BBLP & Herefordshire Council

ORLETON CULVERT ASSESSMENT TECHNICAL NOTE

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1 INTRODUCTION

WSP has been commissioned by Balfour Beatty Living Places and Herefordshire Council to create a Technical Note to summarise a simplistic hydraulic assessment of the Ashley Moore culvert/B4361 culvert/ Brimfield brook culvert and Millbrook Way Bridge. The goal is to assess if hydraulic capacity is available at the Millbrook Way bridge, should it be possible to pass more flow through the Ashley Moore culvert.

This Technical Note report describes the existing flood conditions, proposed methodology; assumptions made and highlights specific design considerations to enable Herefordshire Council and Orleton Parish Council to consider the next steps when tackling the flooding issue. WSP have utilised the Briefing Notes produced by Orleton Parish Council regarding the flooding, Ashley Moore and Millbrook Way bridge and site plans as well as drawing on information provided by Herefordshire Council and Balfour Beatty Living Places, such as the Section 19, Bridge Surveys, inspections and Orleton Concept Report 2025 as the basis for the assessment

1.1 CONTEXT

The village of Orleton, located in North Herefordshire, on a branch of the Brimfield Brook approximately 4km upstream of its outfall at the River Teme. Figure 1 shows the location of Orleton. Orleton has faced significant challenges with surface water flooding for many years as highlighted with the Briefing Note included in Appendix A.

The Briefing Note provided by Parish Council on flooding of the B4361 Ashley Moore culvert and Millbrook Way Bridge provides a detailed history of flooding in Orleton, focusing on the persistent reasons for fluvial as well as severe surface water flooding at the Maidenhead junction, the B4361 and Millbrook Way. Flooding has been frequent, with notable events in 2007, 2019, 2020, and throughout winter 2023–2024. Table 1 lists rainfall totals corresponding to these events, highlighting the vulnerability of the area.

Table 1: Rainfall during flood events experienced in Orleton (Source: Brief Note on defects in the design and construction of Millbrook Way Bridge, July 2024)

Experience Flood Event	24hour Rainfall Totals
20.07.2007	62.4mm
20.10.2019	40.2mm
15.02.2020	34.2mm
12.10.2023	22mm
19.10.2023	30.2mm
03.12.2023	22.4mm
02.01.2024	21.2mm
08.02.2024	21.8mm
24.11.2024	43.4mm
Note: Data from EA Brimfield Rain Gauge / Station ID443286	

Despite the implementation of several flood mitigation schemes, flooding remains a frequent and disruptive issue. The B4361 serves as a vital local link road and is the designated diversion route for the A49, while Millbrook Way provides the primary access into the village. Flooding of either property or highway—particularly when it leads to road closures—raises significant safety concerns and causes considerable disruption to residents and traffic.

The flooding event on 24 November 2024, associated with Storm Birt, highlighted the vulnerability of the area. The primary cause of flooding during this event was the overtopping of Brimfield Brook upstream of the Ashley Moore culvert. This was due to insufficient hydraulic capacity and complex hydraulic interactions, which led to a substantial accumulation of water in the area. The overtopping resulted in water flowing onto the B4361 and subsequently into Orleton village. Additionally, the limited capacity of the existing highway drainage system exacerbated the surface water flooding.

Figure -1: Large Scale Map showing the location of Orleton

1.2 SCOPE OF WORK

Orleton Parish Council has prepared a proposal to address the design issues associated with the Ashley Moore culvert and Millbrook Way bridge as part of ongoing efforts to manage village flooding. The proposal outlines the indicative locations of the culvert and bridge, provides a brief history and summary of alterations made to the culverts, and details the identified design and construction deficiencies as well as the existing channel or brook capacity. However, to fully understand water flow dynamics and develop effective flood mitigation strategies that reduce flooding along Millbrook Way a detailed hydrologic modelling is necessary.

WSP have been commissioned by Balfour Beatty Living Places working for Herefordshire Council to take this assessment which includes:

- Build a hydraulic model based on the information available, rainfall data and hydraulically test system for a series of return periods.
- Undertake a desk-based analysis of proposal, reviewing the performance of the culvert

2 METHODOLOGY

2.1 CATCHMENT AREA

The first step in the process involved identifying the catchment area. QGIS software was used to delineate the catchment extent and assess the topography for both the Ashley Moore Culvert and the Millbrook Way Bridge, utilising high-resolution LIDAR (Light Detection and Ranging) data. To validate the delineated catchments, a secondary review was conducted using data from the UK Centre for Ecology and Hydrology. Figure 2 illustrates the catchment area located upstream of the B4361 culvert.

