

Water Resource Benefits of Working With Natural Processes

Project Summary Presentation

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Agenda

- Project Introduction
- Generic Conceptualisation
- Literature Review Summary
- Data Review Summary
- Wider Recharge Areas
- WWNP Measures
- Priority Catchment Area of Interest Summaries
- Summary and Recommendations

Project Aims and Background



- **Aims**

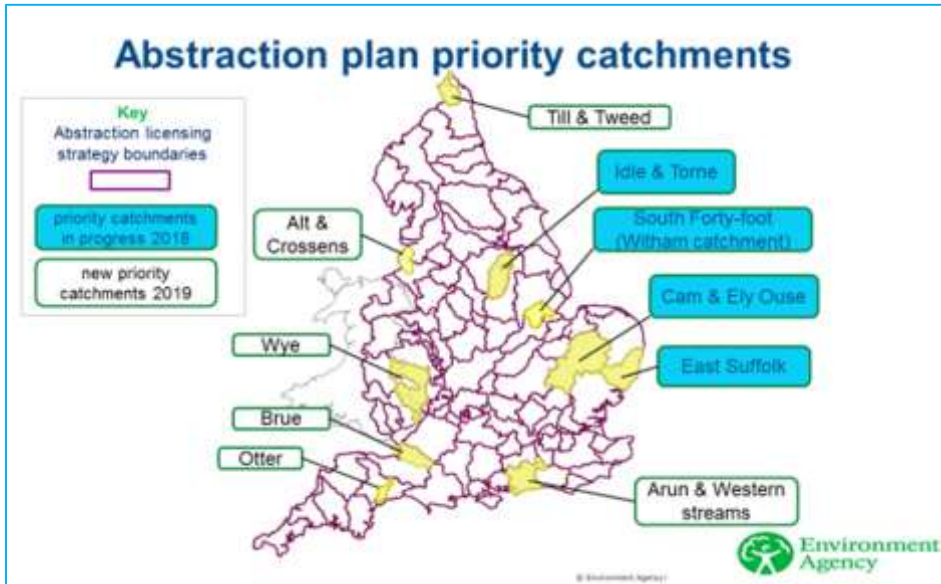
- Assess potential water resource benefits of Working With Natural Processes (WWNP)
- Recommend measures more favourable to recharge
- Investigate potential across Priority Catchment areas stemming from the Abstraction Review

- **Background**

- Embed WWNP into the catchment approach
- Integrate these approaches into future licencing strategies as part of future Abstraction Plan and Reform
- Deliver on Defra 25-year environmental plan and WFD
- Maintain water resource resilience

Project Areas

- 9 Priority Catchments and Areas of Interest (AoI)
- 9 Wider Recharge Areas and WWNP Intervention Areas Assessed
- 8 Conceptual Models

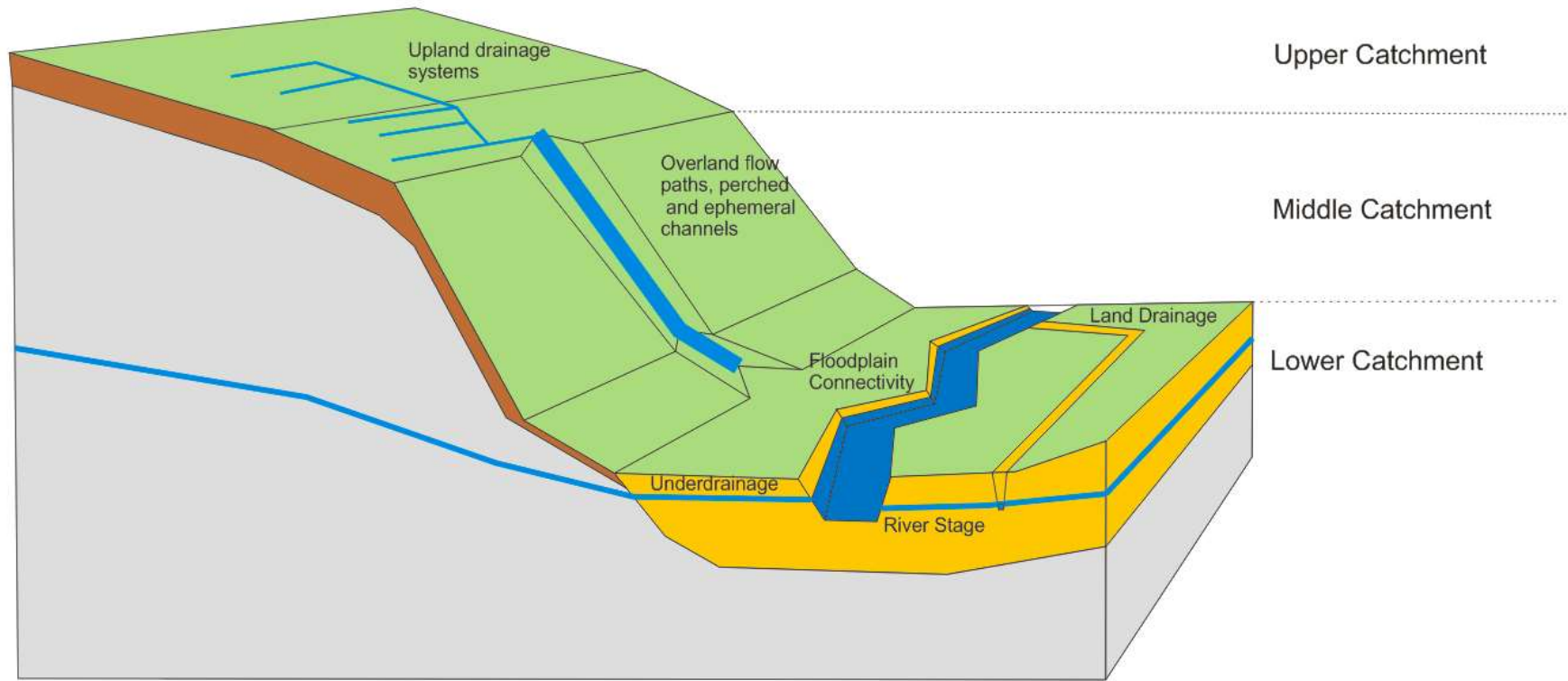


Generic Conceptualisation

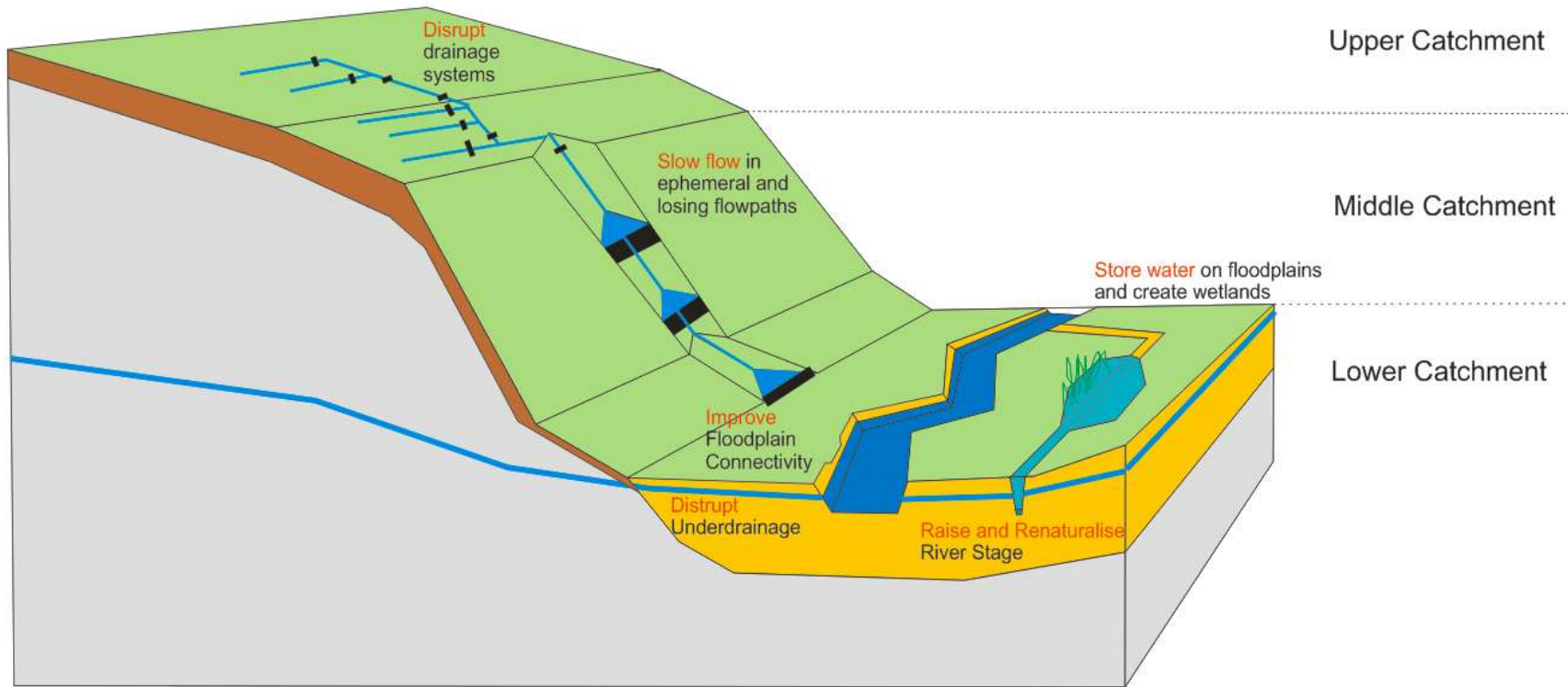
Generic Conceptualisation

- What is the Generic Conceptual Model?
- Focus on where WWNP inventions can affect groundwater resources
 - So a focus on shallow systems
- Catchment has been broken down
 - Upper,
 - Middle,
 - Lower.
- Land Use and Land management,
- A tool and a summary.

Generic Conceptualisation



Generic Conceptualisation



Literature Review

Summary



Literature Review - Topics

- **Woodland Creation and Rewilding**
- **Storage**
 - Leaky Barriers and Large Woody Debris
 - Runoff Attenuation Features, Offline Storage and Washlands
 - River Restoration and Floodplain Reconnection
 - Managed Aquifer Recharge
- **Soil and Land Use Management**

Literature Review – Woodland & Rewilding

- **Woodland Creation**

- Significant control on water balance (canopy size and root-depth)
- Broadleaved more beneficial for recharge over conifer
- Provide shelter reducing adjacent land evapotranspiration losses
- Lower density and less mature more favourable for recharge
- Riparian planting can slow flows but consider water demands
- Environmental response dependent on prior land use (eg. grazing)
- Water quality improvements but dependent on species

- **Rewilding**

- Beaver introduction multiple successes with water management
- Heathland restoration benefits over woodland creation
- Significant benefit in biodiversity and habitats
- Environmental response dependent on prior land use (eg. grazing)

Literature Review – Storage Potential

- **Leaky Barriers and Large Woody Material**
 - Increase floodplain reconnection and hillslope storage
 - Can utilise local timber resources (eg. re-purposed ash)
 - Can store and direct surface runoff to recharge areas
 - Sediment and water quality filtering benefits
 - Should follow EA guidance for managing potential impacts
- **Runoff Attenuation Features, Offline Storage and Washlands**
 - Can store and direct surface runoff to recharge areas
 - Enhanced low-flow water retention increasing baseflows
 - Improve biodiversity particularly in groundwater dependent terrestrial ecosystems
- **River Restoration and Floodplain Reconnection**
 - Increase infiltration onto floodplain for recharge
 - Reduce incision of watercourses and associated aquifer drainage
- **Managed Aquifer Recharge**
 - Confined aquifer dependent to retain groundwater locally

Literature Review – Soil and Land Use

- **Soil and Land Use Management**

- Crop-type control on water balance important to consider
- Winter cover crop can reduce surface runoff but consider water balance
- Reduced conventional tillage, ploughing, grazing and soil compaction key to minimising surface runoff and maximising recharge
- Spreading can improve soil organic matter content and soil moisture capacity and associated drainage

WWNP Matrix

- WWNP Measure Group
- WWNP Measure Types
- Project WWNP GIS Categories
- Water Resource Benefit Indicator
- Funding Scale
- Potential Water Resource **Benefit** and **Evidence**
- Potential Water Resource **Disbenefit** and **Evidence**
- **Multiple Benefits**
- **Areas to Avoid**

WWNP Matrix - Illustration

WWNP Measure Group	WWNP Measure Types	Project WWNP CS Categories	WII Funding Goal	Potential Water Resource Benefits	Evidence	Potential Water Resource Dis-Benefits	Evidence	Multiple benefits	Areas to avoid
Upper Catchment Land and Runoff Management	Runoff attenuation storage features on hillslopes including ponds, bunds, infiltration trenches and swales	WWNP RAF WWNP CS	Small-scale capital construction	1. Improves water storage, promotes infiltration and groundwater recharge where sited over permeable geology	1. Larson and Safferman, 2008 1. Hankin et al., 2016 1. Zhao et al., 2016	1. Reservoir Act 1975 regulates areas of significant storage volume and this threshold may reduce in future 2. Sedimentation can develop over time and result in clogging reducing infiltration 3. Surface ponding can result in poor soil aeration and restrict infiltration	1. GOV.UK, 2010 2. Larson and Safferman, 2008 3. USDA & NRCS, ND	Slow and attenuate surface runoff for flood risk reduction and delayed recharge Capture and filter sediment loads Capture and filter diffuse pollutants Improved biodiversity and habitat creation	In close proximity to contaminated land which may mobilise pollutants In close proximity to abstractions sensitive to groundwater quality eg. SPZs Generating storage volume >10,000m3
	Peatbog restoration including grip blocking and vegetation restoration	WWNP RAF WWNP CS	Land management	1. Sustains groundwater level and raises water table 2. Kinder Plateau, Derbyshire- water tables increased by 35mm over a 3-year period 3. Water tables raised by 20mm in Lake Vrynwy catchment, Wales	1. Krause et al., 2007 2. Pilkington et al., 2015 3. Wilson et al., 2010			Slow and attenuate surface runoff for flood risk reduction and delayed recharge Capture and filter diffuse pollutants Improved biodiversity and habitat creation Carbon sequestration	Careful management around SS3Is
	Tillage/ploughing and sub-soiling management	WWNP SPS WWNP LCM	Farming Management	1. Conventional tillage can increase soil infiltration rates compared to no tillage 2. Sub-soiling can increase infiltration by 10% through enhanced porosity after 2-years 3. Slot mulch can increase infiltration and increase water storage by 41% 4. Contour ploughing can retain surface runoff for recharge	1. Lepore et al., 2006 1. Gomez et al., 1999 2. Sojka et al., 1993 3. McConkey ND 4. Hart et al., 2004	1. Conventional tillage can reduce soil infiltration rates compared to no tillage 2. Modifies soil properties by decreasing porosity and lowering hydraulic conductivity	1. Elliot & Ethera, 1999 2. Carter and Colvick 1971	Conservation tillage can reduce soil erosion and diffuse pollution rates	Avoid conventional tillage in areas of fragile and erodible soils, particularly on steep hillslope gradients
	Peatbog drainage		Land management	1. Short-term initial drainage increases near-surface water storage capacity	1. Rogger et al., 2017	1. Increased soil moisture deficit reducing groundwater recharge and oxidation of peat will lower water tables and reduce peat thickness and reduce water storage	1. Rogger et al., 2017		Careful management around SS3Is
	Land and in-field drainage features	WWNP SPS WWNP LCM	Farming Management	1. Reduces local water table improving soil storage capacity Can divert surface water to more permeable areas	1. Blanc et al., 2012	1. Can promote rapid surface runoff and exacerbate diffuse pollution	1. Blanc et al., 2012	Improved crop yield	Areas susceptible to surface water flood risk or flashy fluvial flooding

See main report Appendix A for full WWNP Matrix

Data Review

Summary



- Aims:
 - Identify relevant datasets for understanding **WWNP potential, constraints** and provide **WWNP and groundwater contextual information**
- **WWNP Potential**
 - EA Evidence Base (2017) WWNP Features
 - Surface water and fluvial flood risk areas indicating flow pathways (eg. Risk of Flooding from Surface Water, Flood Zone 2, Historic Flood Map)
 - Land cover datasets (eg. LCM2015 and CORINE 2018)
 - Agricultural land classification (eg. low grades with less productivity)
 - EA Groundwater Vulnerability Map (recharge potential)

