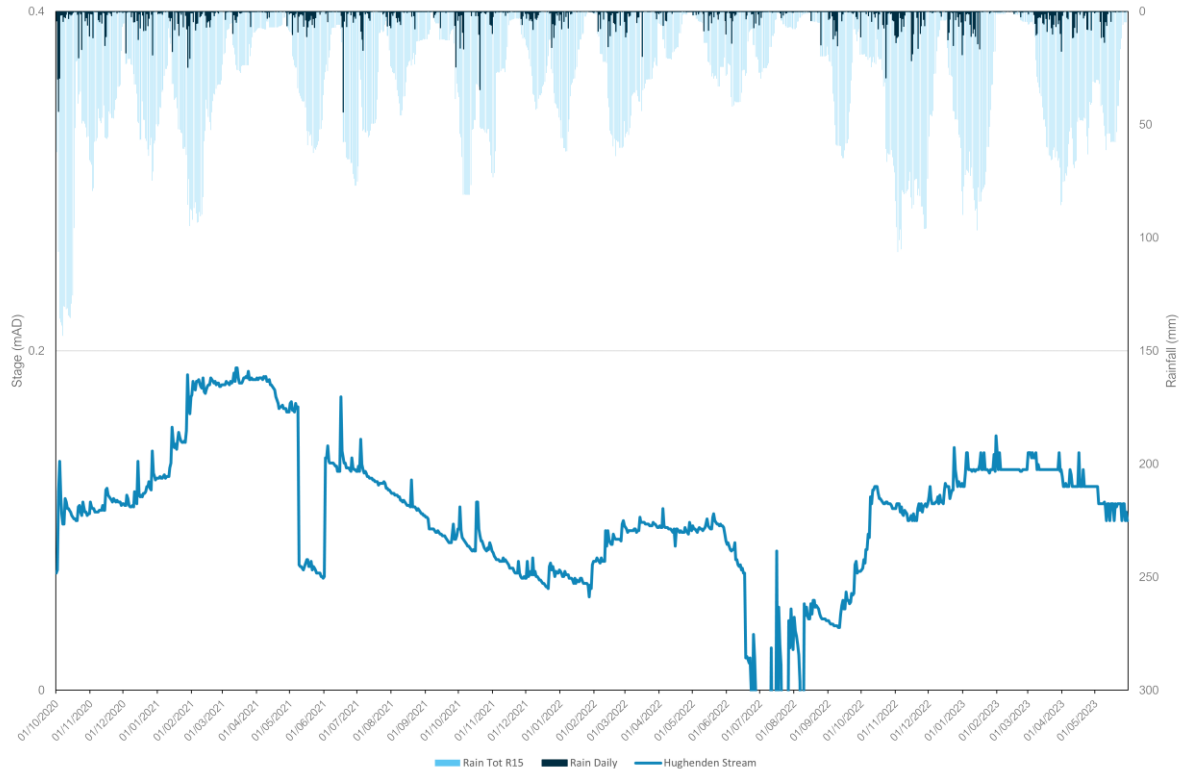

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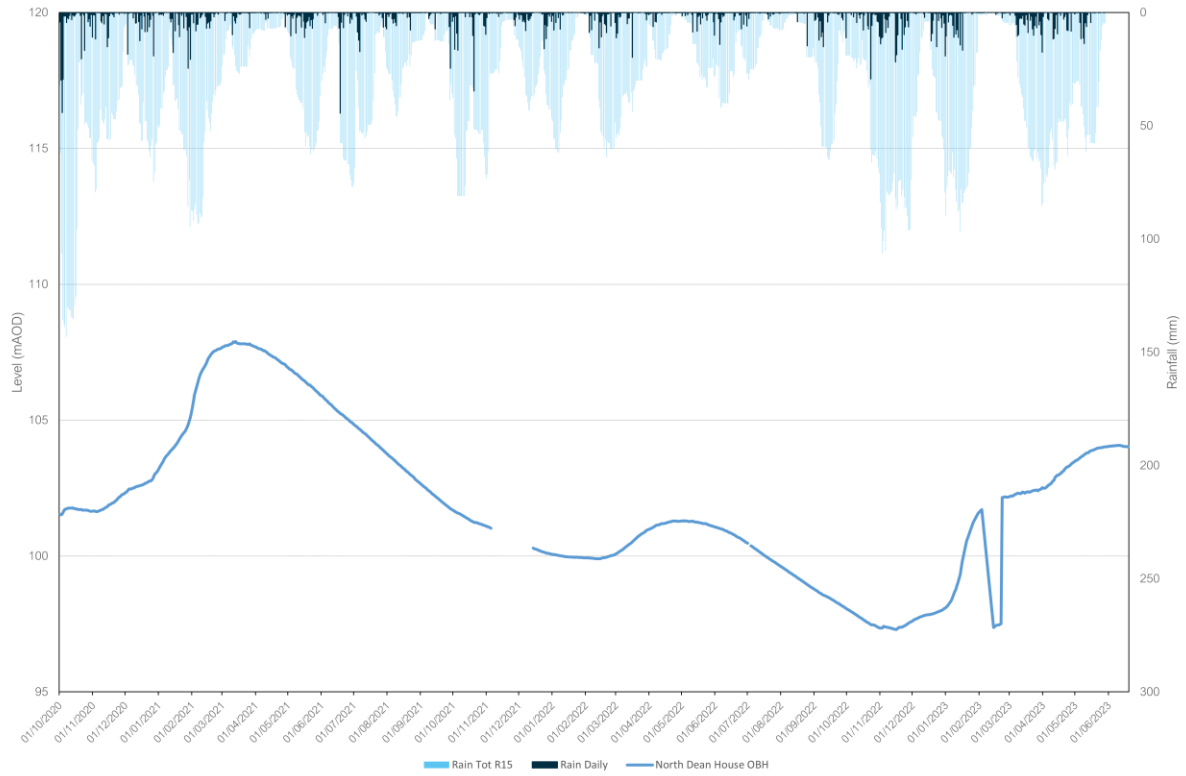