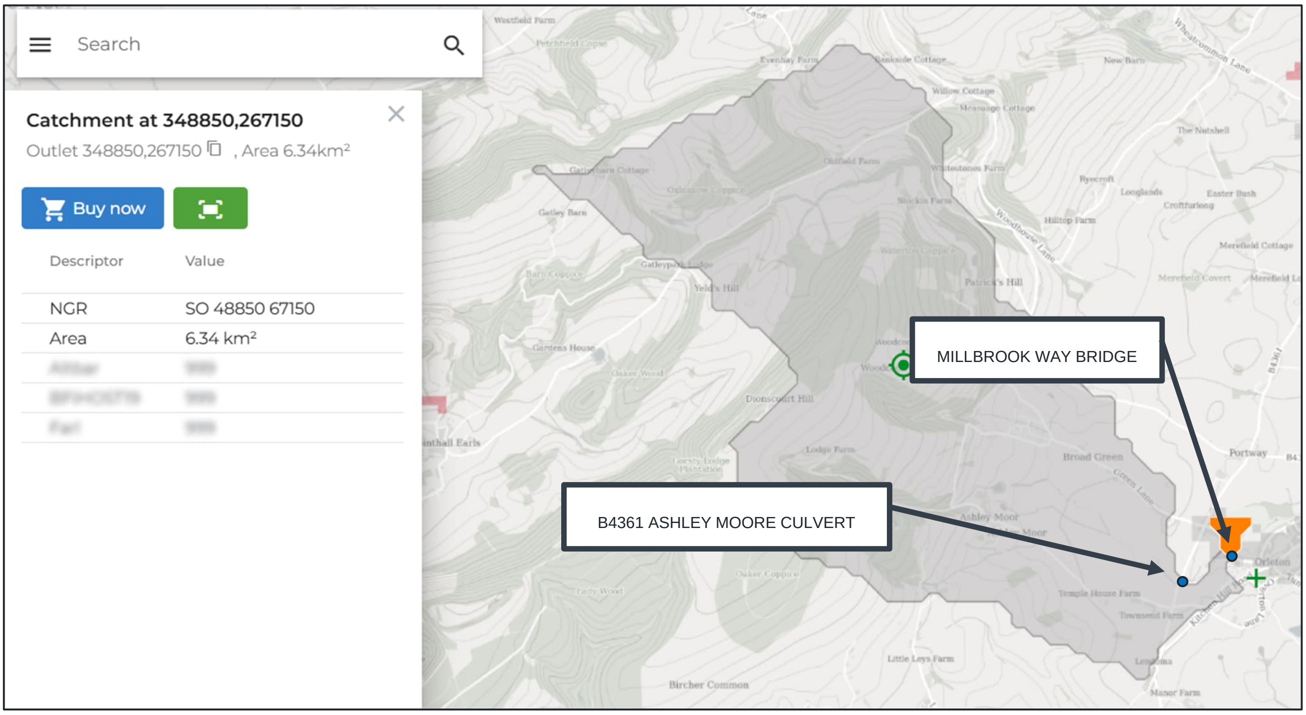


Figure -2: Catchment Area (Source: UK Centre for Ecology and Hydrology, Aug 2025)

Table 2 provides a summary of the catchment areas draining to each of the key pinch point locations, Millbrook Way Bridge having a marginally larger catchment as it is ~ 400m downstream. A Percentage Impervious Area (PIMP) value of 30% has been applied to the total catchment area, based on the assumption that the majority of the land consists of agricultural land with a mix of arable and pasture. This value suggests that approximately 70% of surface water should infiltrate into the soil. It is important to acknowledge and verify during subsequent modelling the actual infiltration capacity of the soil, as video footage from the November 2024 event, shared by the local community, shows significant flooding at the B4361 culvert. This raises concerns about whether the assumed infiltration rate accurately reflects on-the-ground conditions.

Table 2: Summary of Catchment Areas

Description	Area (ha)
Ashley Moore Culvert	626
Millbrook Way Bridge	634

2.2 EXISTING DRAINAGE REVIEW

The Briefing Note on B4361 culvert and Millbrook Way bridge, along with desk-based analysis, has been used to identify the existing condition and dimensions of the culverts and bridge.

2.2.1 B4361 ASHLEY MOORE CULVERT

The route of the watercourse has changed a number of times during its history. Figure 3 shows that the original route passed through a culvert located slightly south-west (~30m) of the current culvert. The present culvert arrangement was initially built to carry an agricultural drainage ditch, which now serves as the brook's main channel.

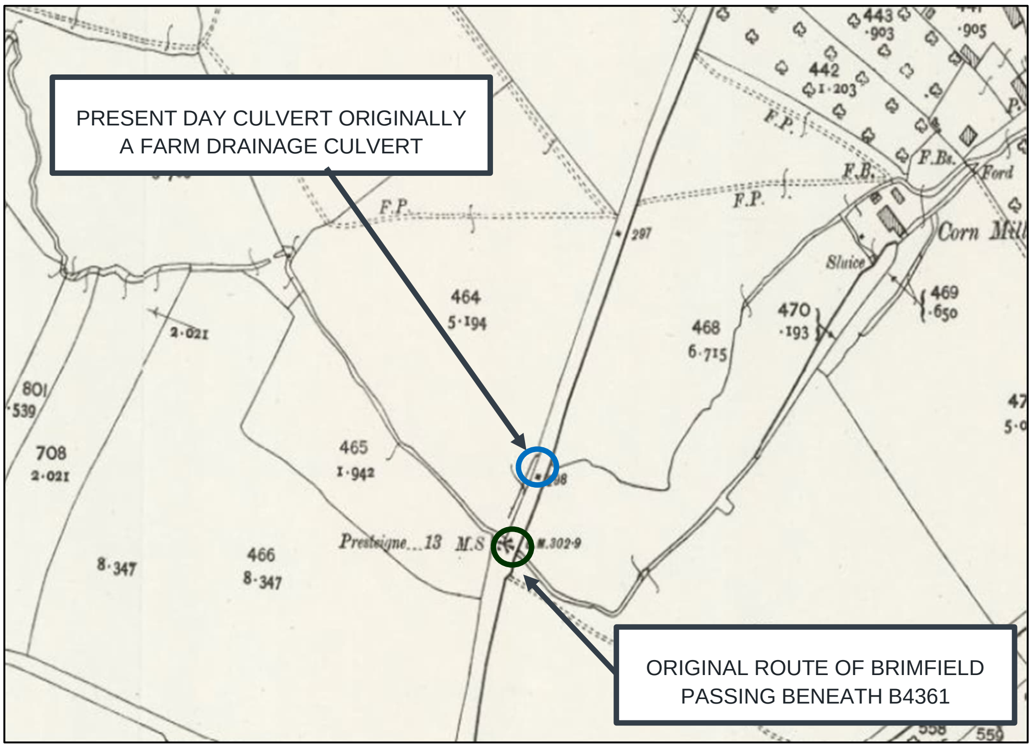


Figure -3: 1914 map showing the original culvert beneath B4361 for passage of Brimfield Brook