- **WWNP Constraints/Sensitivities**
 - Fluvial flood risk areas indicating areas where groundwater may discharge reducing recharge (eg. Flood Zone 2, Historic Flood Map)
 - Land cover datasets indicating urban areas or areas of existing target cover (eg. LCM2015 and CORINE 2018)
 - Agricultural land classification (eg. high grades with more productivity)
 - EA Groundwater Vulnerability Map (recharge barriers)
 - Groundwater flood maps indicating where elevated groundwater may reduce recharge (eg. JBA/BGS groundwater flood maps)
 - Environmental sensitive sites (eg. SSSI, GWDTE, SAC)
 - Groundwater sensitivities (eg. SPZs, DWSZs, Nitrate Vulnerable Zones)
 - Landfill and authorised waste sites
 - Mining facilities and activity

Data Review

- **WWNP and Groundwater Contextual Information**
 - Topographic data for indicating flow pathways and developing conceptual models (eg. 2m LiDAR DTM)
 - WFD surface water and groundwater status
 - BFIHOST 1km² grid (for informing groundwater connection and recharge)
 - BGS bedrock and superficial geology (eg. 50k datasets)
 - EA aquifer designation (for informing aquifer storage)
 - Soil texture and drainage (eg. LandIS NATMAP)
 - Water resource availability
 - Potential evapotranspiration data (eg. MORECS/MOSES)
 - SCIMAP (for informing hillslope hydrological connectivity)

Wider Recharge Areas

Wider Recharge Areas

- Aims:
 - Classify areas based on their soil drainage, superficial and bedrock recharge potential
 - Enable locally engaged landowners to contribute where potentially outside WWNP defined areas
- Key dataset sources:
 - EA Groundwater Vulnerability Map
 - EA Aquifer Designation
 - BFIHOST
 - LandIS NATMAP Soilscales

Wider Recharge Areas

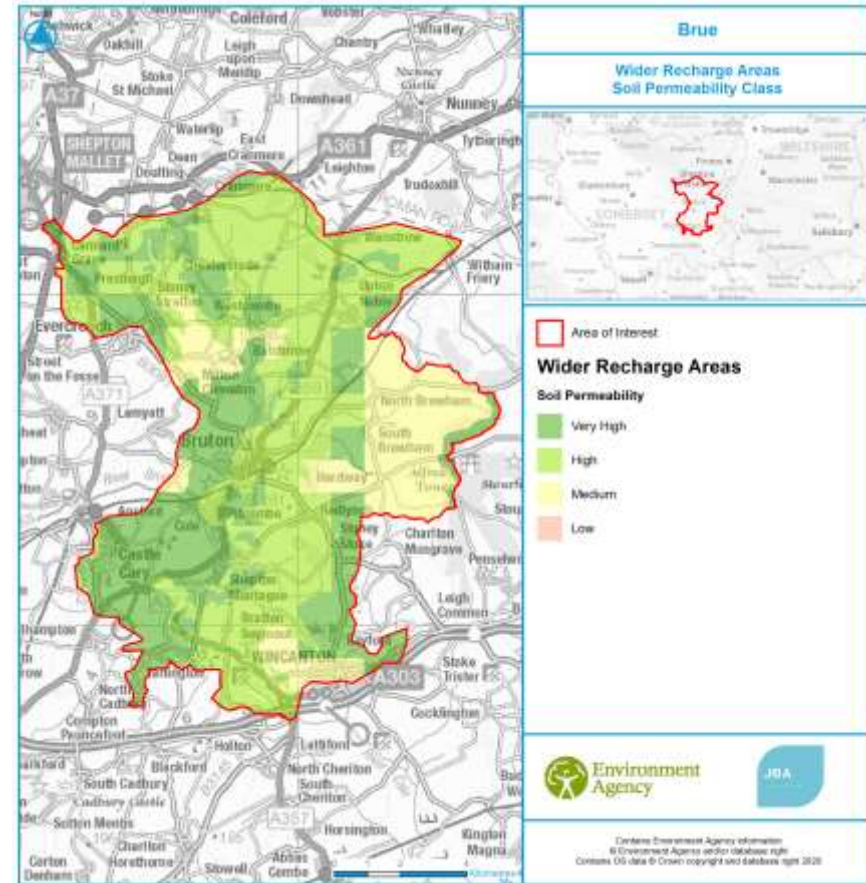
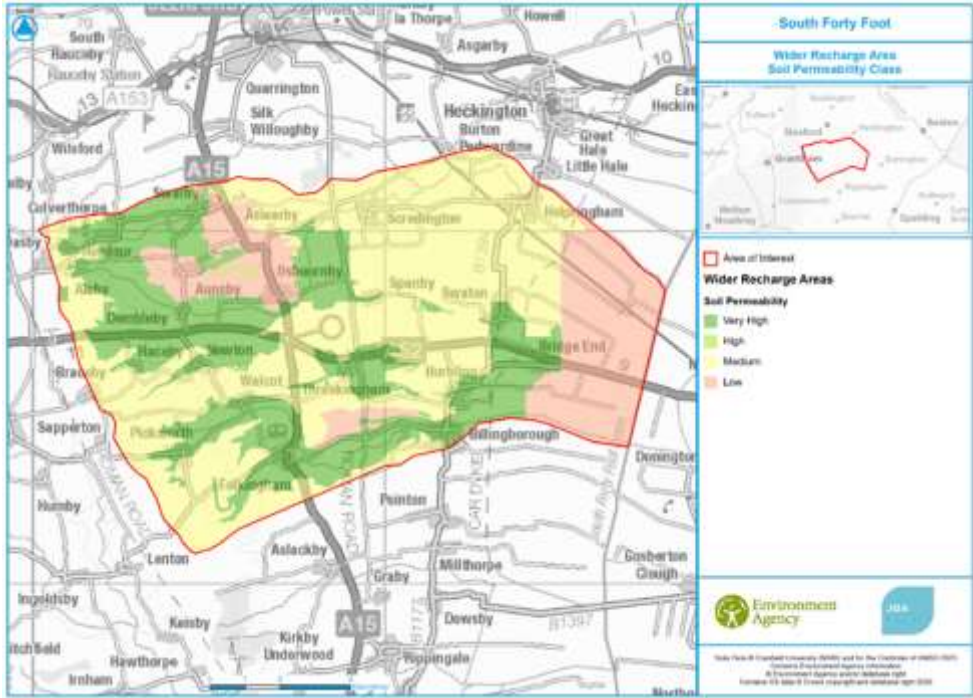
Superficial and Bedrock Recharge Potential

Attribute	Attribute Classes	Superficial Score	Bedrock Score
BFI The higher the value, the greater the inferred infiltration into both superficial and bedrock aquifer types	>70%	0	0
	≥40% and ≤70%	1	1
	<40%	2	2
Drift patchiness/cover The greater the cover, the greater recharge potential to superficial aquifers, although the greater barrier to bedrock aquifers. Areas with no designated superficial aquifer were deemed to expose bedrock aquifers for recharge and not be available for superficial recharge. Data based on BGS' GeoSure database.	<90%	2	0
	>90%	0	2
	No designated superficial aquifer	100 (Absent)	0
Drift thickness The greater the thickness, the greater storage potential to superficial aquifers although greater barrier to bedrock aquifers. Areas with no designated superficial aquifer were deemed to expose bedrock aquifers for recharge and not be available for superficial recharge. Data based on BGS' GeoSure database.	<3m	2	0
	3-10m	1	1
	>10m	0	2
	No designated superficial aquifer	100 (Absent)	0
Superficial recharge potential/permeability Recharge potential based on its primary and secondary constituents as defined by SNIFFER (2006) ⁹ Quaternary geology specialists.	High	0	0
	Medium	1	1
	Low	2	2
	No designated superficial aquifer	100 (Absent)	0
Bedrock flow Bedrock flow type through the unsaturated zone. Data based on BGS' GeoSure database.	Fractures well connected	N/a	0
	Fractures poorly connected	N/a	2
	Mixed	N/a	1
	Intergranular	N/a	2
Aquifer designation High aquifer storage size representing a greater recharge potential. Secondary (undifferentiated) includes superficial till deposits that were deemed to conservatively provide storage similar to Secondary A designations. Data based on EA designations.	Principal	0	0
	Secondary A, and Secondary (undifferentiated)	1	1
	Secondary B	2	2
	Unproductive/Absent	100	100

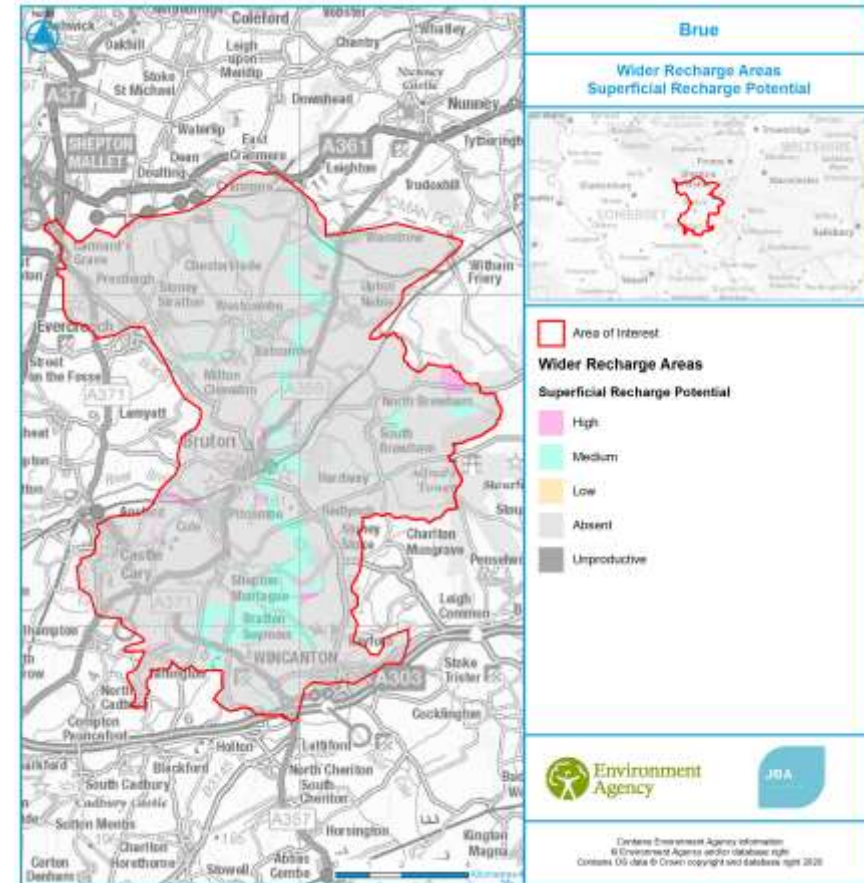
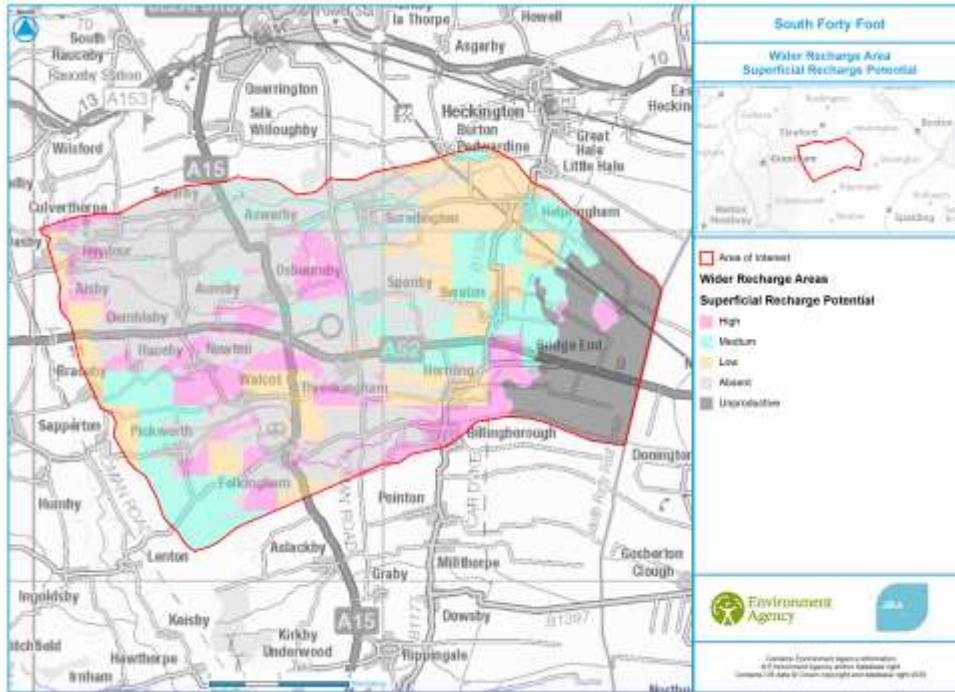
Soil Drainage

Soil Drainage	Class (Soil Perm)
Freely Draining	Very High
Slightly Impeded Drainage	High
Impeded Drainage (slowly permeable soils)/Variable	Medium
Naturally Wet/Surface Wetness/Blank (water)	Low

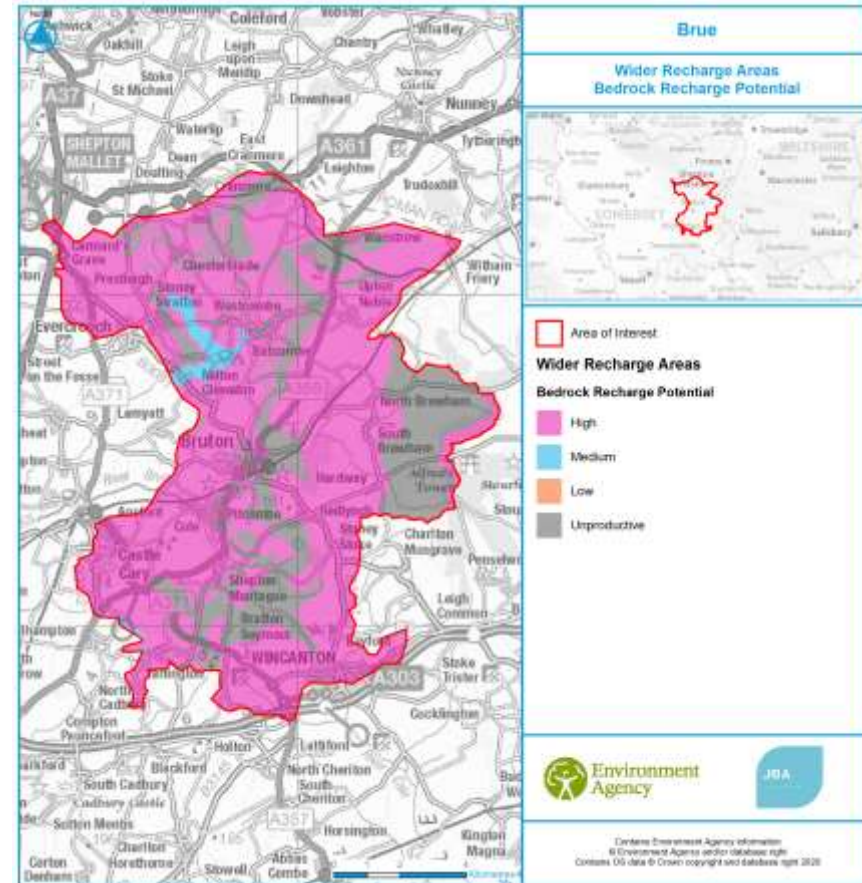
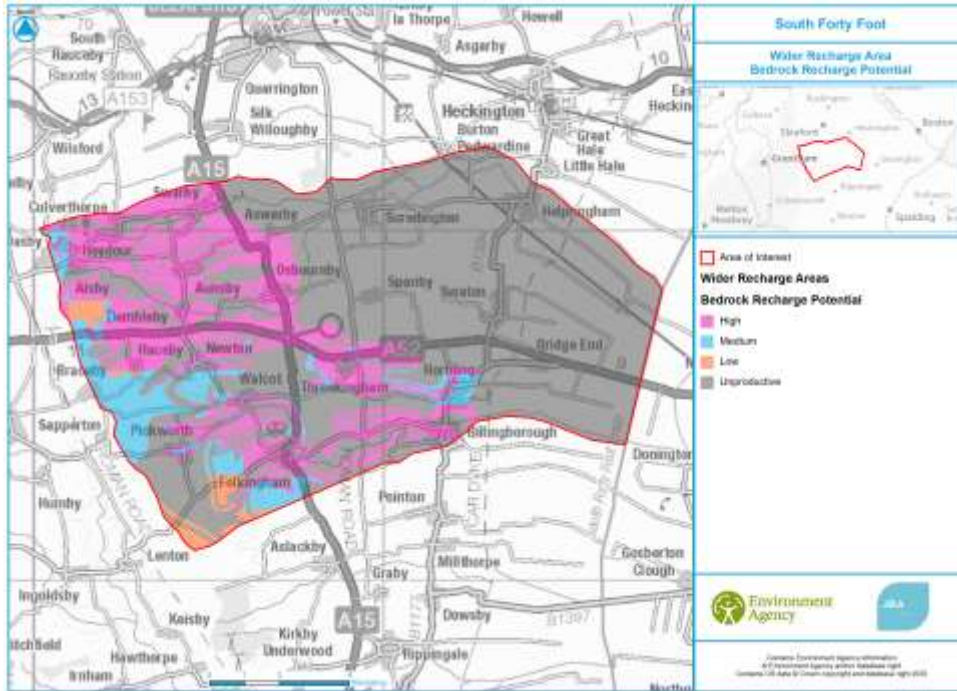
Soil Drainage - Examples



