Department for Environment Food & Rural Affairs

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Appendix D: Method validation in the Kent, Stour and Wharfe catchments

FRS17183/R2 Appendix D

Flood and Coastal Erosion Risk Management Research and Development Programme

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Professor Doug Wilson
Chief Scientist

Executive summary

Various methods have been tested and evaluated to assess the ability to predict in-channel geomorphological activity at the reach scale, under both existing conditions and with future climate change (FRS17183/R1-R3).

These are:

- ST:REAM
- CAESAR-Lisflood
- Half-yield method
- Shear stress data mining method

The results are reported in this document (Appendix D to FRS17183/R2).

New results were produced using the method work flows (FRS17183/R2 Appendix C). These were validated at spot check locations against available fluvial audit data.

A number of points were selected in the 3 test catchments: 10 in the Kent catchment, and 8 in the Stour and Wharfe catchments for the ST:REAM, CAESAR-Lisflood and half-yield method.

Spot check locations were chosen based on the following criteria:

- where processes of erosion and deposition are known to operate
- where the watercourse is known to be relatively stable
- other random locations across the catchment

The results for the ST:REAM, CAESAR-Lisflood and half-yield methods in the River Kent are presented in FRS17183/R2 - Developing and evaluating methods to identify erosion, transport and deposition on a national scale. The results for the Wharfe and Stour catchments are shown in section 1 of this report.

The shear stress data mining method was investigated separately and the results for all 3 catchments are presented in section 2.

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1 Method validation in the Stour and Wharfe catchments

D1 Results summary

Table D.1 shows that of the 2 methods available for the Stour catchment, the half-yield method most accurately represents the identified geomorphological processes in the Stour catchment, with a 38% agreement rate between the fluvial audit data and the model results. The agreement rate increases to 75% for the half-yield method if spot check locations that lack a nearby RHS data point are excluded from the calculation. In comparison, ST:REAM performs less well in the Stour catchment, with only a 13% agreement rate between the fluvial audit data and model results.

Table D.1 Stour catchment validation summary

	Does method result agree with audit data – Y/N		
Spot check	**ST:REAM**	**CAESAR-Lisflood**	**Half-yield**
Stour_01	N	Not tested	No sample point available
Stour_02	Y	Not tested	Y
Stour_03	N	Not tested	No sample point available
Stour_04	N	Not tested	N
Stour_05	N	Not tested	No sample point available
Stour_06	N	Not tested	Y
Stour_07	N	Not tested	Y
Stour_08	N	No results	No sample point available
Success rate matching audit	**13%**	**Not tested**	**38%**

Table D.2 shows that of the 2 methods available for the Wharfe catchment, the half-yield method most accurately represents the identified geomorphological processes in the Stour catchment, with a 50% agreement rate between the fluvial audit data and the model results. The agreement rate increases to 100% for the half-yield method if spot check locations that lack a nearby RHS data point are excluded from the calculation. In contrast, ST:REAM performs less well in the Wharfe catchment, with a 38% agreement rate between the fluvial audit data and model results.

Table D.2 Wharfe catchment validation summary

	Does method result agree with audit data – Y/N		
Spot check	**ST:REAM**	**CAESAR-Lisflood**	**Half-yield**
Wharfe_01	N	Not tested	No sample point available
Wharfe_02	Y	Not tested	Y
Wharfe_03	Y	Not tested	Y
Wharfe_04	Y	Not tested	No sample point available
Wharfe_05	N	Not tested	No sample point available
Wharfe_06	N	Not tested	No sample point available
Wharfe_07	N	Not tested	Y
Wharfe_08	N	No results	Y
Success rate matching audit	**38%**	**Not tested**	**50%**

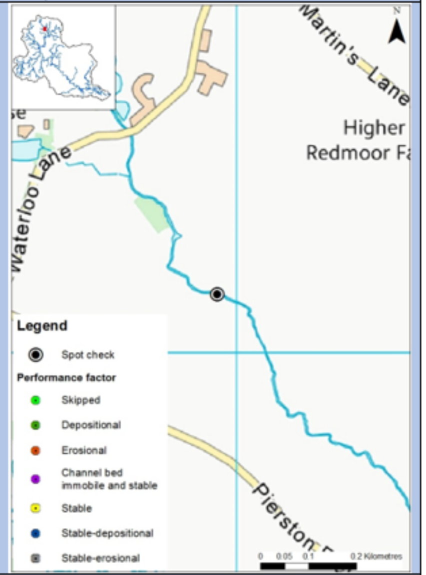
Reach: Stour_01, Watercourse: River Stour, OS NGR: 378958, 129122

Audit data

ST:REAM

CAESAR-Lisflood

Half-yield



Audit data	ST:REAM	CAESAR-Lisflood	Half-yield
The following data was extracted from the reach audit shapefile:	In the **ST:REAM** model, the reach is classified as depositional.	Not tested	No RHS sample point available for this reach.

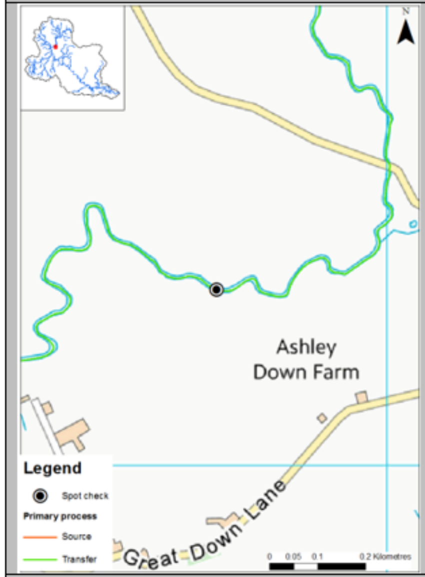
Dominant process:	Transfer
Description:	Agricultural reach
Dominant bed material	Gravel bed where undisturbed
Widening	Present
Realignment	Present
Resectioning	Localised artificial form around STW near Silton and Waterloo Mill
Geomorphology	Passive meandering
Evidence of incision/aggradation:	No
Floodplain connectivity:	Not recorded
Fine sediment:	Not recorded

Key process(es): Transfer

Conclusion:

- **Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.**
- **The audit classified the reach as passive meandering (i.e. minimal morphological activity). This suggests some deposition could occur, however sediment will also pass through the reach.**
- **Based on this ST:REAM may not depict the correct process.**

Figure D.1 Results validation: Stour 01

<table>
<tr><th colspan="4">Reach: Stour_02, Watercourse: River Stour, OS NGR: 378644, 120367</th></tr>
<tr><th>Audit data</th><th>ST:REAM</th><th>CAESAR-Lisflood</th><th>Half-yield</th></tr>
<tr>
<td>
</td>
<td>
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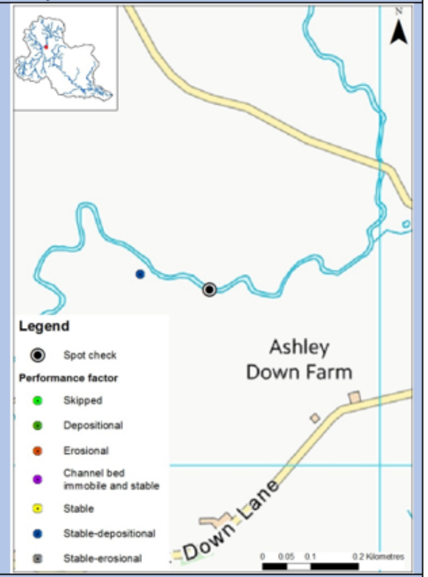
<td></td>
<td>
</td>
</tr>
<tr>
<td>The following data was extracted from the reach audit shapefile:
<table>
<tr><td>Dominant process:</td><td>Transfer</td></tr>
<tr><td>Description:</td><td>Agricultural reach</td></tr>
<tr><td>Dominant bed material:</td><td>Gravel</td></tr>
<tr><td>Widening:</td><td>Not recorded</td></tr>
<tr><td>Realignment:</td><td>Not recorded</td></tr>
<tr><td>Resectioning:</td><td>Not recorded</td></tr>
<tr><td>Geomorphology:</td><td>Passive meandering</td></tr>
<tr><td>Evidence of incision/aggradation:</td><td>Slightly incising due to slow floodplain aggradation</td></tr>
<tr><td>Floodplain connectivity:</td><td>Well-connected to wide floodplain</td></tr>
<tr><td>Fine sediment:</td><td>Deposited in floodplain</td></tr>
</table>
Key process(es): Transfer</td>
<td>In the ST:REAM model, the reach is classified as transfer.</td>
<td>Not tested.</td>
<td>In the Half-yield method, there is one RHS data point within the vicinity of the spot check location.

The RHS point is classified as stable-depositional in terms of the Performance Factor (P = -0.33) and Effectiveness Index (E = -0.97). This indicates:

In-channel flows dominant
Incised/recovering
Frequent flows most effective at depositing
Gradual bed raising
</td>
</tr>
<tr><td colspan="4">Conclusion:

The audit classified the reach as passive meandering, with a dominance of transfer processes.
Based on this both ST:REAM and the Half-yield method match relatively well to the audit results.
</td></tr>
</table>

Figure D.2 Results validation: Stour 02

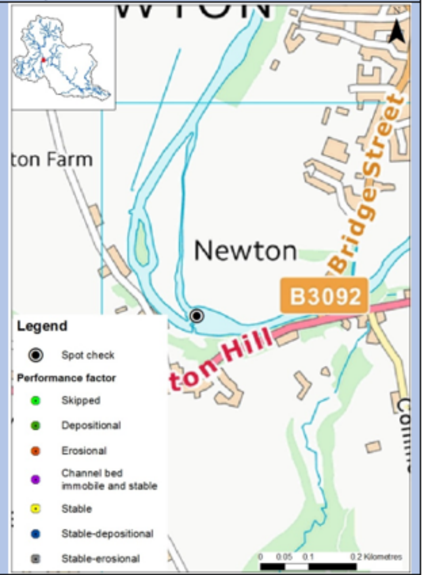
Reach: Stour_03, Watercourse: River Stour, OS NGR: 378197, 113558

Audit data

ST:REAM

CAESAR-Lisflood

Half-yield



Audit data	ST:REAM	CAESAR-Lisflood	Half-yield
The following data was extracted from the reach audit shapefile:	In the **ST:REAM** model, the reach is classified as depositional.	Not tested.	No RHS sample point available for this reach.

Dominant process:	Transfer
Description:	Agricultural reach
Dominant bed material	Gravel
Widening	Not recorded
Realignment	Not recorded
Resectioning	Not recorded
Geomorphology	Passive meandering (but some bank erosion)
Evidence of incision/aggradation:	Yes - incised
Floodplain connectivity:	Connected
Fine sediment:	Not recorded

Key process(es): Transfer

Conclusion:

- **Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.**
- **The audit classified the reach as transfer.**
- **Based on this ST:REAM may not depict the correct process, as the reach was calculated to be depositional in nature.**

Figure D.3 Results validation: Stour 03

<table>
<tr><th colspan="4">Reach: Stour_04, Watercourse: River Stour, OS NGR: 385533, 109243</th></tr>
<tr><th>Audit data</th><th>ST:REAM</th><th>CAESAR-Lisflood</th><th>Half-yield</th></tr>
<tr>
<td>
</td>
<td>
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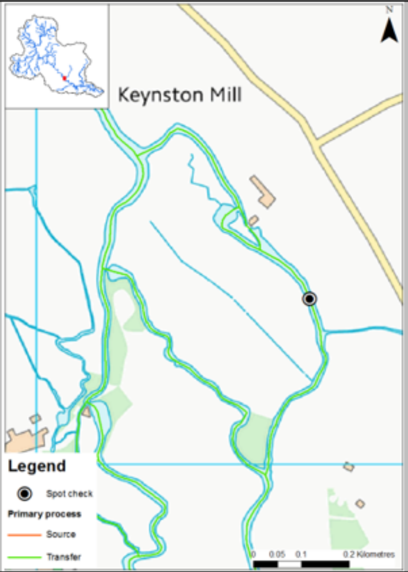
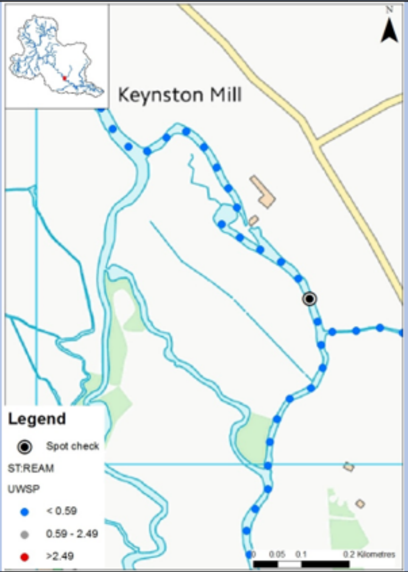
<td></td>
<td>
</td>
</tr>
<tr>
<td>The following data was extracted from the reach audit shapefile:
<table>
<tr><td>Dominant process:</td><td>Transfer</td></tr>
<tr><td>Description:</td><td>Chalk reach to Blandford Forum</td></tr>
<tr><td>Dominant bed material</td><td>Gravel</td></tr>
<tr><td>Widening</td><td>Not recorded</td></tr>
<tr><td>Realignment</td><td>Not recorded</td></tr>
<tr><td>Resectioning</td><td>Not recorded</td></tr>
<tr><td>Geomorphology</td><td>Passive, low sinuosity and stable</td></tr>
<tr><td>Evidence of incision/aggradation:</td><td>Not recorded</td></tr>
<tr><td>Floodplain connectivity:</td><td>Connected</td></tr>
<tr><td>Fine sediment:</td><td>Storage on floodplain of fines</td></tr>
</table>
Key process(es): Transfer</td>
<td>In the ST:REAM model, the reach is classified as depositional.</td>
<td>Not tested.</td>
<td>In the Half-yield method, there is one suitable RHS data point within the vicinity of the spot check location.

The RHS point is classified as depositional in terms of the Performance Factor (P = 2.65) and Effectiveness Index (E = 0.70). This indicates:

Wide/shallow and/or coarse sediment
Flood flows dominant
Infrequent flows most effective at depositing
Bar-berm building
Possible deposition of fines
</td>
</tr>
<tr><td colspan="4">Conclusion:

Only two tested methods available.
The audit classified the reach as transfer, with deposition of fines on the floodplain.
Based on this ST:REAM and Half-Yield may not depict the correct process, as they both suggest that depositional processes are dominant.
</td></tr>
</table>

Figure D.4 Results validation: Stour 04

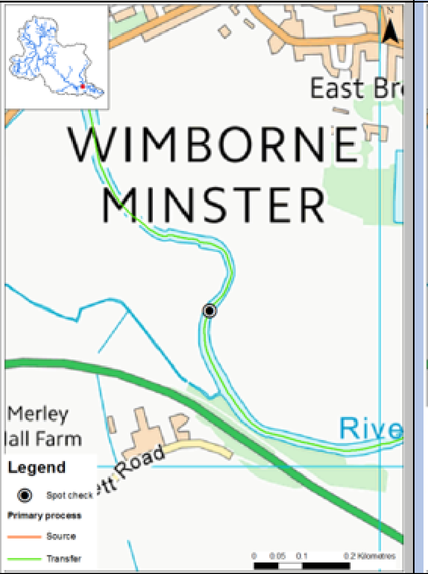
<table>
<tr><th colspan="4">Reach: Stour_05, Watercourse: River Stour, OS NGR: 391570, 103344</th></tr>
<tr><th>Audit data</th><th>ST:REAM</th><th>CAESAR-Lisflood</th><th>Half-yield</th></tr>
<tr>
<td>
</td>
<td>
</td>
<td></td>
<td>
</td>
</tr>
<tr>
<td>The following data was extracted from the reach audit shapefile:
<table>
<tr><td>Dominant process:</td><td>Transfer</td></tr>
<tr><td>Description:</td><td>Blandford Forum to A31</td></tr>
<tr><td>Dominant bed material</td><td>Gravel</td></tr>
<tr><td>Widening</td><td>Not recorded</td></tr>
<tr><td>Realignment</td><td>Not recorded</td></tr>
<tr><td>Resectioning</td><td>Not recorded</td></tr>
<tr><td>Geomorphology</td><td>Passive meandering and sinuous</td></tr>
<tr><td>Evidence of incision/aggradation:</td><td>Not recorded</td></tr>
<tr><td>Floodplain connectivity:</td><td>Not recorded</td></tr>
<tr><td>Fine sediment:</td><td>Input from tribs. And banks from cattle poaching</td></tr>
</table>
Key process(es): Transfer</td>
<td>In the ST:REAM model, the reach is classified as depositional.</td>
<td>Not tested</td>
<td>No RHS sample point available for this reach.</td>
</tr>
<tr><td colspan="4">Conclusion:

Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.
The audit classified the reach as transfer.
Based on this ST:REAM may not depict the correct process, as the reach was calculated to be depositional in nature.
</td></tr>
</table>

Figure D.5 Results validation: Stour 05

Reach: Stour_06, Watercourse: River Stour, OS NGR: 400646, 099325

Audit data



The following data was extracted from the reach audit shapefile:

Dominant process:	Transfer
Description:	A31 to Wimbourne Minster
Dominant bed material	Gravel
Widening	Not recorded
Realignment	Not recorded
Resectioning	Not recorded
Dredging	Dredged extensively in the late 20thC, not fully recovered
Geomorphology	Passive meandering and sinuous
Evidence of incision/aggradation:	Not recorded
Floodplain connectivity:	Not recorded
Fine sediment:	Vegetated berms u/s of weir, medium term store of fines

Key process(es): Transfer

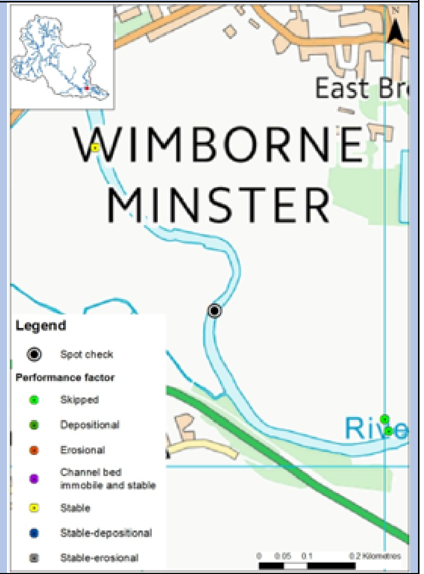
ST:REAM

In the **ST:REAM** model, the reach is classified as depositional.