In 1926, the original culvert was infilled, and the brook was redirected to flow north-east along the B4361, eventually passing beneath it via a former field drainage culvert. Figure 4 shows the downstream end of the current B4361 culvert, from inspection by Balfour Beatty it is incorporated into the model as a circular 900mm diameter pipe. Due to subsidence risks, in 1988 a new 900mm diameter concrete pipe was installed to provide a more direct route, as shown Figure 5 and Appendix B.

Reports and drone footage shared by the Parish Council, indicate that during heavy rainfall, significant flows breach the watercourse banks upstream of the 900mm culvert. Observations show a 90-degree bend in the channel just before the culvert entrance (Point A), contributing to hydraulic complexity. The March 2025 Parish Council report, *Briefing Note on the Design and Capacity of Brimfield Brook,* refers to features such as an "S-bend," "obstructing culvert," and "choke culvert and trap wing," all located immediately upstream of the culvert. There are no details of these features but clearly the hydraulic conditions upstream of the B4361 are complex. Due to the absence of level or profile data for these features, these complexities have not been incorporated into the hydraulic modelling.

Figure -4: Downstream of B4361 Ashley Moore culvert, believed to be part of original field drainage

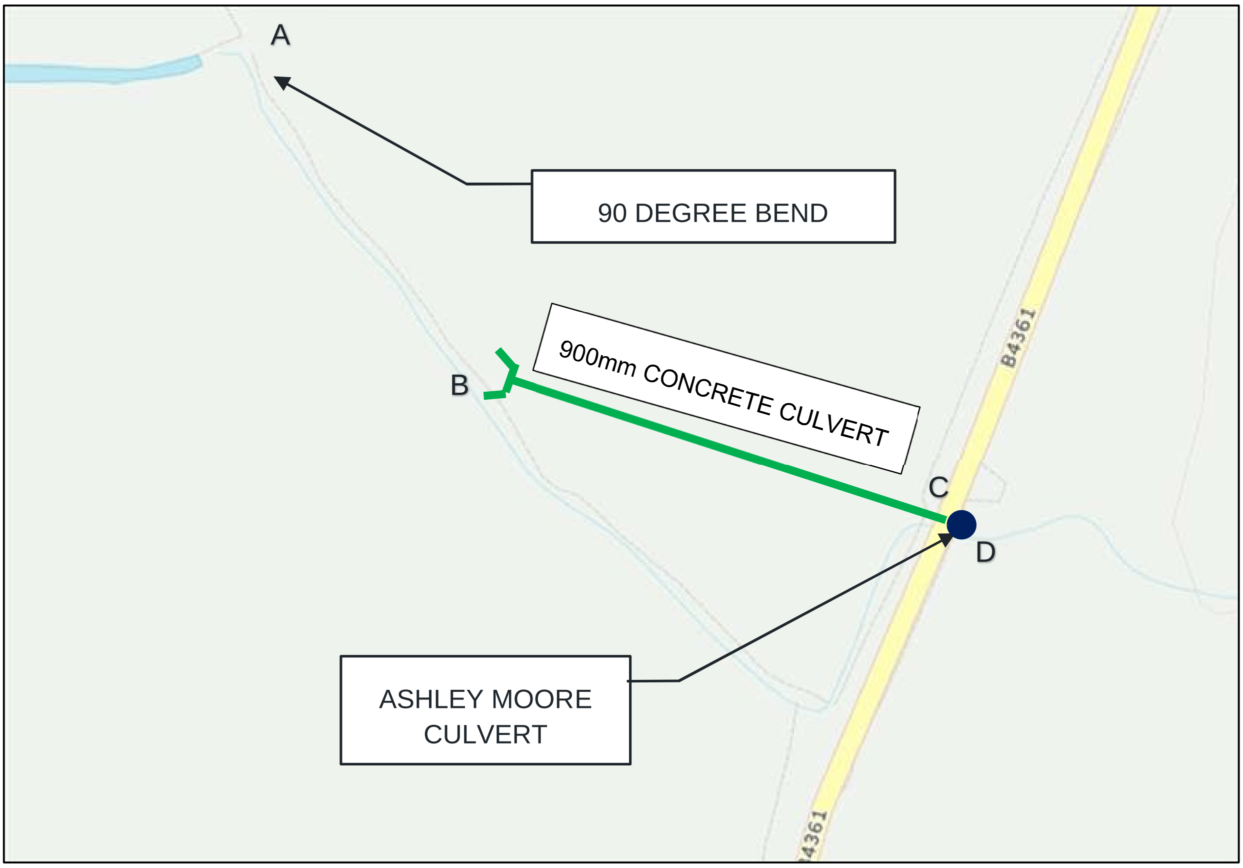


Figure -5: Indicative location of the Ashley Moore culvert and later addition within the agricultural field.

