

Water Framework Directive: Investigation of significant groundwater derived nutrient impacts at Merthyr Mawr, South Wales, UK.

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British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Outline

- ⇒ **Water Framework Directive, Groundwater Dependent Terrestrial Ecosystems and the ‘wetland test’**
- ⇒ **Merthyr Mawr investigation**
- ⇒ **Discussion**
- ⇒ **Conclusions**

WFD timetable



Water Framework Directive (2000/60/EC)

Requires an assessment of whether groundwater is causing *'significant damage to terrestrial ecosystems that are directly dependent on that groundwater'*.

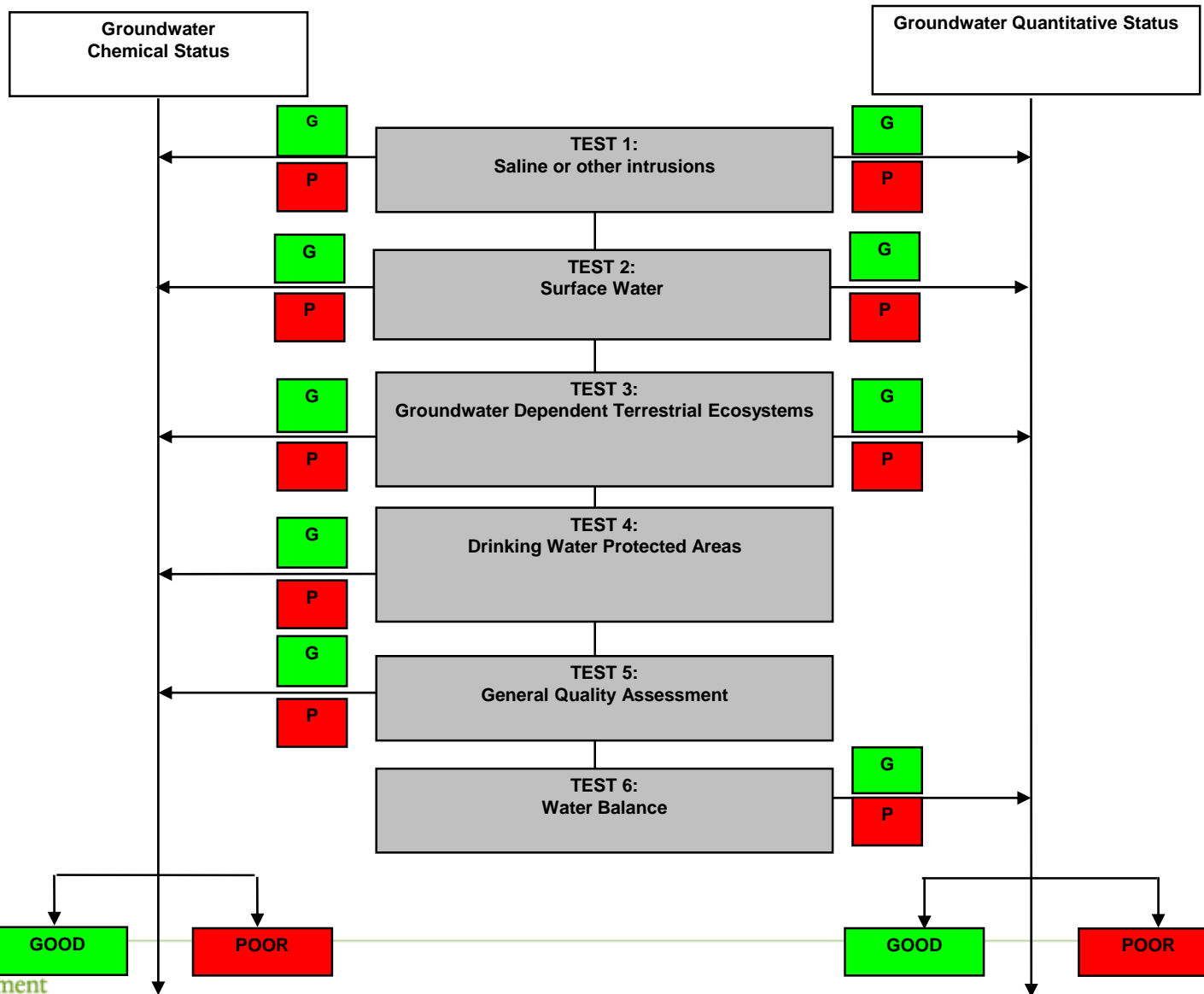
(WFD Annex V 2.3.2)

UKTAG (paper 5c) define the term 'significant damage' as a function of:

- ➔ *'Degree of damage' occurring to a GWDTE (caused by groundwater-related factors);*
- ➔ *the 'significance' or 'conservation value' of the ecosystem;*

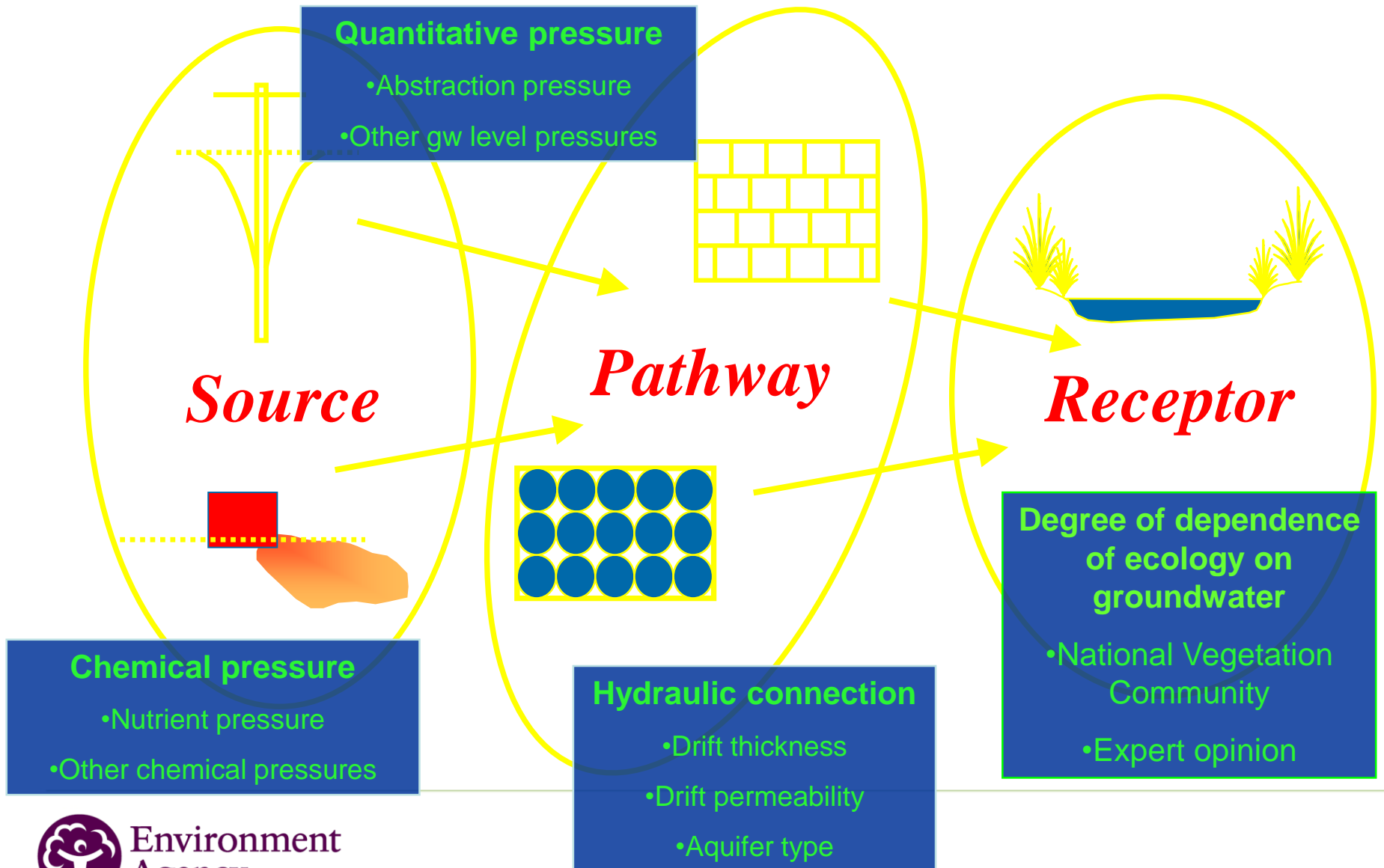


Classification tests – groundwater status



The results of each test are combined for overall classification of POOR or GOOD STATUS for both quantity and chemical. The worst result is reported for the groundwater body.