CAESAR-Lisflood

Not tested.

Half-yield



In the **Half-yield** method, there is one suitable RHS data point located upstream of the spot check location.

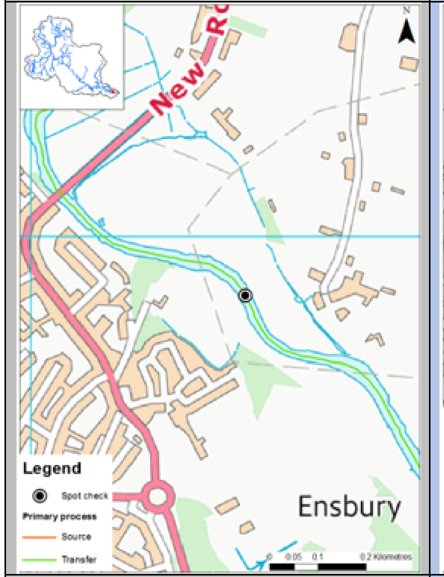
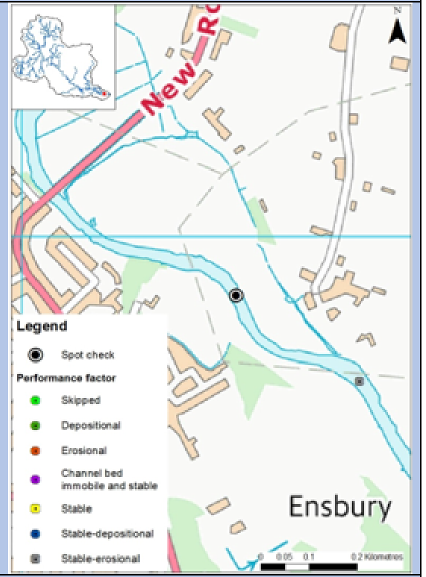
The RHS point is classified as stable in terms of the Performance Factor (P = -0.15) and Effectiveness Index (E = -0.12). This indicates that there is a balance in sediment yield between the in-channel and overtopping flows.

Conclusion:

- **Only two tested methods available – both display different processes. ST:REAM classifies the reach as depositional, whereas the Half-yield method classifies the reach as stable.**
- **The audit classified the reach as transfer – however, past dredging is likely to have disrupted past processes.**
- **Based on this the Half-Yield results are most closely aligned to the existing conditions.**

Figure D.6 Results validation: Stour 06

Reach: Stour_07, Watercourse: River Stour, OS NGR: 408444, 096878

Audit data	ST:REAM	CAESAR-Lisflood	Half-yield
			

Audit data

The following data was extracted from the reach audit shapefile:

Dominant process:	Transfer
Dominant bed material	Gravel
Widening	Not recorded
Realignment	Not recorded
Resectioning	Not recorded
Dredging	Present (1980s) – triggered knickpoint erosion
Artificial features:	Bed check weirs installed to reduce knickpoint erosion after extreme dredging
Geomorphology	Passive meandering with weir pools associated with gravel bars
Evidence of incision/aggradation:	Not recorded
Floodplain connectivity:	Present, but constrained
Fine sediment:	F/p is net sink for fine sed.

Key process(es): Transfer

ST:REAM

In the **ST:REAM** model, the reach is classified as depositional.

CAESAR-Lisflood

Not tested

Half-yield

In the **Half-yield** method, there is one suitable RHS data point located downstream of the spot check location.

The RHS point is classified as stable-erosional in terms of the Performance Factor (P = 0.13) and Effectiveness Index (E = 1). This indicates:

- Undersized channel and/or coarse sediment
- Flood flows dominant
- Infrequent flows most effective at eroding
- Bed scour
- Possible deposition of fines

Conclusion:

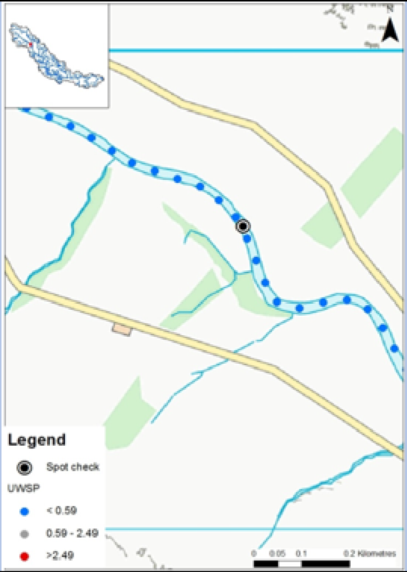
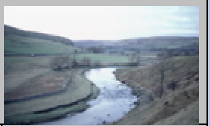
- **Only two tested methods available.**
- **The audit classified the reach as transfer.**
- **Based on this ST:REAM may not depict the correct process, however, Half Yield which describes the reach as stable-erosional is likely to be representative of the audit results.**

Figure D.7 Results validation: Stour 07

<table>
<tr><th colspan="4">Reach: Stour_08, Watercourse: River Stour, OS NGR: 394408, 107208</th></tr>
<tr><th>Audit data</th><th>ST:REAM</th><th>CAESAR-Lisflood</th><th>Half-yield</th></tr>
<tr><td>
</td><td>
</td><td></td><td>
</td></tr>
<tr><td>The following data was extracted from the reach audit shapefile:
<table>
<tr><td>Dominant process:</td><td>Transfer</td></tr>
<tr><td>Dominant bed material</td><td>Gravel</td></tr>
<tr><td>Widening</td><td>Not recorded</td></tr>
<tr><td>Realignment</td><td>Not recorded</td></tr>
<tr><td>Resectioning</td><td>Not recorded</td></tr>
<tr><td>Dredging</td><td>Not recorded</td></tr>
<tr><td>Artificial features:</td><td>Not recorded</td></tr>
<tr><td>Geomorphology</td><td>Passive meandering, static</td></tr>
<tr><td>Evidence of incision/aggradation:</td><td>Not recorded</td></tr>
<tr><td>Floodplain connectivity:</td><td>Not recorded</td></tr>
<tr><td>Fine sediment:</td><td>Not recorded</td></tr>
</table>
Key process(es): Transfer</td><td>In the ST:REAM model, the reach is classified as depositional.</td><td>Not tested.</td><td>No RHS sample point available for this reach.</td></tr>
<tr><td colspan="4">Conclusion:
• Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.
• The audit classified the reach as transfer, however limited data is available.
• Based on this ST:REAM may not depict the correct process.</td></tr>
</table>

Figure D.8 Results validation: Stour 08

Reach: Wharfe_01, Watercourse: River Wharfe, OS NGR: 396592, 469632

Audit data	ST:REAM	CAESAR-Lisflood	Half-yield
			
The following data was extracted from the reach audit shapefile: 	In the **ST:REAM** model, the reach is classified as depositional.	Not tested	No RHS sample point available for this reach.

Dominant bank material:	Till
Dominant bank structure:	Cohesive
Dominant bank erosion process:	Geotechnical
Acceleration of erosion occurring:	No
Evidence of incision:	No
Evidence of aggradation:	No
Dominant bed material:	Coarse gravel, with some boulders and cobbles
Dominant biotope:	Run, with some riffles
Dominant deposition:	Mesoscale, unstable gravel bars

Key process(es): Transfer

Conclusion:

- **Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.**
- **The audit classified the reach as transfer.**
- **Based on this, ST:REAM does not depict the correct process as the reach was calculated to be depositional in nature.**

Figure D.9 Results validation: Wharfe 01

<table>
<tr><th colspan="4">Reach: Wharfe_02, Watercourse: River Wharfe, OS NGR: 398068, 467168</th></tr>
<tr><th>Audit data</th><th>ST:REAM</th><th>CAESAR-Lisflood</th><th>Half-yield</th></tr>
<tr>
<td>
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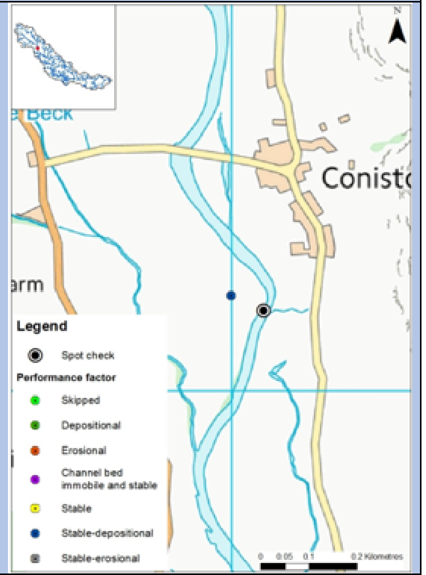
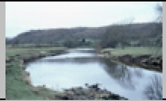
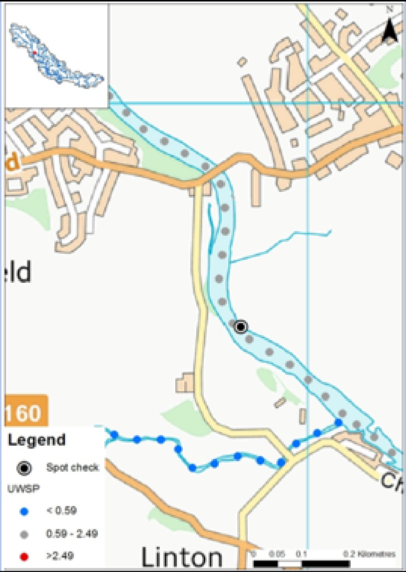
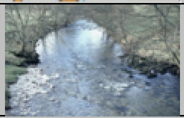
<td>
</td>
<td></td>
<td>
</td>
</tr>
<tr>
<td>The following data was extracted from the reach audit shapefile:

<table>
<tr><td>Dominant bank material:</td><td>Fines</td></tr>
<tr><td>Dominant bank structure:</td><td>Cohesive</td></tr>
<tr><td>Dominant bank erosion process:</td><td>Geotechnical, with fluvial and burrowing processes</td></tr>
<tr><td>Acc. of erosion occurring:</td><td>No</td></tr>
<tr><td>Evidence of incision:</td><td>Yes – exposed tree roots</td></tr>
<tr><td>Evidence of aggradation:</td><td>No</td></tr>
<tr><td>Dominant bed material:</td><td>Cobble, with some coarse gravel</td></tr>
<tr><td>Dominant biotope:</td><td>Runs, with some pools and riffles</td></tr>
<tr><td>Dominant deposition:</td><td>Small numbers of mesoscale, unstable boulder and cobble bars</td></tr>
</table>
Key process(es): Transfer</td>
<td>In the ST:REAM model, the reach is classified as transfer.</td>
<td>Not tested</td>
<td>In the Half-yield method, there is one suitable RHS data point within the vicinity of the spot check location.

The RHS point is classified as stable-depositional in terms of the Performance Factor (P = 0.11) and Effectiveness Index (E = -1). This indicates:
• In-channel flows dominant
• Incised/recovering
• Frequent flows most effective at depositing
• Gradual bed raising</td>
</tr>
<tr><td colspan="4">Conclusion:
• Only two tested methods available.
• The audit classified the reach as transfer.
• Based on this, ST:REAM and Half-Yield depict the correct process.</td></tr>
</table>

Figure D.10 Results validation: Wharfe 02

<table>
<tr><th colspan="4">Reach: Wharfe_03, Watercourse: River Wharfe, OS NGR: 399860, 463533</th></tr>
<tr><th>Audit data</th><th>ST:REAM</th><th>CAESAR-Lisflood</th><th>Half-yield</th></tr>
<tr><td>
</td><td>
</td><td></td><td>
</td></tr>
<tr><td>The following data was extracted from the reach audit shapefile:

<table>
<tr><td>Dominant bank material:</td><td>Fines</td></tr>
<tr><td>Dominant bank structure:</td><td>Cohesive</td></tr>
<tr><td>Dominant bank erosion process:</td><td>Geotechnical, with some burrowing</td></tr>
<tr><td>Acceleration of erosion occurring:</td><td>No</td></tr>
<tr><td>Evidence of incision:</td><td>No</td></tr>
<tr><td>Evidence of aggradation:</td><td>No</td></tr>
<tr><td>Dominant bed material:</td><td>Cobble, with some coarse gravel and boulders</td></tr>
<tr><td>Dominant biotope:</td><td>Glide</td></tr>
<tr><td>Dominant deposition:</td><td>Mesoscale, unstable silt bars</td></tr>
</table>
Key process(es): Transfer</td><td>In the ST:REAM model, the reach is classified as transfer.</td><td>Not tested.</td><td>In the Half-yield method, there are two RHS data points within the vicinity of the spot check location.

One RHS point is classified as stable-depositional in terms of the Performance Factor (P = 0.23) and Effectiveness Index (E = 0). This indicates:
The channel is wide/shallow and/or has coarse sediment
Balance in sediment yield between in-channel and overtopping flows
Bar-berm building
The other RHS point, slightly further upstream, is calculated to have an immobile and stable channel bed. This indicates that the channel will act as a transfer reach for smaller sediment sizes and potentially depositional for fines. Channel banks might also be subject to erosion in high energy reaches.</td></tr>
<tr><td colspan="4">Conclusion:
Only two tested methods available.
The audit classified the reach as transfer.
Based on this, both ST:REAM and the half-yield method depict the correct process.</td></tr>
</table>

Figure D.11 Results validation: Wharfe 03

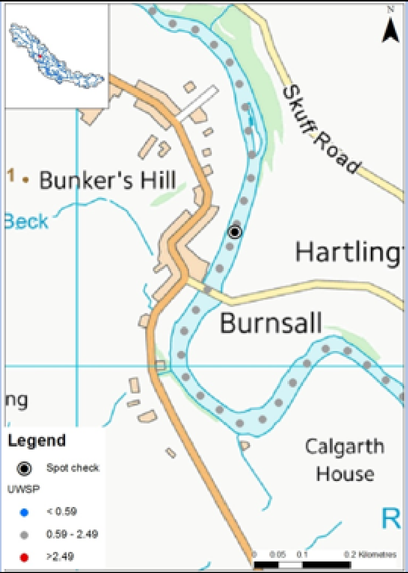
Reach: Wharfe_04, Watercourse: River Wharfe, OS NGR: 403328, 461280

Audit data

The following data was extracted from the reach audit shapefile:

Dominant bank material:	Fines
Dominant bank structure:	Cohesive
Dominant bank erosion process:	Geotechnical, with some fluvial
Acceleration of erosion occurring:	No
Evidence of incision:	No
Evidence of aggradation:	No
Dominant bed material:	Coarse gravel, with some fine gravel and cobbles
Dominant biotope:	Glide
Dominant deposition:	Mesoscale, unstable gravel bars
Key process(es): Transfer	

ST:REAM

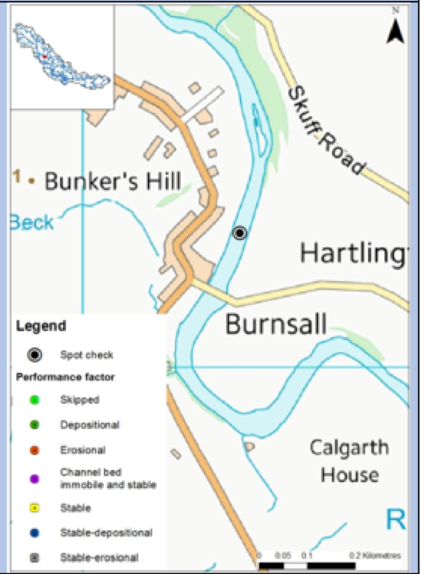


In the **ST:REAM** model, the reach is classified as transfer.

CAESAR-Lisflood

Not tested.

Half-yield



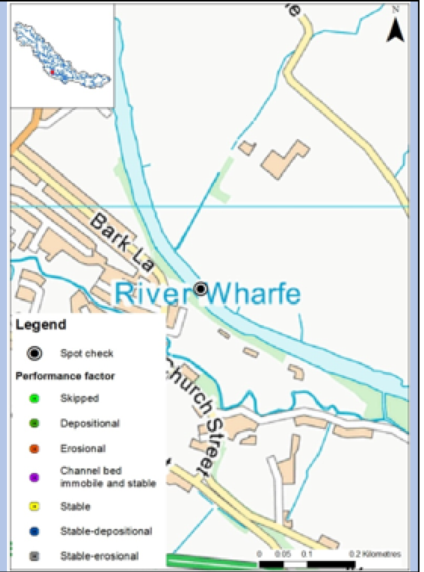
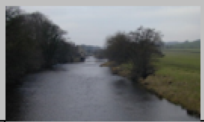
No RHS sample point available for this reach.