2.2.2 MILLBROOK WAY BRIDGE

Millbrook Way Bridge is the most flood-prone location in Orleton. Constructed in the 1960s, the Millbrook Way Bridge replaced a ford that previously allowed unobstructed flow of Brimfield Brook. To provide sufficient headroom, ground levels were raised by approximately 1.2m, creating saddles on both sides and reducing flood protection for nearby properties.

The bridge comprises a central pier and two culverts (2.38m wide × 0.83m high). The northern culvert is aligned with the brook, while the southern culvert is obscured by an earth bank, Figure 6. This causes uneven flow distribution, with water favouring the northern culvert and swirling eddies forming at the southern entrance. As flow increases, sediment and debris accumulate at the southern culvert, reducing capacity. This is exacerbated by surface water from upstream of the B4361 flowing down Millbrook Way and rejoining the brook just upstream of the bridge, generating crossflow turbulence and further reducing culvert efficiency. The inadequate capacity of the upstream B4361 culvert compounds these issues. Volunteers have maintained this culvert since 2021 to improve conveyance during flood events.

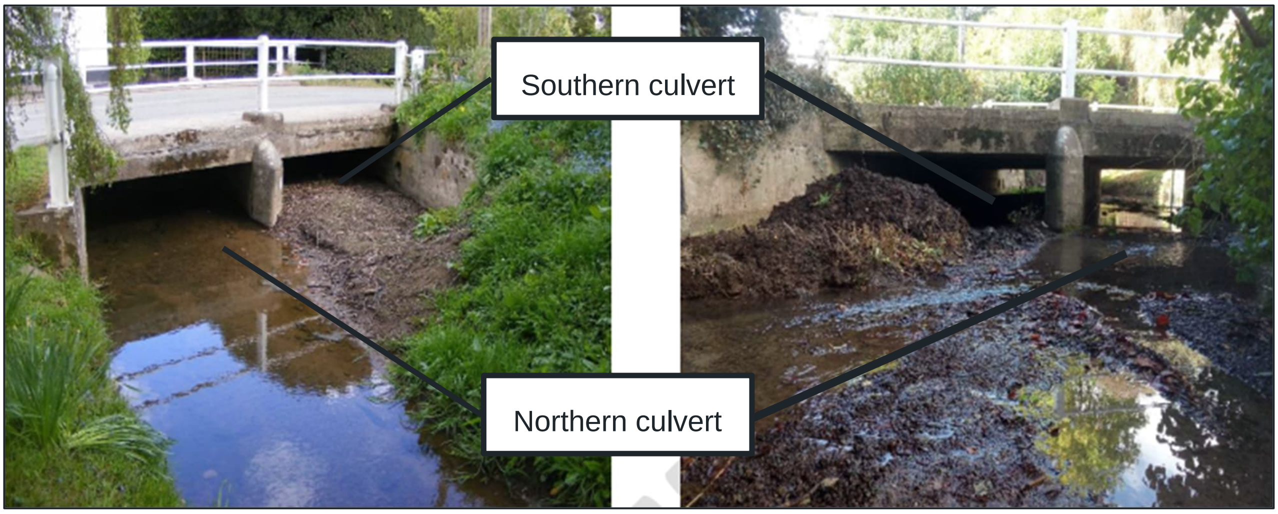


Figure -6: Photographs of Millbrook Way bridge from upstream (left) and downstream (right) 2021

2.3 HYDRAULIC MODELLING

A simplified hydraulic modelling exercise was conducted for Ashley Moore Culvert and Millbrook Way Bridge using Causeway Flow due to limited data for a full hydrological model. The following approach and data have been used:

- **Rainfall Data**

In hydraulic models, rainfall data plays a crucial role in simulating and predicting water flow and behaviour in various systems. The FEH22 model was used for rainfall inputs, offering improved accuracy over its predecessor FEH2013 and FSR due to a larger, more recent dataset and better spatial coverage.

- **Design Standards**

The networks are designed for a 1 in 100-year return period, ensuring the system was tested for peak flow rates and ensuring the worst-case scenarios are simulated. The network has been run for critical storms for 2yr, 30yr and 100yr return periods. Design parameters are shown in Figure 7.

- **Climate Change Allowances**

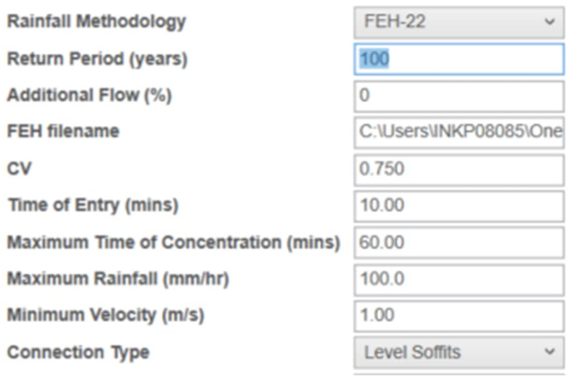
The Environment Agency provides guidance on how to use these allowances in flood risk assessments and strategic flood risk assessments. At a local level, Herefordshire Council has produced the SUDS Handbook and Highways Development Design Guide. There are no specific Climate Change allowances in either of these Herefordshire documents and therefore defer to the "Wye MC Management Catchment peak rainfall allowances" which has the following values:

  - +25% for 30-year return period
  - +40% for 100-year return period

- **Flow Calculations**

The Colebrook-White and Manning equations are both used in fluid mechanics to calculate flow characteristics, but they serve different purposes and are applied in different contexts. Because the model includes both channels and culverts, both methodologies and equations have been used to calculate flow rate.

