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Definition of the zone of hydrological influence relating to Bostraze Bog, West Penwith, Cornwall. (2018)

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Background - Penwith Downs Moors and Heaths in west Cornwall has been submitted for possible SSSI designation. NVC surveys have been completed, and some of the key features of interest for the proposed site are valley mires, the largest and most significant of which is Bostraze Bog (centred on NGR 139300 31950), located around 2.5 km east-north-east of St. Just. The existing fen and bog SSSI selection guidelines advise that sufficient land should be included within the SSSI boundary to protect the interest feature and its hydrology.

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Contractor - LOW, R

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Further information
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Definition of the zone of hydrological influence relating to Bostraze Bog, West Penwith, Cornwall

Dr Rob Low (Rigare Ltd)

Definition of the hydrological unit for Bostraze Bog, Cornwall (Rigare 1666_r1_v1, March 2018).docx

D2019 00014868 Definition of the hydrological unit for Bostraze Bog, Cornwall (Rigare 1666_r1_v1, March 2018)

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1 Introduction

1.1 Background

Penwith Downs Moors and Heaths in west Cornwall has been submitted for possible SSSI[1] designation. NVC[2] surveys have been completed, and some of the key features of interest for the proposed site are valley mires, the largest and most significant of which is Bostraze Bog (centred on NGR 139300 31950), located around 2.5 km east-north-east of St. Just.

The existing fen and bog SSSI selection guidelines advise that sufficient land should be included within the SSSI boundary to protect the interest feature and its hydrology. Guidance for determining boundaries for valley mire features states:

Wetlands in basins and valley bottoms can be supplied with water from various sources including surface run-off from within the catchment, groundwater seepage and direct rainfall. The site boundary of these wetlands should encompass the following:

- *all influencing slopes;*
- *all springs, flushes and seepages that supply the wetland;*
- *all ditches, channels and peripheral drains that influence site hydrology;*
- *depending on the ecohydrology of the site and landscape setting, it may be necessary to include whole fields above the slope as well in order to protect the wetland feature from nutrient-enriched run-off and sub-surface flow e.g. through sandy soils;*
- *the outflow stream for some distance to prevent lowering of the stream bed which would lower the water level in the wetland.*

The area including all of the above features can be considered as that in which land use, management and activities can influence hydrological supporting conditions for interest features within the proposed SSSI; this is termed the *zone of hydrological influence* hereafter.

1.2 The work reported here

During spring 2018, Dr Rob Low (Rigare Ltd) was commissioned to define the zone of hydrological influence for Bostraze Bog, through a scope of work detailed in *final bostraze specification + iad.docx*, as follows:

- A full analysis of information collated from NE/EA and other available sources.
- Field Survey:
  - Peat depth survey across the wetland basin (guide 3 to 4 transects across the main basin at 20 m intervals).
  - Water chemistry/flow of all available water features particularly all above ground inflows (pH, conductivity and estimate flow rate).

A two-day field visit was carried out 26th and 27th March 2018 with Richard Penny and Vaughan Robbins (both Natural England). The activities on these days were focused on achievement of the main objective of the project, namely collecting information to inform definition of the zone of hydrological influence. With the time available it was

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[1] Site of Special Scientific Interest

[2] National Vegetation Classification

not possible to carry out an extensive peat survey, or comprehensively to measure water flows and physical water quality parameters[3].

1.3 Acknowledgments

Grateful thanks are extended to Vaughan Robbins for his very detailed knowledge of the site and surrounding ground, Richard Penny for his management of the project, including gaining access permissions, and various land-owners for granting access to their land.

1.4 Further information

If any further information is required about the execution and results of this project, please contact:

- Richard Penny (richard.penny@naturalengland.org.uk), or
- Vaughan Robbins (vaughan.robbins@naturalengland.org.uk); or,
- Rob Low (rob@rigare.co.uk); Project consultant for Natural England.

[3] It is also worth noting that; 1) ground conditions and vegetation within extensive parts of the site would suggest that a detailed risk assessment should be carried out in relation to lone working for peat thickness measurement, and 2) significant extra time would be required to measure peat thickness at the specified spatial intensity.

2 The site and its hydro-environmental setting

2.1 The site

An important pre-requisite for the work reported here was confirmation of the area(s) representing Bostraze Bog in the context of the project. The results of NVC surveys were supplied as images; these were imported to ArcGIS and geo-referenced using commonly identifiable points[4]. The NVC communities which define Bostraze Bog were then confirmed with Vaughan Robbins (Natural England), allowing the approximate boundaries of the site to be drawn.

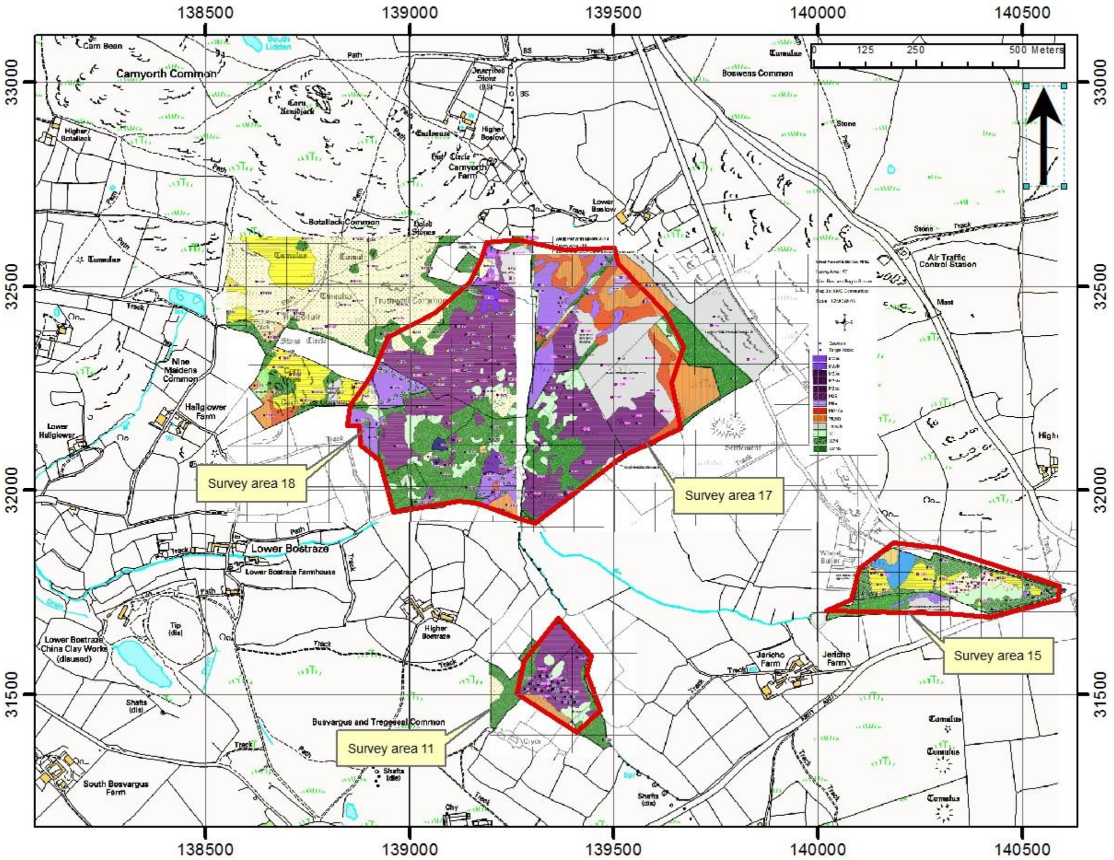

Figure 2.1-1. Polygons (red) enclosing bog communities representing Bostraze Bog, developed from geo-referenced images of the NVC survey.