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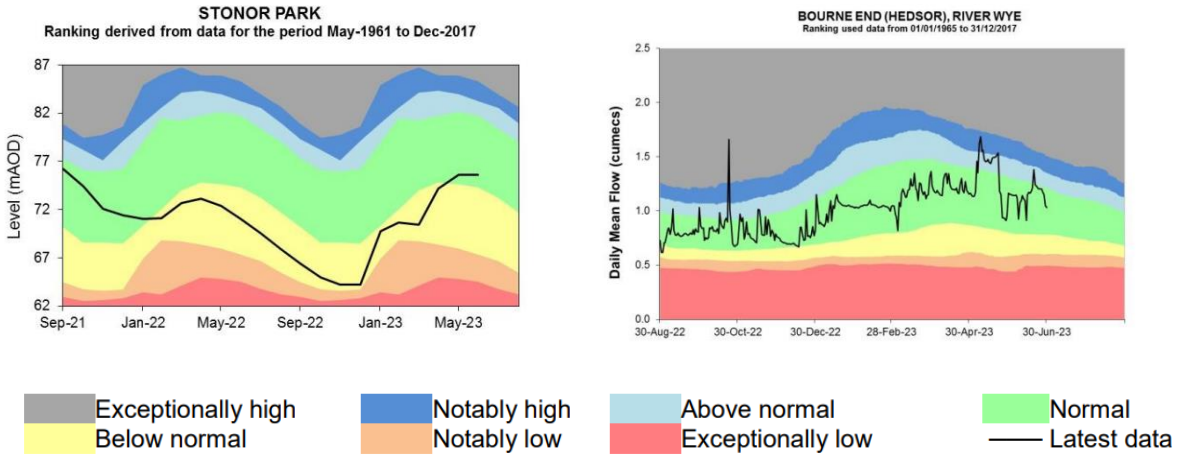


Extract from - [Water Situation Report (publishing.service.gov.uk)]

Network Performance

Within the Little Marlow catchment there are two sites detailed within the Environment Agency Consents Database which have an Event Duration Monitor (EDM) fitted. As part of the process of matching GISMP catchments to EDM sites, an additional EDM site has been included in this year's report, which was not included in last year's addendum report. No spills were recorded at the additional overflow site – High Wycombe – in 2022 or in 2021.

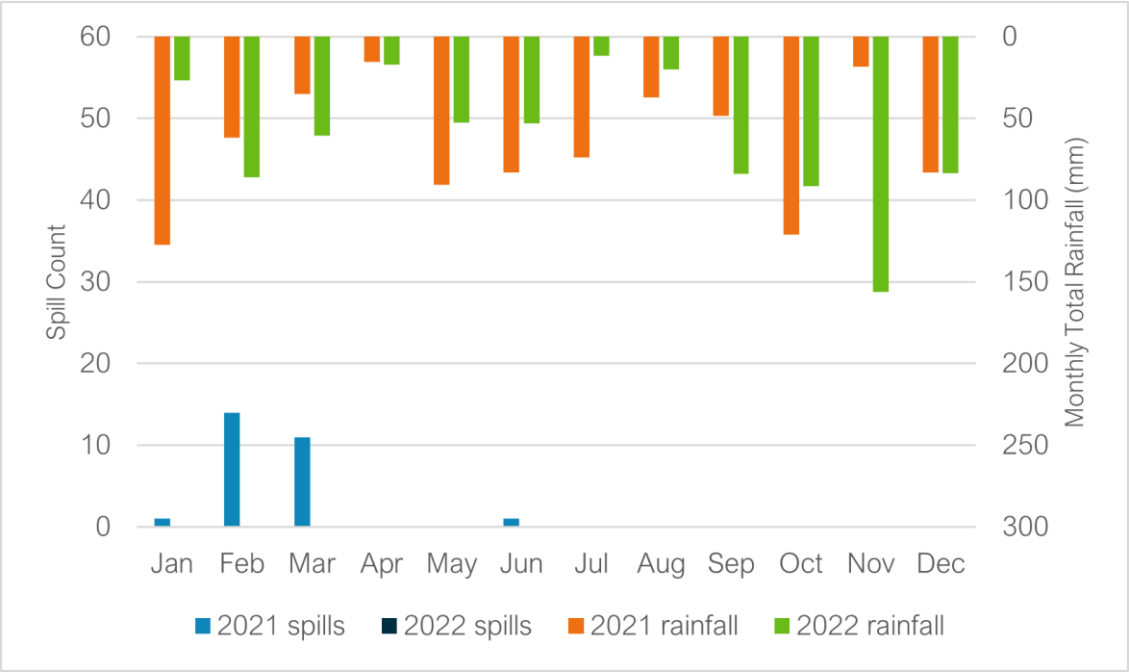
Table 7 below details the last 2 years performance of overflow 'Little Marlow STW'.