- Colebrook-White: For turbulent flow in full pipes
- Manning's: For open channels and partially full pipes



Rainfall Methodology	FEH-22
Return Period (years)	100
Additional Flow (%)	0
FEH filename	C:\Users\NKP08085\One
CV	0.750
Time of Entry (mins)	10.00
Maximum Time of Concentration (mins)	60.00
Maximum Rainfall (mm/hr)	100.0
Minimum Velocity (m/s)	1.00
Connection Type	Level Soffits

Figure-7: Design Settings (Causeway Flow, September 2024)

2.4 DATA AVAILABILITY AND ASSUMPTIONS

This assessment has been undertaken at a high-level, in line with the scope defined by the client. The analysis is based on limited available data and is not intended to provide a detailed hydraulic evaluation. A comprehensive assessment would require significantly more information, including accurate culvert and bridge dimensions, current structural condition, topographic and CCTV surveys, and detailed data on upstream and downstream channel connections. In the absence of this data, several assumptions have been made to enable a simplified modelling approach. These assumptions are outlined below for each location.

- **Hydrological Parameters**

A Standard Percentage Runoff (SPR) of 30% (0.3) was adopted, consistent with industry standards. The 2010 Amey Report noted an anomalously low SPR of 16%, suggesting a more responsive catchment. However, due to the absence of full hydrological modelling details, the lower SPR was not used.

- **Peak Flow Estimation**

The catchment characteristics produced unusually high peak flows in the initial model. These were deemed inconsistent with anecdotal evidence. Instead of adjusting parameters through trial and error, peak flows were derived using the HR Wallingford Greenfield runoff estimation tool, applying the FEH statistical method for rainfall.

2.4.1 ASHLEY MOORE CULVERT

- **Culvert Configuration**

Historical reports and photographic evidence indicate that the Ashley Moore culvert comprises a 900mm diameter pipe (approximately 94m in length), which connects to a stone culvert of similar diameter beneath the B4361. Anecdotal evidence suggests the stone culvert may be larger in diameter; however, in the absence of definitive measurements, the downstream culvert has been assumed to match the upstream diameter.

- **Obstructions**

Reports suggest a Welsh Water pipe crosses the bore of the stone culvert. As no specific details were provided, this potential obstruction was excluded from the hydraulic model. It is noted that any obstruction within the culvert could significantly affect hydraulic performance.

- **Upstream Channel Complexity**

No level or profile data is available for the upstream channel. Observations indicate a sharp 90-degree bend immediately before the culvert entrance. The March 2025 Parish Council report references additional features such as an “S-bend,” “obstructing culvert,” “choke culvert,” and “trap wing,” all located upstream. These features introduce hydraulic complexity that have not been incorporated into the model due to lack of detail.

- **Service Condition**

The 2010 Amey Report highlighted poor service conditions, including silting. While it is possible that maintenance has improved since then, particularly following events such as Storm Bert in November 2024, no updated condition data is available. Therefore, the culvert has been assumed to be clear for modelling purposes.

- **Modelling Approach**

Given the data limitations, a simplified hydraulic model was developed. This included an idealised representation of the existing culvert and comparative scenarios involving improved culvert and channel configurations.

2.4.2 MILLBROOK WAY BRIDGE

- **Catchment Modelling**

The same peak flow estimation method was applied to the larger upstream catchment. The area between Ashley Moore culvert and the bridge was treated as a sub-catchment within the model.

- **Bridge Structure**

Limited data was available regarding the bridge, which comprises two box culverts laid side by side. Anecdotal and historical consultant reports were used to infer construction details, flood levels, and service condition.

- **Hydraulic Complexity**

The hydraulic conditions surrounding the bridge are complex and would require more extensive data collection and modelling than was feasible at this stage.

- **Modelling Assumptions**

The model assumes unobstructed culverts correctly aligned with the channel. An additional scenario was modelled where only one culvert was hydraulically effective.

2.5 NETWORK MODELLING

2.5.1 ASHLEY MOORE CULVERT

The existing condition for the Ashley Moore culvert was modelled from Point A to Point D, refer to Figure 5 for location references, based on available documentation and engineering assumptions, this included information provided by the Parish Council's briefing note, photographic evidence and historical reports. In addition to the existing scenario, a proposed improvement option has also modelled for the B4361 Ashley Moore culvert which will be discuss further in Section 3.

Existing Configuration

As mentioned, the limited survey data meant the following assumptions were made:

- **Point A:** S-bend culvert; no dimensions available.
- **Point B:** Choke culvert or S-trap; no dimensions available.
- **Point C:** Based on a road cover level of 90.041m and culvert depth of 1.2m (from the 1988 location plan), the invert level was calculated as 88.841m.
- **Point D:** Reported to be larger than Point B; diameter assumed to be 900mm for consistency.
- **Section A to B**: Ground Levels were inferred from LiDAR, and invert levels estimated using assumed gradients. This section was modelled as an open channel with a 1.0m wide base and 0.75m depth (0.45m water depth and 0.3m freeboard) based on photographs from the Parish Council
- **Section B to C:** Culverted watercourse comprising a 900mm concrete pipe, extending approximately 94m before joining the B4361 culvert.
- **Section C to D:** 900mm diameter stone arch culvert, approximately 6m in length. The vertical height from the base of the watercourse to the crown of the arch is 1.2m, and the total height to the top of the parapet coping stones is 2.8m (as confirmed via client emails).