Figure 2.1-1 shows the geo-referenced images of the NVC surveys which represent Bostraze Bog; these are parts of the survey areas designated 11, 15, 17 and 18 for the NVC survey, as indicated on the figure. The mire-related NVC communities are predominantly:

- M23 *Juncus effuses/acutiflorus-Galium palustre* rush pasture, including the *J. acutifloris* (M23a) and *J. effuses* (M23b) sub-communities (light purple shading).
- M25 *Molinia Caerula-Potentilla erecta* mire, including *Erica tetralix* (M25a), *Anthoxanthum odoratum* (M25b) and *Angelica sylvestris* (M25c) sub-communities (dark purple shading).
- M6a *Carex echinata-Sphagnum recurvum/auriculatum* mire, *C. echinata* sub-community.

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[4] It is worth noting that the nature and location of the site meant that very exact geo-referencing (i.e. better than +/- 5 m) was not require in the context of the project.

The central light grey shaded area within survey area 17 represents a mosaic of NVC M25b, M23b and M6a.

Figure 2.1-1 also shows the approximate boundaries of the bog communities adopted for the current project to represent Bostraze Bog. They are referred to hereafter as the Central (39 ha), Southern (3 ha) and South-eastern (6 ha) Areas of the Bog.

Relatively little information is available about the ecohydrology of the NVC communities noted above, with no entries in the standard references of Environment Agency (2010) and Wheeler *et al* (2009). The relative dependence of the communities on groundwater discharge for favourable hydrological supporting conditions is given in UKTAG (2004), as follows:

- M23 and M25. Low groundwater dependency (score = 3). This means that sites including these habitats should only be included in risk assessments under the GWDTE[5] test of the Water Framework Directive if they are found to be coincident with a groundwater body with high surface interaction.
- M6. Moderate groundwater dependency (score = 2). As above, but the groundwater body must have at least moderate surface interaction.

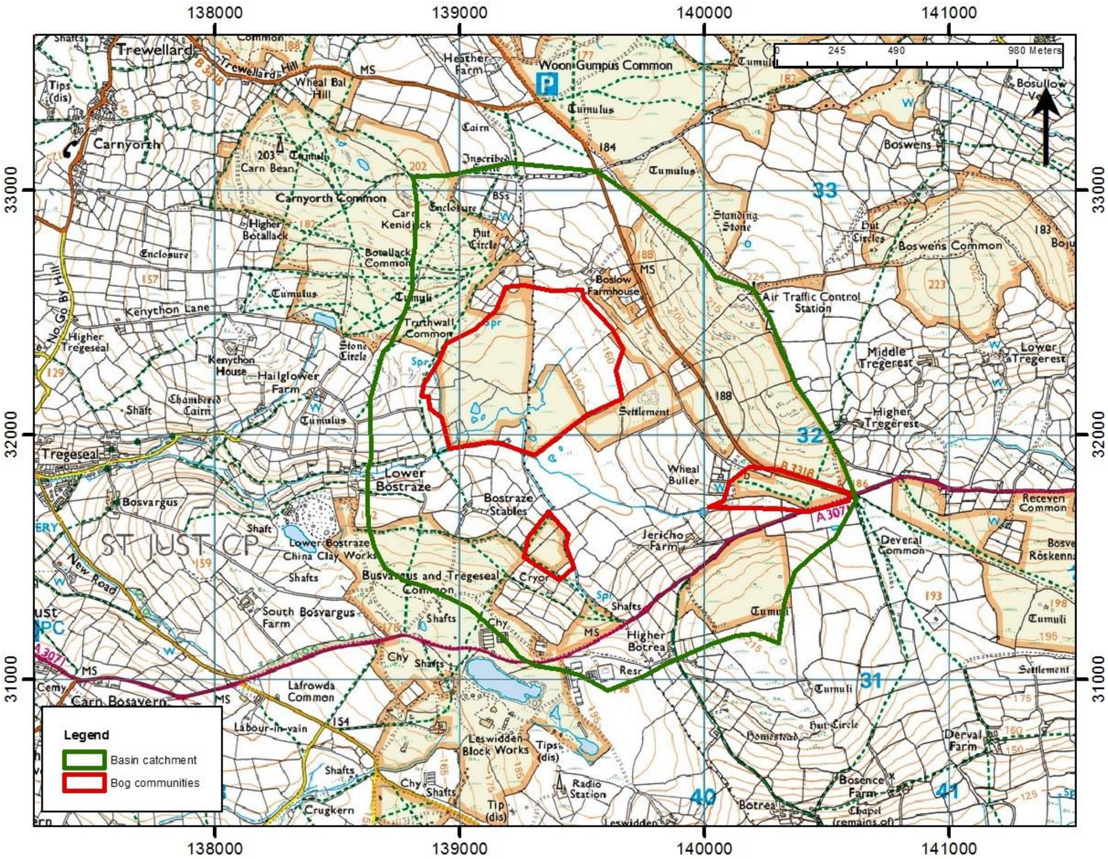

Figure 2.3-1. Topographic setting of Bostraze Bog, and the topographic catchment of the basin in which it is located.

[5] Groundwater Dependent Terrestrial Ecosystem

2.2 Climate

Climatic average (1981-2010) values are available[6] for the Camborne and Culdrose weather stations, located around 25 km east-north-east and 25 km east of the site respectively, as follows (Culdrose values in brackets):

- Rainfall = 1061.3 (998.8) mm/yr, 70% of the UK average of 1154 mm/yr.
- Rain-days (> 1 mm) = 151.2 (150.3) days.
- Maximum temperature = 13.4 (13.7) °C.
- Minimum temperature = 8.3 (7.9) °C