Superficial Recharge Potential - Examples



Bedrock Recharge Potential - Examples



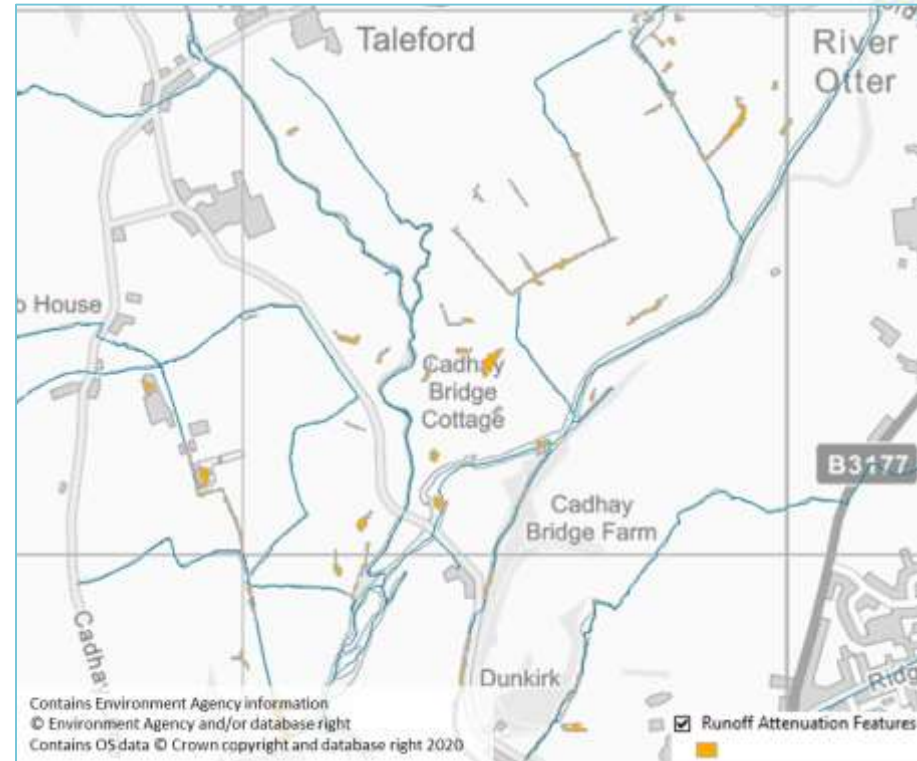
WWNP Measures

WWNP Intervention Definition

- Aims:
 - To define a set of WWNP features applicable to the local catchment and groundwater processes
 - To define their recharge and multiple benefit potential and highlight potential constraints
- Initially adopted EA Evidence Base (2017) features:
 - Runoff attenuation features
 - Floodplain reconnection features
 - Tree/woodland planting features (riparian, floodplain, wider)
- Expanded to include:
 - Wider surface water flood risk
 - Arable and grassland land cover

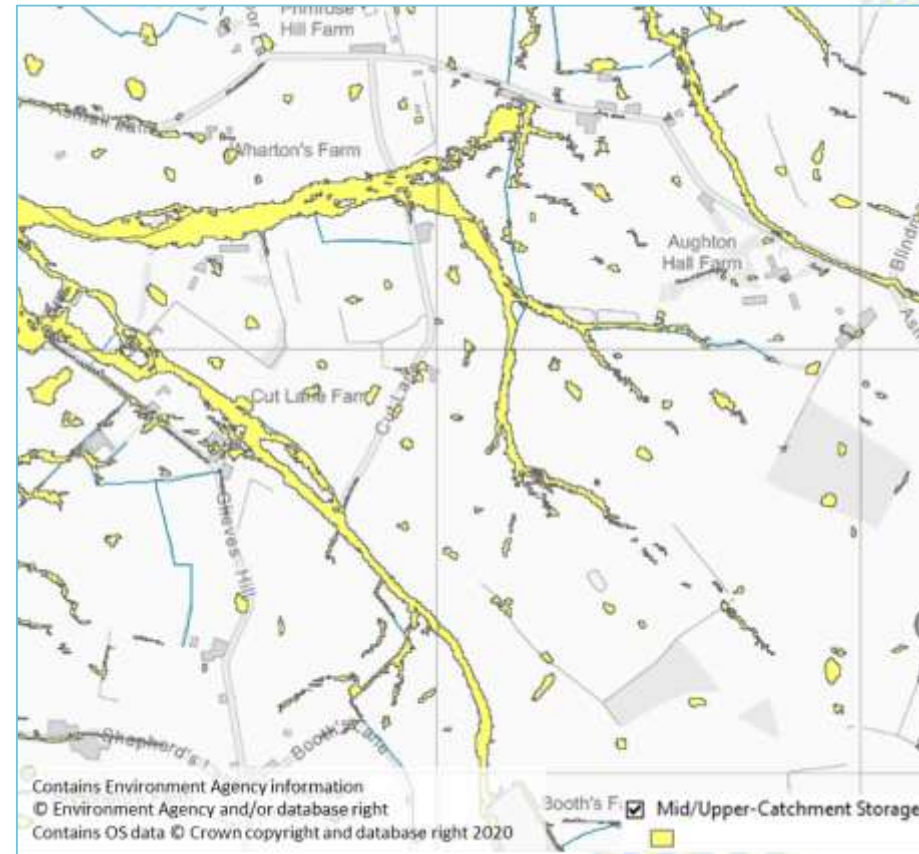
WWNP Runoff Attenuation Features

- **WWNP_RAF** GIS features
 - Small areas of existing surface water accumulation/ponding that could be enhanced
 - Local measures to intercept or divert water onto floodplain
 - Measures may include:
 - Large woody barriers, gully blocking, bunds and small-scale floodplain reconnection and storage measures



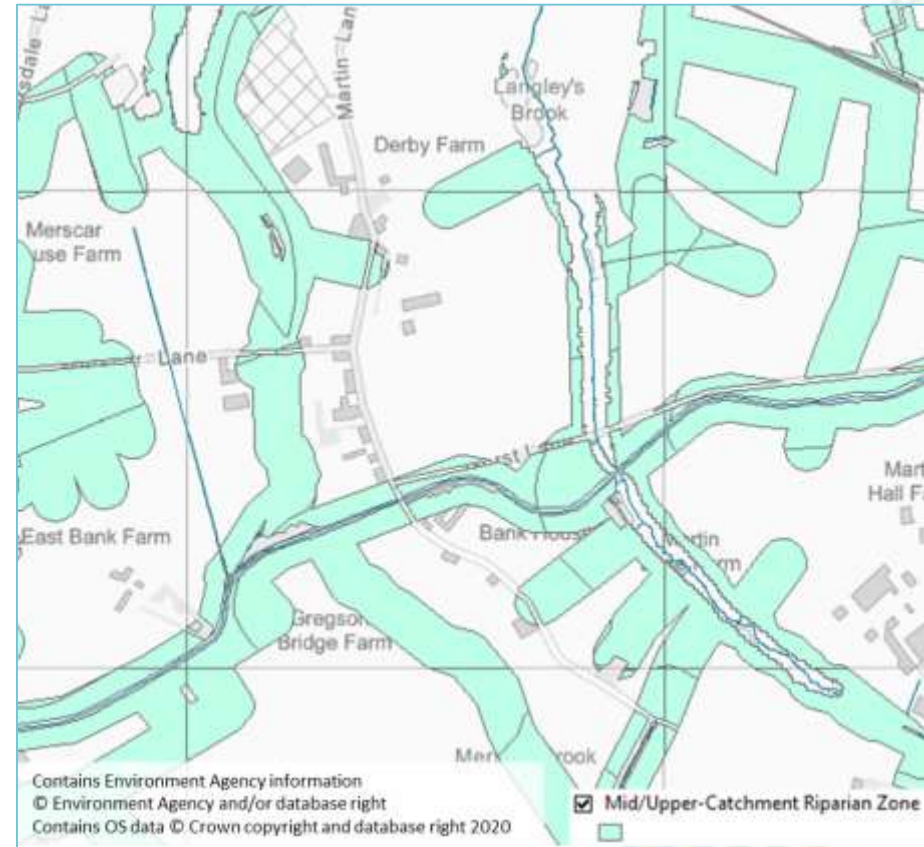
WWNP Mid/Upper-Catchment Storage

- **WWNP_CS** GIS features
 - Wider areas of surface flow accumulation across hillslope and minor streams/watercourses
 - Measures to attenuate and slow surface runoff and promote floodplain reconnection
 - Measures may include:
 - Large woody barriers, riparian planting and small/medium-scale river restoration measures



WWNP Mid/Upper-Catchment Riparian Zone

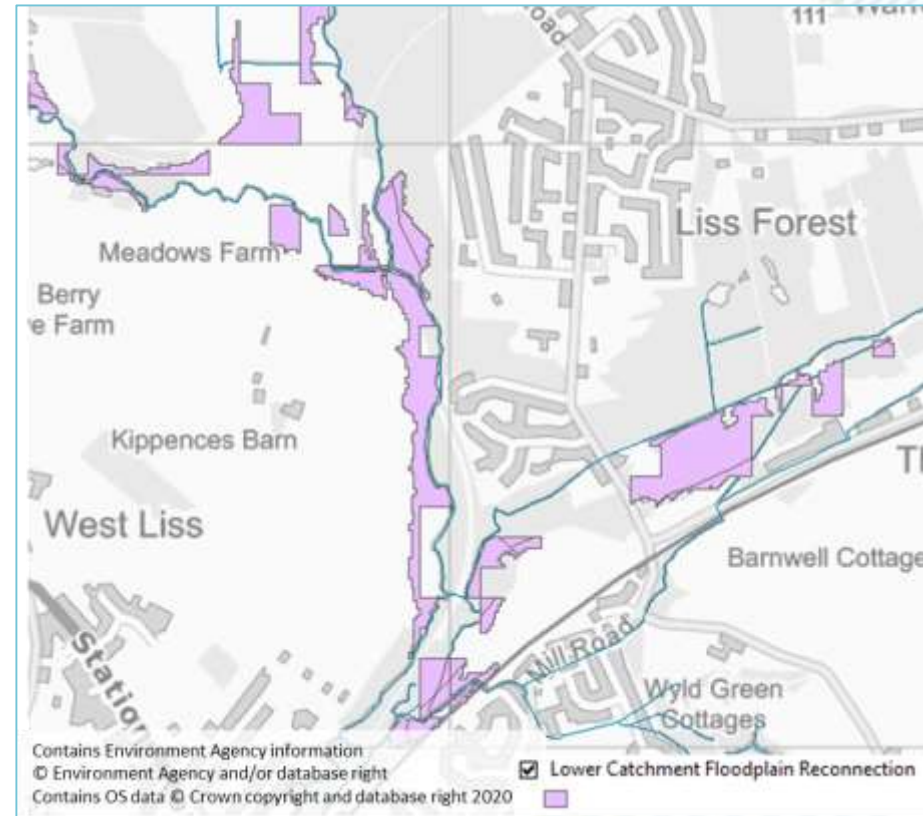
- **WWNP_RZ** GIS features
 - Corridors adjacent to watercourses that are predicted to reside outside the floodplain
 - Measures to attenuate and slow fluvial flows and promote floodplain reconnection
 - Measures include:
 - Large woody barriers, riparian planting, rewilding and small/medium-scale river restoration measures



WWNP Lower Catchment Floodplain Reconnection

• WWNP_FRQP GIS features

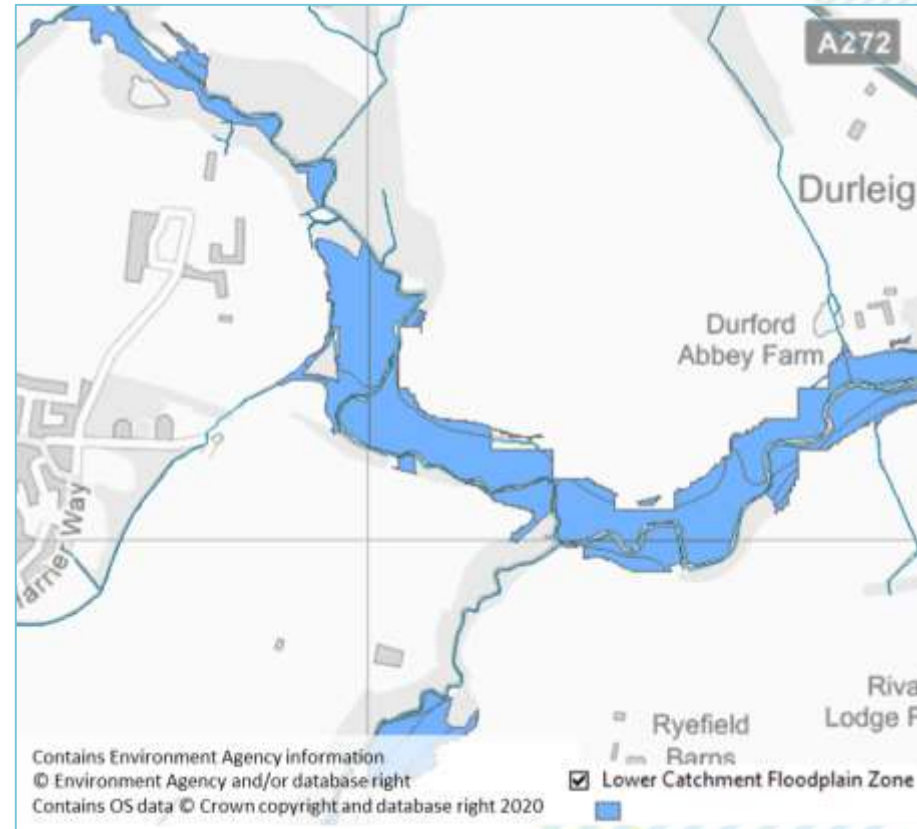
- Areas within the floodplain deemed at a national-scale to have a lower watercourse connectivity and associated likelihood of flooding
- Measures to attenuate fluvial flows and promote floodplain reconnection and storage
- Measures include:
 - Large woody barriers, floodplain reconnection, wetland and storage area development and medium-scale river restoration measures



Consider flood risk to receptors and potential for high groundwater levels to reduce recharge

WWNP Lower Catchment Floodplain Zone

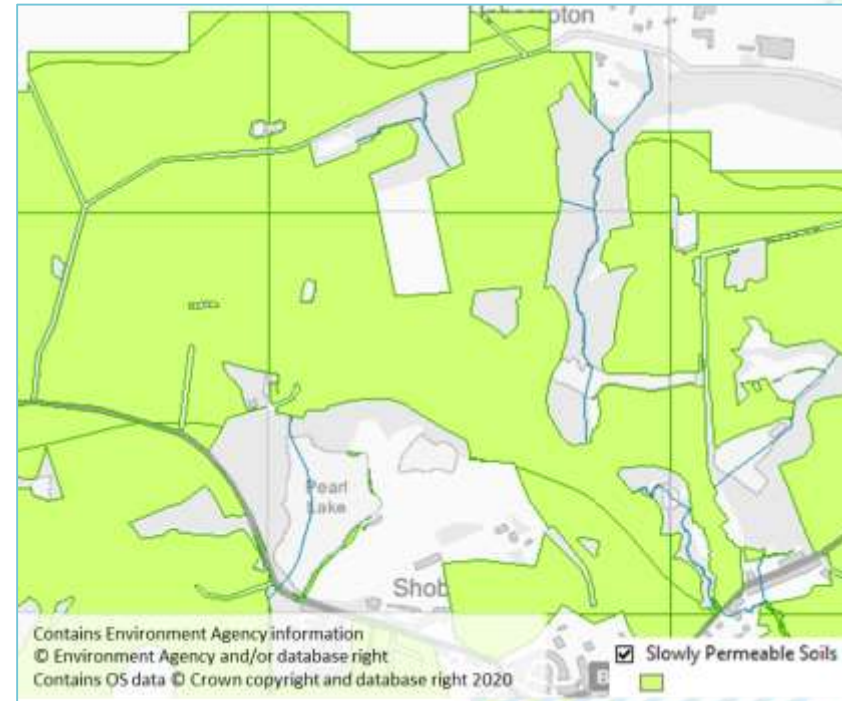
- **WWNP_FZ** GIS features
 - Areas within the floodplain deemed at a national-scale to have a higher watercourse connectivity and associated likelihood of flooding
 - Measures to attenuate fluvial flows and promote floodplain reconnection and storage
 - Measures include:
 - Floodplain planting, wetland development and medium/large-scale river restoration measures



Consider flood risk to receptors and potential for high groundwater levels to reduce recharge

WWNP Slowly Permeable Soils

- **WWNP_SPS** GIS features
 - Areas across catchment with impeded soil drainage or significant superficial till cover
 - Measures to reduce surface runoff and improve infiltration and associated recharge
 - Measures include:
 - Improving soils, de-compacting, crop cover and type management and planting of less dense woodland such as shelterbelts or wood pasture to increase infiltration rates.