Conclusion:

- **Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.**
- **The audit classified the reach as transfer.**
- **Based on this ST:REAM depicts the correct process.**

Figure D.12 Results validation: Wharfe 04

Reach: Wharfe_05, Watercourse: River Wharfe, OS NGR: 408416, 449829

Audit data	ST:REAM	CAESAR-Lisflood	Half-yield
			
The following data was extracted from the reach audit shapefile: 	In the **ST:REAM** model, the reach is classified as depositional.	Not tested.	No RHS sample point available for this reach.

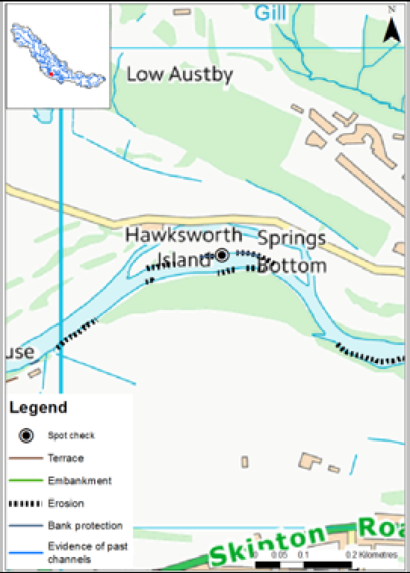
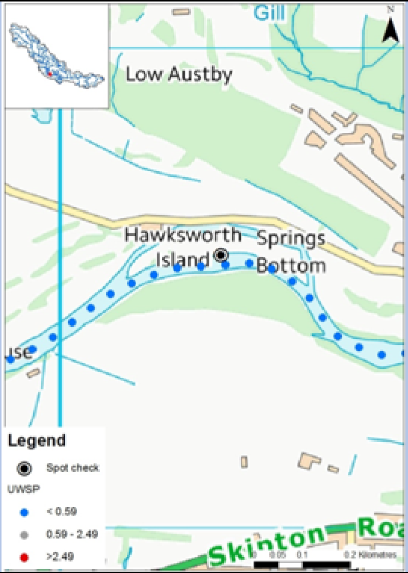
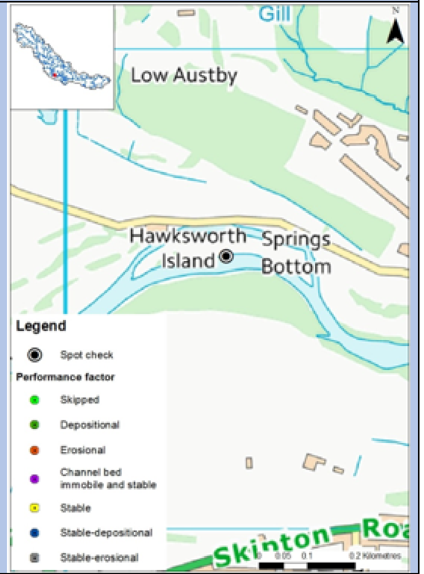
Dominant bank material:	Coarse gravel
Dominant bank structure:	Non-cohesive
Dominant bank erosion process:	Fluvial
Acceleration of erosion occurring:	Yes - poaching
Evidence of incision:	No
Evidence of aggradation:	Yes – floodplain deposition
Dominant bed material:	Coarse gravel
Dominant biotope:	Run
Dominant deposition:	Mesoscale, unstable gravel bars

Key process(es): Transfer

Conclusion:

- **Only one tested method available. The Half-yield method could not be used due to the lack RHS data in the area.**
- **The audit classified the reach as transfer.**
- **Based on this, ST:REAM does not depict the correct process, as the reach was calculated to be depositional in nature.**

Figure D.13 Results validation: Wharfe 05

Reach: Wharfe_06, Watercourse: River Wharfe, OS NGR: 410334, 448569			
Audit data	**ST:REAM**	**CAESAR-Lisflood**	**Half-yield**
			
The following data was extracted from the reach audit shapefile:	In the **ST:REAM** model, the reach is classified as depositional.	Not tested.	No RHS sample point available for this reach.

Dominant bank material:	Fines
Dominant bank structure:	Cohesive
Dominant bank erosion process:	Fluvial
Acceleration of erosion occurring:	No
Evidence of incision:	No
Evidence of aggradation:	Yes – floodplain deposition
Dominant bed material:	Coarse gravel, with some cobbles
Dominant biotope:	Glide with some riffles
Dominant deposition:	Mesoscale, unstable gravel bars

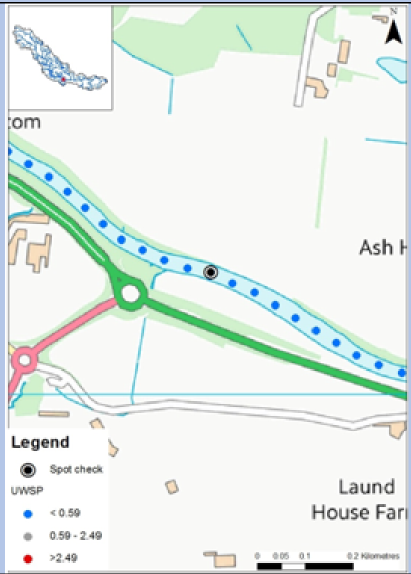
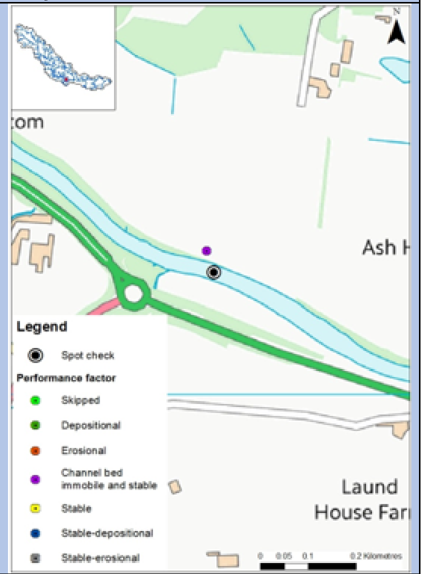
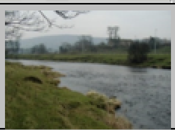
Key process(es): Transfer

Conclusion:

- **Only one tested methods available. The Half-yield method could not be used due to the lack RHS data in the area.**
- **The audit classified the reach as transfer.**
- **Based on this, ST:REAM does not depict the correct process, as the reach was calculated to be depositional in nature.**

Figure D.14 Results validation: Wharfe 06

Reach: Wharfe_07, Watercourse: River Wharfe, OS NGR: 417515, 446256

Audit data	ST:REAM	CAESAR-Lisflood	Half-yield
			
The following data was extracted from the reach audit shapefile: 	In the **ST:REAM** model, the reach is classified as depositional.	Not tested.	In the **Half-yield** method, there is one suitable RHS data point within the vicinity of the spot check location. In the **Half-yield** method the reach is calculated to have an immobile and stable channel bed. This indicates that the channel will act as a transfer reach for smaller sediment sizes and potentially depositional for fines. Channel banks might also be subject to erosion in high energy reaches.

Dominant bank material:	Fines, with some sand
Dominant bank structure:	Cohesive
Dominant bank erosion process:	Geotechnical, with some burrowing
Acceleration of erosion occurring:	No
Evidence of incision:	No
Evidence of aggradation:	No
Dominant bed material:	Coarse gravel, with some fine gravel and cobbles
Dominant biotope:	Glide with some riffles
Dominant deposition:	Macroscale, unstable and stable silt deposits
Key process(es): Transfer	

Conclusion:

- **Only two tested methods available.**
- **The audit classified the reach as transfer.**
- **Based on this Half-Yield depicts the correct process. ST:REAM does not depict the correct process as the reach was calculated to be depositional in nature.**

Figure D.15 Results validation: Wharfe 07

Reach: Wharfe_08, Watercourse: River Wharfe, OS NGR: 431821, 446282

Audit data

The following data was extracted from the reach audit shapefile:

Dominant bank material:	Fines, with some sand
Dominant bank structure:	Cohesive
Dominant bank erosion process:	Geotechnical, with some burrowing
Acc. of erosion occurring:	No
Evidence of incision:	No
Evidence of aggradation:	No
Dominant bed material:	Coarse gravel, with some fine gravel and cobbles
Dominant biotope:	Glide with some riffles
Dominant deposition:	Macroscale, unstable and stable silt deposits

Key process(es): Transfer

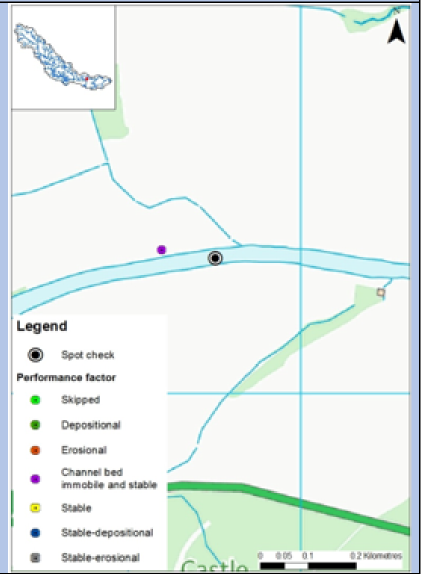
ST:REAM

In the **ST:REAM** model, the reach is classified as depositional.

CAESAR-Lisflood

Not tested.

Half-yield



In the **Half-yield** method, there is one suitable RHS data point within the vicinity of the spot check location.

In the **Half-yield** method the reach is calculated to have an immobile and stable channel bed. This indicates that the channel will act as a transfer reach for smaller sediment sizes and potentially depositional for fines. Channel banks might also be subject to erosion in high energy reaches.

Conclusion:

- **Only two tested methods available**
- **The audit classified the reach as transfer**
- **Based on this, the Half-yield method depicts the correct process. ST:REAM does not depict the correct process as the reach was calculated to be depositional in nature.**

Figure D.16 Results validation: Wharfe 08

2 Validating the shear stress data mining method

2.1 Test catchments

Three different test catchments were identified where fluvial audit data is available, showing field-based observations of erosion and deposition. These are:

- River Kent (Cumbria)
- River Wharfe (Yorkshire)
- River Stour (Dorset)

2.2 Background

A selection of areas within the pilot catchments were analysed. Reaches in contrasting areas of the catchment were chosen to identify any specific reach characteristics where the results appear more or less meaningful.

In a small number of areas within a pilot catchment the results were compared with ground truth data (fluvial audit data) to understand how accurately the model predicts processes of erosion and deposition.

The assumptions on D50 (50 mm) are likely to be more relevant for the first 2 catchments, so validation there is more significant. The Stour is expected to have a finer D50, and therefore the results are likely to be less representative of this catchment.

2.3 Validating against field data

The fluvial audit process aims to identify different types of geomorphological form and features within a reach, rather than solely identifying broader scale processes. The fluvial audit outputs provided for the Kent and Wharfe centre on bank erosion rather than in-channel scour, so it may be important to assess what the national model predicts at the bank edges. Key ‘sediment sinks’ are also recorded in the fluvial audit data sets, representing areas of deposition. For the Wharfe, additional data on particular reaches was available, including 'significant erosion' or ‘deposition’ areas. The assumption is that D50 = 50 mm in the available SSDM maps is most representative of the Wharfe and the Kent, and is likely to be too large for the Stour.

2.4 Comparison in Kent catchment

An overview map of the upper Kent catchment is shown in Figure D-17, where it is evident that the raw model outputs (red - erosion, yellow - deposition, green - transition) are much more extensive than the fluvial audit data and cover the minor channels and flow pathways. There are some large areas of yellow (deposition) that coincide with fluvial audit sediment sinks, and some long areas of red (erosion) that coincide with recorded areas of bank erosion. The SSDM output is clearly more extensive at this broad scale, but it should be noted that the fluvial audit data is only available for the main channel, and it is mainly centred on bank erosion (blue lines).

Figure D-18 zooms in to an area where there are more processes occurring, before subsequent figures are used, incorporating aerial photography, to compare outputs at a reach-by-reach level in more detail.

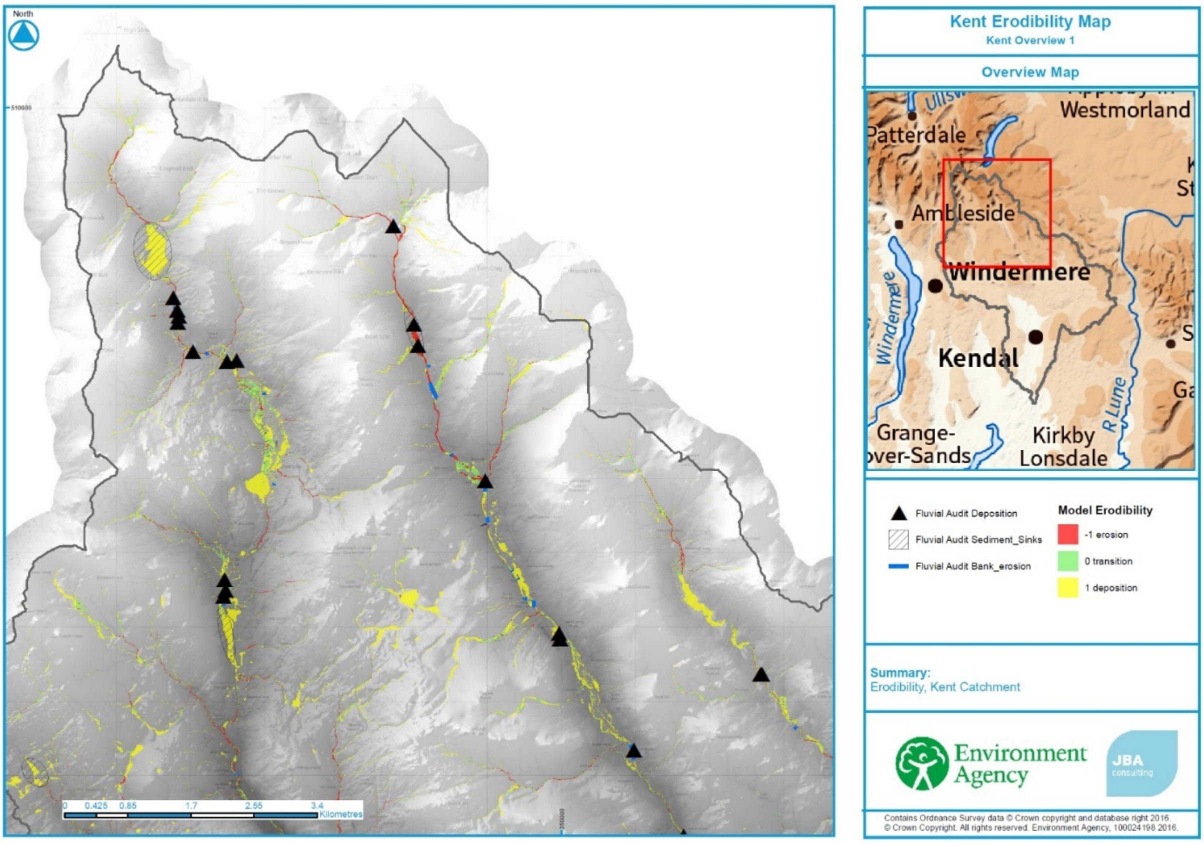


Figure D-17 Overview of Kent

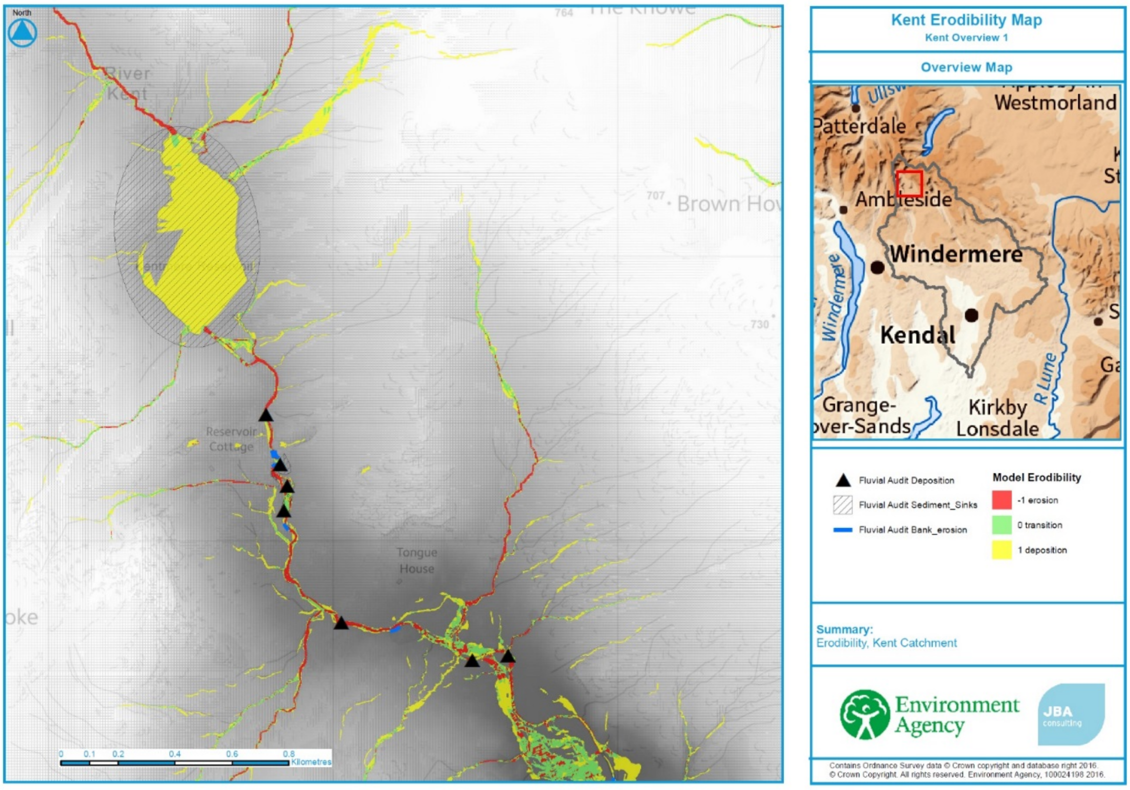


Figure D-18 Kent catchment processes

Figure D-18 zooms into an area where there is a lot of activity, and with the exception of side tributaries, the blue bank erosion areas are picked up. However, the modelled areas of erosion (red) are much more extensive than the recorded erosion areas (blue), since the model is predicting high shear stress whether that results in scour or bank erosion.