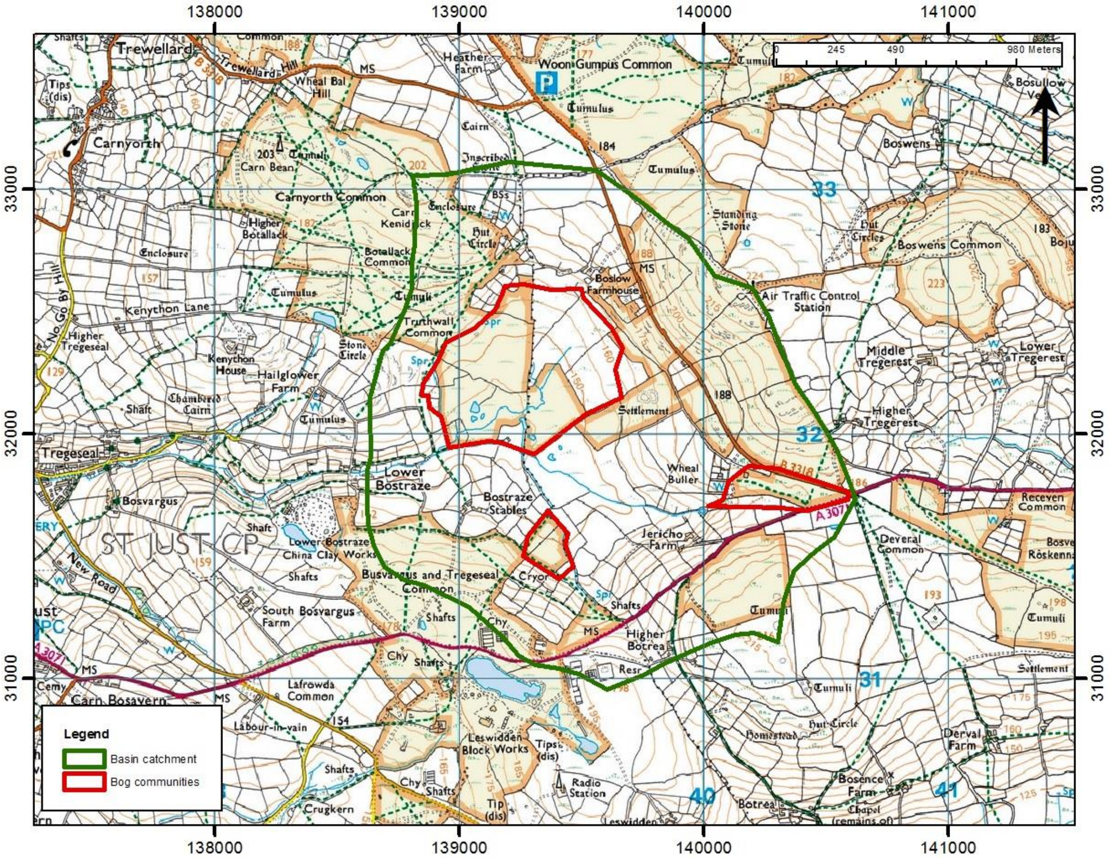

Figure 2.3-1. Topographic setting of Bostraze Bog, and the topographic catchment of the basin in which it is located.

2.3 Topography and geology

Bostraze Bog is located within a near-circular basin within the rolling topography of the West Penwith peninsula (Figure 2.3-1). The centre of the basin lies at c. 140 mAOD, and it is almost closed, being surrounded by higher ground rising to 175-220 mAOD on all but its western side where an incised valley runs westwards towards Tregeseal. The topographic catchment of the basin, to the hamlet of Lower Bostraze (302 ha), drawn with reference to the ground surface contours on the OS 1-25,000 scale mapping, is included in Figure 2.3-1. Figure 2.3-2 is a screenshot from Google Earth Pro which gives provides a further perspective on the topographic setting of the site.

[6] https://www.metoffice.gov.uk/public/weather/climate/ at the time of writing

Figure 2.3-3 is an extract from the BGS's[7] 1:50,000 scale geological mapping of the area (Sheet 351, Penzance, BGS, 1984). The larger Penwith peninsula is largely coincident with the Land's End granite intrusion. There are five other major outcrops of granite in the south-west of England, all being offshoots from the underlying Cornubian batholith.

The following is taken from both BGS (1984), Jones *et al* (2000) and Smedley and Allen (2004), all of which are recommended if further detail is required.

The topographic basin within which the site is located is largely underlain by medium- and coarse-grained biotite-granite which is commonly composed of quartz, potassium feldspar, plagioclase feldspar, biotite, muscovite and tourmaline. Potassium feldspar megacrystals can reach nearly 20 cm in length but they are usually in the range 1.5-5 cm.

Figure 2.3-2. Screenshot from Google Earth Pro, looking north-west across the Bostraze Bog basin, with the polygons containing the bog communities shown in red.

Fine-grained biotite-granite crops out along the north-eastern watershed of the basin, and at the north-western apex including the upstanding outcrop of Carn Kenidjack; this type of granite occurs as a flat-lying sheet over the medium- and coarse-grained biotite-granite.

The weathering carapace of the granites at outcrop is highly variable; it is often several metres thick in valleys but may be thin or absent on higher ground.

The lower central area of the basin is covered with a superficial deposit of Head. This was formed largely during the late Pleistocene through the re-working of earlier weathering products by periglacial processes. Typically it consists of a heterogeneous mixture of local rock types in a matrix of fine sand, silt and clay. BGS (1984) notes that a general mantle of between 0.5 and 2.0 m of Head covers much of the area, but that it is not shown on the geology map for reasons of clarity; basins and valleys have permitted greater accumulations.

Soils are generally thin with compositions reflecting the bedrock lithology. Most are well-drained gritty loamy soils with a surface humic-rich horizon in places and

[7] British Geological Survey

sometimes well-developed thin iron pans. It is worth noting that no peat is mapped within the basin.

2.4 Surface water and groundwater hydrology

Hydrogeological study of the local granites has been limited (geographically) to the extensive studies concerning the geothermal potential of the Carnmenellis Granite, which is located around 30 km east of the site. The physical similarity of the granite outcrops in the south-west mean that much of the knowledge of the surface water and groundwater behaviour of the Carnmenellis Granite can be applied to the Land's End Granite with reasonable confidence.