Risk assessment approach



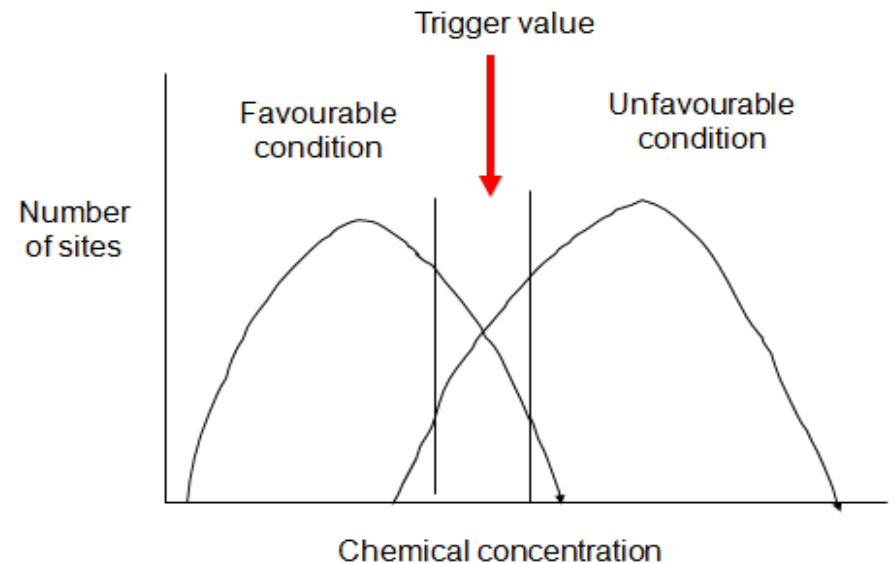
Chemical pressure component

River Basin Cycle 1

- ➔ Groundwater orthophosphate (or modelled loading)
- ➔ 95%ile of background conc (*EA & BGS baseline reports*)
- ➔ Low threshold from surface water
- ➔ preferred trophic conditions of plant communities (*Meade et al., 2006*)

River Basin Cycle 2

- ➔ Groundwater nitrate monitoring (or modelled loading)
- ➔ threshold value related to wetland type



Protecting the plant communities and rare species of dune wetland systems



Ecohydrological guidelines for wet dune habitats

Wet dunes phase 2



Environment Agency, 2010.
[Ecohydrological guidelines for wet dune habitats. Wet dunes phase 2.](#)
[Click here for free download](#)

UK Technical Advisory Group on the Water Framework Directive

Technical report on groundwater dependent terrestrial ecosystem (GWDTE) threshold values.

This technical report is defined by the UKTAG. It documents the principles to be adopted by agencies responsible for implementing the Water Framework Directive (WFD) in the UK. This method will evolve as it is tested, with this report being amended accordingly.

Working Paper Version:	V8; 23 March 2012	Status: final for consultation
WFD Requirement:	Classification schemes, regulation, environmental Standards, groundwater, wetlands	UKTAG Review:

1. Background and Aim

The Water Framework Directive (WFD) sets out objectives for the water environment. These include the protection, enhancement and restoration of surface water, groundwater and water dependent protected areas and prevention of deterioration. Environmental standards and conditions are needed to set the level of control to meet these objectives. For example, how much water can be abstracted, or how much of a pollutant can enter the environment, without causing harm to the health of aquatic plants and animals - harm that would compromise the achievement of the Directive's objectives.

The UK Technical Advisory Group (UKTAG), comprising representatives of the UK environment and conservation agencies, is responsible for providing advice on technical aspects of the WFD to the UK administrations. The UKTAG Wetland Task Team (WTT) provides technical advice on wetland aspects of WFD implementation to the UKTAG.

Groundwater dependent terrestrial ecosystems (GWDTE) are wetlands which critically depend on groundwater flows and /or chemistries (WG-C; Schutten et al, 2011). As part of the assessment of groundwater status, we are required to assess if a GWDTE has been significantly damaged and if the pressure causing this damage has been transmitted via a groundwater body. The magnitude of damage (i.e. 'significance') is related to the societal (conservation in UK) importance of the features of the wetlands and the degree of change to these features resulting from the pressure (WG-C; Schutten et al, 2011).

Threshold values are needed to determine what groundwater concentrations of chemicals, if exceeded, would indicate a pressure that could be (or actually is) causing damage to the GWDTE. In practise the values are used as a risk screen to trigger further investigation where needed. A combination of a damaged GWDTE (such as failure to meet conservation objectives) and exceedance of the relevant threshold values triggers further investigations (see groundwater chapter of the UKTAG consultation document; UKTAG 2012). These investigations need to confirm whether damage has occurred, substantiate the hydrogeological and hydrochemical pathway(s) between the groundwater body and GWDTE, and the outcome would inform groundwater body status assessment.

UKTAG, 2012. [Threshold Values for nitrate](#)

[Click here for free download](#)

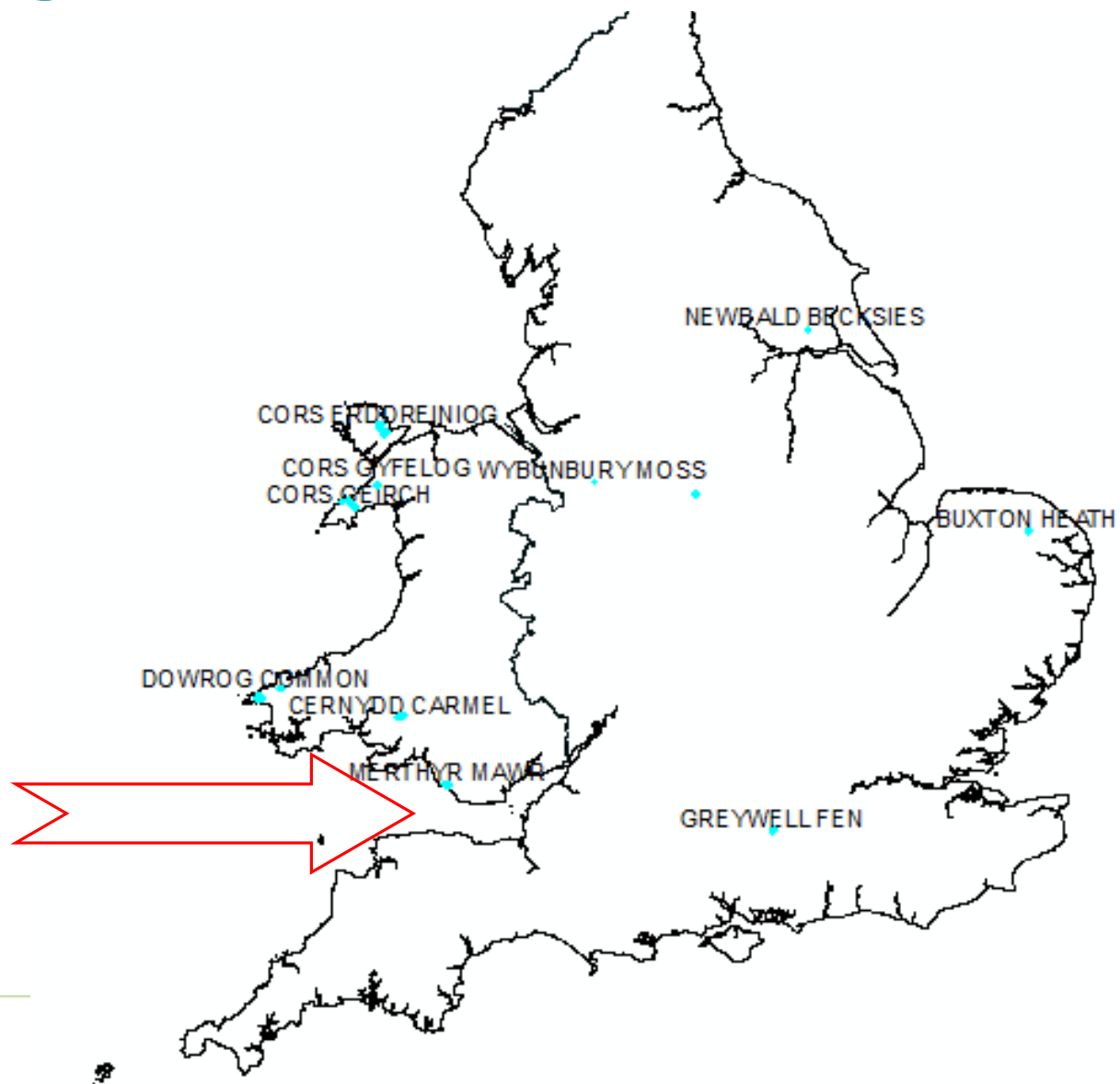
Proposed nitrate threshold values (mg/l N)