Hydrological Parameters

Time of Concentration (Tc) was calculated using both the Kirpich and Bilham equations, yielding inconsistent results:

- **Kirpich**: Tc = 1 hour
- **Bilham:** Tc = 9 hours
- **2010 Amey Report:** Time to Peak   2.6 hours

Due to the unreliability of these estimates, Tc was not used directly. Instead, base flow was incorporated into each return period event to improve flow estimation accuracy. Surface water runoff rates were calculated using the UK SuDS Greenfield Runoff Estimation Tool, applying the FEH statistical method. These rates were added as base flow inputs to the culvert model. Results are summarised in Table 3, with detailed calculations provided in Appendix C.

Table 3: Estimated Surface Water Runoff Rates

Flow Rates (l/s)	2 year (0.0%CC)	30 year (0.0%CC)	100 year (0.0%CC)
EXISTING SCENARIO - Outflow	833	1873	2407

2.5.2 MILLBROOK WAY BRIDGE

The existing condition of the Millbrook Way Bridge was modelled using available topographic data and historical records. A portion of the upstream channel was included in the model, starting at Point A following the route of the channel encompassing a flow path length of 416m, measured using Civils 3D.

Existing Configuration

For modelling purposes the following levels, dimensions and channel gradients have been derived from available data:

- **Road Cover Level:** 87.9m (from topographic survey).
- **Culvert Soffit:** 87.59 (0.3048m) below road.
- **Invert Level**: 86.765m
- **Culvert Dimensions:** Based on the 1959 long section drawing:
  - **Culvert 1**: 2.38m (width) × 0.83m (height)
  - **Culvert 2**: 2.38m (width) × 0.82m (height)
  - **Length**: Approximately **7m**

Hydraulic Capacity and Flood Risk

Inferring levels from the topographic survey and data from the Environment Agency's UK Flooding Service, Figure 8, there is an indication that property flooding may begin at a water level of 87.41m AOD, which corresponds to a depth of 0.65m above the assumed bed level of 86.76m AOD. This threshold is lower than the bridge soffit level of 87.59m AOD, meaning that properties could be at risk of flooding even when the culvert is not operating at full capacity.

1.17m	Water reaches the highest level recorded at this measuring station (2 January 2024)
0.65m	Property flooding is possible above this level
0.50m	Low-lying land flooding possible above this level. One or more flood alerts may be issued.
0.19m	Top of normal range
0.10m	**Latest level**

Figure-8: Mill Brook trigger levels at Orleton, Millbrook Way (Station 9421) (Source: UK Flooding Service via Gov.uk, August 2025)

Historical flood records show that fluvial and surface water flooding events have exceeded the property flood threshold, with recorded levels reaching up to 88.08m AOD. The limited headroom between the flood threshold (87.41m AOD) and the culvert soffit (87.59m AOD), just 0.18m, highlights the system's vulnerability to extreme events. As reported by the Parish Council, it is believed that modifications to the culvert and lowered outfalls have further reduced available capacity, contributing to premature surface water flooding.

The scope of this modelling work and investigation did not include a comprehensive account of all potential sources of additional flow, such as surface water exceedance entering the system upstream. As a result, there may be scenarios where properties are at risk of flooding even when the culvert is not surcharged. Further detailed design work would be required to explore alternative methods for reintroducing excess water into the brook.

Table 4: Millbrook Way Bridge – Summary of Water Levels

Description	Depth above Bed Level	Level (m AOD)	Source of Information
Upstream Bed Level	N/A	86.76	Assessed from topo survey of road level (87.9m AOD) and interpretation of 1959 drawings (1.14m to IL)
Upstream Bridge Soffit	0.83	87.59	BL + culvert height
Overtopping of channel upstream of bridge	0.95	87.71	Orleton Parish Council Report July 2024 *start of fluvial flooding
Highest level recorded at bridge gauge	1.17	87.93	EA's UK check for flooding service (see Figure 8)
Extract from bridge gauge level on 0900h 24/11/24	1.32	88.08	Orleton Parish Council Report March 2025 *(N.B. this level is not recorded on the UK check for flooding service)*
Property flooding possible	0.65	87.41	UK check for flooding service (see Figure 8)
Flooding from gully affecting Ford House	0.76	87.52	Orleton Parish Council Report July 2024

2.5.3 PROPOSED OPTION

To the purposes of the modelling, one option to improve flow has been explored by replacing the existing 94 m long, 900 mm diameter culverted watercourse with an open channel designed as follows:

- Width: 900 mm
- Depth: 750 mm
- Side slopes: 1:1 (simplified for modelling)

This configuration was modelled to assess potential hydraulic benefits. However, it is important to note that, this alternative is a simplified representation that assumes stable 1:1 side slopes and consistent channel geometry. The approach abstracts detailed site-specific factors such as variable roughness, sediment transport, and transient flow effects to focus on the primary hydraulic improvements offered by the open channel. Results of this proposed option are discussed in Section 3.