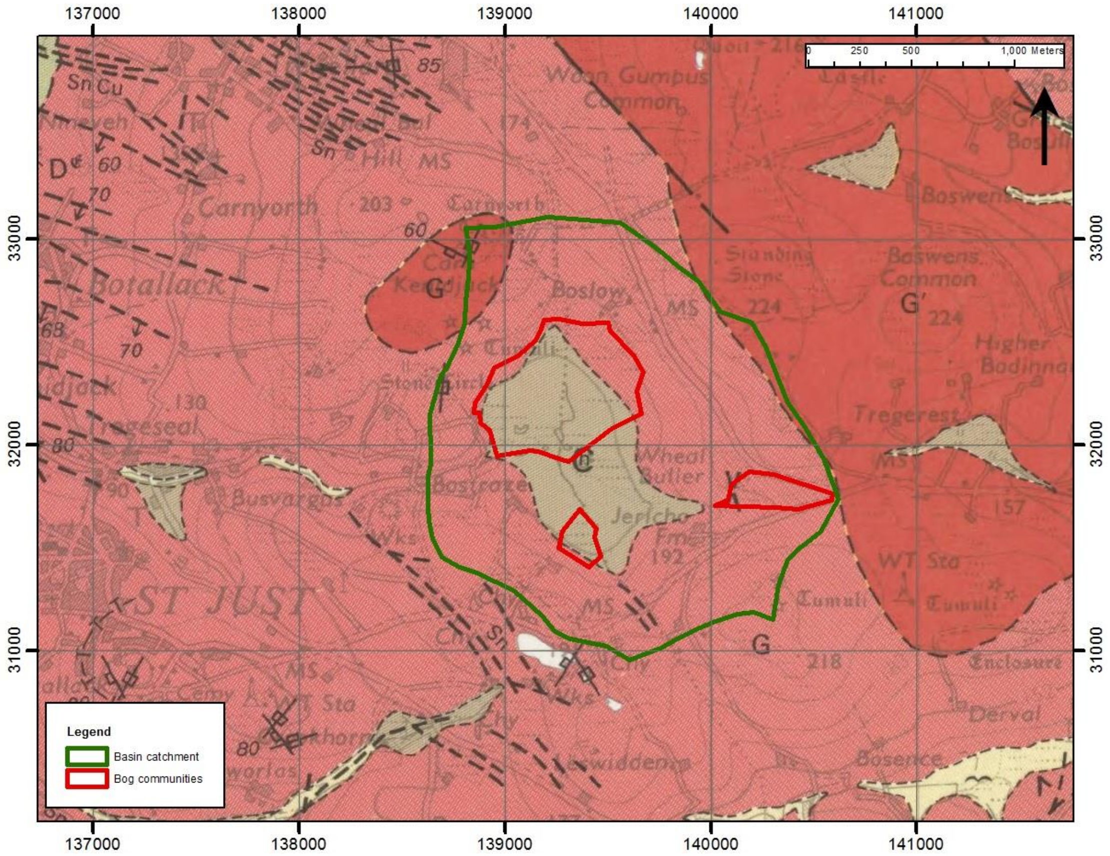

Figure 2.3-3. Extract from BGS 1:50,000 scale geological map of the area, Sheet 351 Penzance (BGS, 1984). Pink = Biotite-granite; medium- to coarse-grained, Red = Biotite-granite; fine-grained, Buff = Head, Yellow = Alluvium. Contains British Geological Survey materials © NERC 1984.

Smedley and Allen (2004) note that effective infiltration is dependent on local soils and vegetation, but is typically in the range 500-700 mm/a. Baseflow indices for rivers draining the Carnmenellis Granite are around 0.7, indicating significant groundwater storage, although lower values are reported for the Bodmin Moor Granite (0.57) and Dartmoor (0.48).

Jones *et al* (2000) note that the granites are characterised by fracture permeability with groundwater storage and flow occurring entirely within discrete fractures separated by a rock matrix of negligible permeability. There is a marked reduction in permeability with depth due to the fractures becoming tighter and less common. This effectively imposes a base to the aquifer, commonly quoted as occurring at 30-40 m below ground level.

It is interesting to note that records for two water wells (SW43SW/1 and SW43SW/2-6) at Tregerest, immediately east of the basin in which the site is located, are available on the BGS website. The former reports water found at 14 m, 17 m and 20 mbgl, and the latter reports a groundwater yield of 450 litres over 1 hour from a 30 m depth, 150 mm diameter borehole. These can be taken as evidence of significant groundwater storage and aquifer permeability in the immediate area of the site.

Mining has also had a major impact on hydrogeology in parts of the Carnmenellis and Land's End Granites, with adits, shafts, lode structures and mine workings all acting as conduits and storage zones for groundwater. Derelict buildings and chimneys immediately south of the basin in which the site is located indicate that there was extensive local mining; its effect on the local hydrogeology is uncertain.

Smedley *et al* (1989) notes that perched water table occur in some areas, though hydraulic connection between the solid bedrock and weathered regolith is often good.

BGS (1989) notes that hydraulic gradients are often steep and indicative of low aquifer permeability.

Having in mind; 1) the relatively thin effective granite aquifer, and 2) the steep hydraulic gradients and (inferred) low aquifer permeability, it has been decided to assume that groundwater catchments are coincident with surface water (topographic) catchments within the study area.

Smedley and Allen (2004) note that higher concentrations of seawater-derived solutes are expected in the south-westerly parts of the Cornish peninsula, with chloride concentrations in recharge waters being up to 38 mg/l, approximately three-times that in inland areas.

3 Walkover survey

The following highlights observations which are relevant to the current project. The field visit took place on 26th and 27th March 2018, before and during which there was significant rainfall which caused fairly extensive surface runoff and shallow interflow. This made it difficult to positively identify small groundwater springs and seepages, although larger springs and seepages were still clearly identifiable.

It is also worth noting that the field visit took place during late spring, when groundwater levels are generally close to their annual high point.

3.1 Central Area

A wide and deep ditch runs downslope along the south-eastern boundary of the Central Area (Points "1" in Figure 3.1-1). The ditch separates wetland habitats to the north-west from agricultural land onto which seafood processing waste has been spread. It is a significant feature (Figure 3.1-2a), being generally 5-6 m wide at ground level, tapering to 3-4 m wide at its base, with a water level close to the base during the field visit; its flow rate was estimated at 10 l/s during the field visit. Mineral substrate (clayey gravel, observed remotely) extends almost to ground level in the banks of the ditch adjacent to the wetland habitat.