The next figures explore this in more detail, starting close to the dam and overspill at Kentmere, since the overspill is exposed (no tree cover) and is likely to have high velocities. This provides an interesting (artificial surface) test.

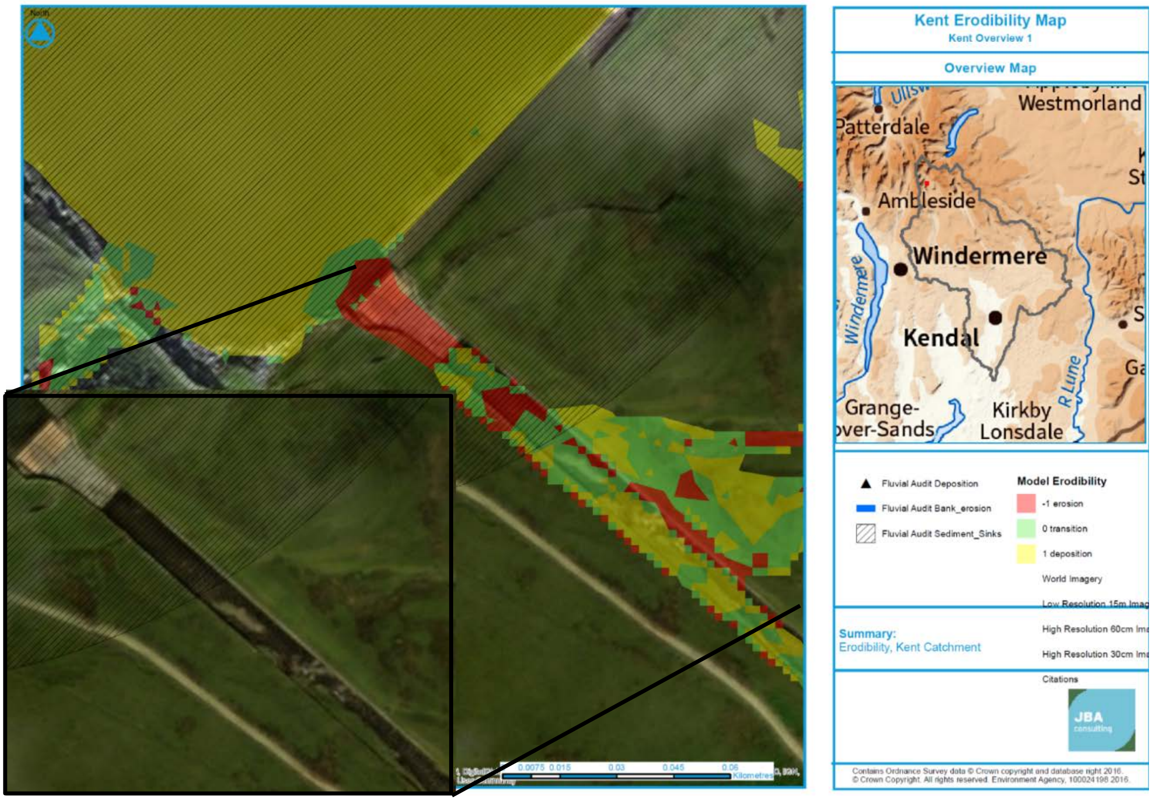


Figure D-19 Kentmere overspill with photo inset

Figure D-19 shows that the model predicts high shear stresses (red) representing erosion, but also some deposition in yellow, which can also be seen in the aerial imagery inset photo without colour theming.

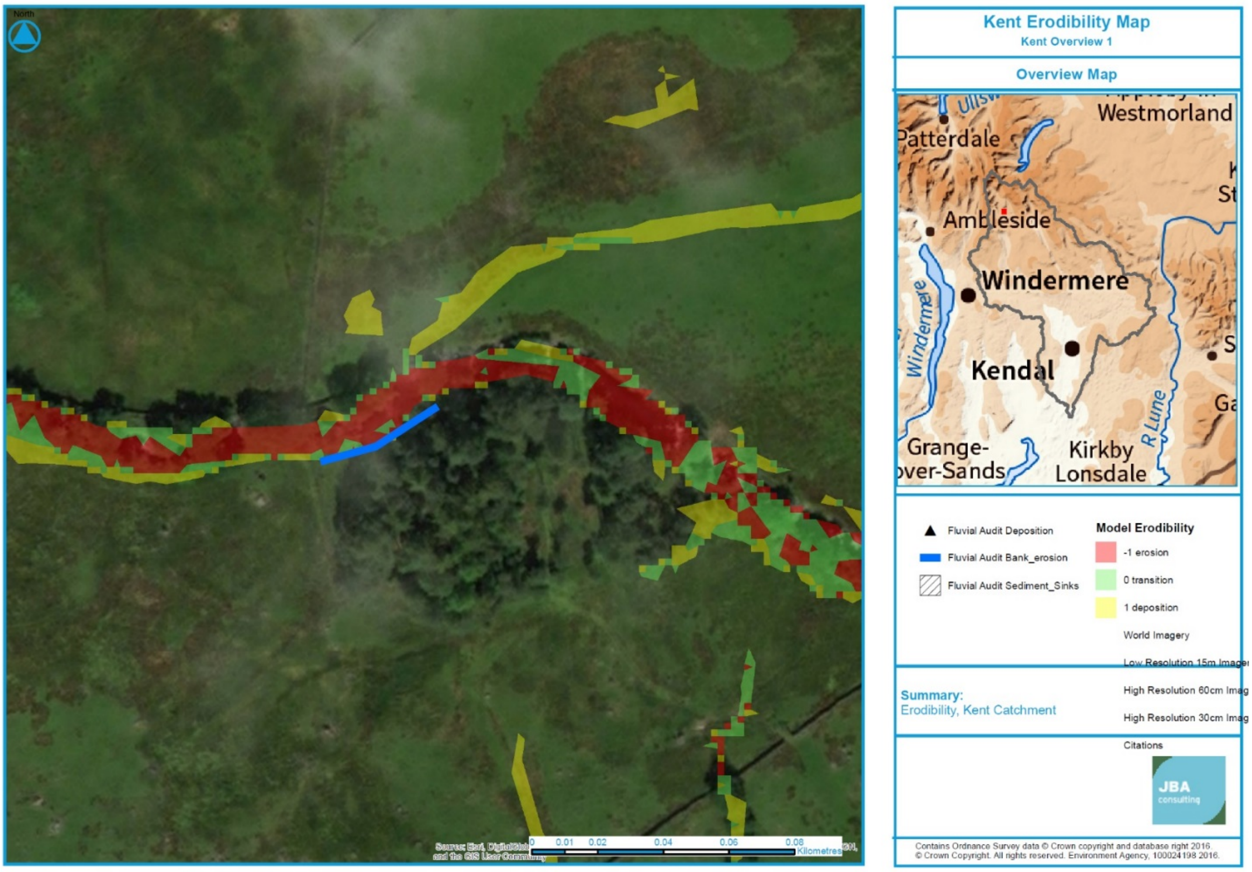


Figure D-20 Kent predicted area of bank erosion

Figure D-20 shows the predicted areas of erosion close to the bank as identified in the fluvial audit, although this example impinges on a wooded area, for which the approach is likely to be less accurate. Trees are filtered from the bare earth digital elevation model (DEM) to form the digital terrain model (DTM) that was used as the basis for the RoFSW maps.

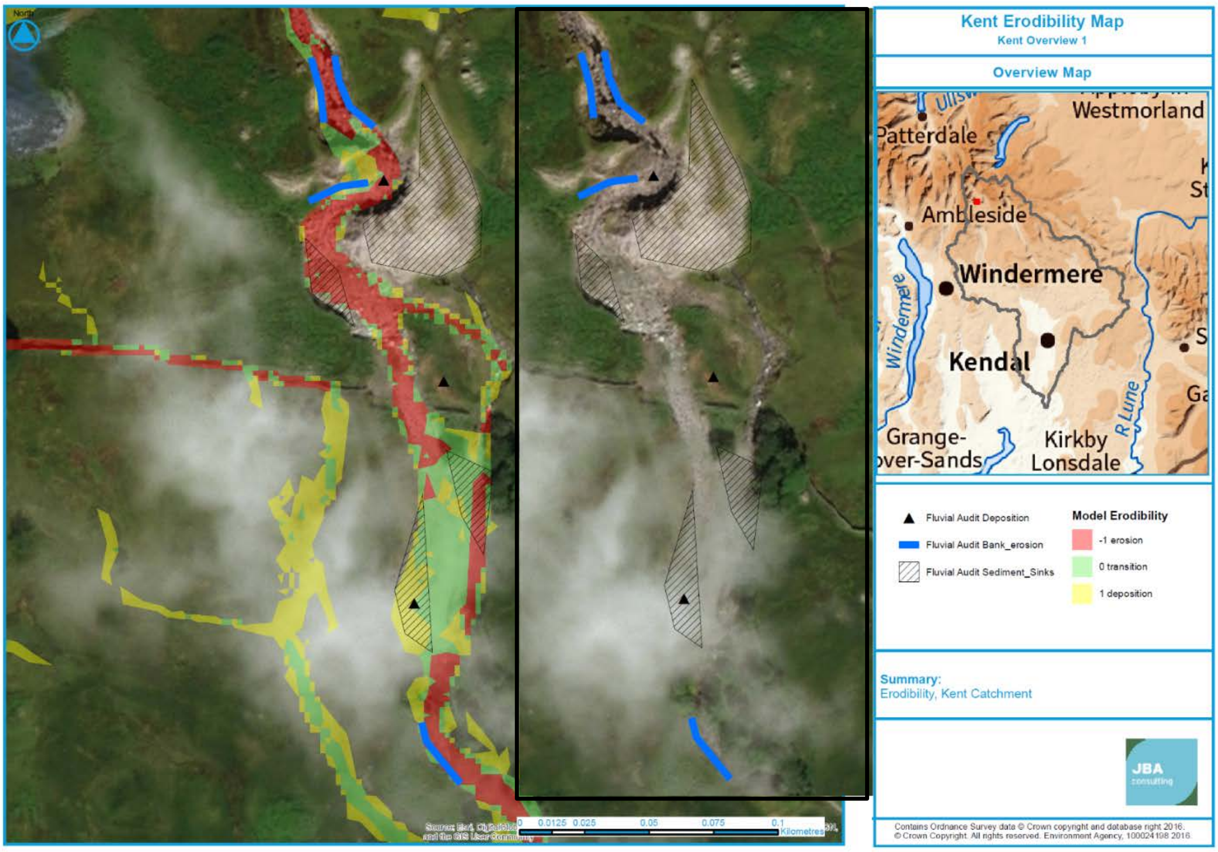


Figure D-21 Kent - complex erosion and deposition area with photo inset right

Figure D-21 covers a complex area of exposed material and bed movement containing areas of erosion and deposition which are partly captured by the SSDM. For the area on the north-east labelled as a ‘sediment sink’, it is likely that a larger probability event (0.1% AEP) would need to be modelled as flows are not predicted in this area.

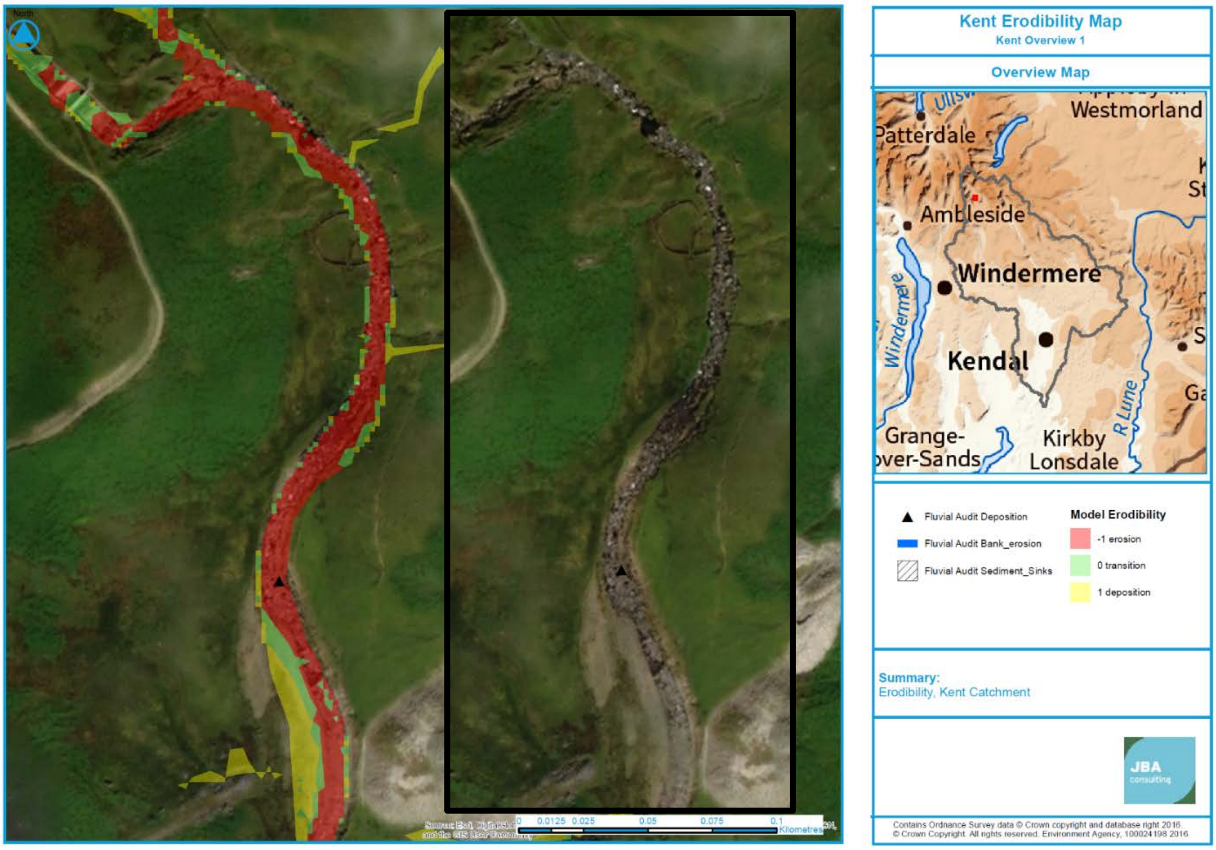


Figure D-22 Kent - complex erosion and deposition area with photo inset right

Figure D-22 represents an area in which the fluvial audit has only recorded a point location of deposition. This is close to the patch of yellow in the modelled maps, although clearly visible from the inset photo is a depositional bar that is more aligned with the model than the fluvial audit, suggesting some limitations in the survey. In this instance, SSDM could be said to have improved reach scale mapping compared to the audit.

Figure D-23 Kent - depositional reach with some bank erosion

Figure D-23 highlights that the model is predicting this reach to be more depositional, differing from the audit which maps bank erosion. However, there are clear signs of deposition in the vicinity. The woodland is likely to reduce the accuracy of the SSDM method here, if there are any artefacts left from the filtering process.

Figure D-24 Kent - Bank erosion captured (red pixels)

Figure D-24 highlights that the model predicts signs of high near bank shear as recorded in the fluvial audit results.