3 MODELLING RESULTS

3.1 ASHLEY MOORE CULVERT

Extensive scenario testing under various rainfall conditions was conducted for the Existing Scenario and Proposed Scenario, this was done to compare flows and review how the model responded to additional flows. The critical storm flows for existing and proposed scenarios are shown in Table 5 and Table 6. As discussed in 2.3, the impact of climate change has been directly applied to the base flows in the model, these percentages vary for return periods in line with industry standards,

Table 5: Ashley Moore Culvert - Existing scenario - Peak Flow Rates (l/s)

Return Period	% Climate Change	Flow rate (l/s)	Peak Water Level	Simulated condition
2-Year	0	833	89.415	NO FLOODING
30-Year	0	1873	89.803	FLOODING
100-Year	0	2407	90.003	FLOODING
2-Year	25	1041	89.490	NO FLOODING
30-Year	25	2341	90.041	FLOODING
100-Year	40	3370	90.041	FLOODING

Table 6: Ashley Moore Culvert - Proposed scenario - Peak Flow Rates (l/s)

Return Period	% Climate Change	Flow rate (l/s)	Peak Water Level	Simulated condition
2-Year	25	1041	89.270	NO FLOODING
30-Year	25	2341	89.544	NO FLOODING
100-Year	40	3370	89.783	FLOOD RISK

Model results simulate flooding at Ashley Moore culvert for the 30-year and 100-year events, in a simplistic representation of the Existing condition. Replacing the 900mm diameter culvert with a basic channel in the model, suggests that improving the hydraulic conditions upstream of the B4361 culvert crossing increases the volume of water passing through. As stated previously, the hydraulic conditions in the watercourse upstream of the B4361 are complex and cannot be fully represented in this model.

3.2 MILLBROOK WAY BRIDGE

As mentioned in Section 2.2, the northern culvert aligns with the brook's flow, while the southern culvert is partially blocked by an earth bank, causing water to favour the northern one and creating swirling eddies at the southern culvert's entrance. This leads to sediment and debris buildup, complicating hydraulic conditions which cannot be assessed without acquiring more detailed data. Consequently, the modelling has been simplified to assess an option analysing two culverts functioning simultaneously and another with just one culvert functioning. Results are presented in Table 7 and Table 8 respectively.

Table 7: Millbrook Way Bridge – Existing Two Functioning Culvert scenario - Peak Flow Rates (l/s)

Return Period	% Climate Change	Flow rate (l/s)	Peak Water Level	Simulated condition
2-Year	0	1208	86.975	NO FLOODING
30-Year	0	2834	87.121	NO FLOODING
100-Year	0	3625	87.184	NO FLOODING
2-Year	25	1510	87.006	NO FLOODING
30-Year	25	3542	87.177	NO FLOODING
100-Year	40	5076	87.288	NO FLOODING

Table 8: Millbrook Way Bridge – Existing One Functioning Culvert scenario - Peak Flow Rates (l/s)

Return Period	% Climate Change	Flow rate (l/s)	Peak Water Level	Simulated condition
2-Year	0	1208	87.088	NO FLOODING
30-Year	0	2834	87.328	NO FLOODING
100-Year	0	3625	87.431	NO FLOODING
2-Year	25	1416	87.122	NO FLOODING
30-Year	25	3301	87.390	NO FLOODING
100-Year	40	4587	87.550	NO FLOODING

The modelling of Millbrook Way Bridge indicates it has sufficient capacity to accommodate the higher return storm flows. The model does not simulate any out of bank flows, even during the 100 year plus climate change event.

As with upstream of the Ashley Moore culvert, the hydraulic conditions at the bridge are complex and require a greater level of data gathering to accurately represent the flow dynamics. For example, with reference to the November 2024 event, levels at the bridge would have been impacted by the downstream watercourse levels, overland flow entering from the surrounding roads etc.

4 DESIGN OPTIONS

One proposed option has been modelled, aimed assess the potential for the hydraulic benefits of the Ashley Moore Culvert. As described and demonstrated in Section 3.1, the model suggests de-culverting of the watercourse immediately upstream of the B4361. As part of this report, the benefits and limitations of this option have been considered as well as a potential alternative aimed to consider all stakeholders.

4.1 OPTION 1: DE-CULVERTING

Description

This option would involve de-culverting 94m along the brook immediately upstream of the B4361, to restore natural flow paths. De-culverting helps with steady flow, improve flow capacity during heavy rainfall events, especially where culverts currently restrict water movement due to blockages which lead to flooding.

Benefits

Improved Flow Capacity:

- Reduces flood risk on the B4361 and Orleton by allowing water to remain in channel with exceedance able to re-enter the watercourse throughout its length.
- Helps prevent stagnation and pooling caused by blocked culverts.

Environmental Enhancement:

- Supports biodiversity and improves water quality.
- Enhances the visual and ecological value of the watercourses.

Long-Term Resilience:

- Easy access for inspection and maintenance.
- Aligns with Natural Flood Management (NFM) strategies already underway in the area.

Limitations

Land Use Constraints:

- Requires cooperation and buy-in from landowner as may impact farming practices and payments.
- Potential disruption to roads and utilities during construction.

Construction Complexity:

- Requires careful hydraulic modelling to avoid unintended erosion or sediment transport.
- Ecological assessments required.

Cost and Maintenance:

- Higher initial costs compared to retrofitting existing culverts.
- Potentially more frequent maintenance to manage vegetation / sediment (simpler than current)

Conclusions

De-culverting offers a sustainable and effective part-solution for Orleton’s flood challenges. It complements existing NFM efforts and supports long-term resilience, though it requires careful planning and collaboration.

4.2 OPTION 2: OVERLAND FLOW CAPTURED

Description

This option involves installing a structure, large open chamber / channel, similar to that shown in Figure 9, to capture and divert flows back into the brook upstream of the B4361 to manage exceedance flows and reduce flood water flowing overland into the village via Maidenhead junction. The structure would be supported by short defence walls and integrated with revised highway drainage to redirect water away from the highway.