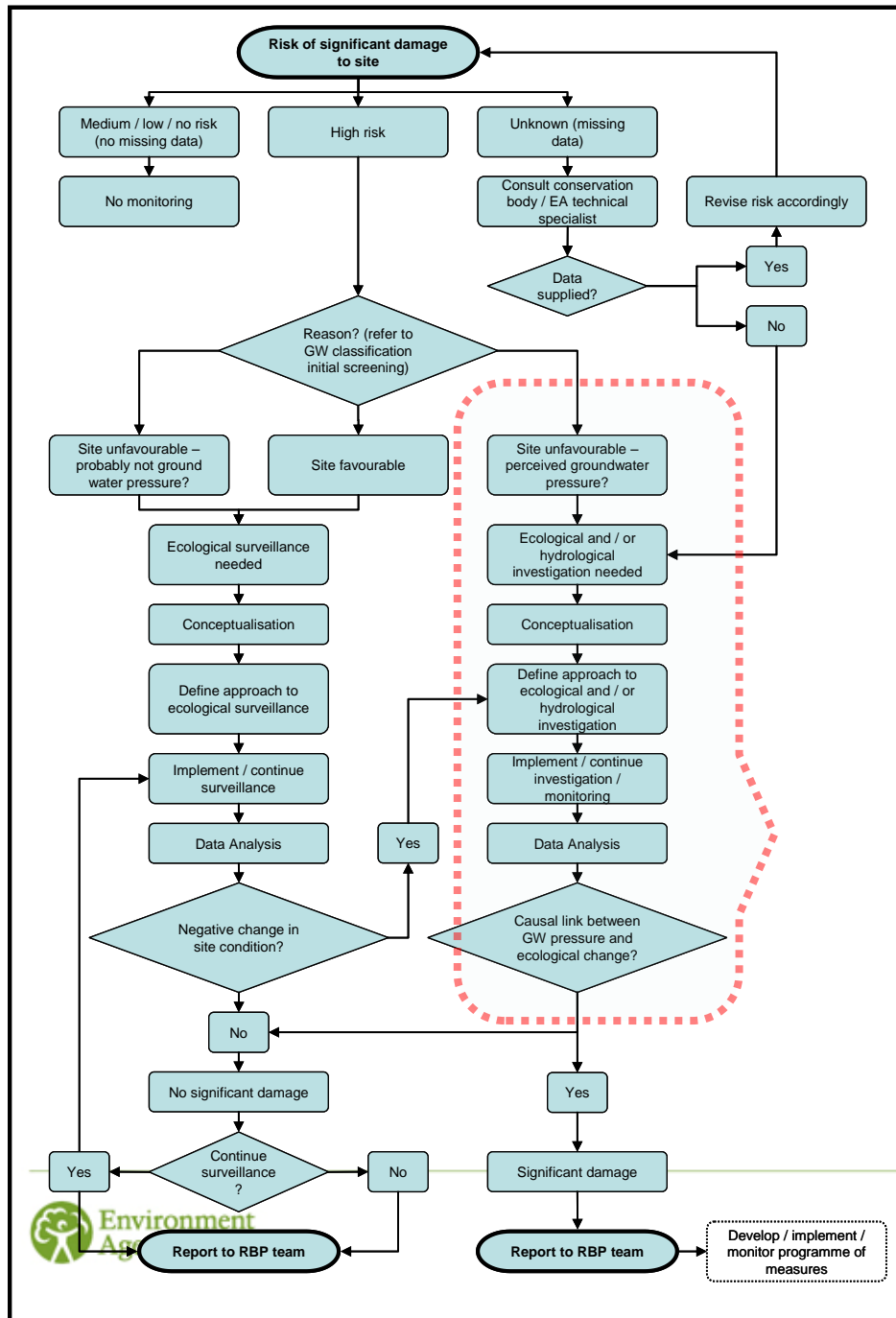
GWDTE category	Altitude <175mAOD	Altitude >175mAOD	Any altitude
Quaking bog	4	1	
Wet Dune			3
Fen (mesotrophic) and fen Meadow)	5	2	
Fen (oligotrophic and wetlands at Tufa forming springs)	4.5	1	
Wet Grassland	6	2	
Wet Heath	3	2	
Peat bog and woodland on peat bog			2
Wetlands directly irrigated by spring or seepage			2
Swamp (mesotrophic) and reedbed			5
Swamp (oligotrophic)			4
Wet Woodland	5	2	

Classification status: Significant damage

1. Ecological quality is assessed using data gathered by the lead conservation agencies.
2. The magnitude of damage is assessed with reference to a series of eco-hydrological guidelines for wetland habitats.
 - For high risk sites, define environmental supporting conditions (e.g. flow, level or chemistry) required to maintain dependent (plant) communities in a favourable state.
 - If the required environmental supporting conditions are not in place, determine the magnitude of the departure from required conditions within the GWDTE.
 - Determine the proportion, if any, of the departure due to anthropogenic pressures compared to other pressures.

Investigations for RBC1 GWDTEs





See 'Guidance on monitoring and investigation of GWDTEs' (2008) report on Environment Agency website

Case Study: Merthyr Mawr

a summary of key investigation techniques

Purpose:

- Further characterise source-pathway-receptor links
- Determine whether significant damage has been caused by groundwater body chemical pressures