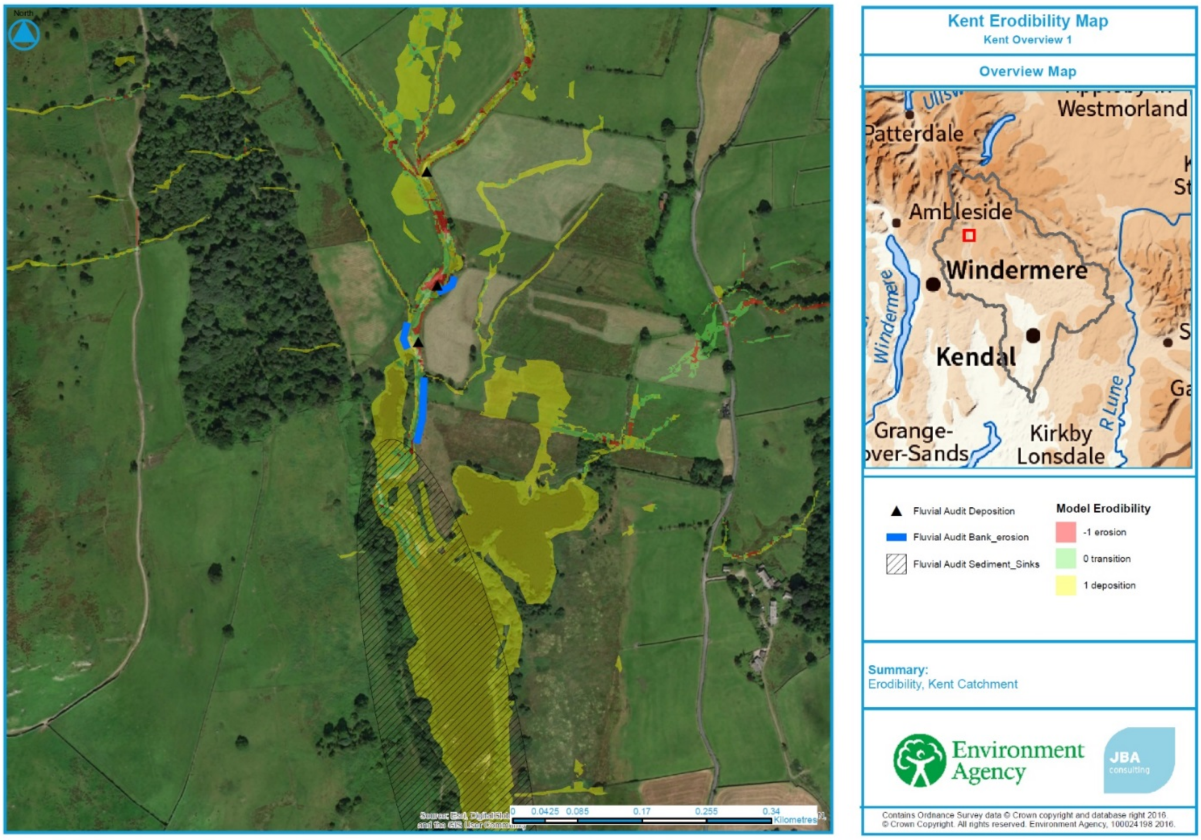


Figure D-25 Kent - Erosion and depositional zones mostly captured by model

Figure D-25 highlights that the model can capture complex reaches of sediment movement quite accurately in comparison with the fluvial audit observations, especially where tree coverage is less.

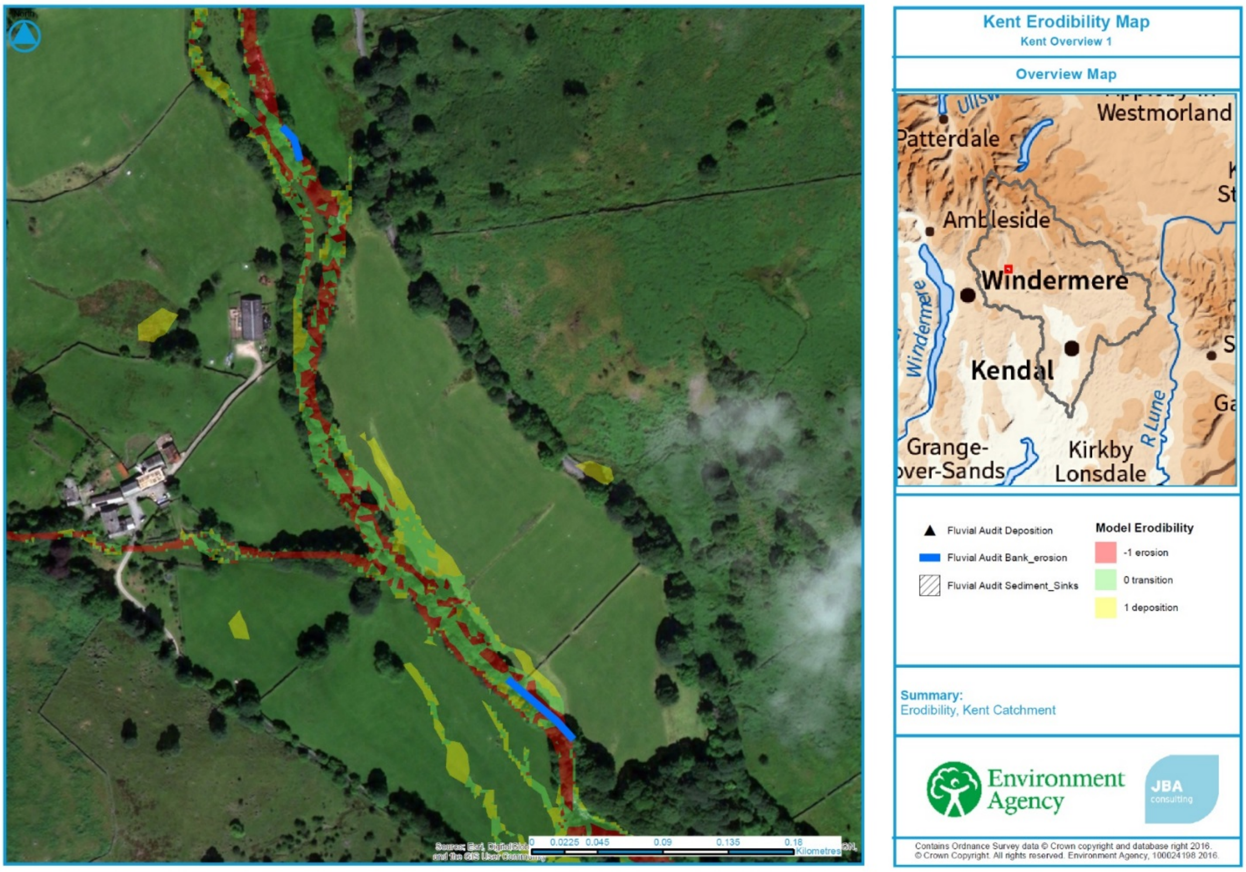


Figure D-26 Kent - High shear predicted near banks

In Figure D-26 there is over prediction of bank erosion compared with the fluvial audit, although it should be noted that the tree cover will provide bank stability which is not represented within the modelling. This could therefore simply be factored into the SSDM output.

Figure D-27 Kent - Bank erosion predicted

Figure D-27 shows agreement with the audit in that there are red pixels illustrating bank erosion close to the left bank where there is less tree cover. Discrepancies between the model and data would again be removed by filtering out the wooded areas.

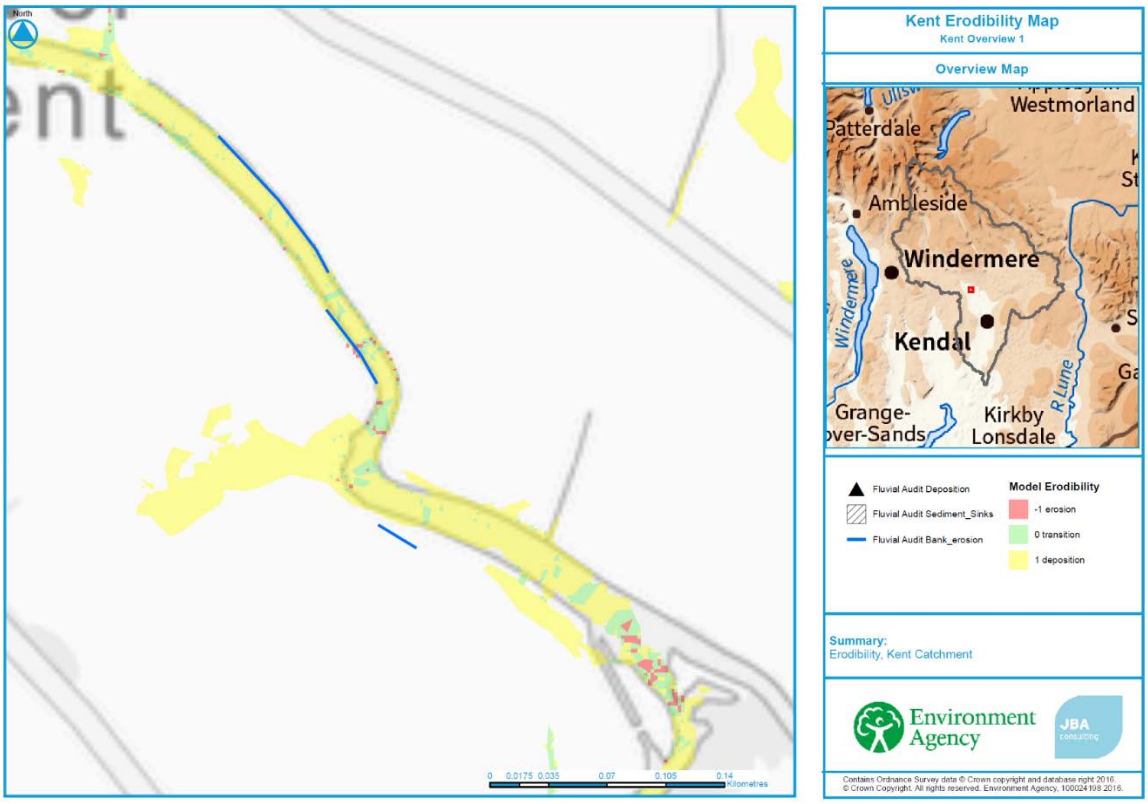


Figure D-28 Kent - SSDM model predicts high near bank shear near surveyed bank erosion

Figure D-28 highlights that small areas of high shear can be important if the method is to be used to predict bank erosion. A 'majority filtering' process would remove these isolated pixels of bank erosion, which are shown to be largely an accurate representation of bank processes.

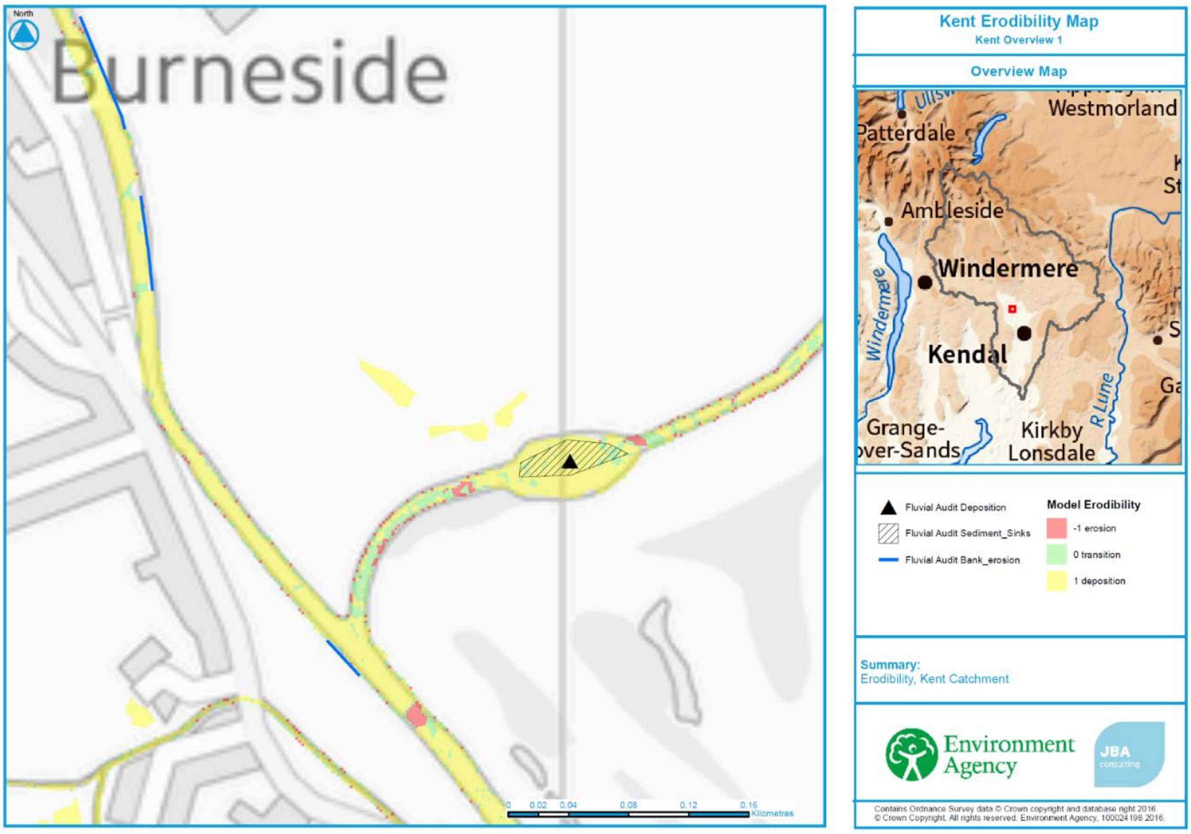


Figure D-29 Kent - Depositional areas identified correctly, with some areas of bank erosion downstream of Burneside

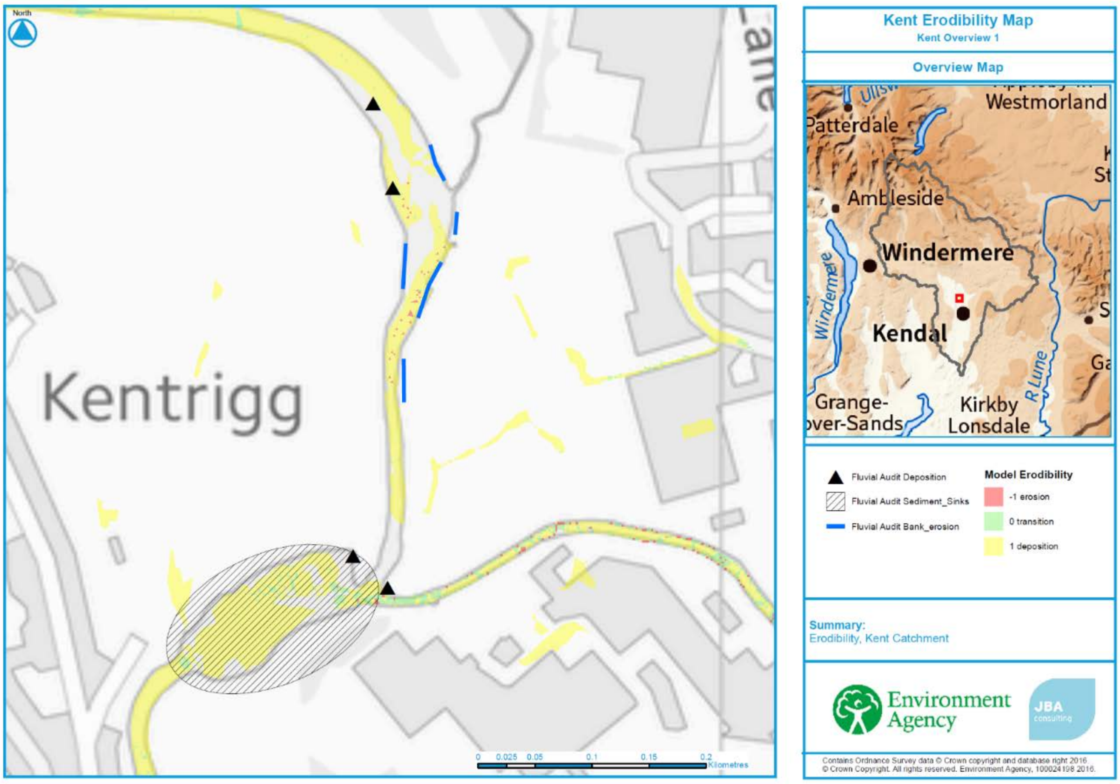


Figure D-30 Kent - Main depositional zones identified, some areas of high shear near identified areas of bank erosion

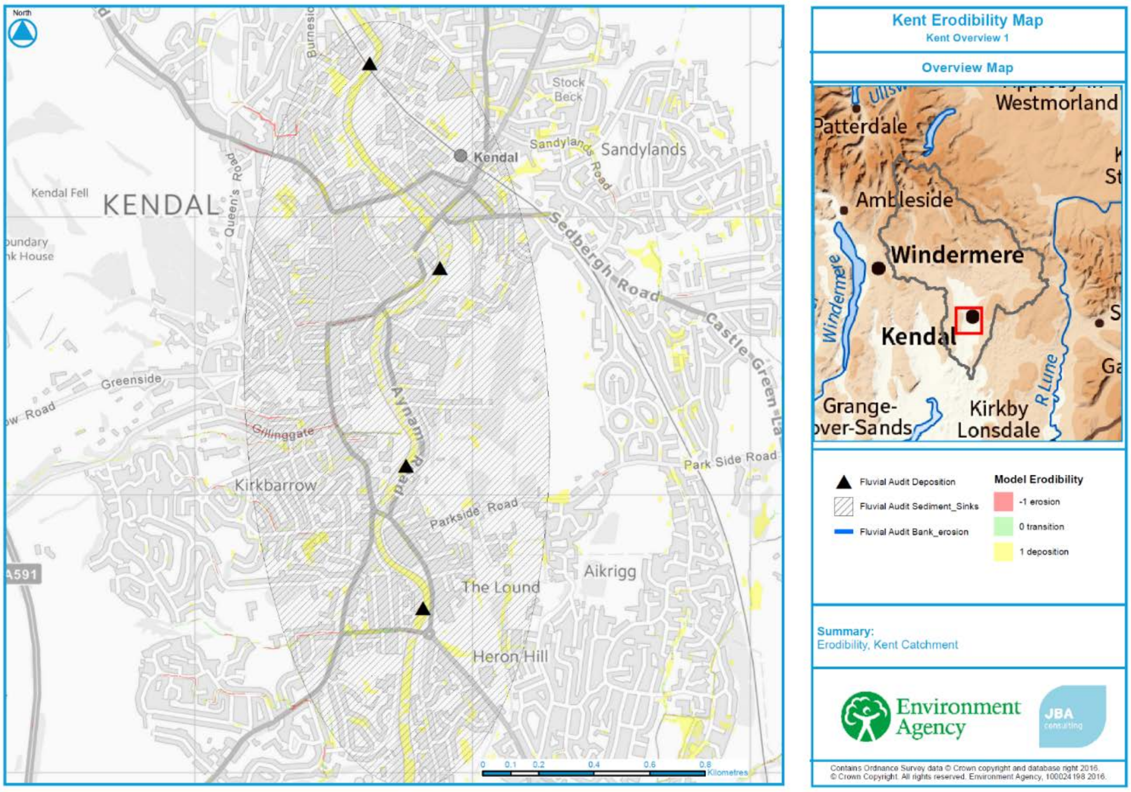


Figure D-31 Model predicts Kendal is a sediment sink as per audit

Figure D-31 illustrates an accurate representation of the recorded depositional processes occurring though Kendal, with solely deposition shown in the model outputs.