WWNP Arable & Grassland Land Cover Management

- **WWNP_LCM** GIS features
 - Areas defined as arable or grassland within Land Cover Map 2015
 - Measures to reduce surface runoff and improve infiltration and associated recharge
 - Measures include:
 - Improving soils, de-compacting, crop cover and type management and planting of less dense woodland such as shelterbelts or wood pasture to increase infiltration rates.

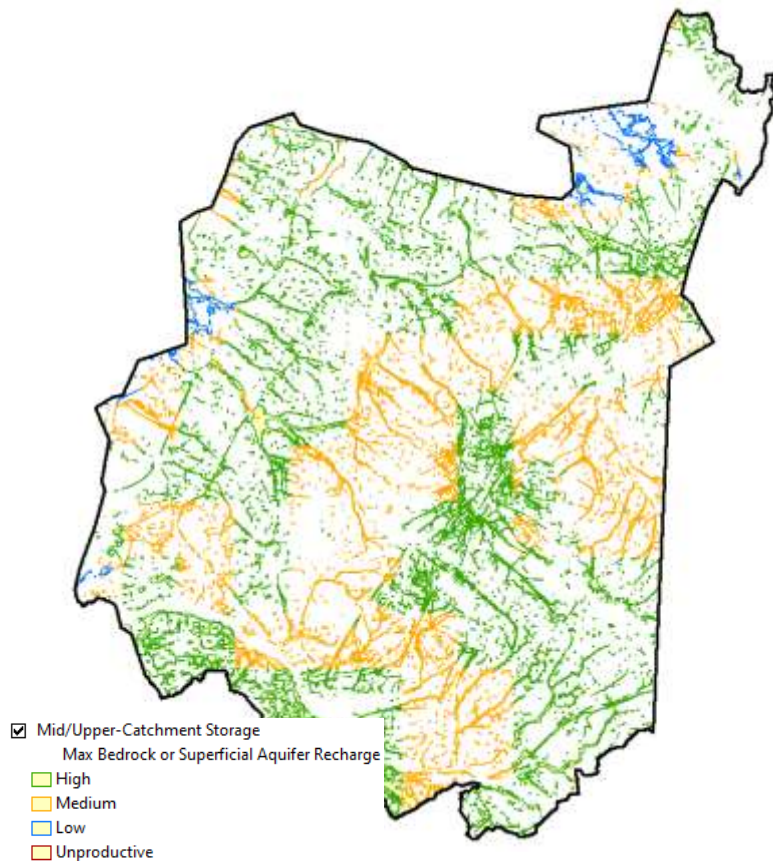


WWNP Attribution

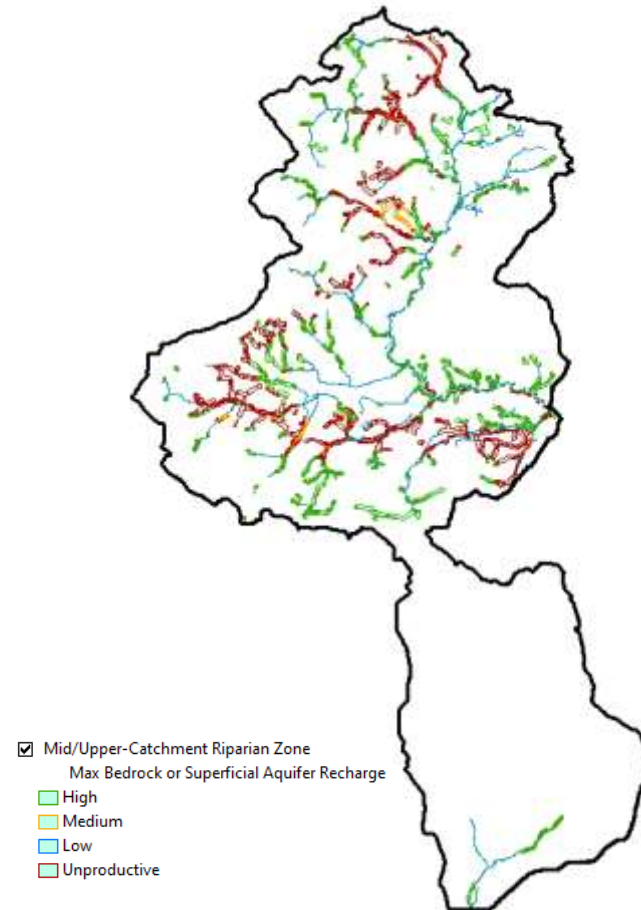
- Aims:
 - To define WWNP recharge and multiple benefit potential and highlight potential constraints
- Includes:
 - Soil drainage class
 - Superficial recharge potential class
 - Bedrock recharge potential class
 - Groundwater flood risk
 - Context (soil, bedrock, superficial, land cover, agricultural land classification)
 - Sensitivities (SPZs, DWSZs, SSSI, GWDTE, SAC)
 - WFD surface water and groundwater classification