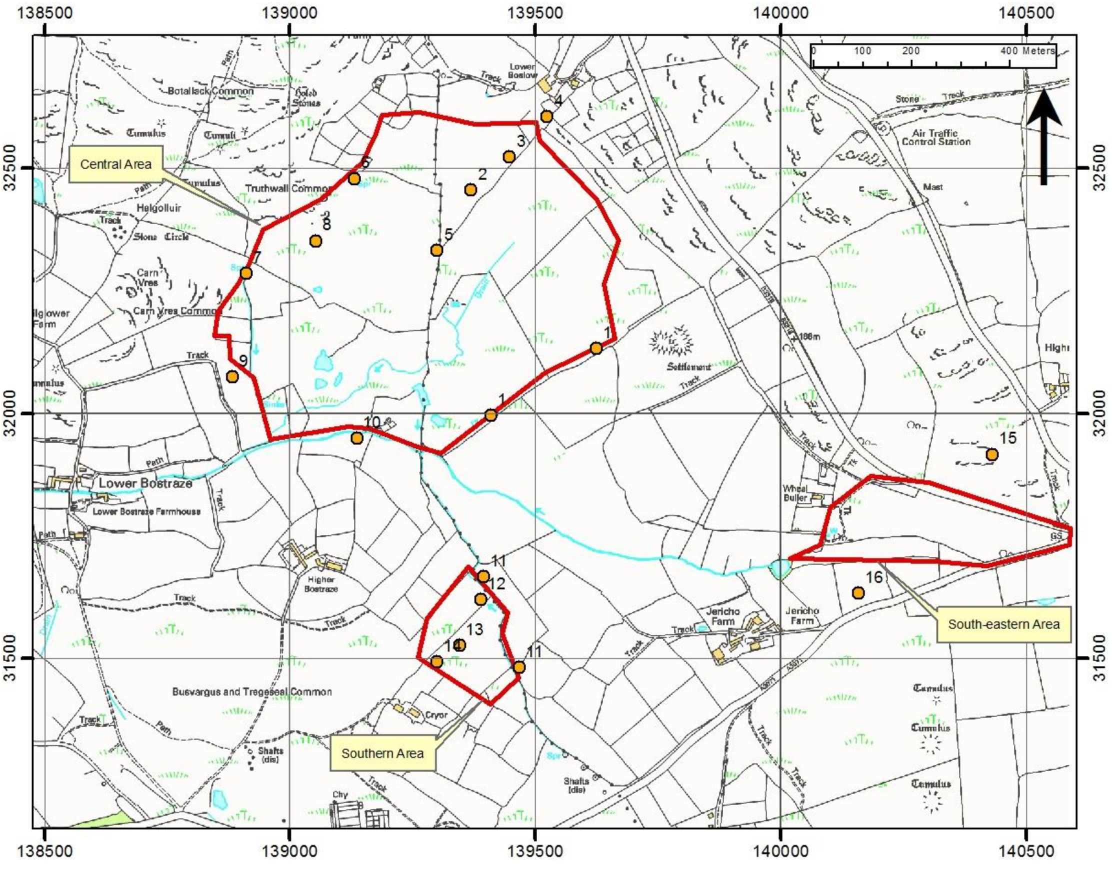

Figure 3.1-1. Site plan showing field observation points.

Three auger holes around 10 m away from the ditch within the wetland habitat, between the two points labelled "1", revealed 25-30 cm of moist black peat or organic topsoil over damp, grey, soft, clayey, fine to medium gravel, with auger penetration only to 35-50 cmbgl; the latter was interpreted as the Head Deposit noted in Section 2.3.

Excavation of the ditch has caused a significant lowering of water level along its course, and this will be having a drawdown effect on the water table within the wetland habitat to the north-west. Figure 3.1-2b shows the 5-10 m-wide strip of drier grassland to the north-west of the ditch; this is probably a result of this drawdown, but could also partly be a result of the slightly elevated ground caused by ditch arisings.

Figure 3.1-2. a) Significant ditch running downslope along the south-eastern edge of the Central Area of wetland habitat (looking upslope), b) slightly raised strip hosting drier grassland communities along the ditch (looking downslope).

Whilst it is inevitable that the ditch will be having a drawdown effect on the water table in the wetland habitat, it is difficult to predict the magnitude and lateral extent of this effect with the available evidence. Both will be positively related to the hydraulic conductivity of the substrate; this appeared to be relatively low in the clayey gravel at shallow depths where it could be sampled with the hand auger, but refusal of the auger probably indicates increasing dominance of gravels and an increase in hydraulic conductivity.

Figure 3.1-3. Unimproved H4 *Ulex gallii-Agrostis curtisii* heath to the left separated from M25a mire to the right by a fenceline.

Significant groundwater discharge and resulting sheet overland flow was observed within the triangular field between ditches in the northern part of the Central Area (“2”) with a particularly strong spring (c. 10 l/s) and associated quaking ground observed at “3”. Recognisable groundwater discharge extended upslope to “4” in this part of the site.

Two significant ditches meet at “5”, with estimated flow rates being 20-30 l/s in both. Bridges across these ditches give access to large area of M25a to the west, but a combination of difficult ground conditions and limited time precluded significant exploration of this area. The springs at the top of this area (“6” and “7”), marked on OS surveys, are however of note. Their location is coincident with the mapped north-western edge of the Head Deposit; resistance to upwards flow of groundwater through the Head Deposits downslope, resulting in groundwater being ‘forced out’ along the upper edge of the Head Deposits, can be inferred[8].

Truthwall Common forms the north-western boundary of the Central Area, and specifically the large area of M25a. Figure 3.1-3 was taken at “8” looking north-eastwards, and shows upland heath to the left and M25a to the right, separated by a fenceline.

Figure 3.1-4. a) Marginally improved grassland, and b) ploughed bare soil, along the western boundary of the Central Area of wetland habitat.

Along its western boundary the Central Area lies against marginally improved grassland (north-west of “7” and Figure 3.1-4a) and ploughed fields (“9” and Figure 3.1-4b). The latter were bare soil during the field visit, and erosion gullies were developing with related deposition on the boundary of the wetland habitat downslope.

Figure 3.2-1. a) Wider (c. 5 m) ditch marking the northern part of the downslope boundary of the Southern Area, and b) the same ditch, although narrower (c. 2.5 m) further upstream on the southern part of the downslope boundary of the Southern Area. Note the light green instream vegetation in both cases, which could indicate nutrient enrichment.

The stream defining the southern boundary of the Central Area (“10”) was not visited during the visit, although it was viewed immediately upstream as being c. 3 m wide and 1.5 m deep, and free-flowing. It was not possible to ascertain during the visit whether the ditch floods onto the site along this boundary. The stream was also viewed at Lower Bostraze hamlet as being free-flowing.

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[8] Although it is worth being alert to a possible circular argument here as the geological mappers might have used the location of the springs to infer the upper boundary of the Head Deposit!

3.2 Southern Area

The Southern Area slopes downwards in a north-easterly direction, downslope of the Cryor farm buildings. Its downslope, north-eastern boundary is the ditch (stream)("11") which drains the southern part of the larger catchment. The ditch is 5 m wide x 1.5 m deep and was flowing at c. 15 l/s during the visit (Figure 3.2-1a); the width decreases to c. 2.5 m further upstream within the Southern Area (Figure 3.2-1b). Instream vegetation was a light green colour during the visit, which could indicate nutrient enrichment. It was not possible to ascertain during the visit whether the ditch floods onto the site.

The depth of water in the ditch was 0.1-0.2 m during the visit, and was therefore almost 1.5 m below the top of the bank on the western (site) side. An auger hole c. 30 m away from the ditch ("12") showed 0.2 m of black crumbly peat over damp, buff-coloured, stiff, clayey, gravelly (fine), silt (Figure 3.2-2a) to 0.4 m where the auger was refused by harder ground (increased gravel content?).

Figure 3.2-2. a) Damp, buff-coloured, stiff, clayey, gravelly (fine), silt sampled between 0.2 and 0.4 mbgl, beneath black crumbly peat, around 30 m from the ditch, and b) spring with quaking ground on the upslope (south-western) boundary of the Southern Area.

The vegetation within c. 15-20 m of the ditch had a notably drier aspect than further upslope, marked particularly by the presence of extensive bracken and brambles, and gorse (*pers comm.*, Richard Penny, during the field visit). This is consistent with the low water level in the ditch (relative to the ground surface within the site) having a drawdown effect on the water table within the site. Again, it is difficult to predict the magnitude and lateral extent of this effect with the available evidence (see comments in Section 3.1).

The vegetation rapidly transitions to M25a upslope, and this is accompanied by a notable increase in substrate wetness. Extensive inter-tussock surface flow was detected extensively across the slope, and whilst it had rained overnight it was thought that the strength and consistency of flow indicated groundwater discharge.