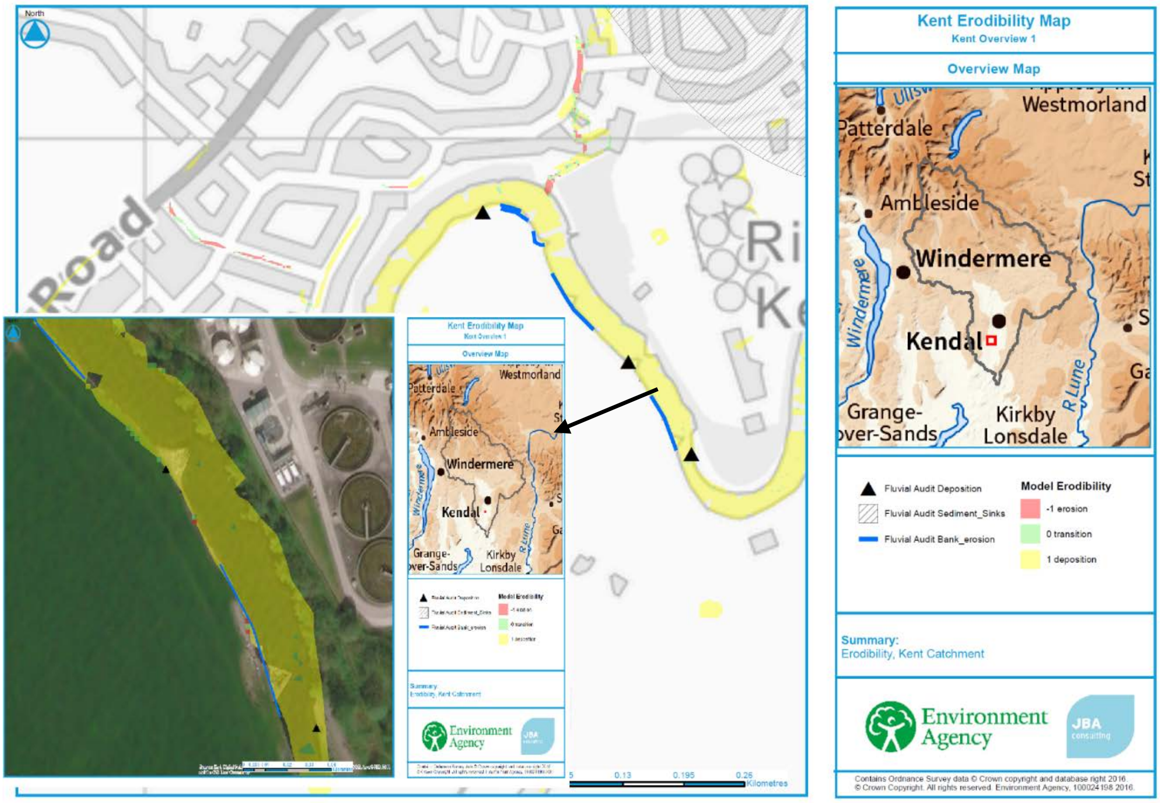


Figure D-32 Kent - Some high shear zones are not obvious unless zoomed in

High shear stresses are predicted along the channel banks, representing identified areas of bank erosion (Figure D-32).

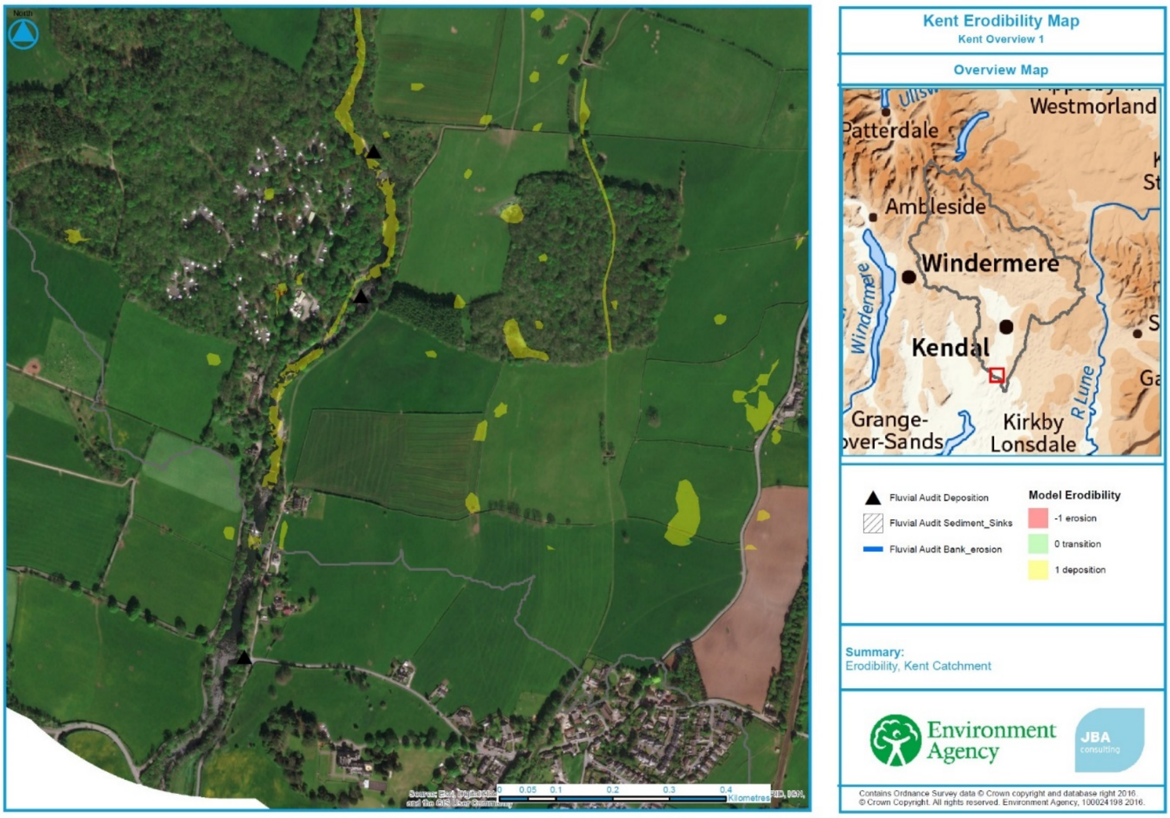


Figure D-33 Kent - Model predicting depositional reach as in the audit (black triangle)

Figure D-33 shows a depositional reach, as identified in the fluvial audit, although it is likely that the flows in this area are under estimated compared to the critical storm duration, given it is a long way downstream.

2.5 Comparison in Wharfe catchment

For the Wharfe, a set of key processes have been tagged onto spatial reach data, as in Table 2-1, along with a shapefile identifying each reach, plus fluvial audit based markers of bank erosion (shown in blue). The severely eroding reaches have been colour themed as pink in the figures below (reaches were 52, 54, 56, 58, 61, 81, 96, 104), and those where there is significant storage/deposition in orange.

Table 2-1 Reach numbers identifying predominant processes in the Wharfe catchment

Reach type	Reach numbers	Process
Active reaches	58, 61, 81, 96, 104	Severely eroding reaches
Active reaches	85, 91, 109	Large sediment storage area
Active reaches	138, 142, 144,	Severely eroding reaches
Active reaches	146	Significant planform change Area of sediment storage
Active reaches	149	Large sediment storage area
Active reaches	52, 54, 56,	Severely eroding reaches

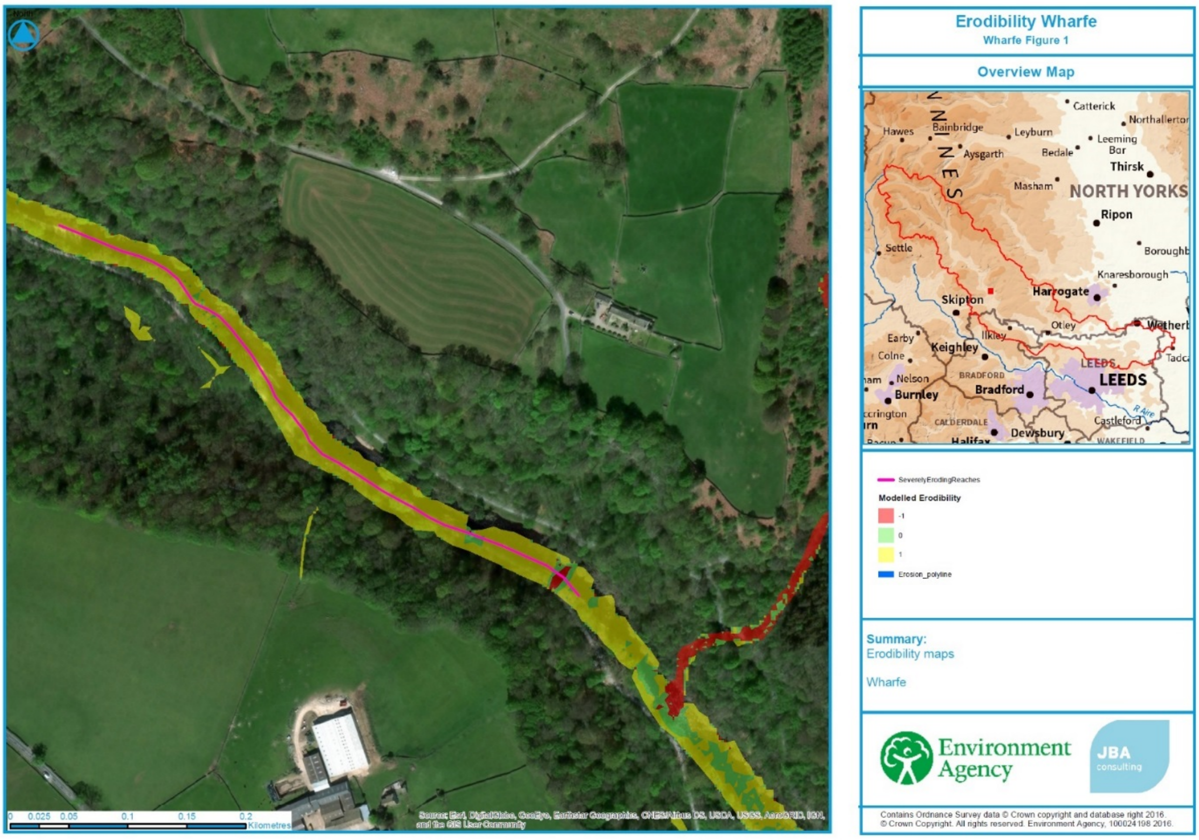


Figure D-34 Wharfe severely eroded reach 52 RP 30

The first map (Figure D-34) is zoomed into reach 52, halfway along the Wharfe catchment, using the erodibility maps based on the 30-year return period (3.33% AEP). It is evident that there are some areas of agreement near the south-eastern end of the reach, where erosion is predicted (red zones). Here the river is reasonably wide, and it suggests that shear stresses based on a larger flow may be necessary in order to represent the potential for channel erosion.

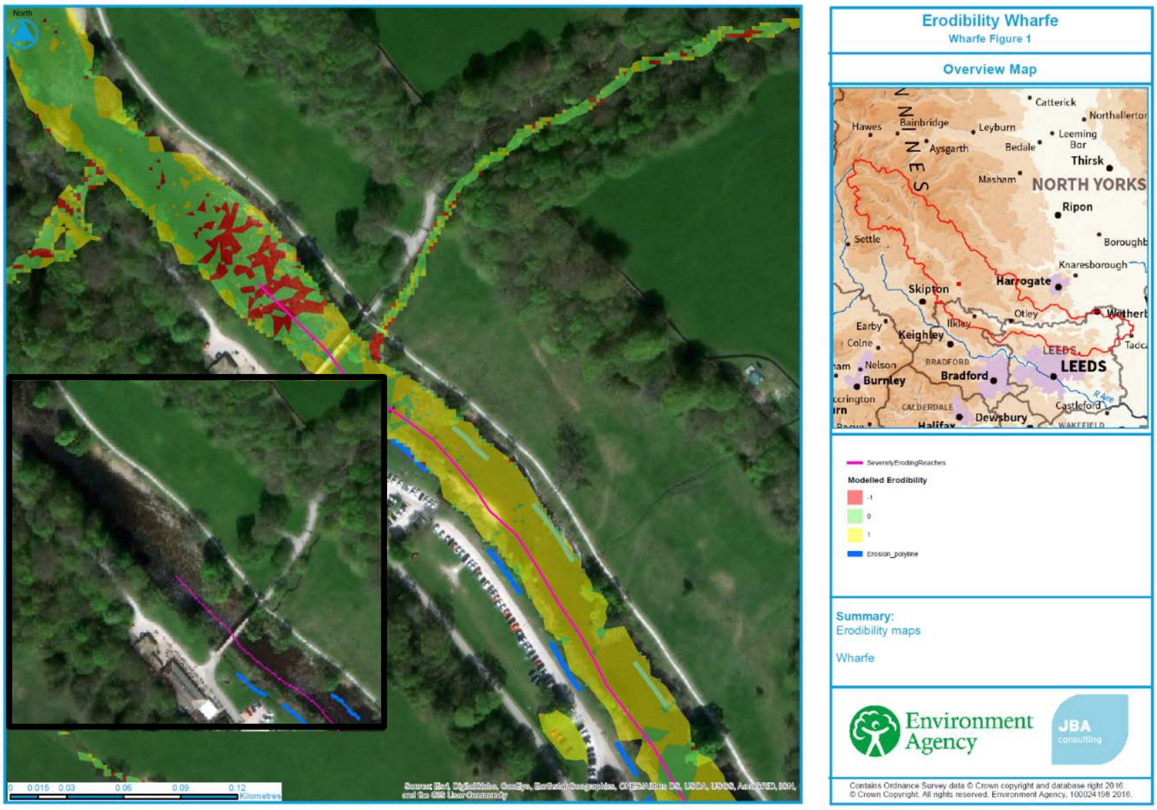


Figure D-35 Wharfe severely eroded reach 54 using RP30 with inset of bed

In Figure D-35, the 30-year return period (3.33% AEP) erodibility map is shown, agreeing well with a large area identified as severely eroded to the NW. An inset in this figure highlights that the channel bed is clearly visible where the modelled erodibility (red zone) is located. Some of the bank erosion is also captured by the SSDM model.