WWNP Attribution Examples

Alt/Crossens
Mid/Upper Catchment Storage

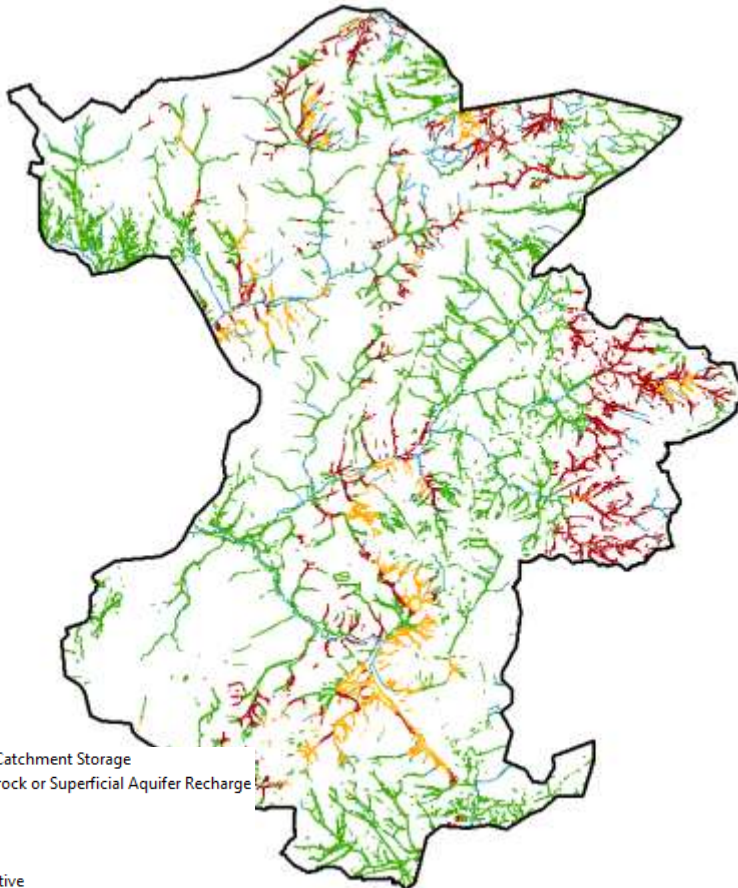


Arun and Western Streams
Mid/Upper Catchment Riparian Zones

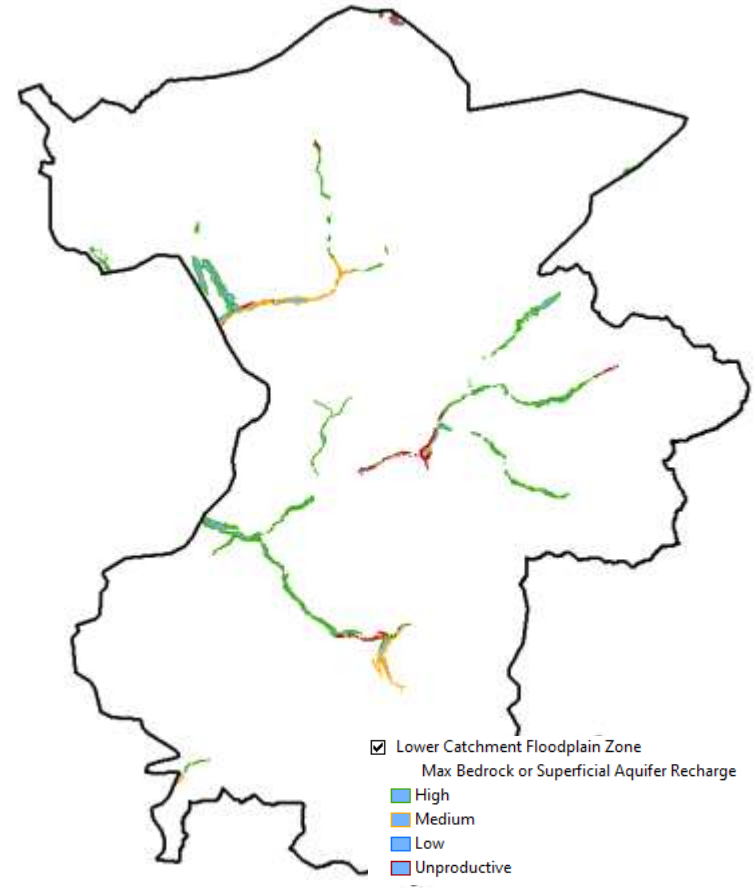


WWNP Attribution Examples

Brue
Mid/Upper Catchment Storage

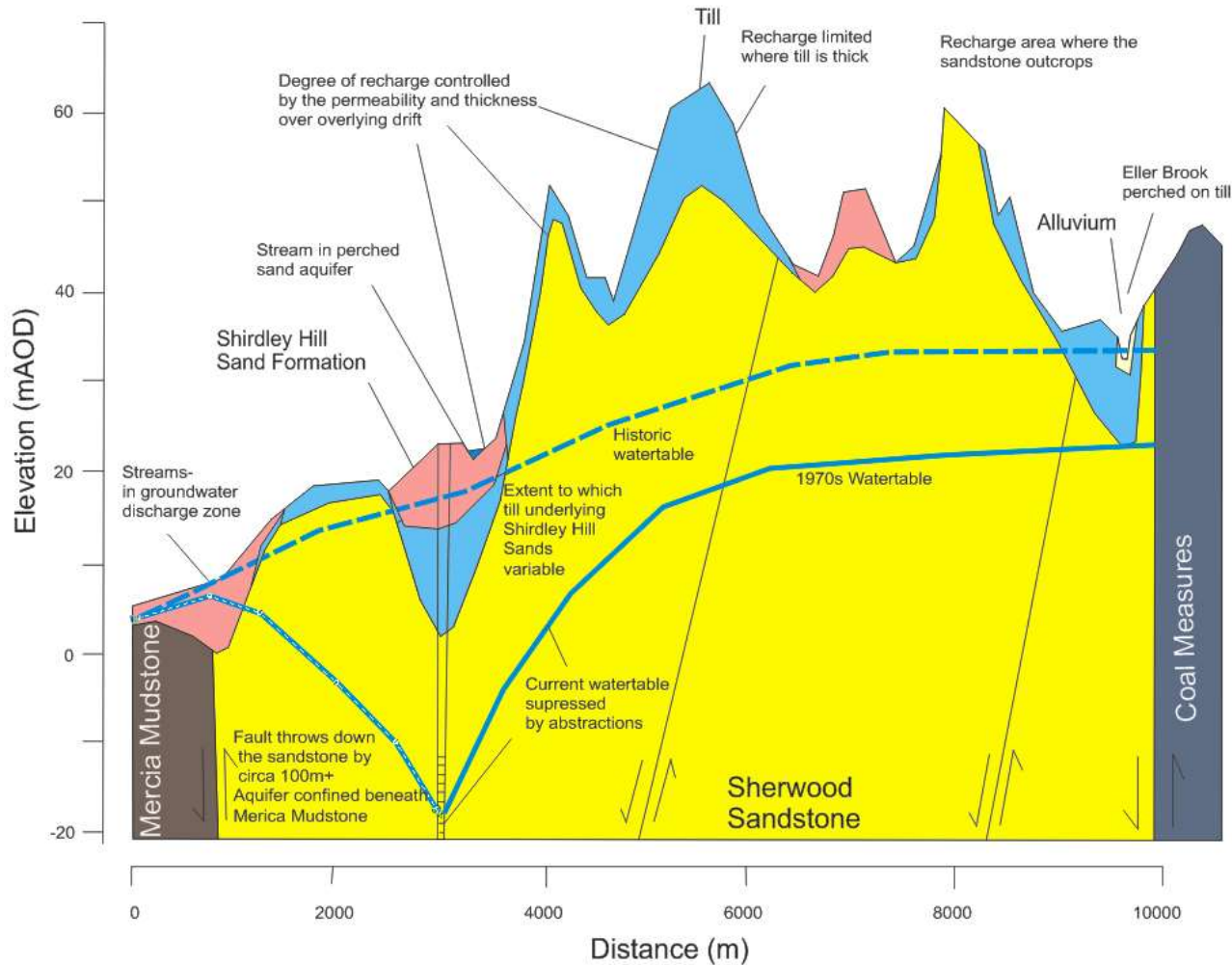


Brue
Lower Catchment Floodplain Zone

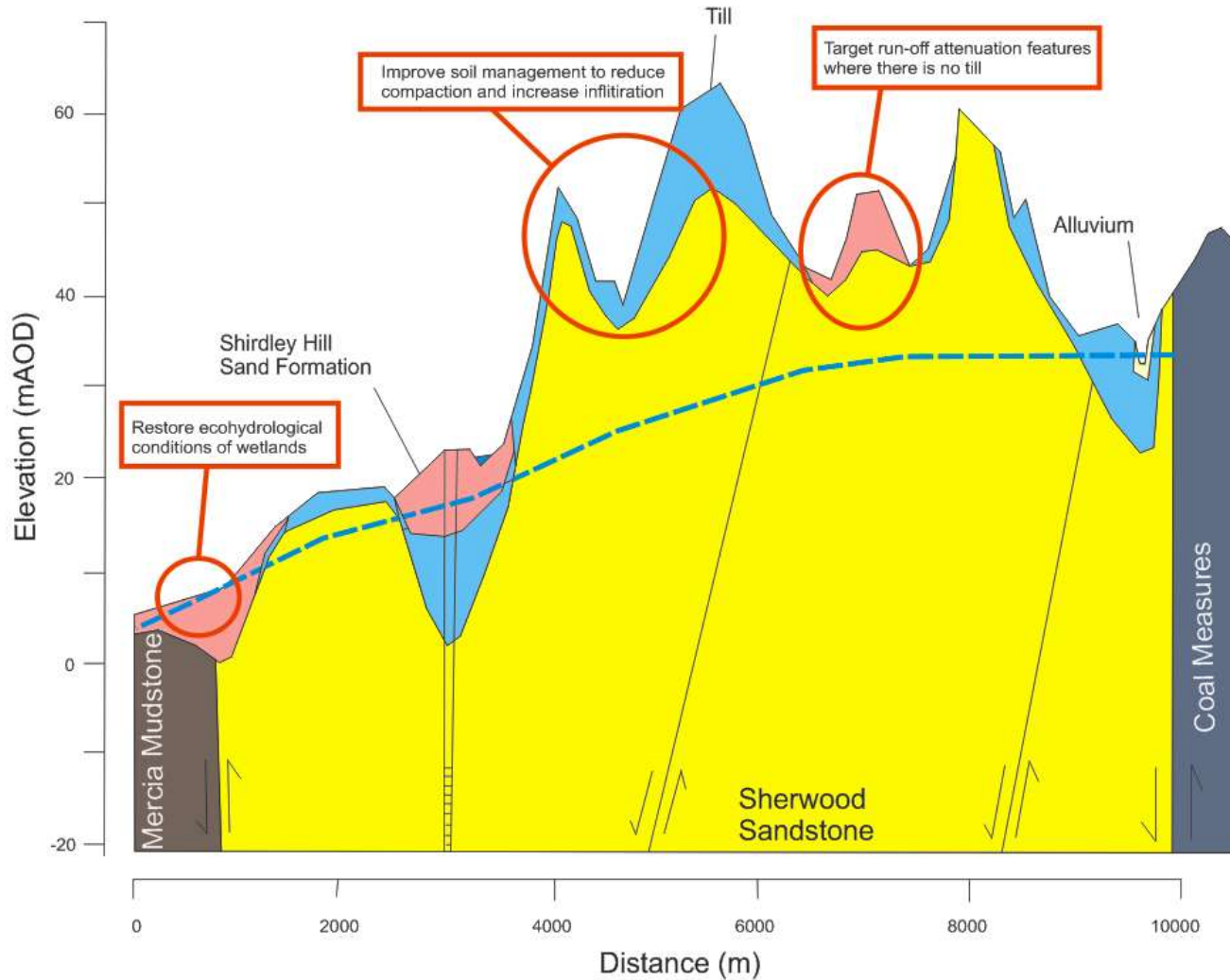


Priority Catchment Conceptual Model Summaries

Alt Crossens – Conceptual Model



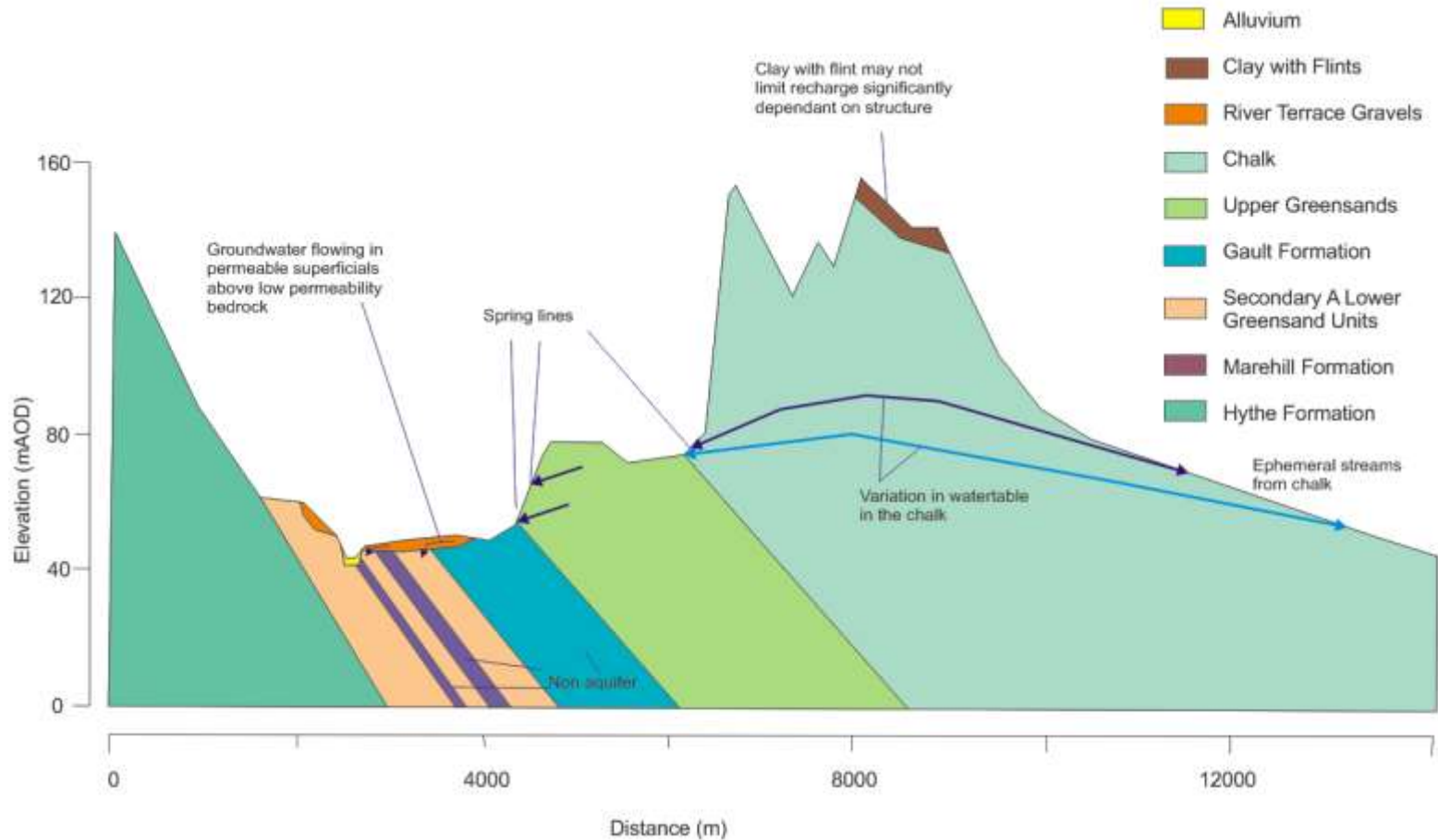
Alt Crossens – Conceptual Measures



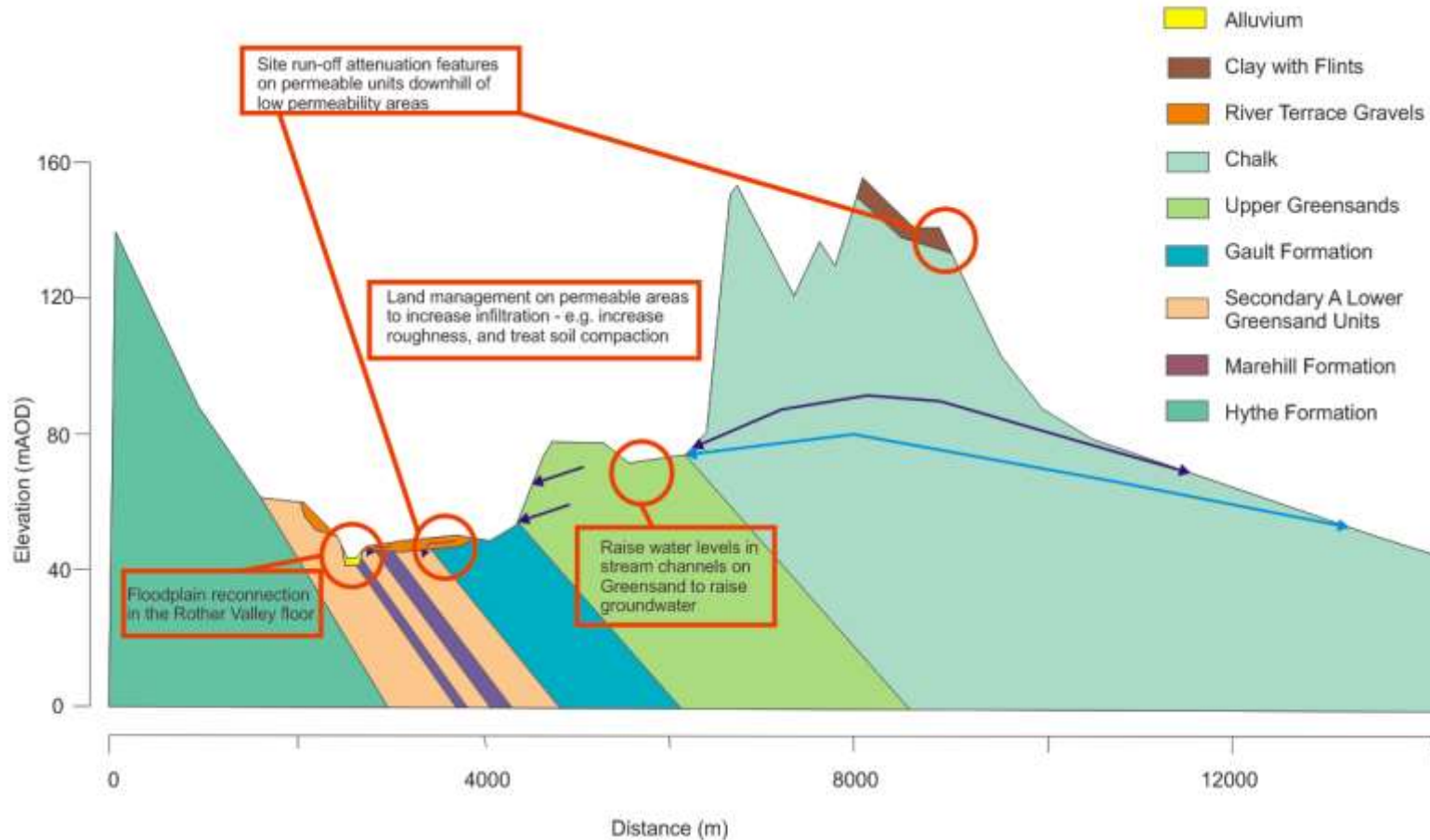
Alt Crossens – Conceptual Measures

- Improved soil management to reduce compaction issues, especially in areas of till.
 - Targeting runoff attenuation features to slow the flow in areas where till does not cover the surface or underlies the Shirdley Hill Sand Formation, so water can more readily recharge the Sherwood Sandstone.
 - Restore the eco-hydrological conditions of groundwater dependent terrestrial ecosystems in the area such as Martin Mere.
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Arun and Western Streams – Conceptual Model



Arun and Western Streams – Conceptual Measures



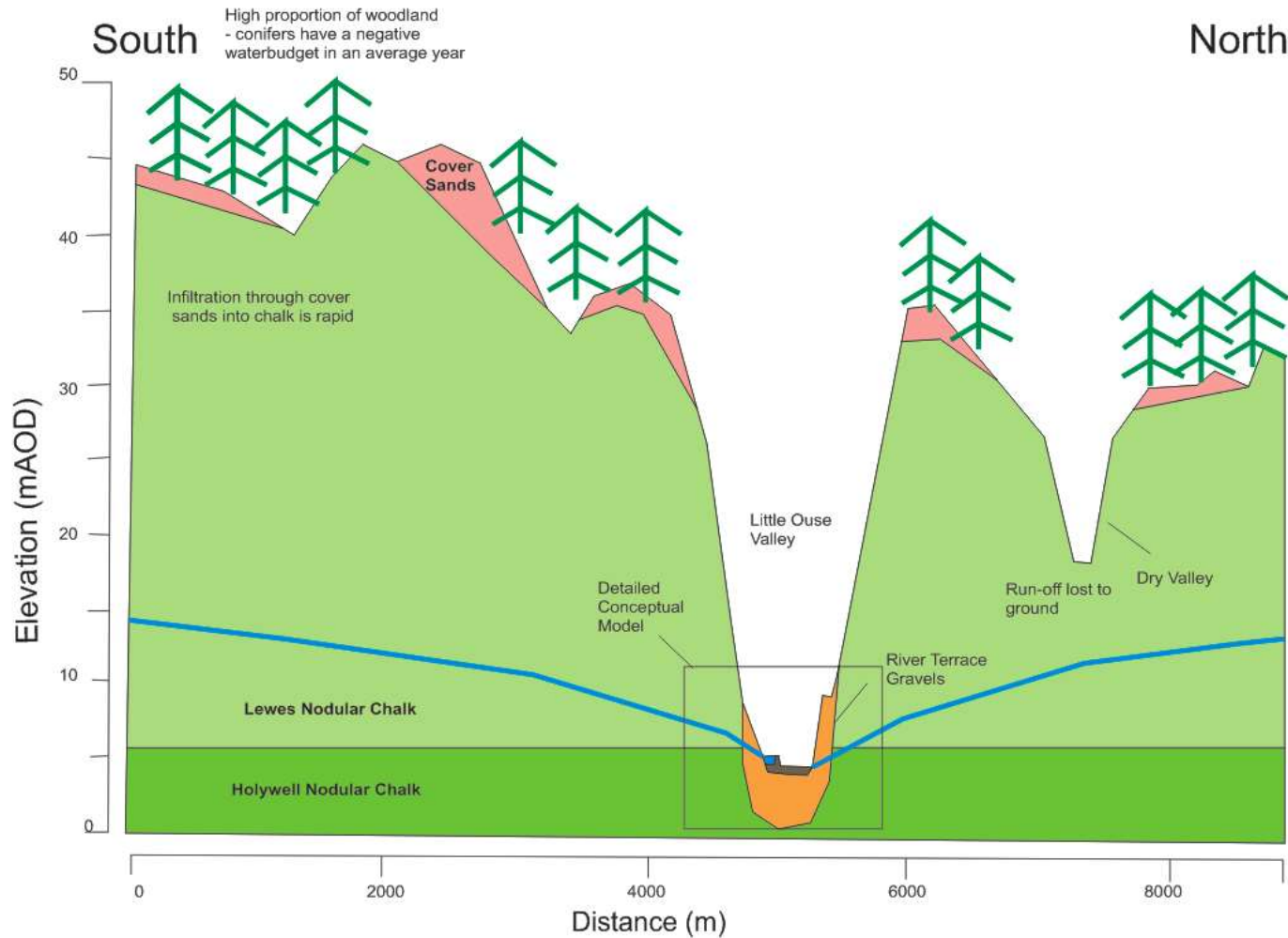
Arun and Western Streams – Conceptual Measures