An auger hole towards upslope margin of the Southern Area ("13") revealed 0.2 m black crumbly peat over 0.2 m silty fine gravel before auger refusal.

Figure 3.2-2b shows a large spring feature located immediately upslope of the wetland habitat in the Southern Area ("14"), marked by significant groundwater discharge and quaking ground. The presence of a spring at the upslope margin of the wetland habitat, discounting the possibility of a local perched groundwater body, along with the gravelly substrate further downslope, is consistent with an active seepage slope covering most or all of the Southern Area.

3.3 South-eastern Area

Access to this area was not possible during the field visit, and the assessment has therefore been carried out through remote observations.

The South-eastern Area is bounded along its upslope, northern side (“15”) by the B3318 road. Unimproved moorland extends upslope of this road to the catchment boundary, and after significant rainfall water was seen ponding against the upslope side of the road (Figure 3.3-1a); no cross-road culverts were observed during a brief inspection. Direct runoff from the road is allowed into the site through road-side culverts (Figure 3.3-1b).

Figure 3.3-1. a) Moorland upslope of the South-eastern Area and B3318, with water ponding against the road after significant rainfall, and b) roadside culvert allowing runoff from the road into the site.

Figure 3.3-2 is a panoramic photograph of the South-eastern Area, taken from “16” in Figure 3.1-1 looking north-eastwards. The site is beyond the line of large rocks in the middle-ground, the latter being more-or-less coincident with the watercourse which has been deepened (*pers comm.*, Vaughan Robbins, during the field visit). The area is relatively steeply sloping (this is difficult to appreciate from Figure 3.1-1), which is thought to preclude any direct hydrological influence of the watercourse on the site, i.e. 1) no drawdown influence on the water table within the site, and 2) no flooding of the site from the watercourse.

Figure 3.3-2. Panoramic photograph showing the South-eastern Area, beyond the large rocks in the middle-ground.

4 Ecohydrological conceptual model

It is firstly worth noting that groundwater discharge has been identified in the field as a significant source of water to the wetland habitats within the Central and Southern Areas of the site. Given that the hydrogeological situation is similar for the South-eastern Area, groundwater discharge is inferred as a significant source of water to the wetland habitats in this area as well. Referring to the NVC community groundwater dependency scores in UKTAG (2004) and related comments in Section 2.1, it is proposed that the site should be identified as a GWDTE.

Figure 4-1 is a schematic cross-section which illustrates key aspects of the ecohydrological functioning of the site; it is based on a generic downslope section which relates closely to the situations in the Central and Southern Areas.

The ecohydrological functioning of the site is characterized by:

- The bedrock medium- and coarse-grained biotite granite which underlies the catchment form a minor aquifer. Significant groundwater storage and permeability relates to the fracture network; fractures become tighter and less common with depth, and this effectively imposes a base to the aquifer at 30-40 mbgl.
- The bedrock is overlain by a superficial deposit (0.5-2 m thick) of Head, which is derived from local weathering products by periglacial activities. This Head, and its related thin overlying soil, are relatively permeable, which means that infiltration of rainfall to become groundwater is much more common than surface runoff. Judged on the available information, it is thought likely that the BFI of the stream leaving the Bostraze basin is between 0.6 and 0.7, meaning that 60-70% of effective rainfall becomes groundwater before discharging from the catchment.
- The relatively thin effective aquifer and steep hydraulic gradients mean that groundwater catchments can be assumed to be coincident with surface water (topographic) catchments.
- Rainfall will infiltrate to become groundwater primarily over the upper parts of the slope (and mostly over moorland in this case). Upwards hydraulic gradients and groundwater discharge will dominate increasingly over the middle and lower parts of the slope.
- Because of its thickness and lithology over the middle and lower parts of the slope, the overlying Head deposit will offer resistance to upwards flow, and groundwater pressure in the bedrock is likely to artesian over large parts of the low-lying centre of the basin.
- The middle and lower parts of the slope form a seepage face, with extensive upwards groundwater discharge; the rate and spatial distribution of discharge will depend on the local thickness and lithology of the Head deposit. It is notable that little peat was discovered during the field visit, and this is characteristic of a soligenous system as described.
- Surface runoff into the wetland habitats will occur during and after significant rainfall events, but can be diverted or held-up by cross-slope roads and/or topographic features.
- Direct rainfall is also a source of water for the wetland habitats within the site.
- The wetland habitats are likely to become increasingly rheo-topogenous towards the centre of the basin, with shallow groundwater flow through peat and Head deposits in response to shallow hydraulic gradients imposed by topography.
- Modified (deepened and/or straightened) streams or ditches frequently form the downstream and adjacent hydraulic boundary condition to the areas of wetland

habitat. The result of stream modification is usually a lowered in-stream water level, and this lowering has a drawdown effect on the water table within the areas of wetland habitat. The drying effect is evident in the vegetation close to the streams; it is difficult to predict the magnitude and lateral extent of this effect with any precision, from the available evidence.

- The role of surface water (i.e. stream/fluvial) flooding as a source of water to the flatter, lower-lying parts of the wetland habitats is currently uncertain. This is because; 1) empirical observations of the frequency and magnitude of flooding under the current drainage condition are not available, and 2), even if 1) were available, they would reflect a condition of enhanced drainage (i.e. straightened and deepened water courses) under which the importance of flooding would be reduced.

  Judged only on the topographic setting of the wetland habitats, within a topographic basin with a central expanse of low-lying, flat ground, it seems likely that surface water flooding would be a source of water to the areas of wetland habitat under natural conditions.

- The dominant WetMec (Wheeler *et al*, 2009) within the site is WetMec 10; Permanent Seepage Slopes. These stretch from an upwards limit where the lowest (usually late summer) water table intersects the ground surface, to much lower down the slope where the ground becomes quasi-flat. WetMec 11; Intermittent Seepage Slopes extend from the upper limit of WetMec 10, upwards to where the highest (usually late spring) water table intersects the ground surface. Over the quasi-flat ground in the centre of the basin it is likely that conditions are rheo-topogenous, possibly referable to WetMec 13a; Embedded Seepage Percolation Surface.