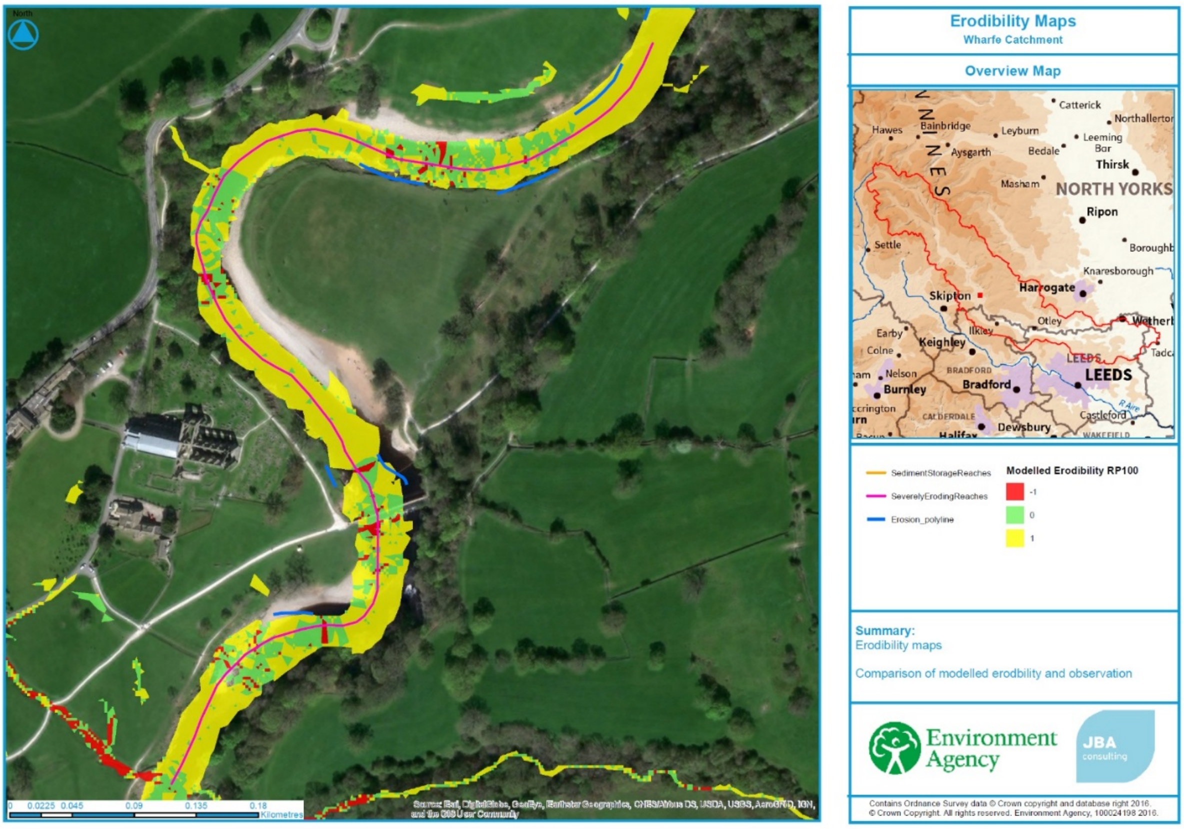


Figure D-36 Wharfe severely eroded reach 56 for RP100

Severely eroding reach 56 is shown in Figure D-36, using the 1% AEP (100-year return period) results, since the 30-year return period outputs did not show very extensive patches of erosion/deposition. The figure clearly captures the main features that were identified in the audit, and therefore the 100-year return period results have been used going forwards.

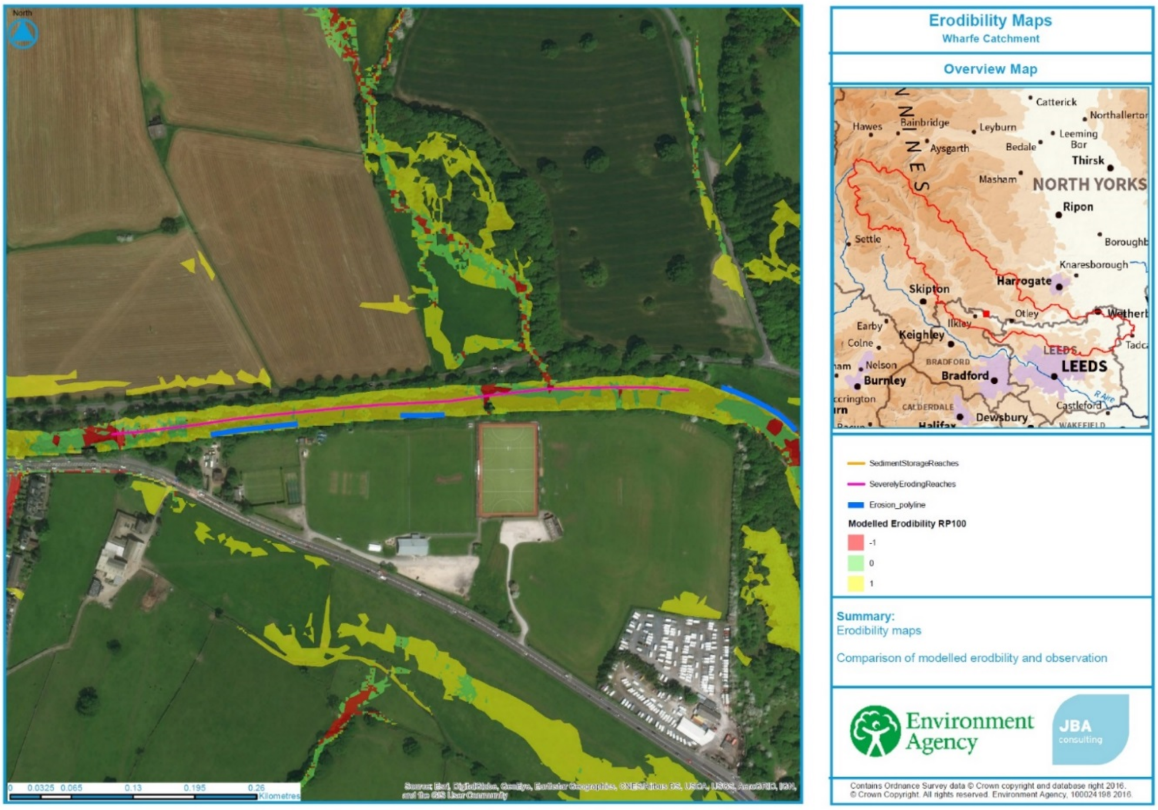


Figure D-37 Wharfe severely eroded reach 58 using RP100

Figure D-37 also shows SSDM prediction of red erosion zones within this reach flagged as having significant erosion.

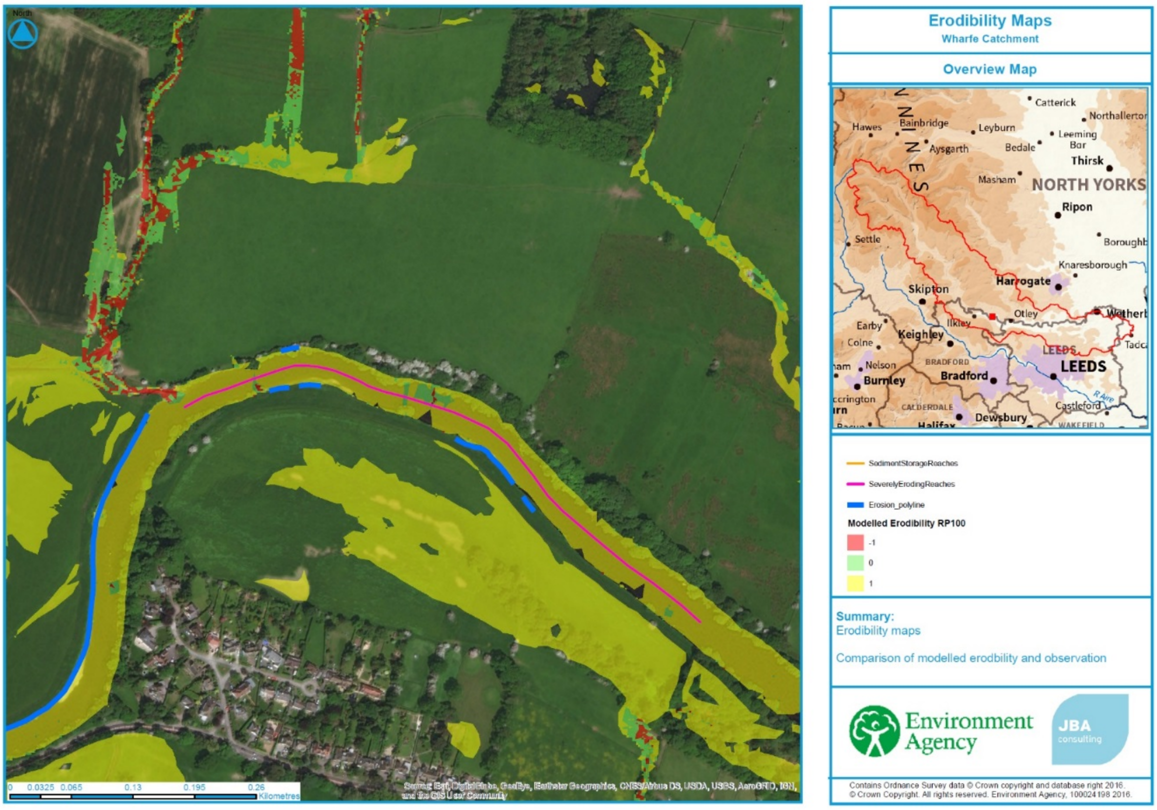


Figure D-38 Wharfe severely eroded reach 61 with inset RP100

This reach (61) shows less agreement with the audit, with some patches of predicted erosion to the west and centre of the reach. There are some high shear stresses in the un-surveyed tributary to the NW; this is likely to be due to high velocities on steep ground shown in Figure D-39.

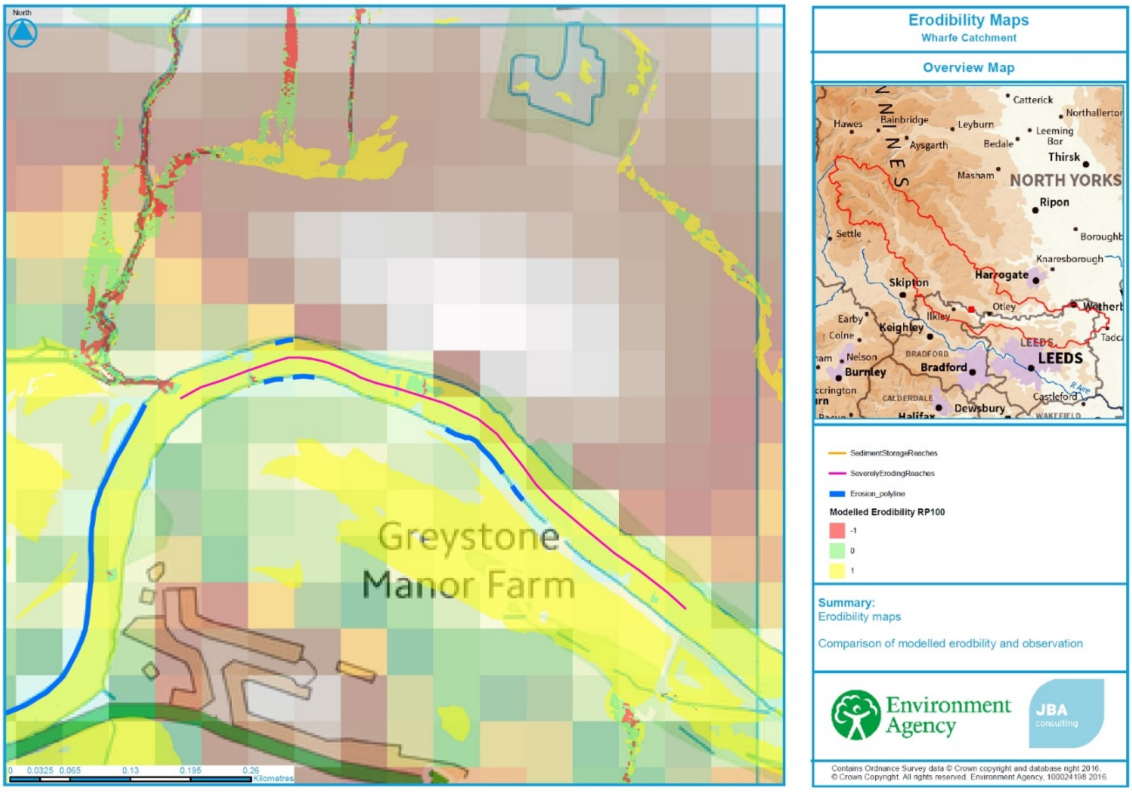


Figure D-39 Wharfe severely eroded reach 61 using RP100, showing steep topography in background LiDAR data

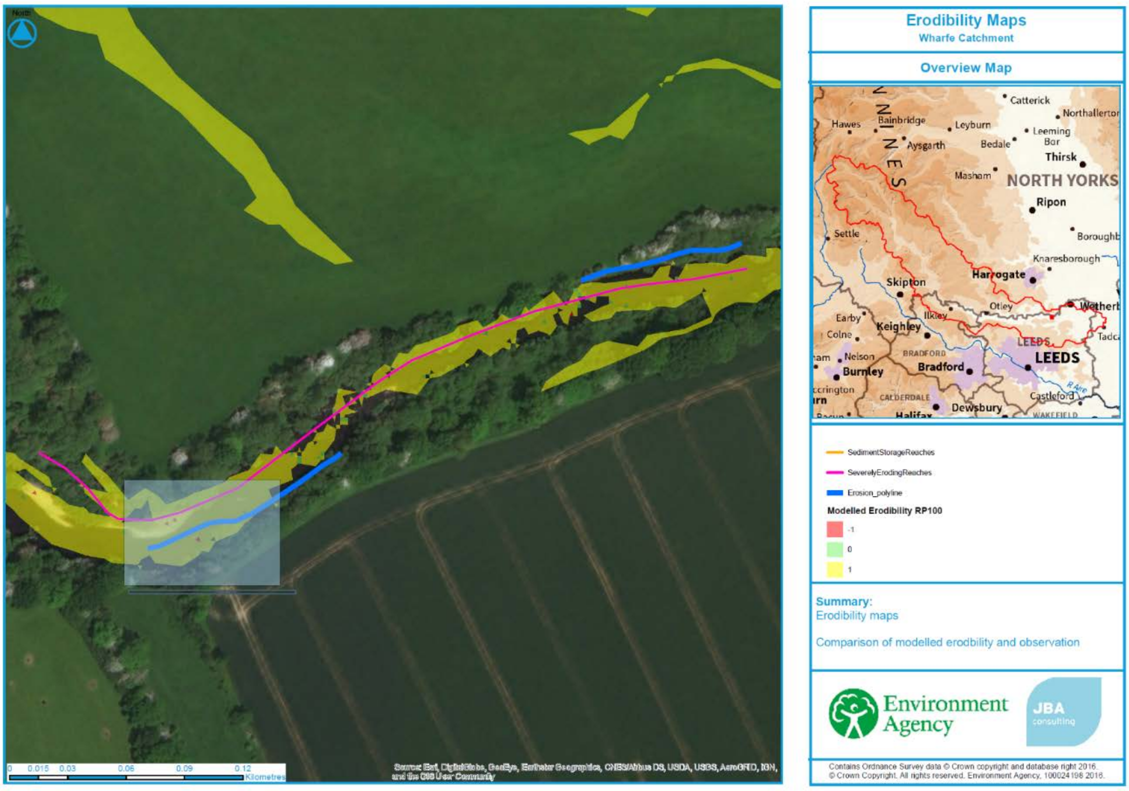


Figure D-40 Wharfe severely eroded reach 96 for RP100 with highlighted patches of high shear

In reach 96, there is a lot of riparian woodland and some areas of erosion are predicted, although predicted erosional zones are minimal compared to the fluvial audit record of significant erosion. It may be useful to compare the 0.1% AEP (1,000-yr return period) output here or use a smaller D50 this far downstream.

F

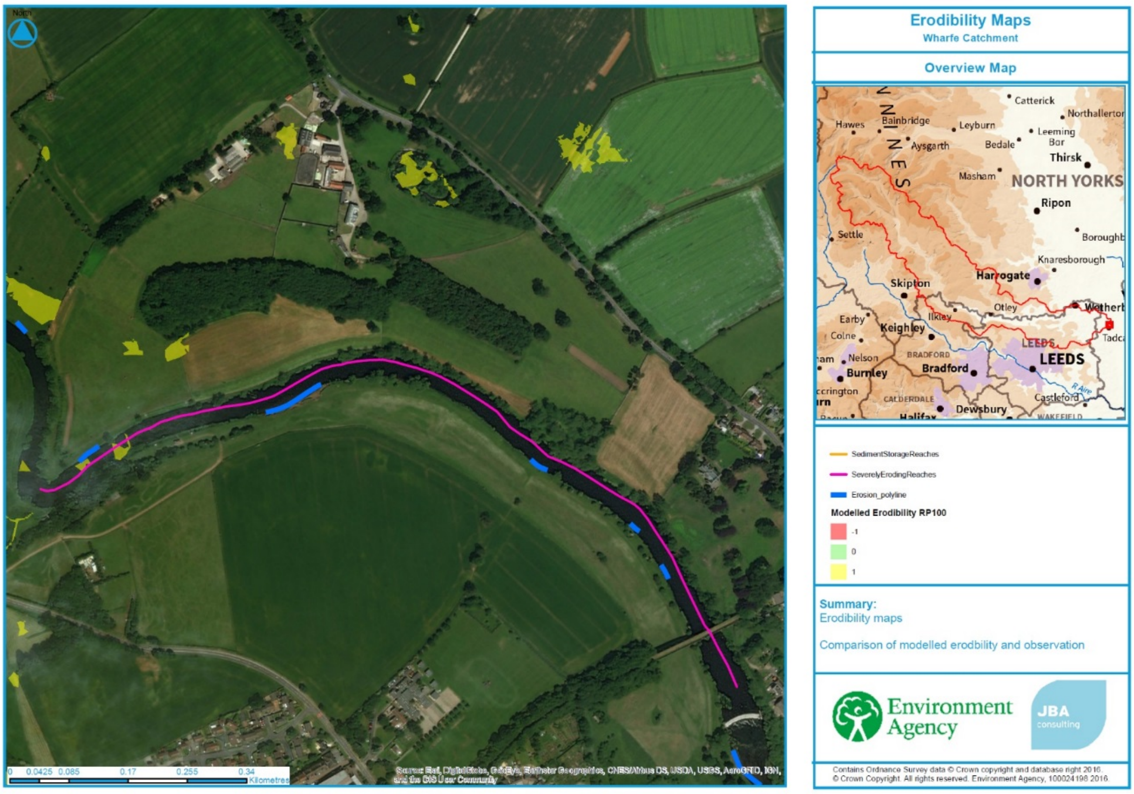


Figure D-41 Wharfe severely eroded reach 104 for RP100

For reach 104, the furthest downstream reach tested, there is little erosion, although some deposition predicted. Based on the aerial photography, the erosion is mainly bank erosion. As before, a smaller D50 and a larger flood may be more important to use this far downstream.