Ecology

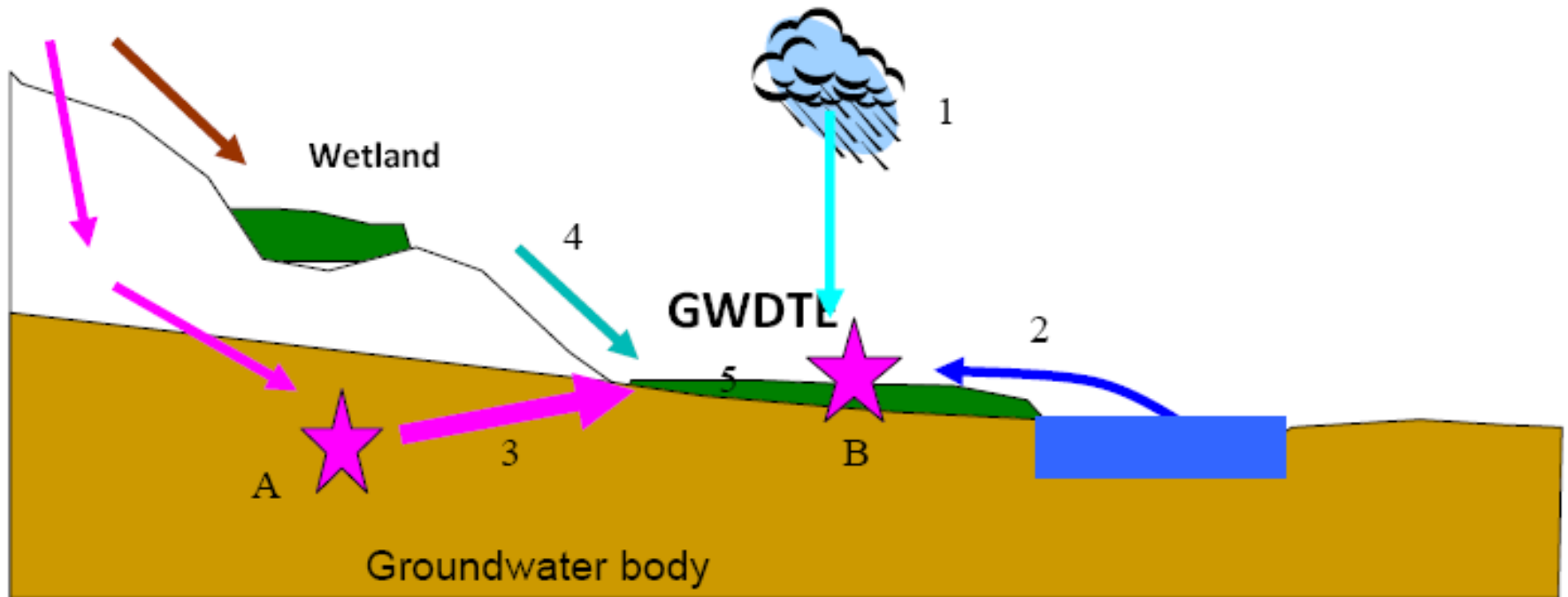


Annex 1 habitats

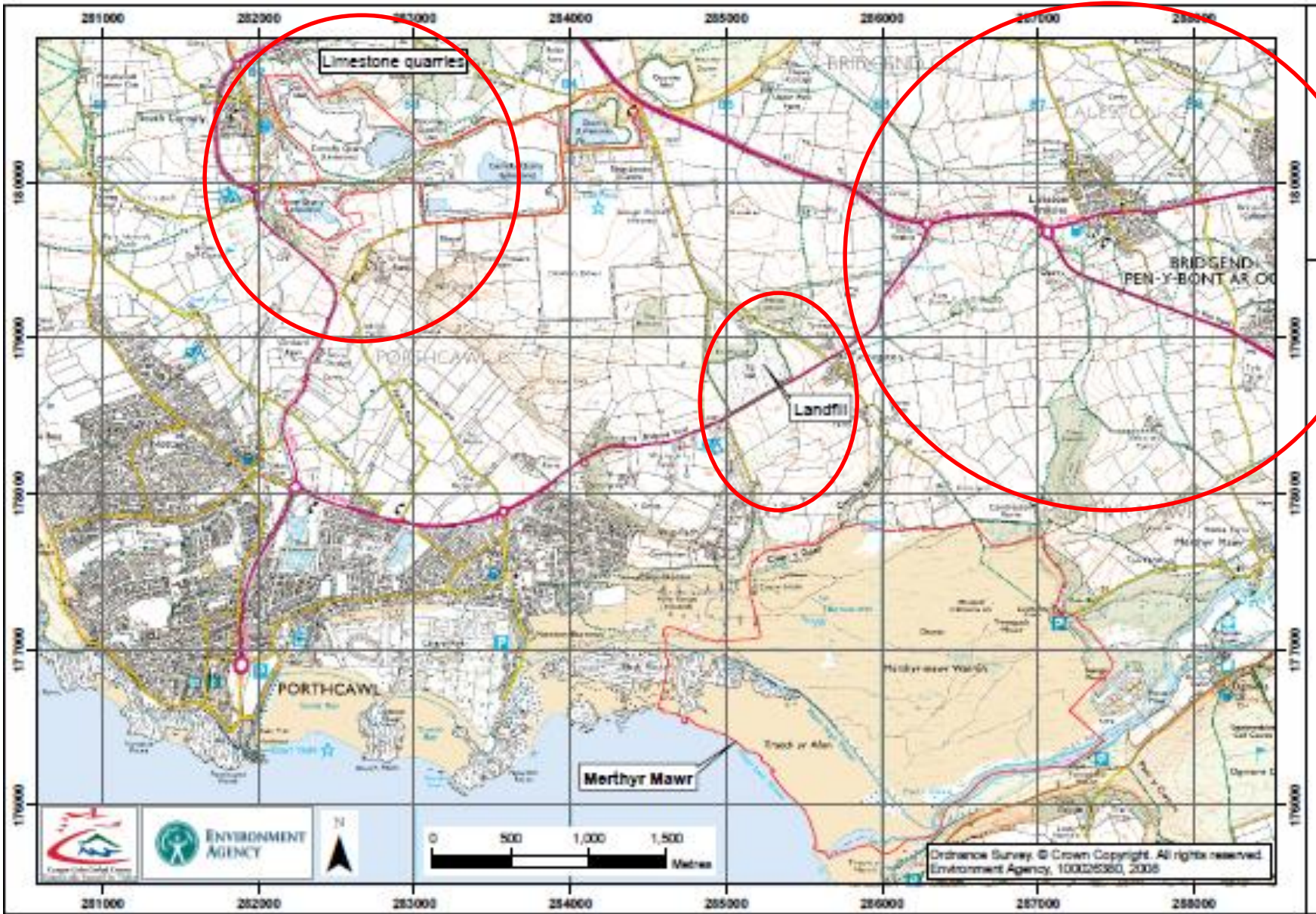
- 2190 Humid dune slacks
- 2170 Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*)
- 2130 Fixed dunes with herbaceous vegetation ('grey dunes')

Nutrient pathways

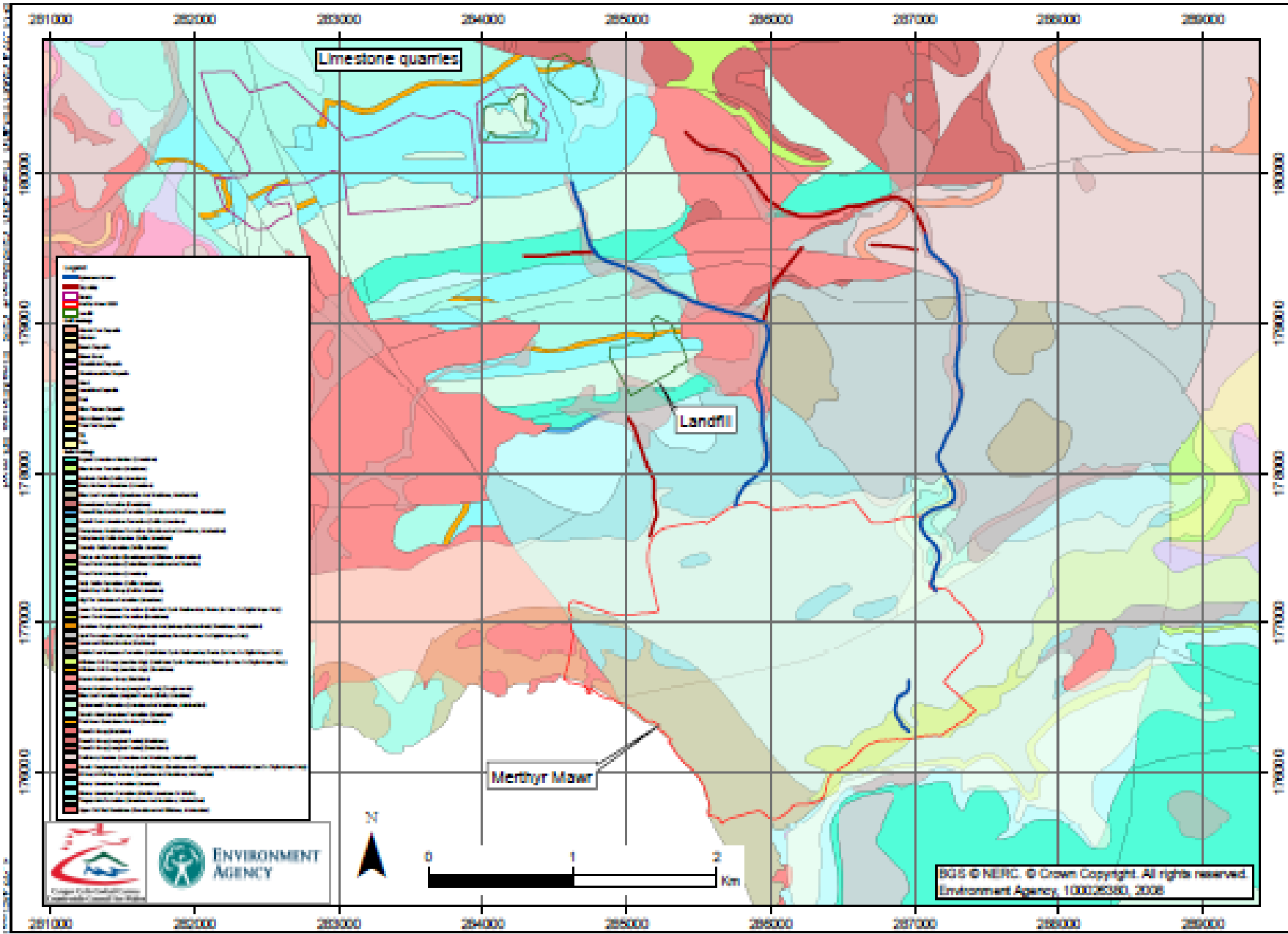
1. aerial deposition
2. surface water and lateral water movement
3. groundwater
4. direct deposition
5. re-mineralised nutrients