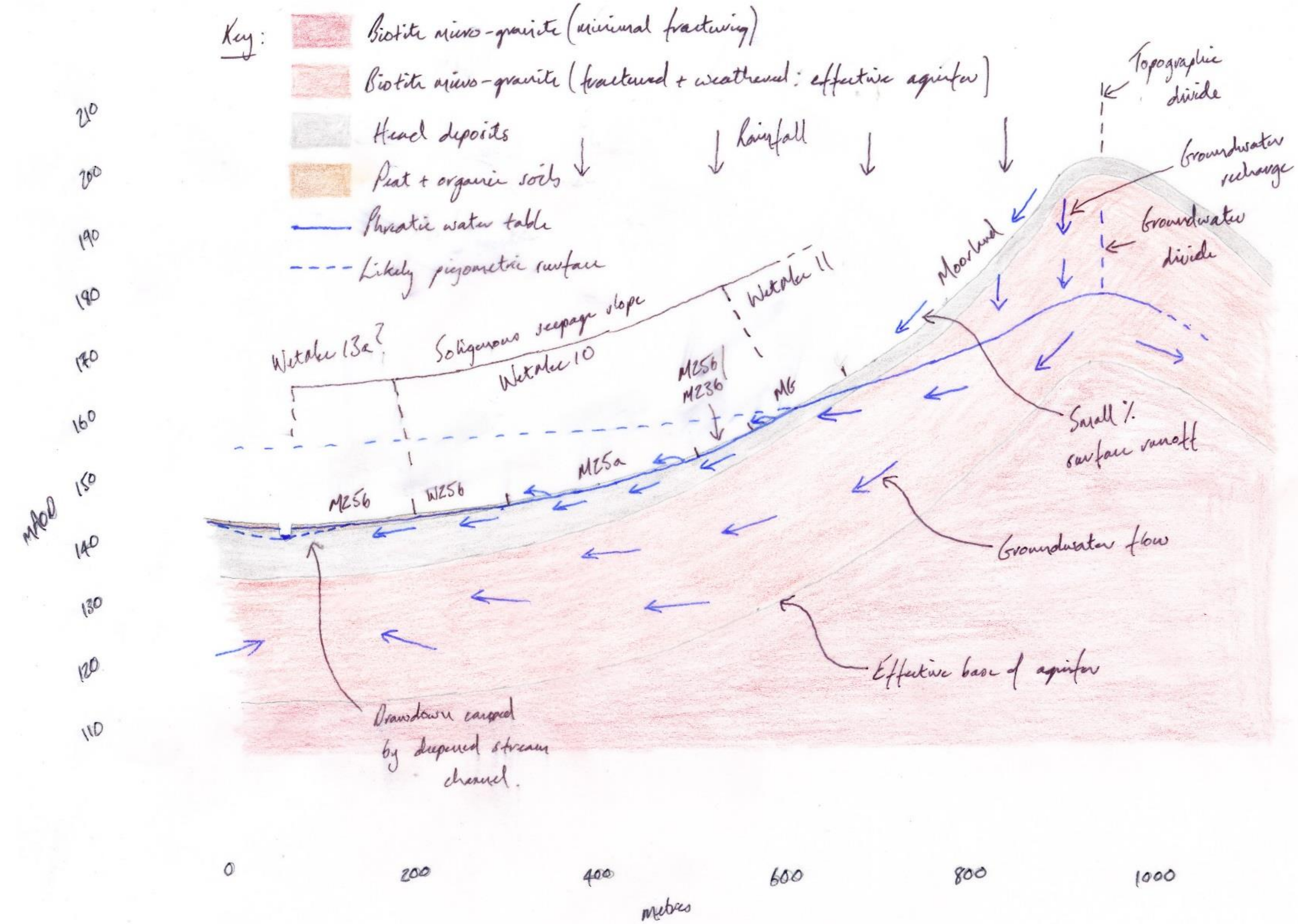

Figure 4-1. Schematic downslope cross-section illustrating key aspects of the ecohydrological conceptual model, as described in this section.

5 Conclusions: Definition of the hydrological units for Bostraze Bog

There are three separate areas of wetland habitat included in Bostraze Bog; each will have a separate hydrological unit, although any two or all units could cover common ground.

Definition of the hydrological units in this case relates primarily to the various types of terrigenous[9] water supply to the sites, as noted in the conceptual model in Section 4. Hence:

- Groundwater discharge. The groundwater catchment up-gradient of the areas of wetland habitat have been included in the hydrological units. It has been noted that the hydrogeological characteristics of the site mean that groundwater catchments can be assumed to be coincident with surface water (topographic) catchments (Section 2.4).

  It has also been assumed that groundwater flow is perpendicular to ground surface elevation contours, as displayed on the OS 1:25,000 survey.

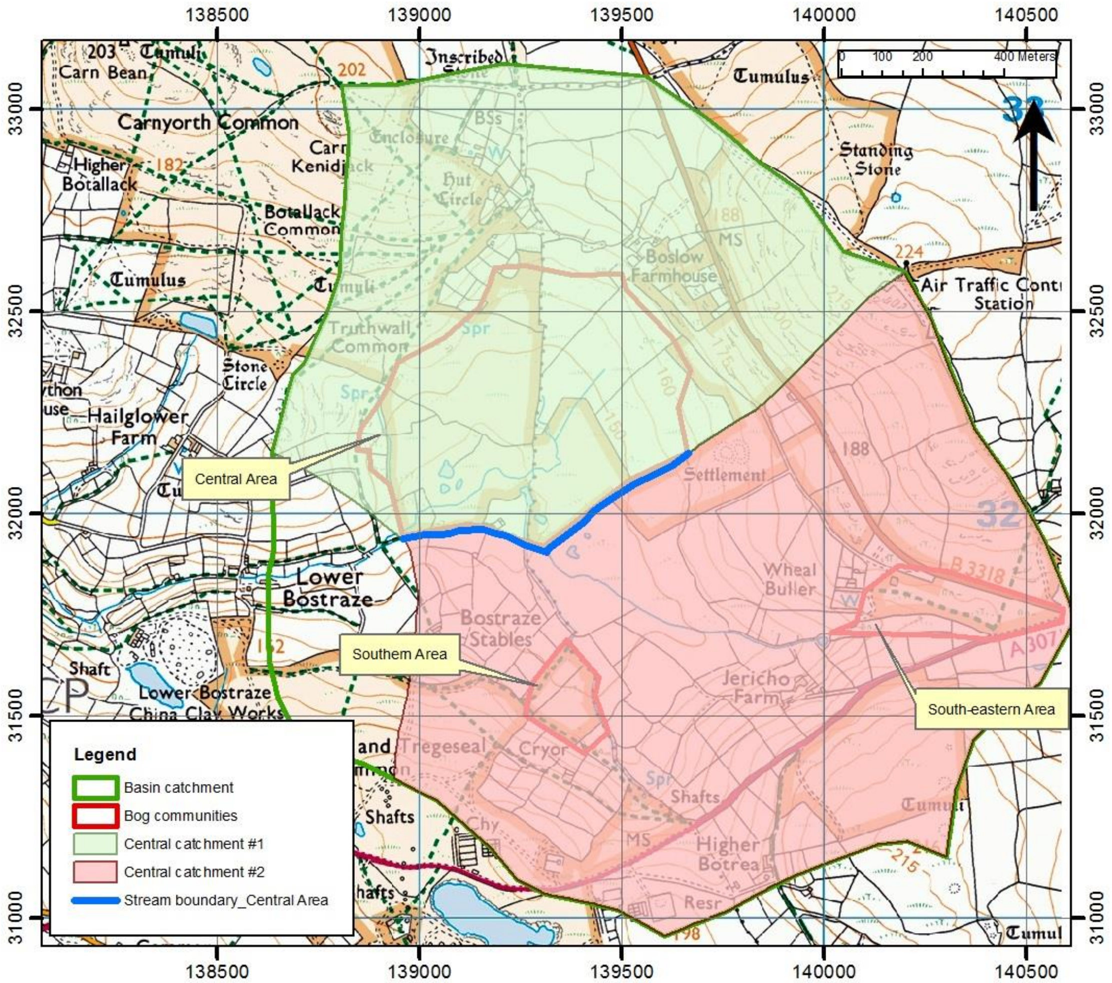

Figure 5-1. Proposed hydrological units for the Central Area of wetland habitats defining Bostraze Bog (see text for details).