Table 7 – Event Duration Monitoring

Overflow	2021		2022	
	Spills	Duration (hours)	Spills	Duration (hours)
Little Marlow STW	27	464.69	0	0

A critical part of the assessment of EDM performance and its relation to groundwater infiltration, is to review the month-on-month spill performance against previous years and the monthly total rainfall values to give context to the performance. Figure 8 below presents the EDM performance trend and rainfall for recent years. Note, one of the Final Settlement Tanks at Little Marlow STW was not in operation during 2021. Therefore, 2021 spills were likely impacted by asset availability, as well as resilience at Little Marlow STW for wet weather periods.

Figure 8 – EDM Monthly Performance



The trend in spill performance across the two recorded years does show variation in spills, with an overall focus on spills during the winter months for the year 2021. The data suggests a wider relationship between rainfall, elevated groundwater levels and overflow spills. No spills were recorded at Little Marlow STW in 2022, with Figure 6 suggesting groundwater levels in the catchment remained below normal throughout the period, and the indicator site data shown in Figure 5 suggesting they were significantly lower than in 2021. However, it is important to note the potential impact of asset availability on spills in 2021.

Investigations & Interventions

This section details the activities that have been undertaken within the catchment within the Hydrological Year 2022-23.

Monitor Installations

The sewer depth monitor (SDM) programme supports long term groundwater understanding within GISMP catchments. Currently, there are a total of 7 monitors installed within the Little Marlow catchment. There are currently no further monitor installs planned.

The data from these will be cross-referenced with other long-term records (where available) within the catchment.

Remediation Works Undertaken this Hydrological Year

Table 9 below provides a summary of the investigations and remediation works undertaken or planned within the Little Marlow catchment in the 2022-23 Hydrological Year, as well as works undertaken in the 2021-22 Hydrological year.

Table 9 – Works Undertaken in the 2022/23 Hydrological Year & in the 2021/2022 Hydrological Year

Investigation/ remediation type	Number/ length undertaken 21/22	Number/ length undertaken 22/23
CCTV survey	432 metres	N/A
Look and lift survey	N/A	N/A
Sewer lining	139 metres*	N/A
Patch lining	10	N/A
Manhole sealing	N/A	N/A
Manhole sealing plates	N/A	N/A
Manhole covers and frames replaced	N/A	N/A

*Lining undertaken in response to findings of CCTV surveys

No interventions/ investigations were carried out in the catchment in the 2022/23 Hydrological Year. However, the system will continue to be monitored and investigations/ interventions carried out as appropriate and when conditions allow.

An upgrade is also planned for Little Marlow STW. This will improve its ability to treat the volumes of incoming sewage, reducing the need for untreated discharges to the environment. The scheme, which is still in the design phase, is likely to be completed in 2027.

Summary

Indicator site data suggests groundwater levels in the Little Marlow catchment were significantly lower in 2022 than in 2021. No EDM spills were recorded at little Marlow STW in 2022, with indicator site data suggesting groundwater levels in the catchment were below normal throughout the period. Although EDM data is indicative of the role of groundwater infiltration on spills in the catchment, it is important to note the potential impact of asset availability on spill frequency in 2021 compared to 2022.

This hydrological year, indicator site data suggests groundwater levels in the catchment have reached higher levels than the previous hydrological year, and EDM data for 2023 will be analysed once available to continue to examine the relationship between groundwater levels and overflow spills in the catchment.

Lift and look and CCTV surveys will be undertaken in the remaining wet winter periods if conditions allow, within this AMP7 period (2020- 2025). The aim of this is to find further priority locations for remediation and investigating/justifying the need for future larger scale lining as part of our 2024 Price Review (PR) process if required.

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