Catchment survey & pressures



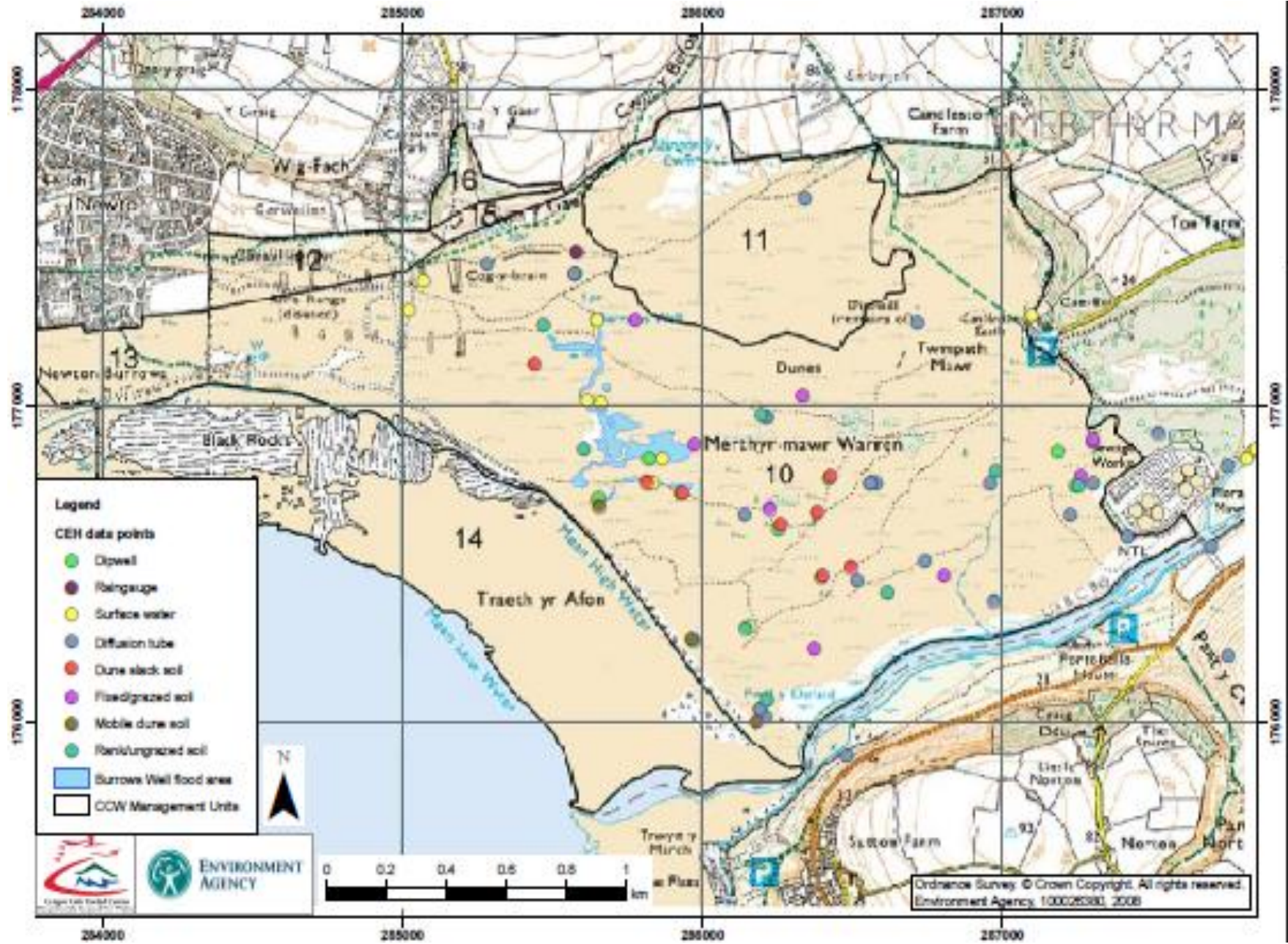
Bedrock Geology



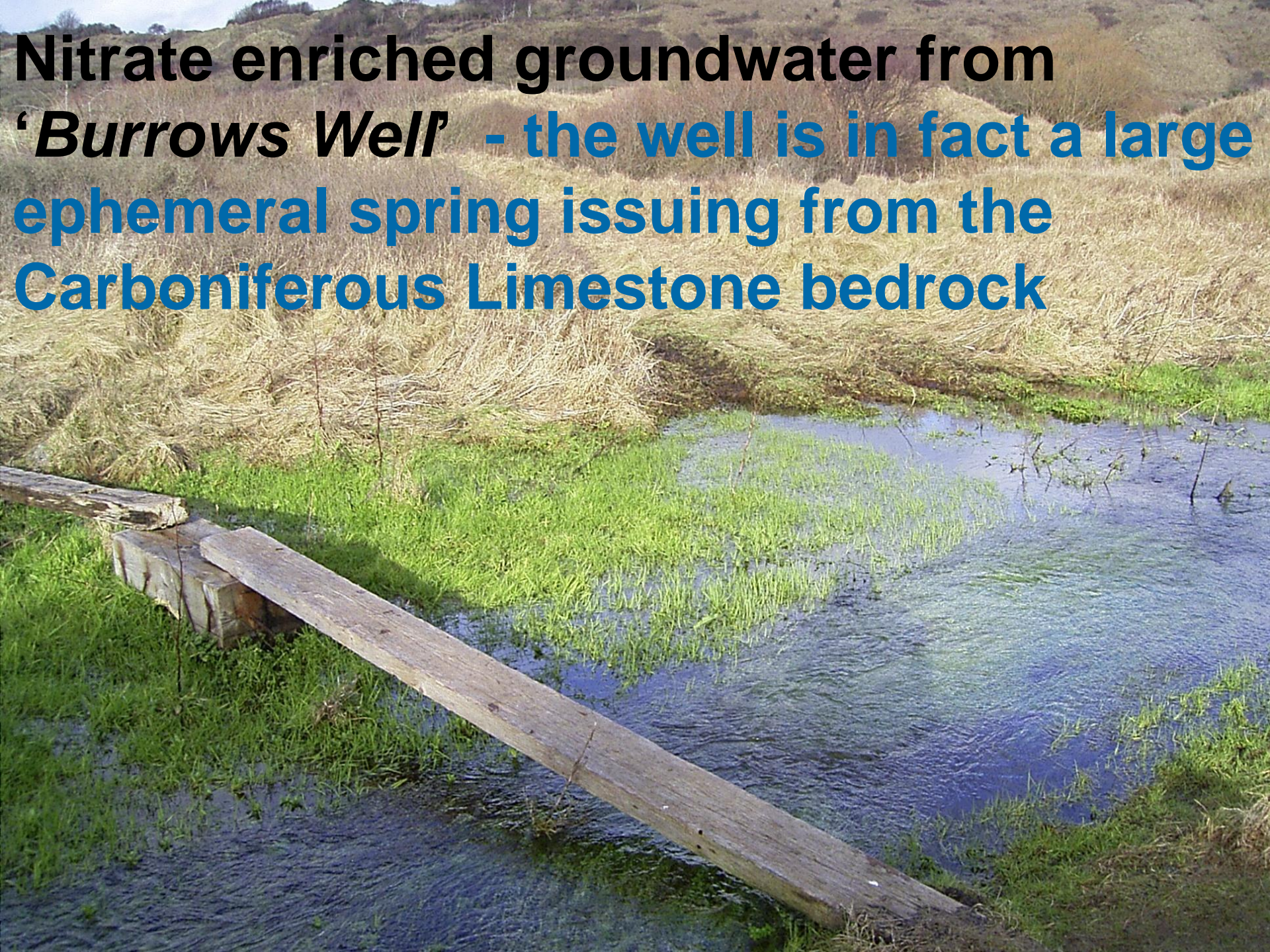
Aerial photographs : 2000s



Previous monitoring



Nitrate enriched groundwater from
'*Burrows Well*' - the well is in fact a large
ephemeral spring issuing from the
Carboniferous Limestone bedrock