- Surface runoff. The surface runoff catchment up-slope of the areas of wetland habitat have been included in the hydrological units. It has been assumed that

[9] Water which has been in contact with the ground before it enters the wetland habitat – essentially a shorthand for anything which isn't direct rainfall.

these are coincident with the surface water (topographic) catchments, as defined by the ground surface elevation contours.

It is worth noting that there will almost certainly be small-scale differences between surface runoff and topographic catchments, caused primarily by anthropic influences such as roads and tracks which divert surface runoff into or out of a topographic catchment. Characterisation of these differences would require significant fieldwork time, and it has not been attempted here.

- Surface water flooding. As noted in Section 4, the role of surface water (i.e. stream/fluvial) flooding as a source of water to the flatter, lower-lying parts of the wetland habitats is currently uncertain. If surface water flooding is a significant source of water, the upstream topographic catchment of the stream should be included within the hydrological unit.

  To allow for the uncertainty for this report, two hydrological units have been defined for each wetland habitat area, one which assumes surface water flooding is a significant source of water to the wetland habitat, and one which assumes that it isn't.

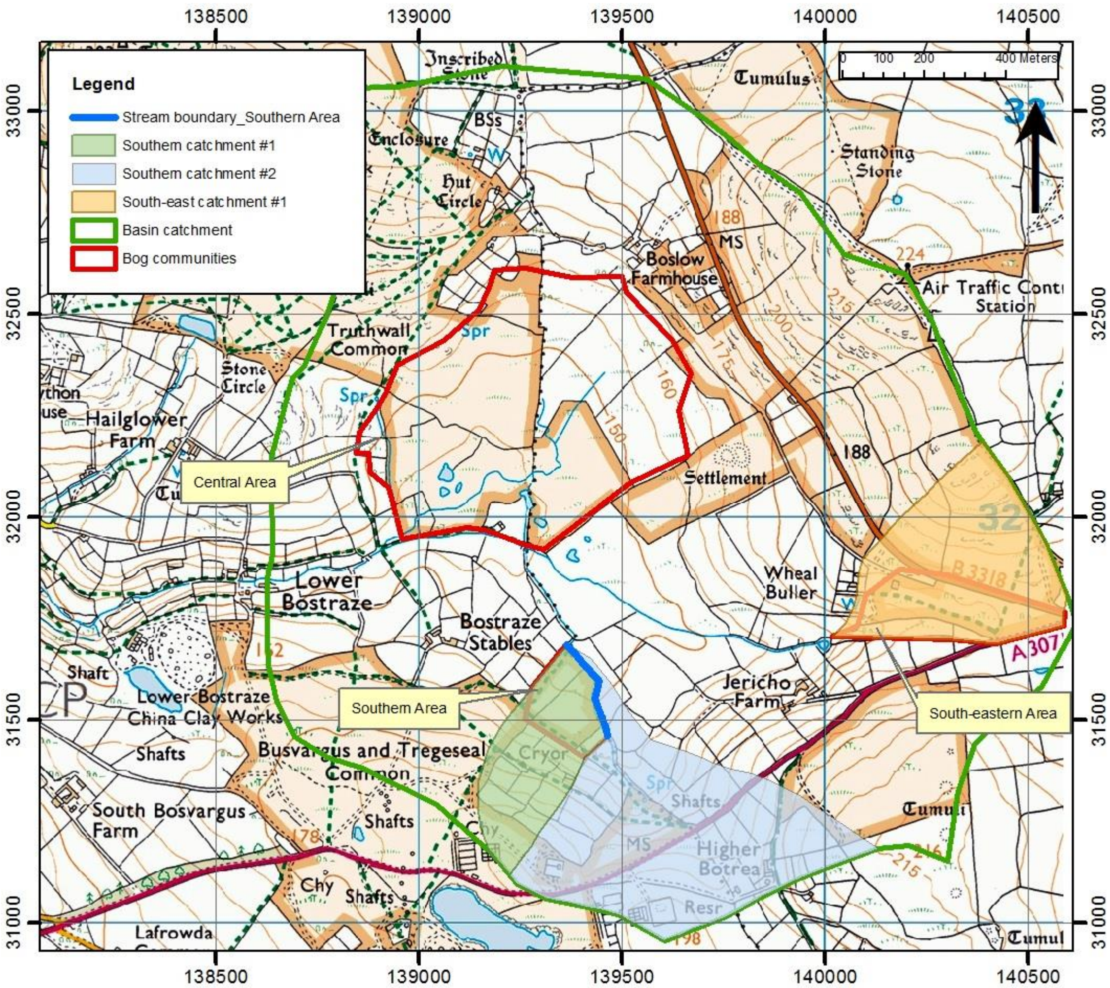

Figure 5-2. Proposed hydrological units for the Southern and South-eastern Areas of wetland habitats defining Bostraze Bog (see text for details).

Bounding streams or ditches have been included within the hydrological unit where they can influence the hydrology of the adjacent wetland habitat, for example through drawdown of soil water levels or through the frequency of surface water flooding.

Streams and ditches downstream of the areas of wetland habitat have not been included in the hydrological units; it is considered that management of these watercourses within reasonable bounds will have little influence on the hydrology of the wetland habitats.

The proposed hydrological units relating to the Central Area are shown in Figure 5-1, and those for the Southern and South-eastern Areas are shown in Figure 5-2. Hydrological units relating to the condition where surface water flooding from bordering stream channels is not a source of water to the wetland habitats are designated #1. The additional area of hydrological unit which would need to be included if surface water flooding was a significant source of water is designated #2.

Bordering stream boundaries have also been highlighted; the hydrological unit should include the whole stream channel, thereby allowing management of the channel within the SSSI designation, in these cases.

It is worth noting that no bordering stream boundary, and no hydrological unit #2 for the South-eastern area of wetland habitat is shown in Figure 5-2. This is because the watercourse is not thought to have any direct influence on the hydrology of the wetland habitat.

6 Recommendations

There are relatively few recommendations relating specifically to the objectives of this project:

1. Ascertain whether surface water flooding represents a significant source of water to the wetland habitats within the site, to enable a choice between the options for hydrological units presented in Section 5 to be made. This could be done through one or more of; a) asking land-owners about the flooding regime on their land-holdings, and/or b) direct observation of the site after periods of heavy rainfall, and/or c) installation of automatic water level recording devices. It is thought that a) and/or b) are likely to be sufficient. Photographic evidence should be sought in relation to b) as the larger hydrological units associated with surface water flooding being a source of water could be challenged.

2. Carry out peat thickness and water quality surveys; the results from such surveys, which were included in the specification for the current project, have not been required for defining the hydrological units for the site.

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