- Increase in recharge overlying the permeable strata through land management:
 - Cover crops or grass seeding to limit winter runoff and sediment generation.
 - Contour working fields so as to limit rapid runoff pathways.
 - Agroforestry or selective hedging/tree planning to limit rapid runoff.
 - Minimum tillage to improve soil structure and infiltration capacity.
 - For sandy soils sub-soiling may break up compacted layers but would also disturb soil structure.
 - Runoff attenuation features to increase infiltration in the permeable areas:
 - Re-infiltration of spring water after flowing over Gault clay.
 - Very high intergranular sandstone storage – considerable storage potential within limited unsaturated zone thickness.
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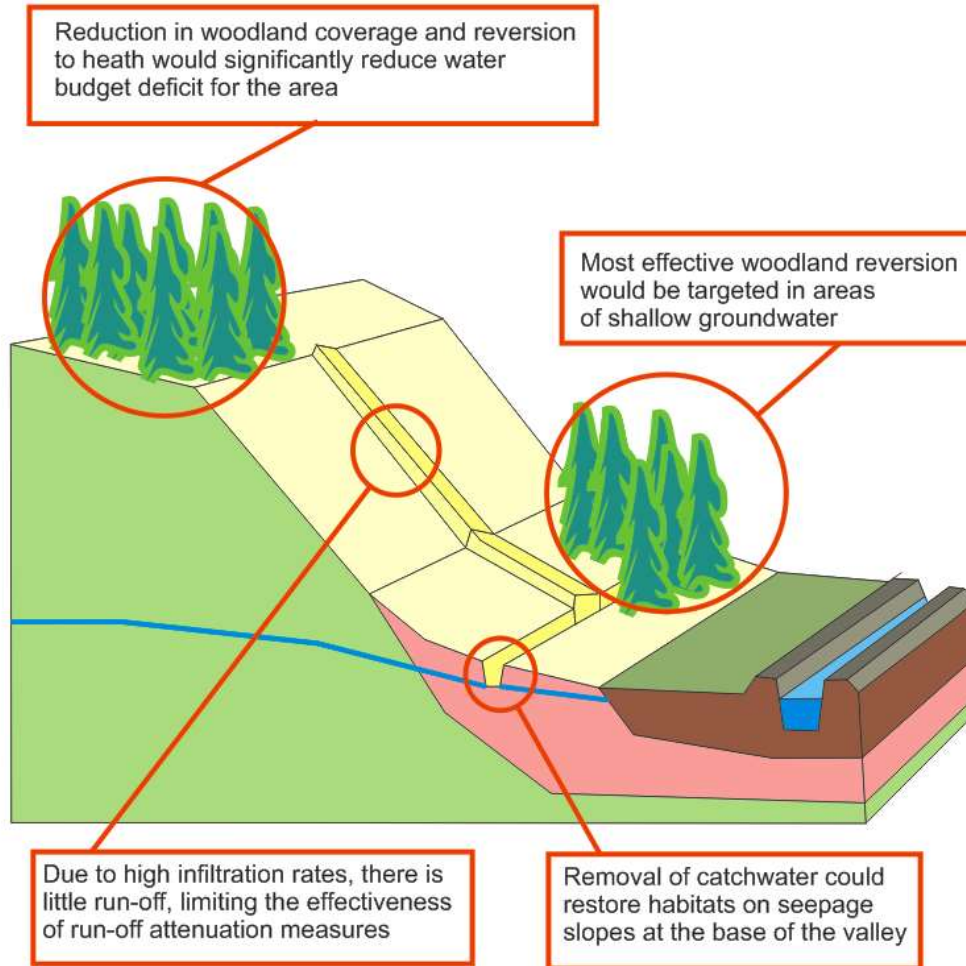
Arun and Western Streams – Conceptual Measures

- Increasing infiltration through land management and runoff attenuation on chalk outcrop at edges of the Clay-with-flints.
 - Careful investigation into raising incised river channels where Greensand aquifer water tables close to surface near rivers.
 - Floodplain reconnection in River Rother valley and larger tributaries as well as the River Ems between Stoughton and Walderton.
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Cam and Ely Ouse- Conceptual Model



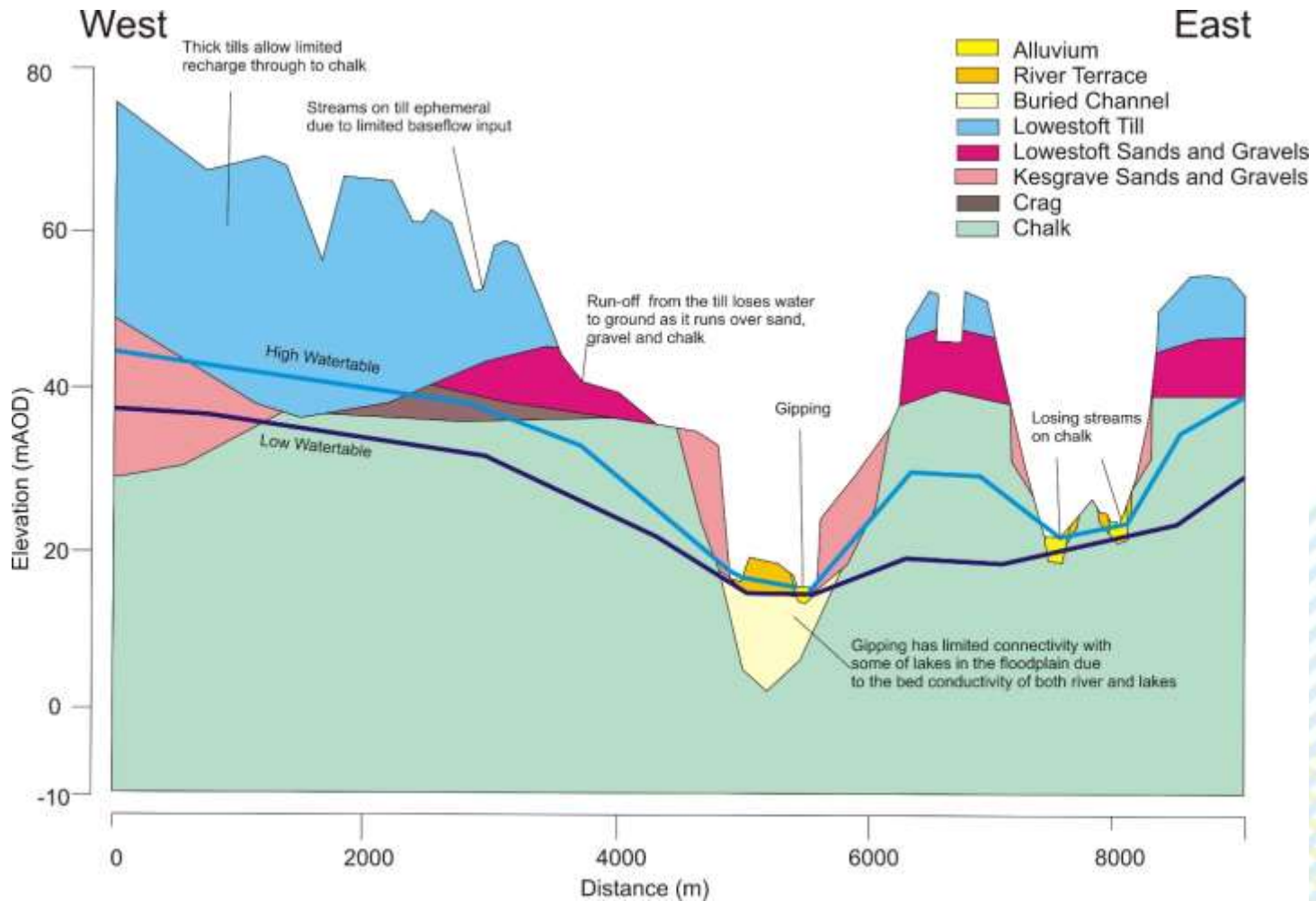
Cam and Ely Ouse– Conceptual Measures



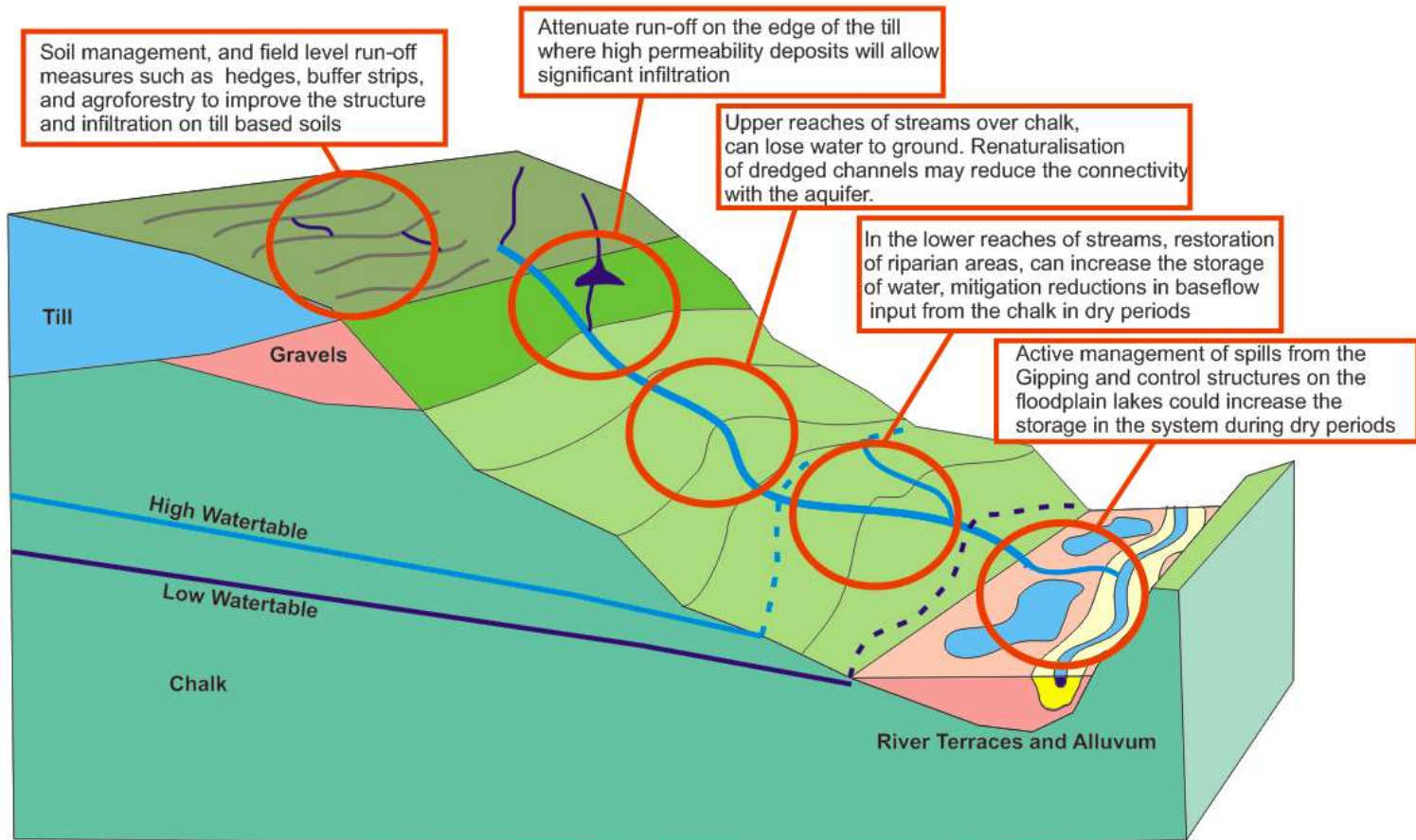
Cam and Ely Ouse– Conceptual Measures

- Modifying the land cover of the area to improve the water budget. In the main, this would involve reducing the coverage of conifers across the area.
 - In areas where the water table lies close to the surface:
 - Removal of catchwaters on the valley sides and restoration of habitats dependent on seepage faces.
 - Removal of woodland in these specific areas, as their root systems which can tap the water table, can continue to transpire at higher rates into dry periods.
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East Suffolk – Conceptual Model



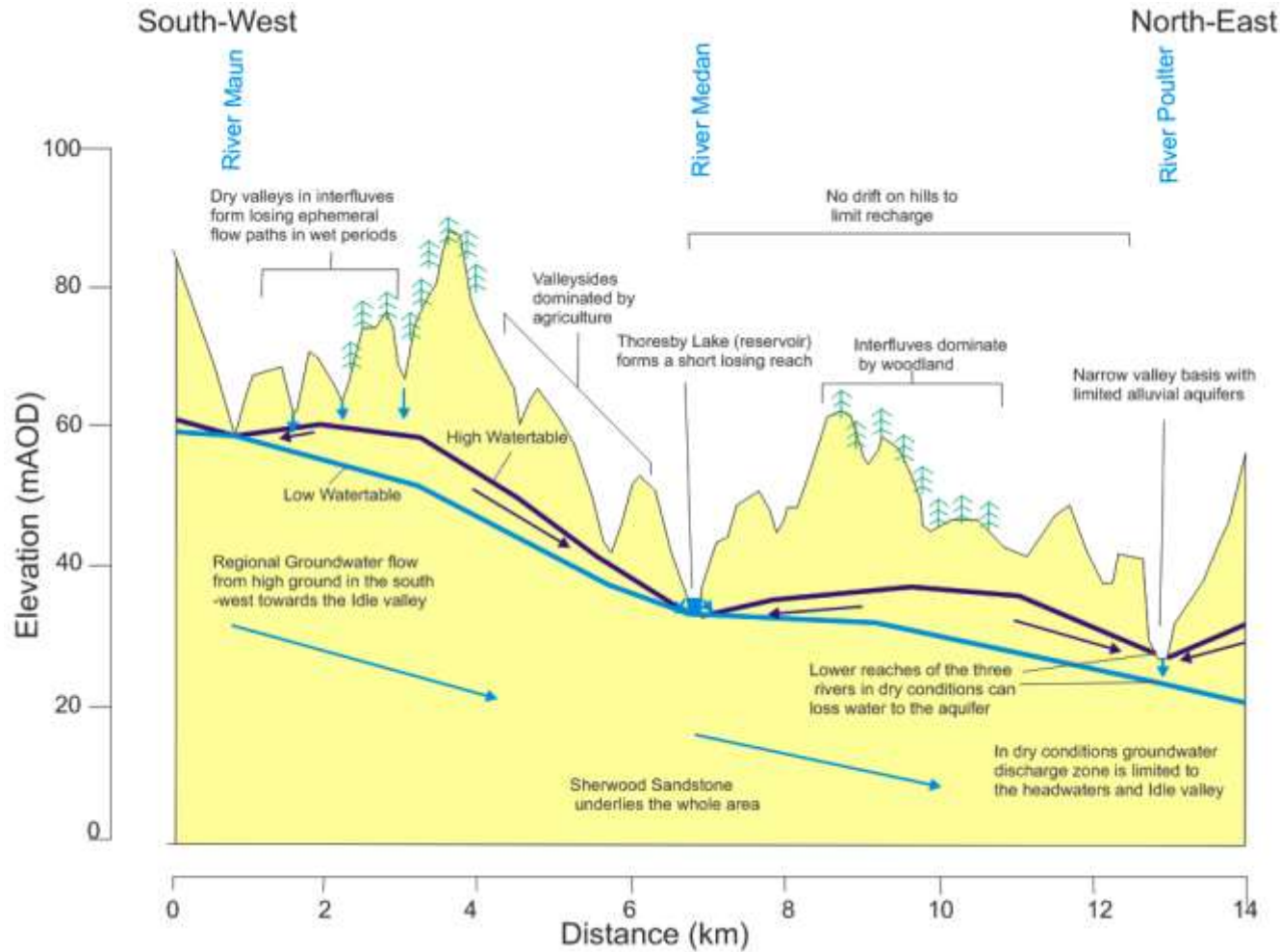
East Suffolk– Conceptual Measures



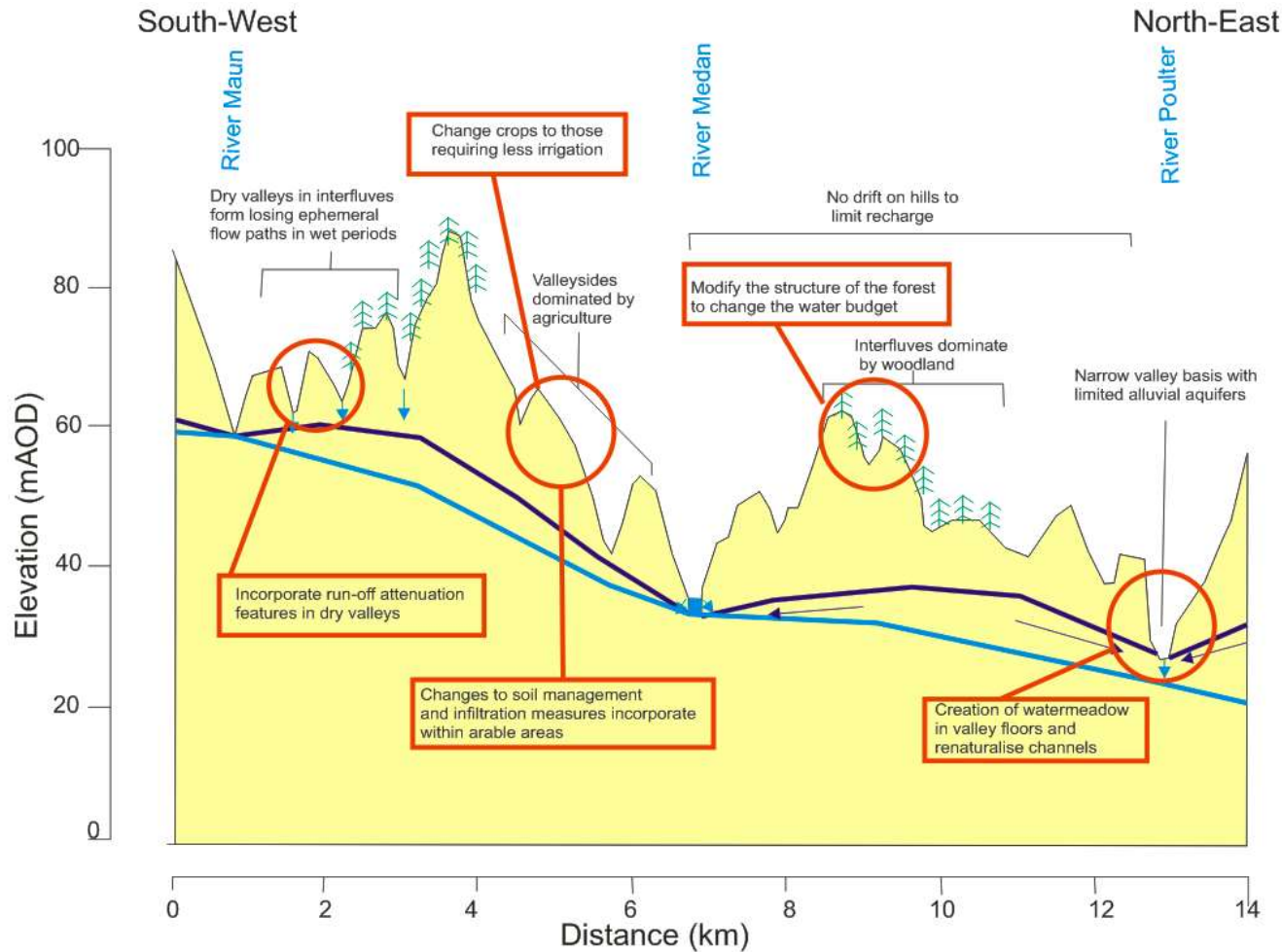
East Suffolk– Conceptual Measures

- Improving infiltration on the till soils that dominate the plateau, focusing on soil management techniques and roughness strips within fields.
 - Run-off attenuation features on permeable deposits on the edge of the till.
 - Improving resilience of streams to low groundwater levels in the chalk by renaturalising the channel and storing more water within the valley floors through riparian restoration.
 - Managing storage of water in the lake systems of the valley floors.
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Idle and Torne– Conceptual Model