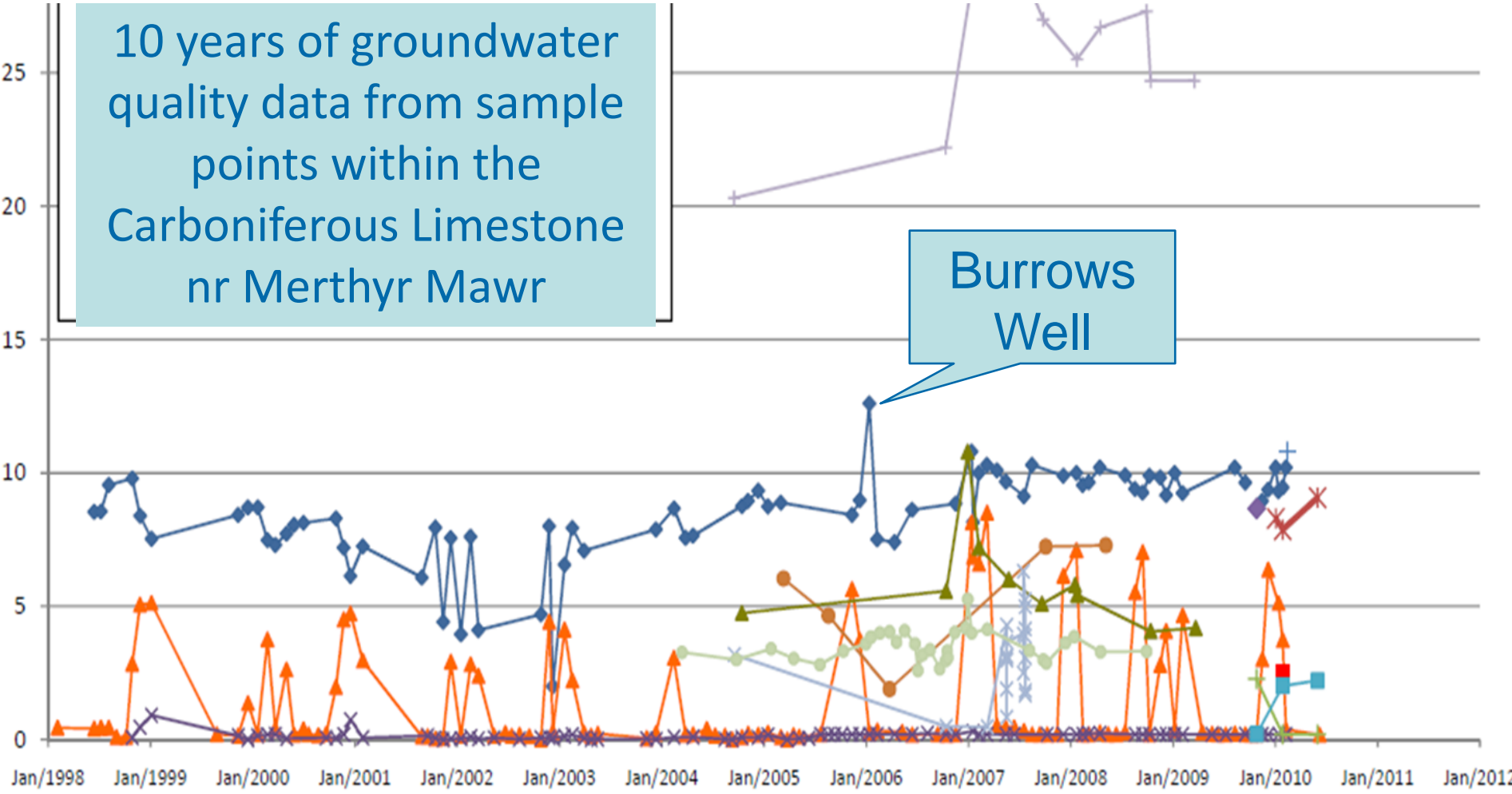
Groundwater level monitoring £ - £££



Water Quality long term (Nitrate-N mg/l)

10 years of groundwater quality data from sample points within the Carboniferous Limestone nr Merthyr Mawr

Burrows Well



Aerial deposition - nitrogen

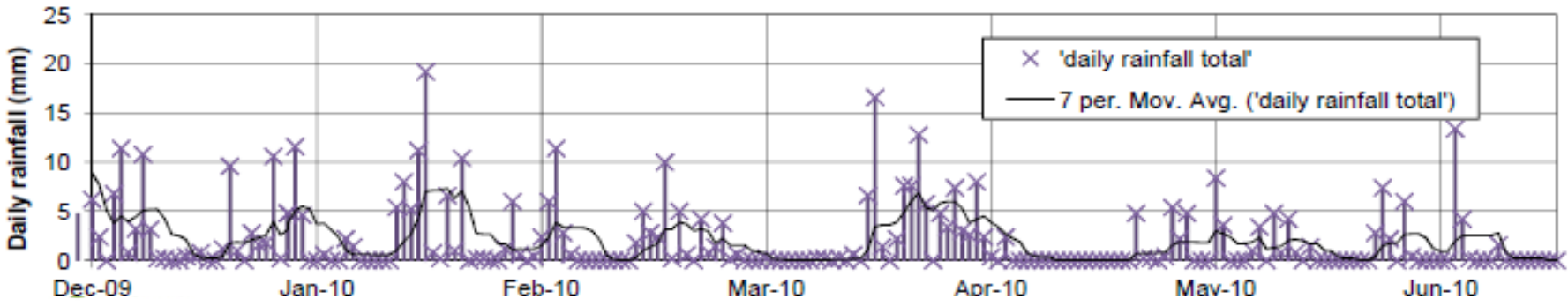
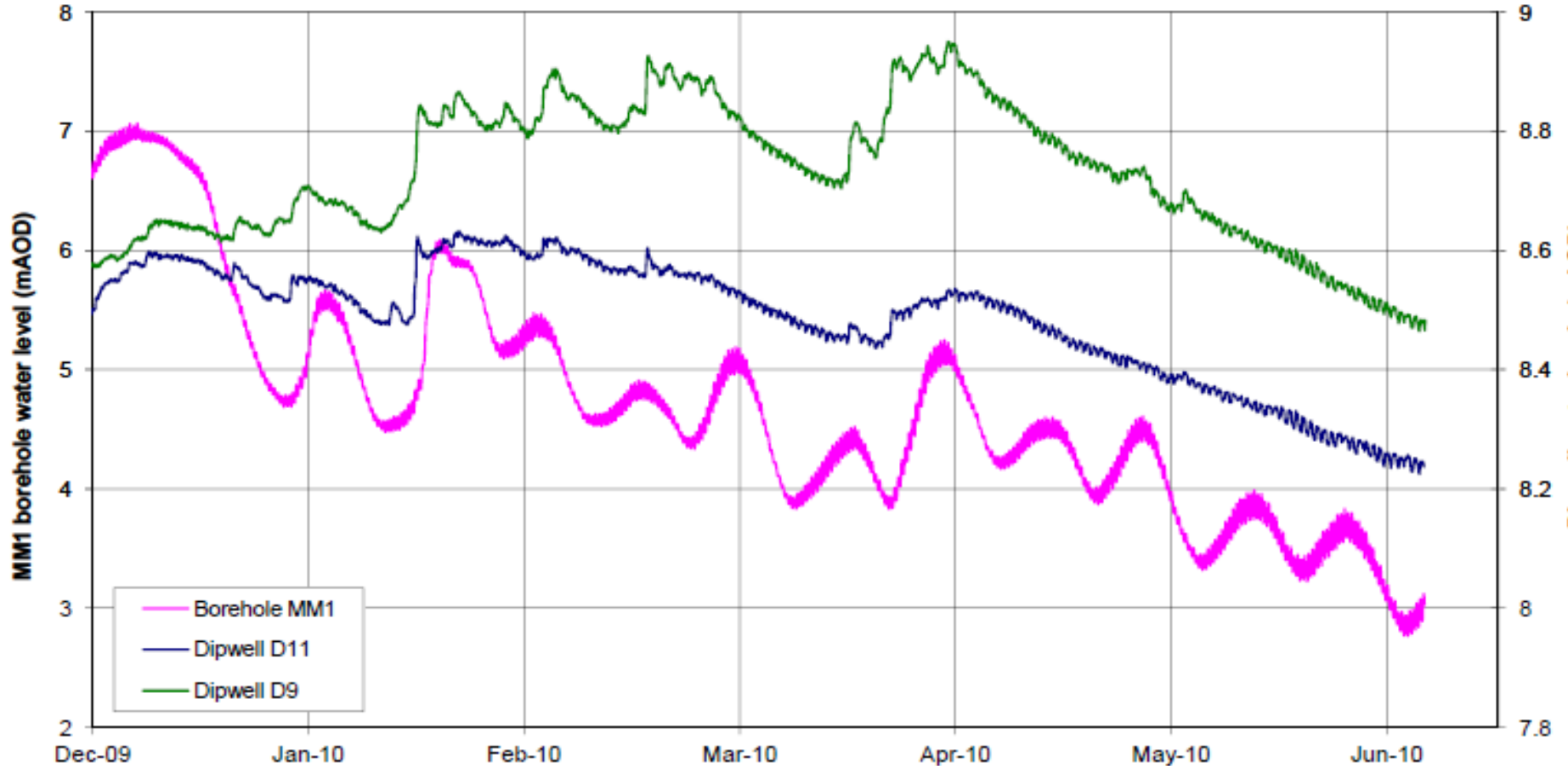
Table B.7 Estimated fluxes of atmospheric nitrogen during 2004/05 (Jones *et al*, 2005)