2.5.1 Significant storage reaches

Three reaches in Table 2-1 are classified as having significant storage. These are highlighted in yellow in the next figures.

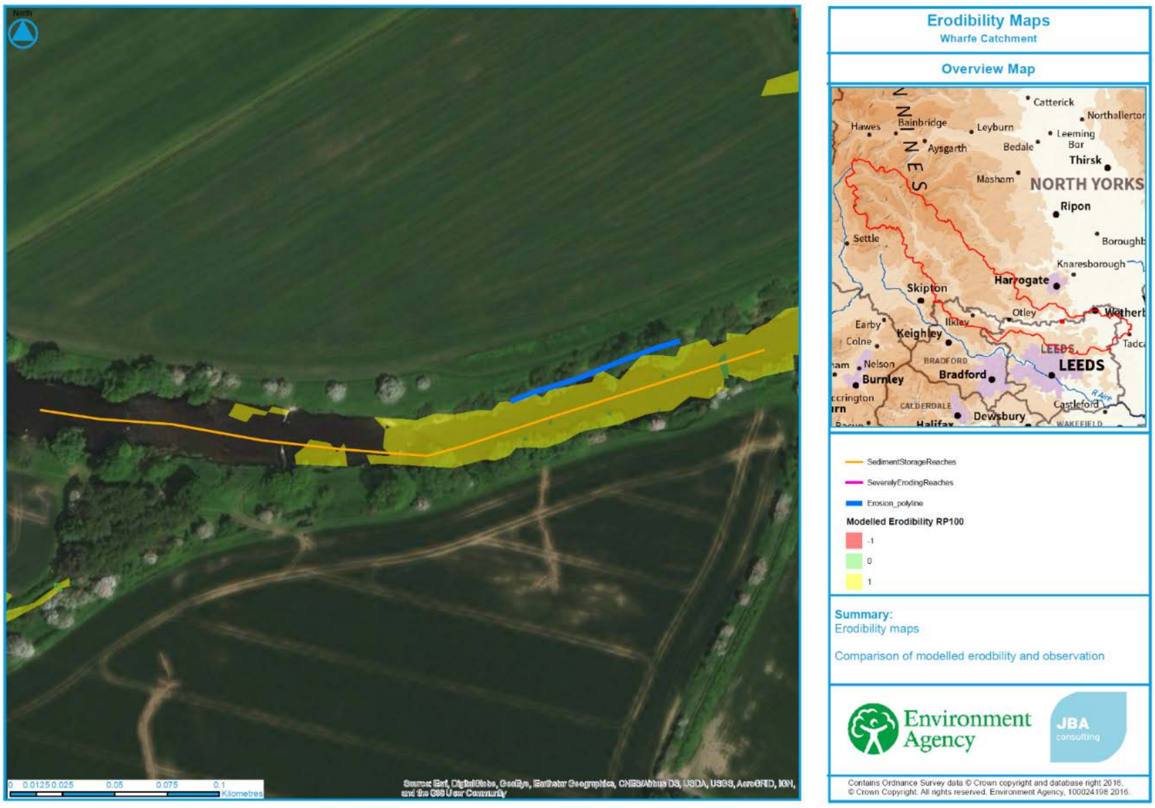


Figure D-42 Wharfe storage reach 85 for RP100

Reach 85 is identified as a storage reach and the model outputs for RP100 match this observation. The short reach of bank erosion is not captured, although the next figure shows this is well captured for another reach.

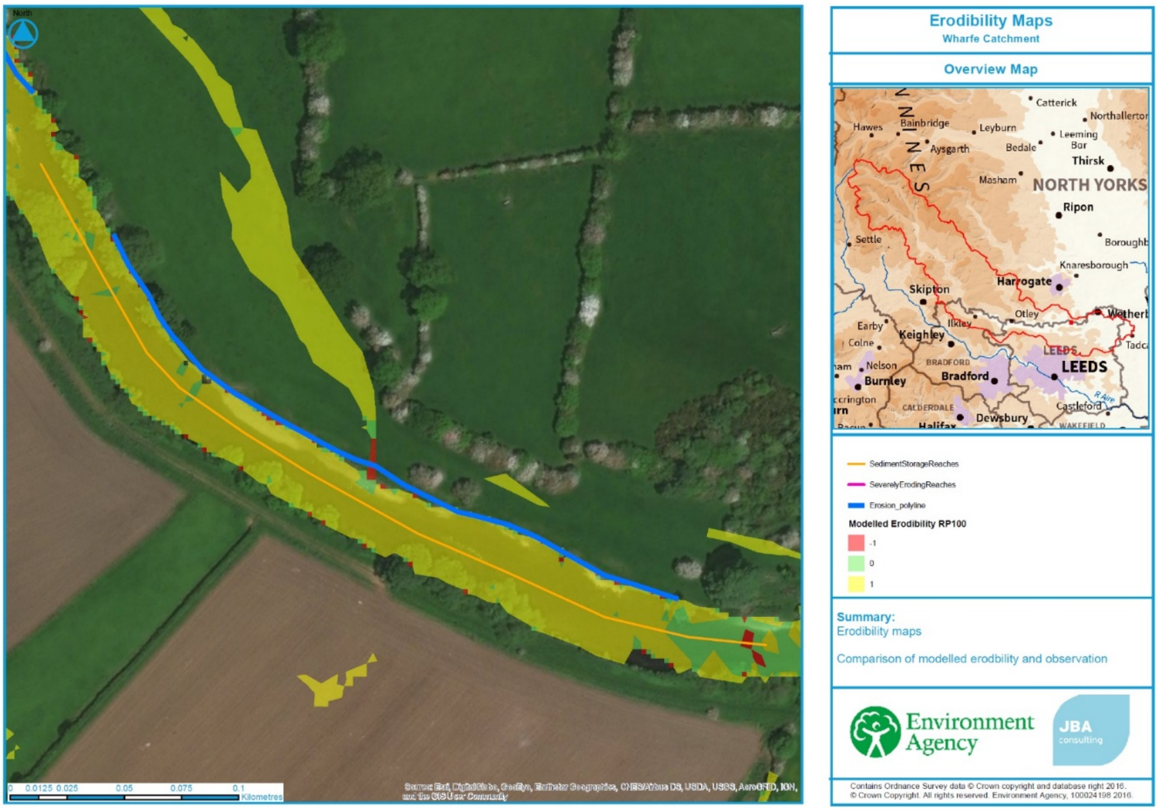


Figure D-43 Wharfe storage reach 96 for RP100

Reach 96 is highlighted as a storage dominated reach and this is captured by the model. In addition, the red areas of higher shear near the banks match well with the blue line, showing observed bank erosion.

However, the final downstream reach 109 has 'large storage areas', but it is predominantly erosive in the RP30, and very erodible for the RP100.

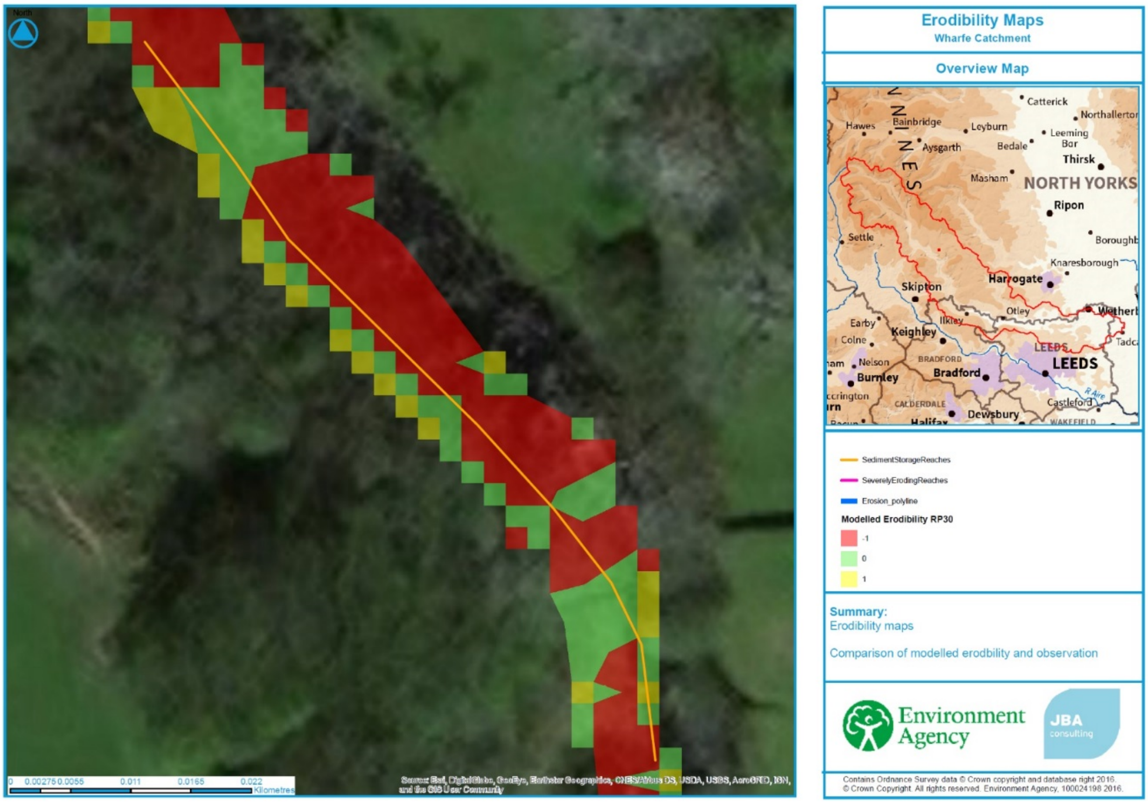


Figure D-44 Wharfe storage reach 109 for RP100

Figure D-44 shows that reach 109 has the largest discrepancy between the SSDM outputs and fluvial audit observations. One characteristic is that it is heavily wooded on both banks, suggesting here that the model output may have been influenced by filtering within the DTM.

2.6 Comparison in Stour catchment

An initial review has been carried out for the Stour catchment. However, it is outside the scope of this assessment to validate the results of this review against fluvial audit data. Figure D-45 gives an overview of the model outputs, while Figure D-46 displays a small area of results compared with available aerial photography. It is important to note that the modelled erodibility maps are likely to be the least representative out of the 3 maps for the Stour, as the D50 is likely to be smaller than the assumed 50 mm.

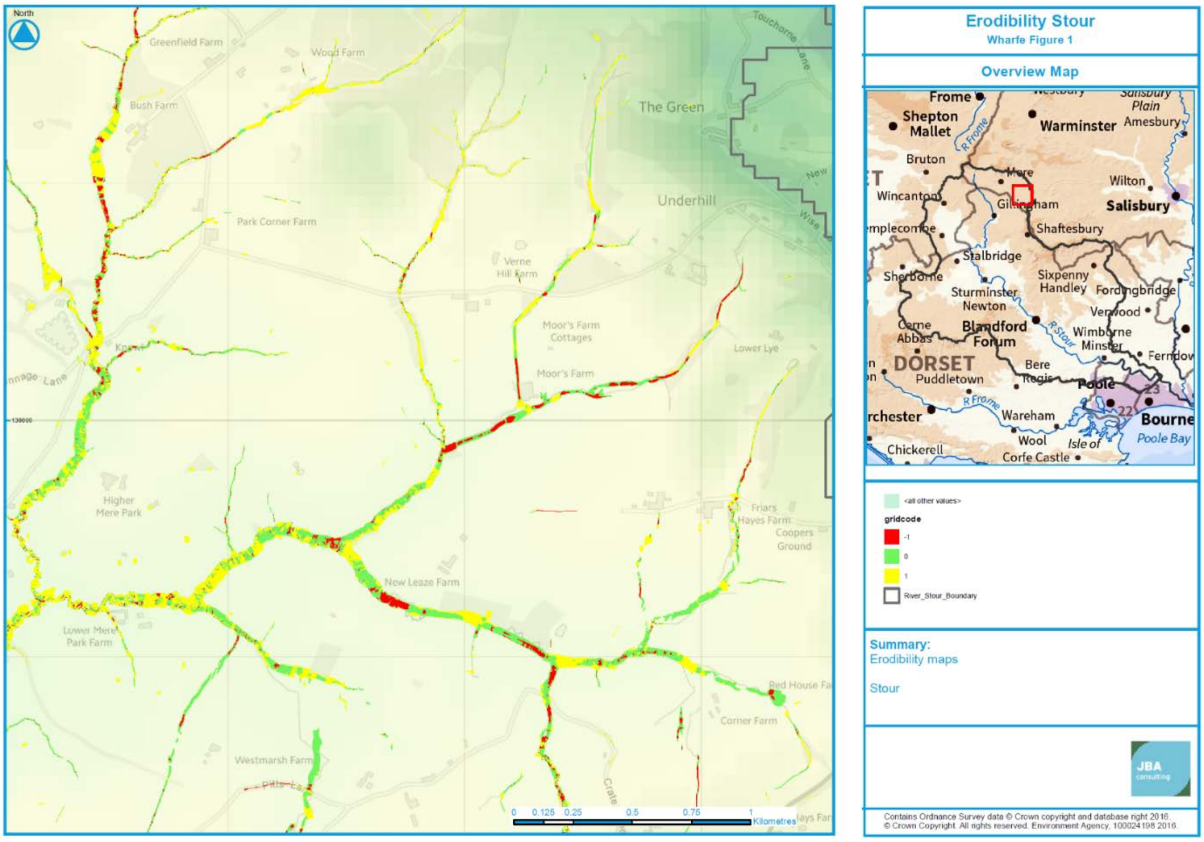


Figure D-45 Overview - Stour headwaters

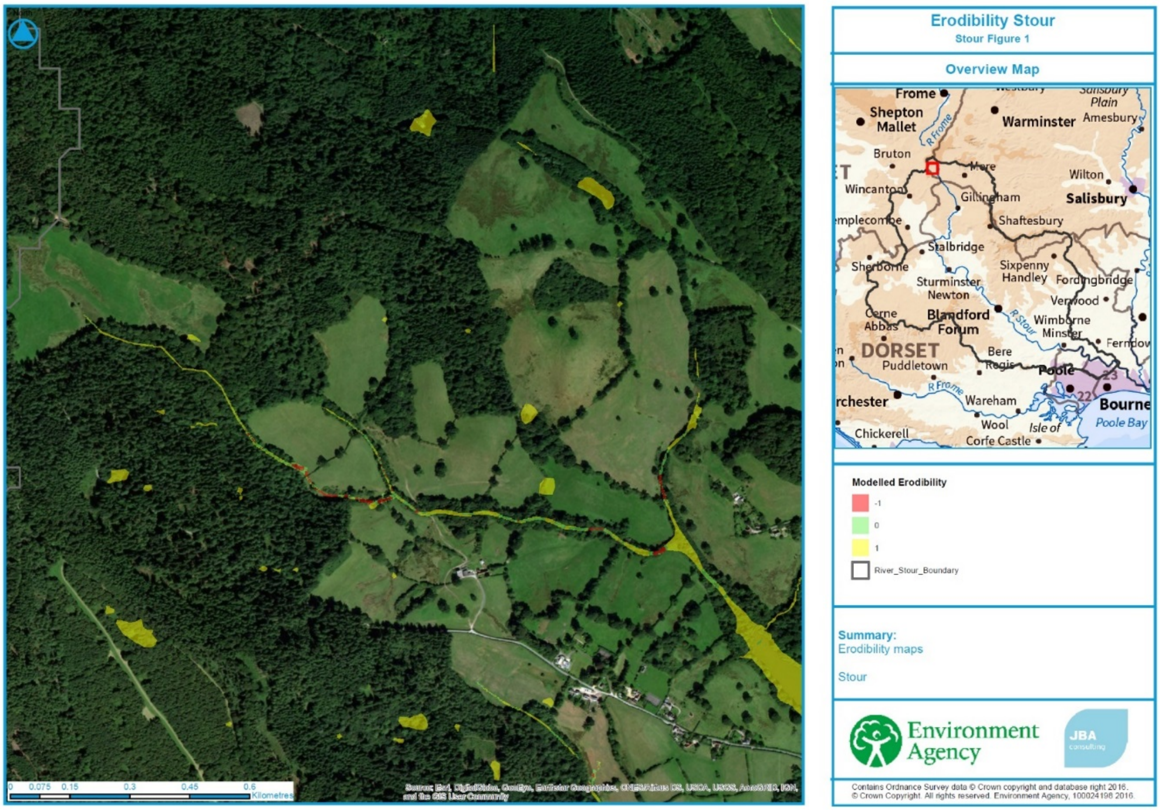


Figure D-46 Erodibility of Stour headwater with aerial

Figure D-46 shows a headwater reach of the Stour, overlaying the model outputs on the aerial photography. Clearly, woodland and vegetation cover make this difficult to assess, and some kind of riparian woodland filter is recommended, as it is likely to improve stability and reduce risk of erosion.

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