Figure-9: Example of open chamber / channel to capture and divert water back into brook (Source: Balfour Beatty Living Places, BB1314 Nook A4103 (Roman Road) Flood Relief Culvert, 2005)

Benefits

Flood Reduction:

- Reduce flooding on at Millbrook Way and the B4361 during smaller events.
- Helps manage exceedance flows and surface water runoff from agricultural land.
- If designed correctly, can intercept flows which have overtopped banks further upstream than the original culvert

Operational Control:

- Lesser disruption to agricultural land during construction and long term.
- Maintenance liability could be Herefordshire Council's if it became a highway drainage asset

Limitations

Limited Effectiveness:

- Only effective for moderate events and lesser capacity than de-culverting

- Limited environmental benefit
- Risk of breaching upstream flooding remains and topography / location may provide minimal benefit if not carefully designed.

Design Challenges:

- Unknown condition and difficulties tying into existing Ashley Moore culvert.
- Re-construction and re-enforcement of the bank / B4361 required
- Potential utility interference to be considered during design
- Requires coordination with highways and landowner.

Redundancy Risk:

- In larger events, overtopping from brook and surface runoff may overwhelm the system rendering it redundant.

Conclusions

While the flow capture chamber could offer relief for specific flood events in Orleton and could provide a solution more appealing to the landowner. Its limitations mean the benefits / cost would need to be carefully considered by Herefordshire Council.

5 CONCLUSIONS AND RECOMMENDATIONS

The simplified modelling exercise indicates that the Ashley Moore culvert is inadequately sized to convey the higher return storm flows, the 30 year and 100 year flood events. The actual situation is exacerbated due to the complicated uncertain hydraulics of the upstream channel arrangement and the likely condition of the current culverts. Improvements to the upstream channels and the Ashley Moore culvert to allow a greater pass through of peak flows to the Millbrook Way Bridge, would avoid large volumes of water building up on the upstream side of the B4361 and discharging in an unregulated manor along and across the B4361 entering Orleton as surface water exceedance flows via Millbrook Way.

In order to confirm this improved conveyance, available capacity and develop an engineering solution for the Ashley Moore culvert, much more detailed data gathering, modelling and design work will be required.

Regarding the capacity Millbrook Way Bridge, within the limitations of this exercise and the data currently available to us, the model indicates the bridge has the capacity convey flows from the higher return storm events, i.e. if Ashley Moor culvert wasn't restricting flow, Millbrook Way bridge could theoretically cope with all tested return periods without flooding.

5.1 RECOMMENDATIONS

Based on the conceptual modelling results and conclusions of this report, the following recommendations are made:

- **Landowner Engagement:** Any scheme to improve conveyance upstream of the B4361, would require working and altering flows on private third-party land. Prior to any further design work, it is therefore paramount that the landowner is involved in discussions and on-board with initial conceptual proposals. Farming practices may render the de-culverting of the 94m unviable from a farm business perspective however an alternative solution may be more palatable.

- **Community Engagement:** It is also paramount that the community and those residents directly impacted by the flooding are consulted and approve the concept of the proposals. Herefordshire Council have a close working relationship with the Parish Council and will be liaising with them regarding the next steps.

- **Upstream Interventions:** From the previous reports and modelling perspective, it is clear that the watercourse overtops the bank, floods across the fields into Orleton prior to reaching Point B, the 900mm culvert and Ashley Moore Culvert. The flooding experienced in Orleton would benefit from upstream interventions, intercepted upstream through NFM (Natural Flood Management) or attenuation storage features as part of a holistic approach to flood risk management.

- **Channel Maintenance:** The condition of the culverted watercourse upstream of Ashley Moore culvert is paramount in ensuring maximum flows are conveyed in a steady manor. This is equally prevalent on the rest of the watercourse immediately upstream where there is evidence of the watercourse breaching its banks. Millbrook Way Bridge has had multiple design and construction changes and issues. The aligned to the brook and proximity of properties means maintenance to improve conveyance in both culverts is highly important. As the Land Drainage Authority, Herefordshire Council are Therefore the water is not freely passing through it.

- **Data Availability:** There is limited data available representing the existing conditions of the soil conditions (infiltration), culverts condition / dimensions and brook characteristics. Therefore it is recommended that a detailed drainage survey is undertaken previous to any further design.

- **Detailed hydraulic modelling:** As discussed throughout the report, data available has limited the confidence of the findings. Further detailed hydraulic modelling is needed to assess the flood volume generated as well as a thorough drainage study regarding the watercourse conveyance within the Orleton village to provide further flood appraisal measure recommendations.

- **Design Optioneering:** The model have looked at one proposed option aimed assess the hydraulic benefits. It proved that de-culverting 94m of watercourse and allowing it to flow un-restricted within an open channel improved the performance and reduces flooding. Within Section 4, an alternative solution has been posed with the potential of being more palatable for the landowner. These Options should be considered by Herefordshire Council with the potential for forming the basis for initial discussions with key stakeholders.

APPENDIX A: ORLETON PARISH COUNCIL BRIEFING NOTE

APPENDIX B: DRAWINGS

1. **UK0029902.8520-WSP-HDG-DR-CD-500-101 - EXISTING CATCHMENT AREA AND LOCATION OF ASHLEY MOORE/B4361 CULVERT AND MILLBROOK WAY BRIDGE**

2. **UK0029902.8520-WSP-HDG-DR-CD-500-102 - PROPOSED OPTIONS AT ASHLEY MOORE /B4361 CULVERT**

APPENDIX C: GREENFIELD RUNOFF RATES

APPENDIX D: CAUSEWAY FLOW – MODEL OUTPUTS

Modelling output summaries for each of the Options shown in Tables 5 to 8.

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