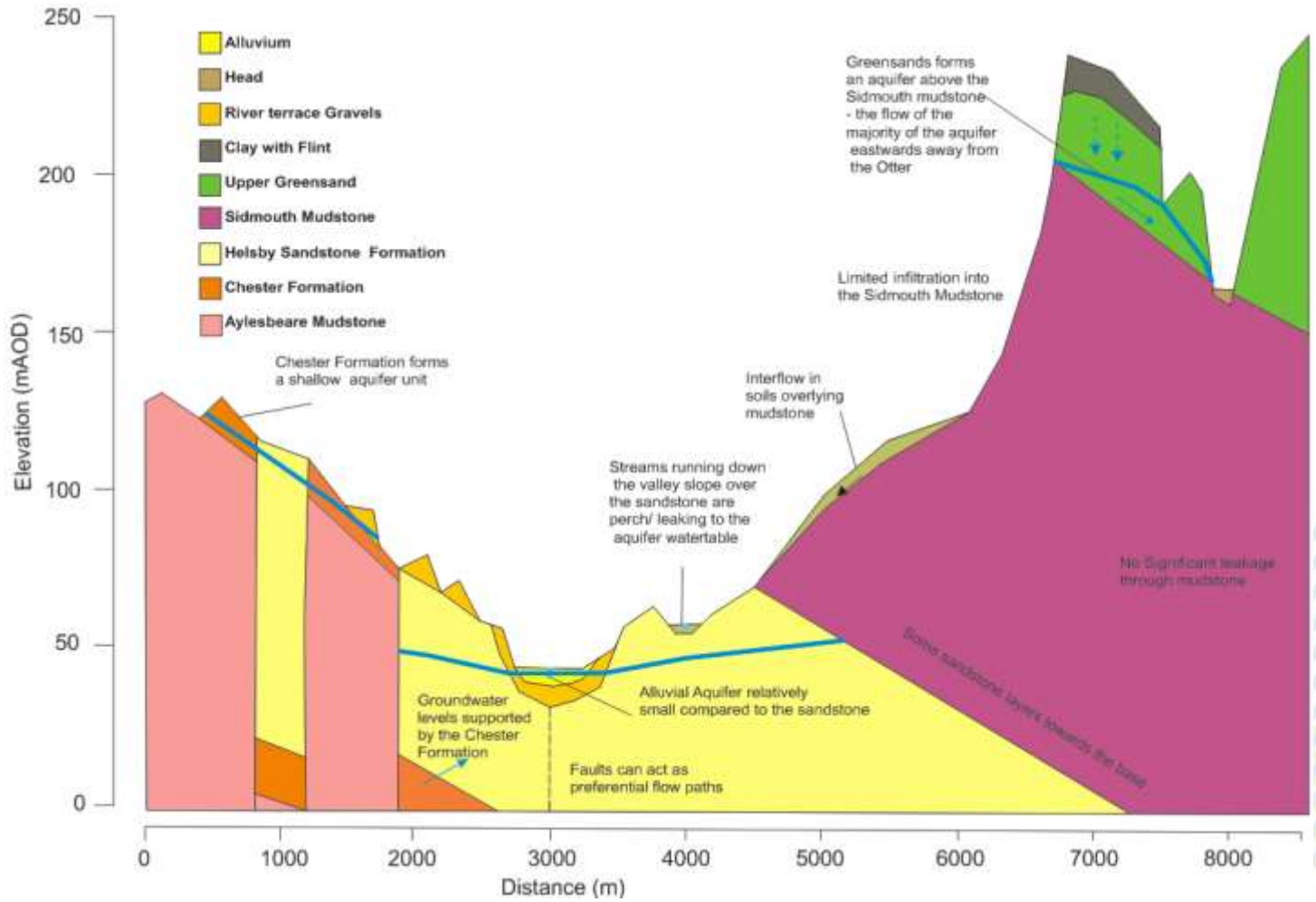
Idle and Torne– Conceptual Measures



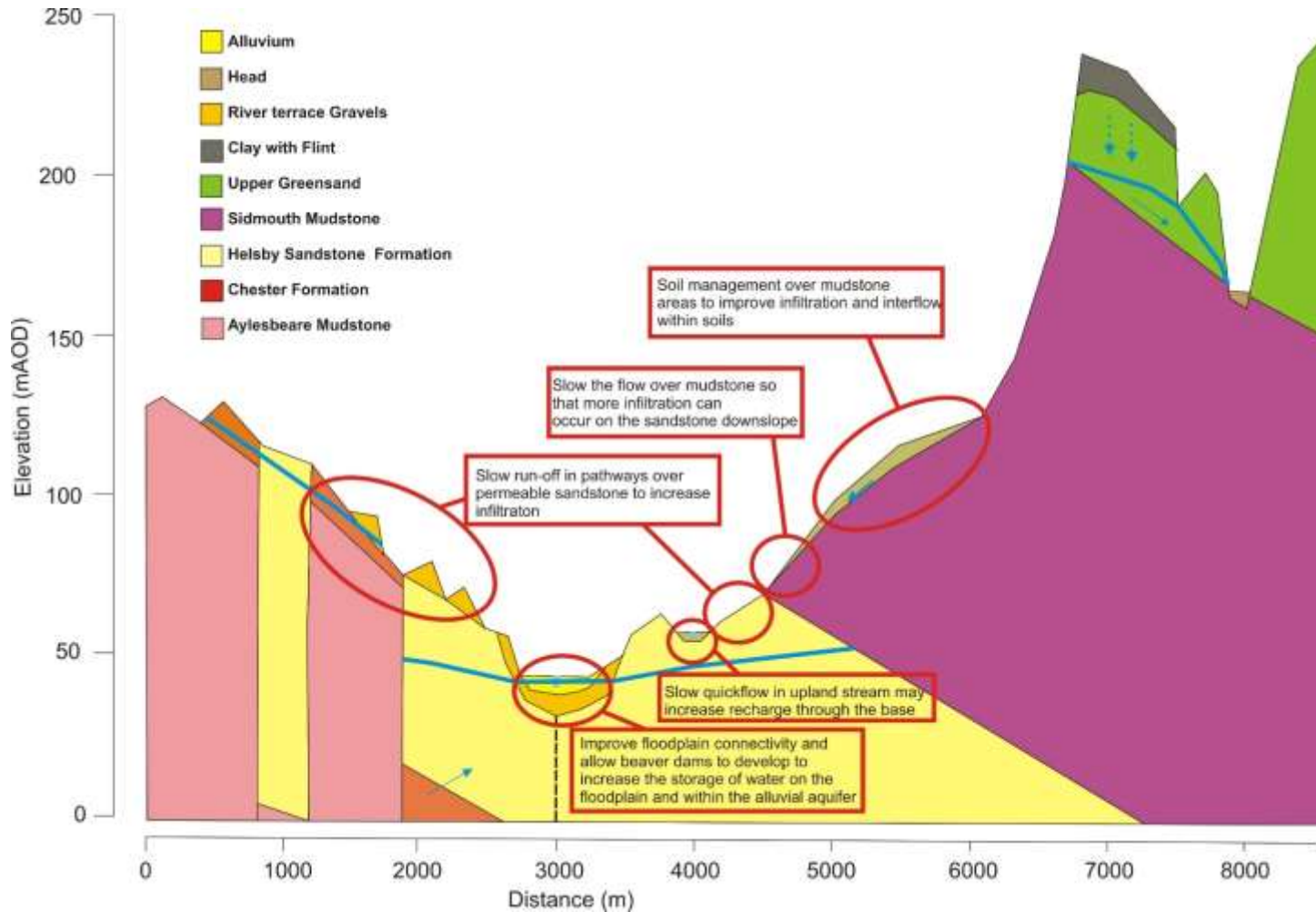
Idle and Torne– Conceptual Measures

- Increasing recharge in the mid catchment area via drainage interventions to increase infiltration from surface water runoff.
 - Blocking or partially blocking the numerous 'dry' valleys to enhance infiltration recharge during significant rainfall events.
 - Managing wooded areas to allow less coniferous woodland and allow drainage which prioritises infiltration.
 - Improved arable land management with soil conservation, increasing infiltration via drainage pathways and shifting to less intensive agriculture to reduce water demand.
 - Renaturalising channels and creation of water meadows within valley floors.
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Otter – Conceptual Model



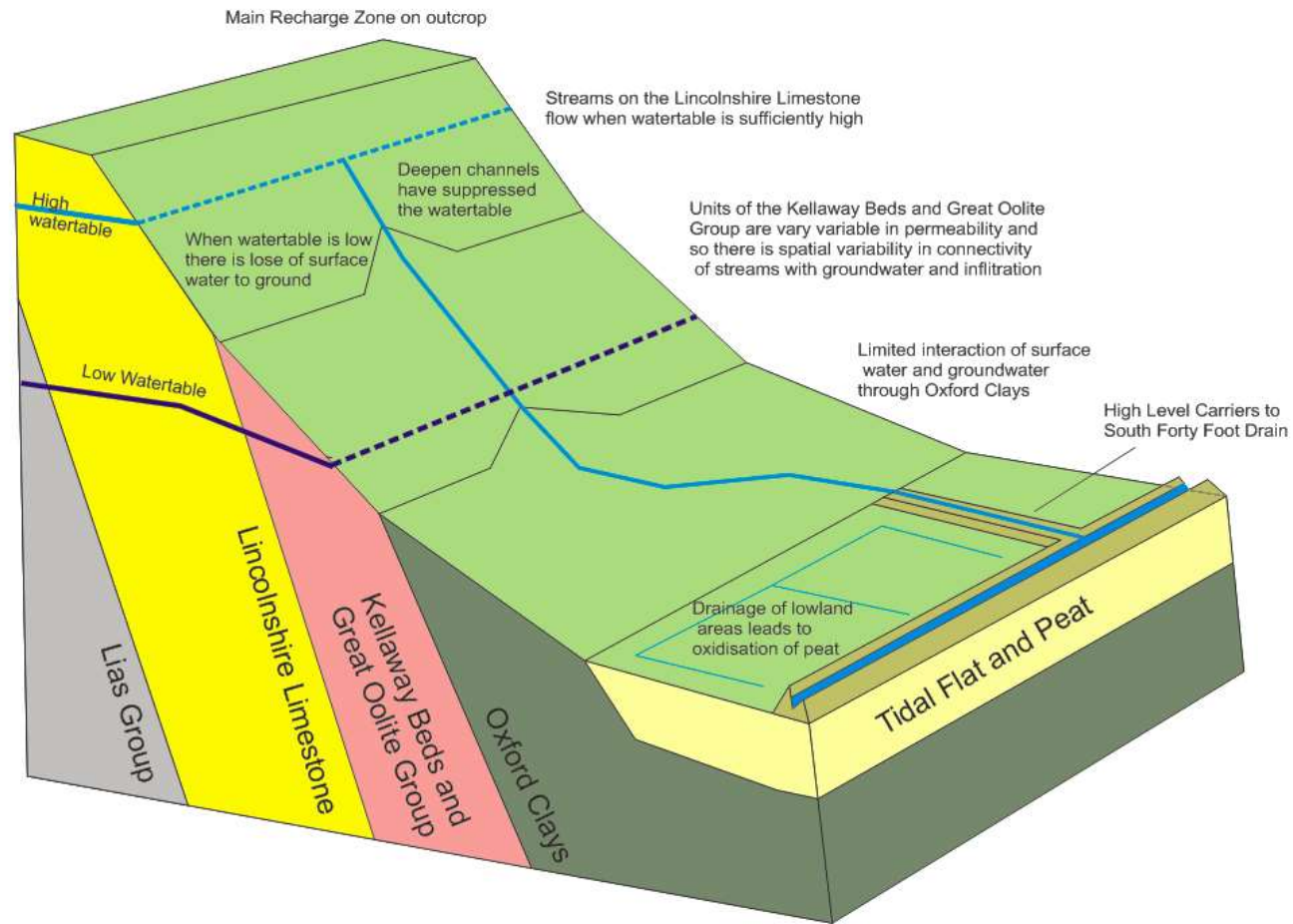
Otter – Conceptual Measures



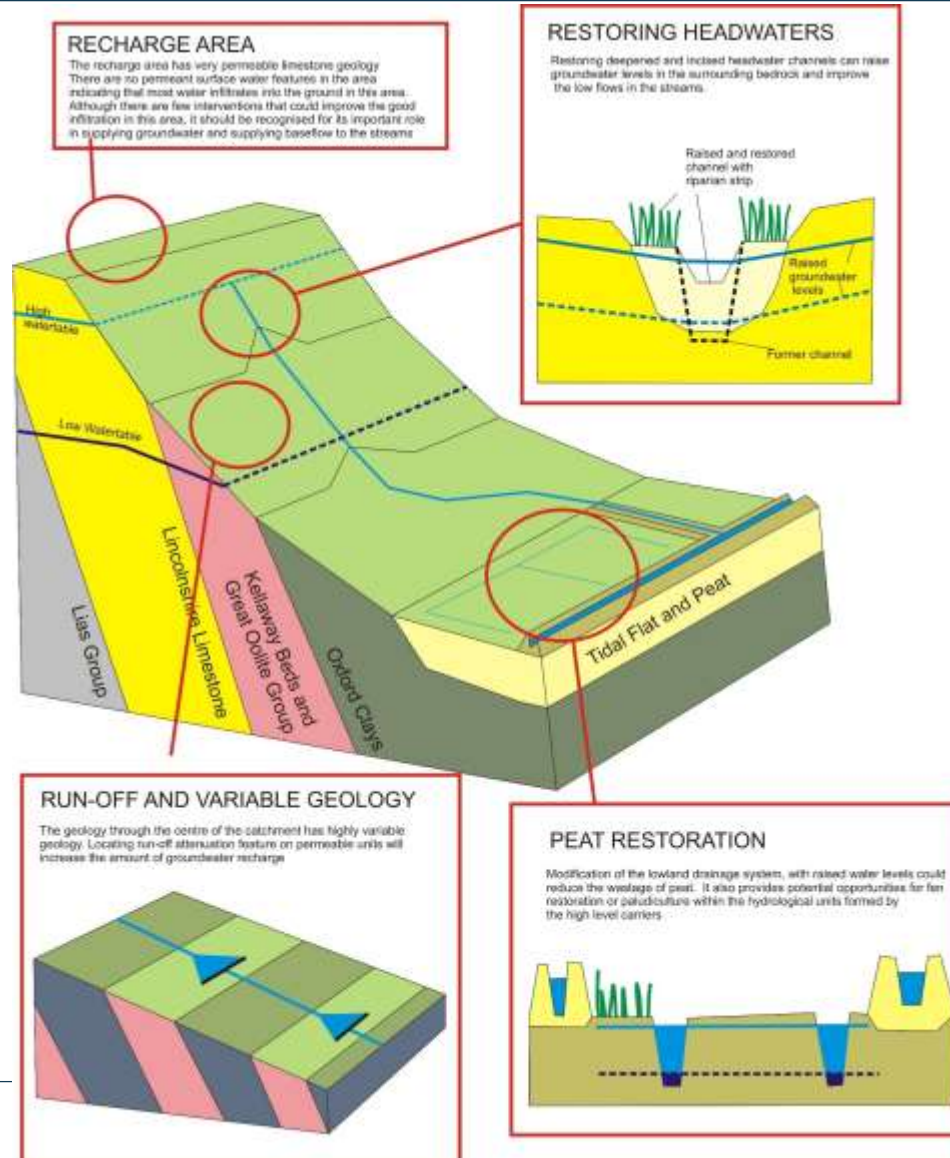
Otter – Conceptual Measures

- Slowing runoff pathways over the thin Chester Formation bedrock to increase recharge.
 - Increasing recharge on margins of Helsby Sandstone where groundwater levels are lower by slowing runoff and improving infiltration recharge from losing watercourses perched over the sandstone.
 - Improved floodplain connectivity in the Otter valley.
 - Slowing runoff to increase recharge through the clay caps to the Upper Greensand beneath and increase interflow over the Sidmouth Mudstone for recharge to the Helsby Sandstone.
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South Forty-Foot – Conceptual Model