Component		Estimated flux	Potential sources
Atmospheric NO ₂	Low variability, sampled at one point	1.03 kgN/ha/yr (9.49 µg m ⁻³)	Data suggests domestic heating rather than heavy industry, road travel, etc
Atmospheric NH ₃	High variability, many sample points	4.4 kgN/ha/yr (0.77 µg m ⁻³)	External: grazing land to the east of the River Ogmore (40-50% higher in east of site) Internal: Buckthorn clearance – not sure why this would happen, microbial breakdown or roots ?
Wet deposition	Measured at rain gauges on site	4.7 kgN/ha/yr	No obvious difference in total N (DON, NO ₃ , NH ₄) across the site although the individual components varied. This may have been due to the method of sample preservation
Total N input		10.13 kgN/ha/yr	

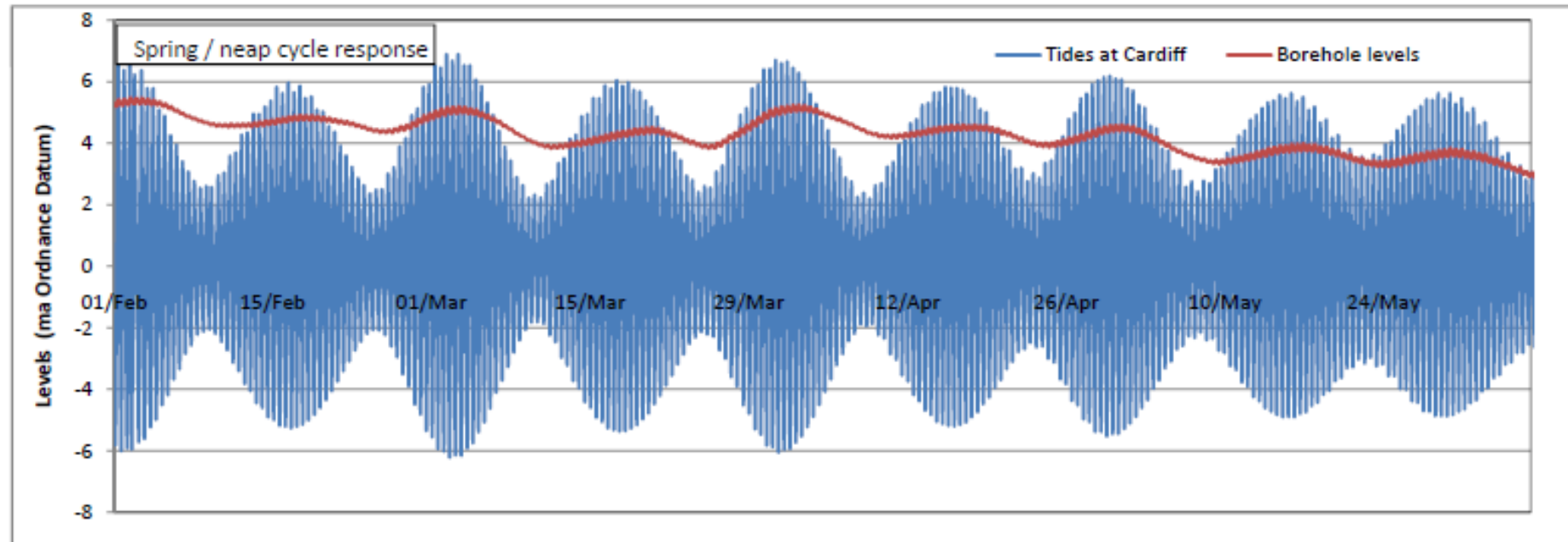
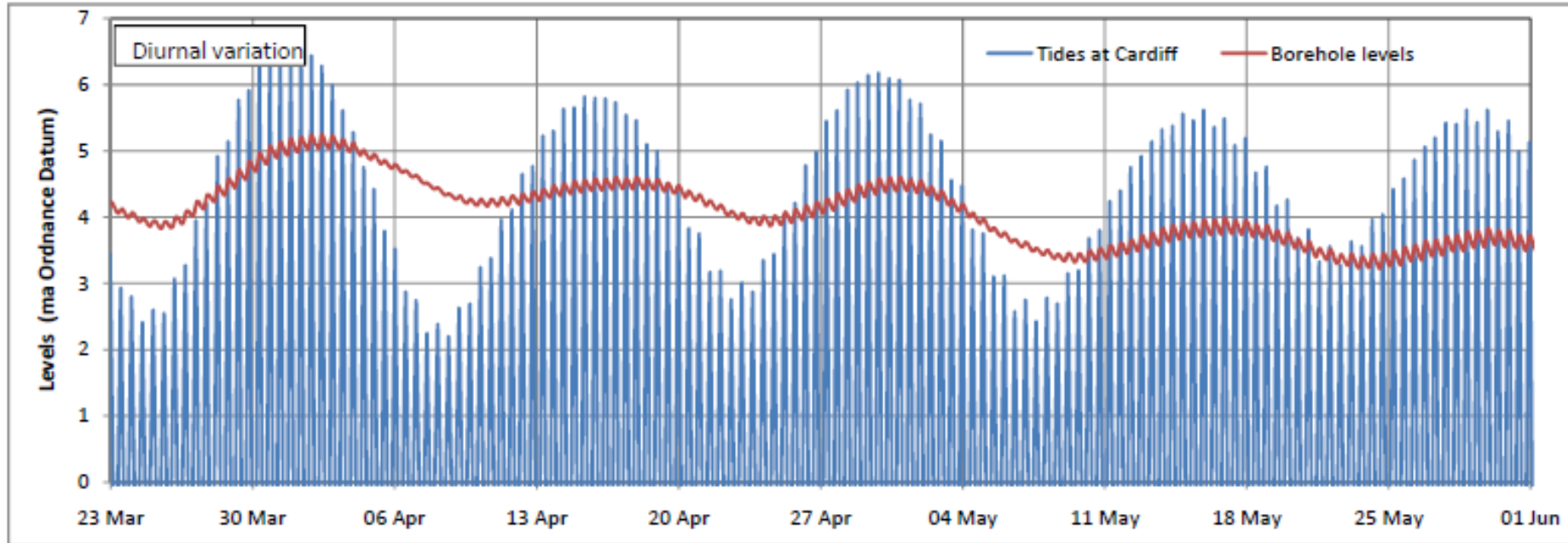
Isotopes and tracers

- ➔ Nitrogen and Oxygen Isotopes (UEA) - delineate source of nitrate in groundwater (atmospheric and inorganic)
- ➔ SF₆ and CFC tracers to age date young (<50 yrs old) groundwater

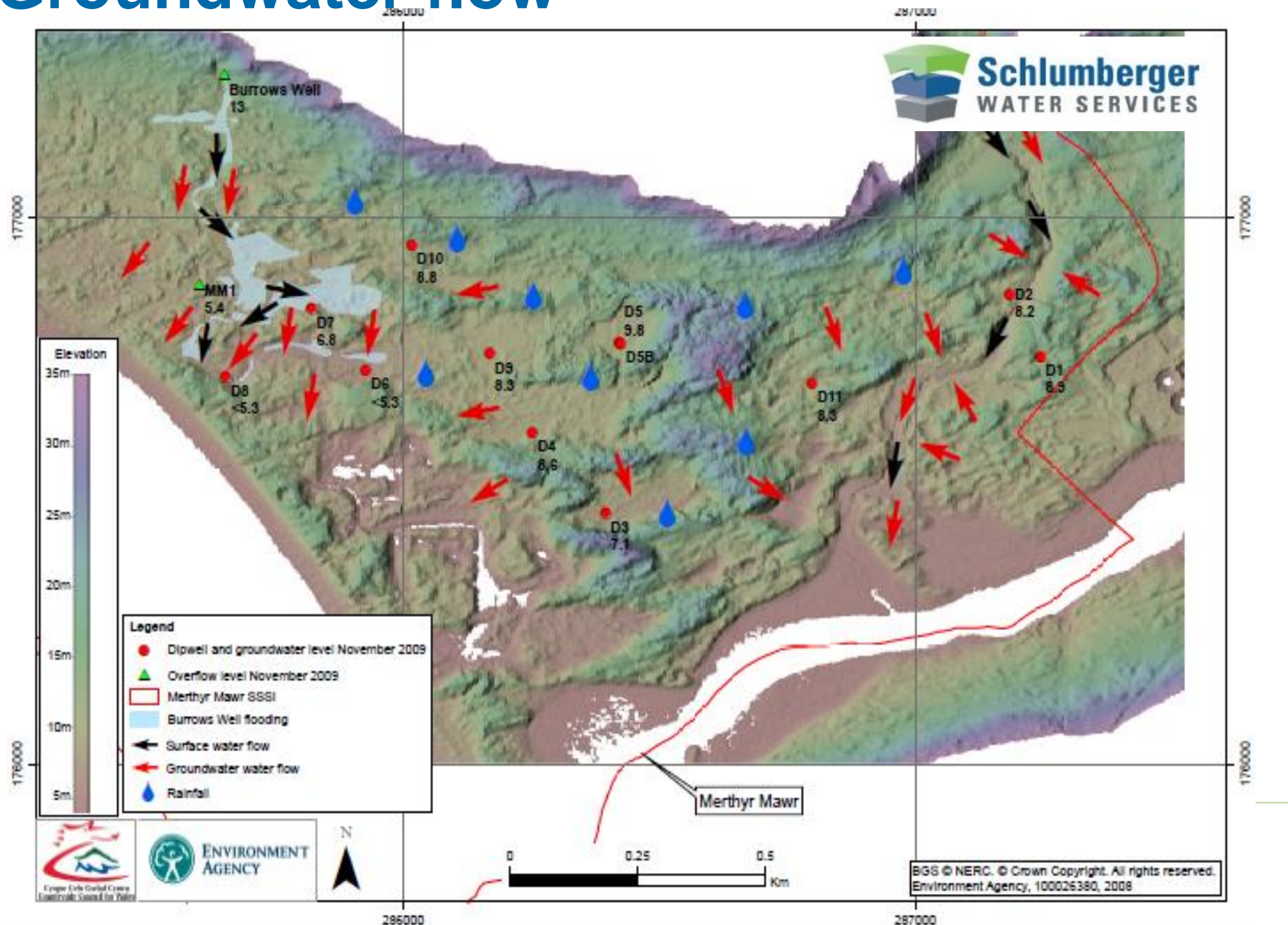
Groundwater level data



Groundwater and tidal levels



Groundwater flow

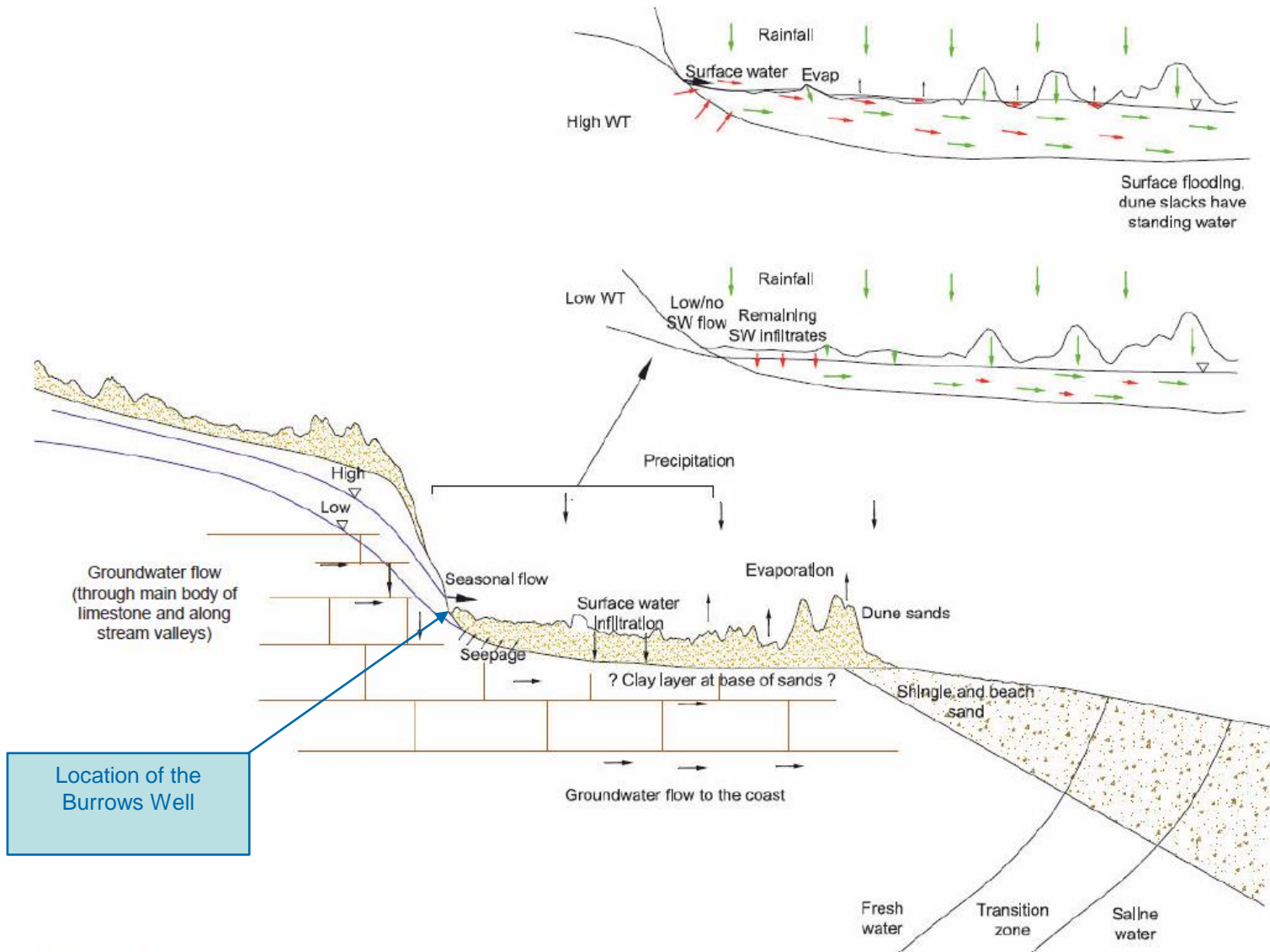


ENVIRONMENT AGENCY



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Environment Agency, 100026380, 2008

Improved conceptual model



Merthyr Mawr: conclusions

- ⇒ Nitrates above threshold
- ⇒ Atmospheric and groundwater nutrient pathways
- ⇒ Site at high risk from chemical pressure
- ⇒ Improved conceptual model (and source - pathway - receptor linkages)

⇒ Evidence for ecological damage ??

downstream from Burrows Well, communities are more typical of MG11 (mesotrophic inundation grassland community) and S28 (fen type communities) than typical SD16 (dune slack communities)

Merthyr Mawr - ongoing issues

- ➔ Groundwater catchment is complex – so difficult to apply land management measures
- ➔ Multiple sources and pathways may contribute in combination to eutrophication related impacts, making assessment complex
- ➔ Without historic NVC mapping, it is hard to understand how this area has changed over time
- ➔ Is there evidence that the humid dune slacks and wider dune wetland interest have been and remain impacted by high N discharge from Burrows Well ?

Effectiveness of techniques

Investigation Methods	Cost	Timescale	Understanding	Decision
	€- €€€	hours - years	low - high	low - high
Site walkover	€	day/s	high	high
Ecological survey	€- €€	days - years	high	high
Local knowledge /review	€	day/s	high	high
Catchment audit	€- €€	days- months	high	high
Drilling / hand auguring	€- €€€	days- weeks	medium	medium
Groundwater level	€- €€€	months-years	medium	medium
Groundwater quality	€- €€€	months-years	medium	medium
-Isotopes and tracers	€€	days	medium	medium
Groundwater model	€€€	months-years	variable	low – high !
Conceptual model	€- €€€	?	high	high

Thank You

Merthyr Mawr Case Study: SWS, 2010. Report Merthyr Mawr
[unpublished] Produced for Environment Agency.

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