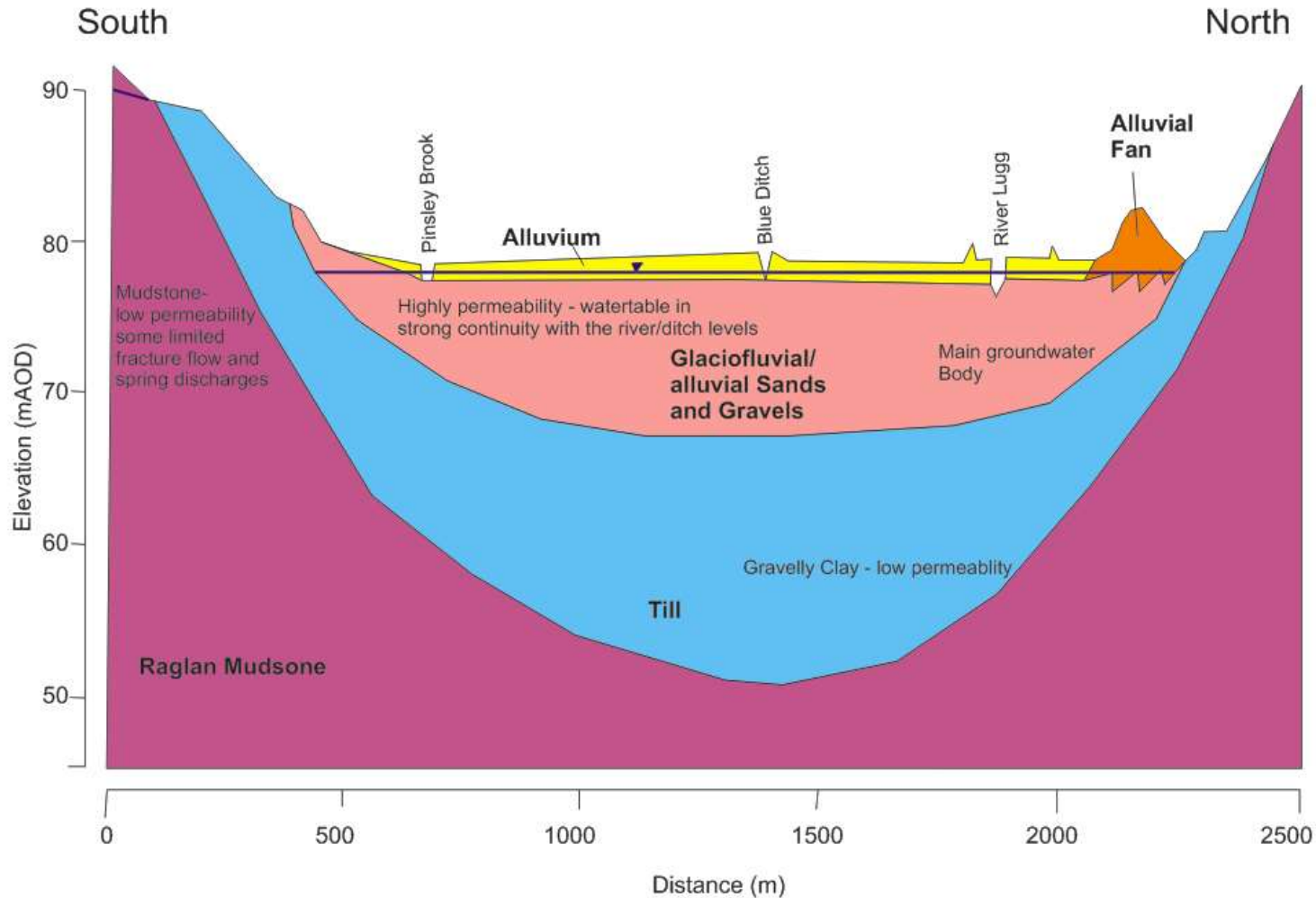
South Forty-Foot – Conceptual Measures



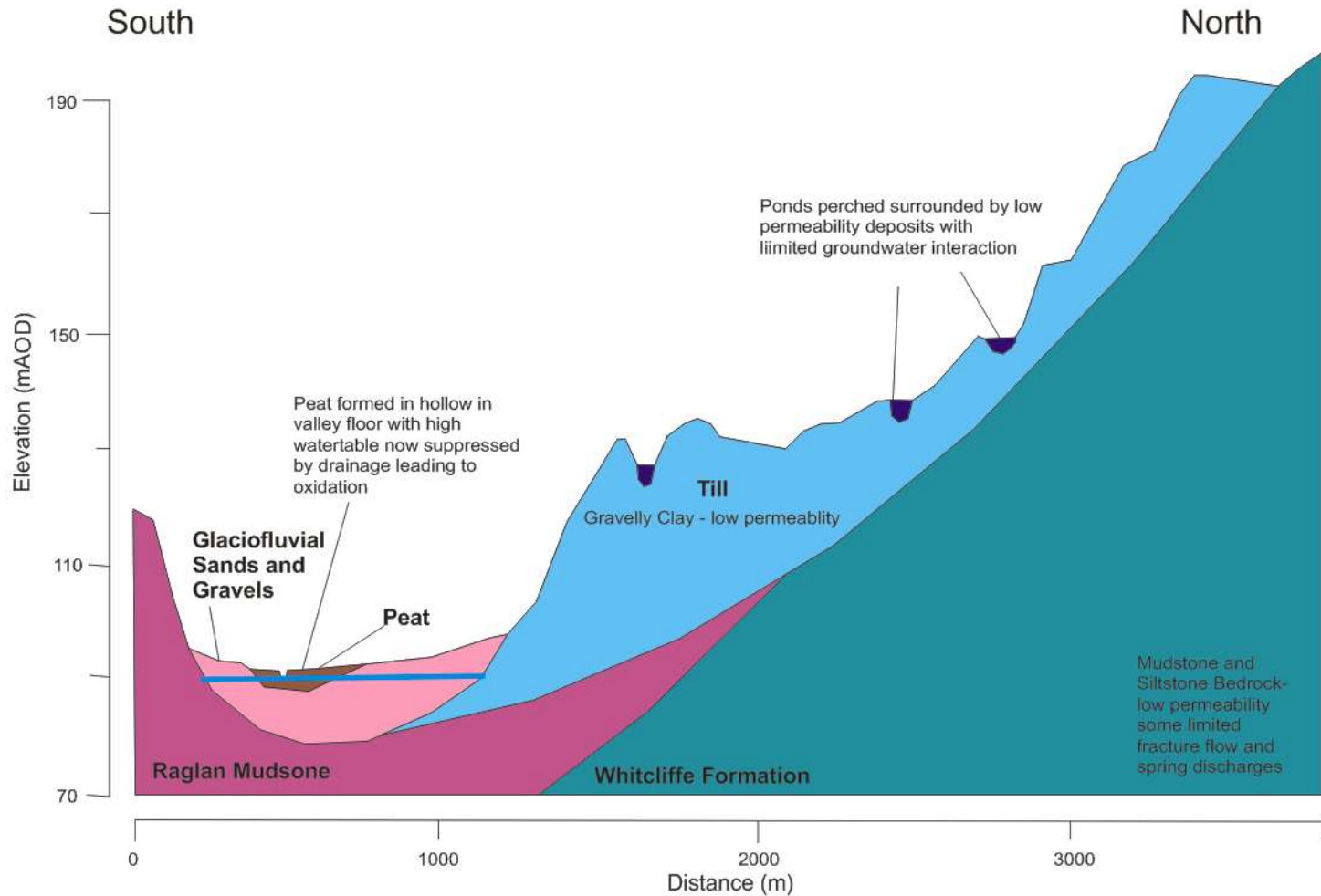
South Forty-Foot – Conceptual Measures

- Restoring deepened and incised headwater streams to raise groundwater levels in surrounding bedrock and improve low flows.
 - Runoff attenuation features located on permeable units to increase groundwater recharge.
 - Mitigating peat loss through modifying the lowland drainage system. This may include potential for raising water levels, fen restoration or paludiculture under careful management.
 - Land-use and soil management practices to promote infiltration and limit runoff generation.
 - Maintaining the important Lincolnshire Limestone recharge area.
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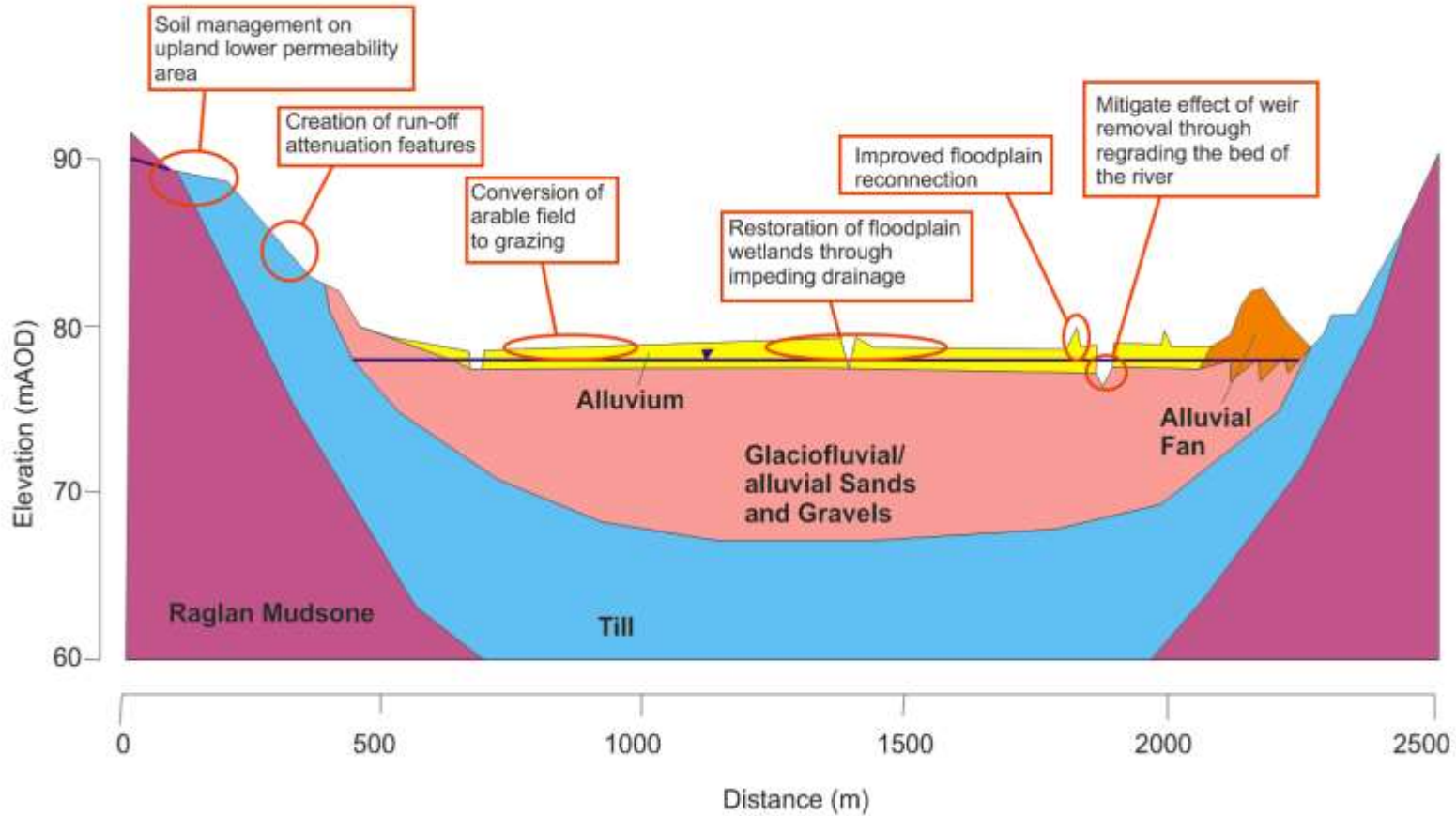
Wye/River Lugg – Conceptual Model (Kingsland)



Wye/River Lugg – Conceptual Model (Shobdon Marsh)



Wye/River Lugg – Conceptual Measures



Wye/River Lugg – Conceptual Measures

- Improved land-use and soil management over lower permeability upland areas including crop cover, interspersing grasses, hedgerow planting and shifting to less intensive agriculture to reduce surface runoff and improve infiltration.
 - Improve upland storage through runoff attenuation features over superficial till and gravels.
 - Improving floodplain reconnection within the lower valley through careful management.
 - Renaturalising drainage ditches to restore floodplain wetlands.
 - Mitigating effects of weir removal on groundwater levels through riverbed regrading.
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Summary & Recommendations

Summary

- Increased awareness of **WWNP** and its **multiple benefits**, particularly its role in generating **water resource benefits**
- **Sensitivity** to **planting cover** and **density** as well as **soils** and **land cover management** on water resources and recharge
 - + Small canopy, short-rooted and lower density planting
 - + Reduced soil compaction and arable intensity
 - + Crop choice and winter cover crop
- **Storage potential** throughout catchment
 - + Direct recharge over permeable geology
 - + Slow flows for delaying recharge – catchment-wide

Summary

- Generation of Wider Recharge Areas to simplify recharge target areas and align with locally engaged landowners
- Generation of catchment-wide WWNP potential measures linked to underlying surface water and groundwater processes
- Matrix summarising WWNP measures, evidence and multiple benefits to provide options to landowners

Recommendations

- **Application of Project Deliverables**
 - Used to screen areas within each AoI to prioritise recharge areas
 - Identify most relevant WWNP intervention types
 - Use more detailed datasets to further support and assess locally
 - Consider updating GIS approaches for varying scales, eg. nationally or local-scale, or utilising Open Data only
- **WWNP Research and Policy**
 - Provide a more holistic assessment of WWNP to balance flood risk and water resource demands and budgets
 - Ensure schemes implemented make consideration for groundwater monitoring

Recommendations

- **Future Work**

- Conduct pilot schemes with long-term monitoring
- Consider potential for SUDS in recharge and storage

- Numerical modelling
 - Rainfall-runoff HYPE modelling developments (as used for Catchment Sensitive Farming)
 - EA regional groundwater modelling to simulate recharge scenarios and groundwater level responses