RIGARE
GROUNDWATER AND WETLAND SCIENCE

SCOPING-LEVEL HYDROLOGICAL ASSESSMENT OF LOWER MOORS SSSI, ISLES OF SCILLY

Report:

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Isles of Scilly Wildlife Trust

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Cover image: Lower Moors SSSI boundary over aerial photograph

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1 Introduction

Lower Moors SSSI[1] (NGR 91200 10600, 10.2 ha) is located immediately to the east of Hugh Town, on the island of St Mary's which is one of the Scilly Isles. In its citation (1976) it is described as a topogenous mire, exhibiting a range of wetland habitats, developed on alluvium and peat overlying granite bedrock.

The SSSI is currently[2] in Unfavourable Recovering condition. The comments provided with the assessment suggest that the swamp habitat is an ecotone between *Phragmites australis* swamp and *Juncus maritimus* salt marsh, and that priorities for management at the site include investigation into the water regime (especially water level management/sluice controls), grazing, cutting management and control of willow. It was also noted that negative indicator species indicate drying of the site, as does the lack of positive indicator species.

The site is contiguous with a waste dump, and an industrial estate where there have been flooding problems.

The aims for the site[3] are for it to be; 1) a fully-functioning floodplain to assist in flood management, 2) a SSSI in favourable condition, and 3) a site for visitors to enjoy. During summer 2014 Dr Rob Low (Rigare Ltd) was invited to develop a conceptual understanding of the hydrology of the site, in the context of the aims for the site and the anthropic pressures detailed above.

A site visit was conducted on 27th August 2014, after a briefing from Sarah Mason (The Isles of Scilly Wildlife Trust Manager). Despite significant efforts some areas of the site proved inaccessible because of the dense reed and scrub growth; this is not thought to have compromised the assessment significantly.

This report presents relevant data (from desk study and field visit) and the conceptual hydrological model. It then provides recommendations relating to achievement of the aims for the site, as detailed above.

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[1] Site of Special Scientific Interest

[2] Last assessed on 3rd December 2012

[3] Email, Sarah Mason, The Isles of Scilly Wildlife Trust, 11 April 2014

2 Hydro-environmental setting

2.1 Topography and surface drainage

The site occupies the central area of a larger, irregular-shaped basin (< 5 mAOD) surrounded predominantly by steep slopes leading to higher ground (~ 30 mAOD), as shown in Figure 2.1-1 which is an extract from the OS 1:25,000 scale mapping. The exceptions to this are where two tributary valleys (marked on Figure 2.1-1) enter the basin along its eastern boundary, and where the basin lies close to the coast along its north-western and southern boundaries.

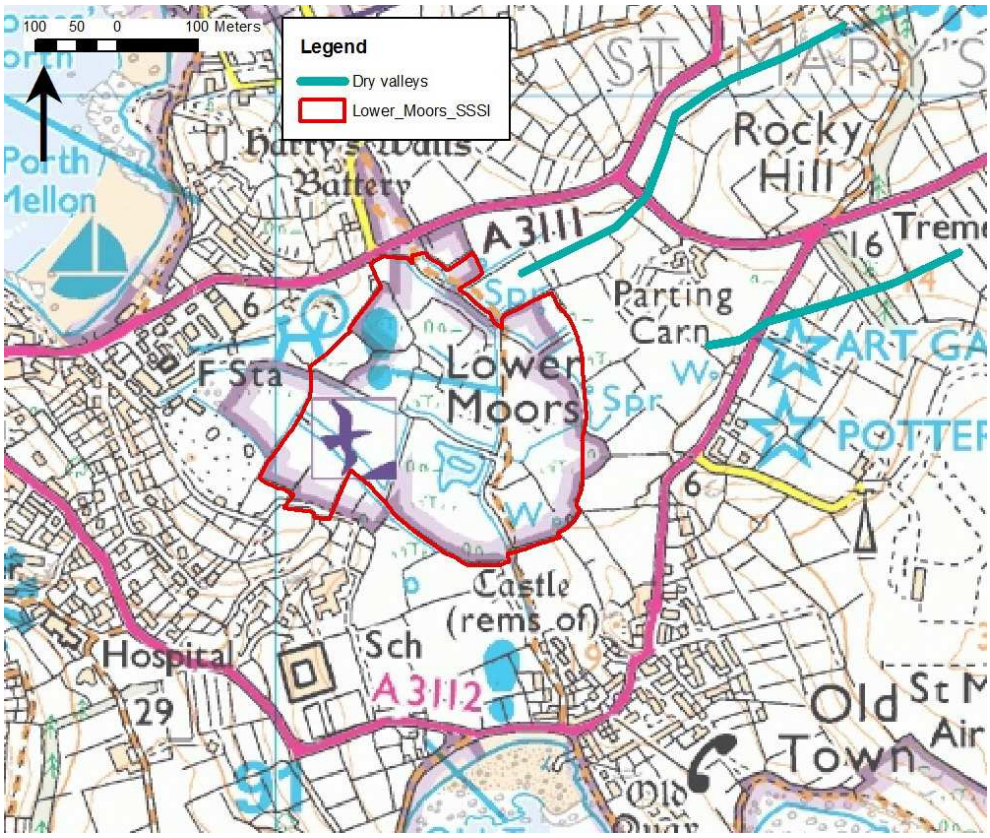

Figure 2.1-1 Extract from OS 1:25,000 scale mapping showing site and environs

There are no streams flowing into the basin (the two tributary valleys entering from the east are dry), but it is likely that direct surface runoff occurs during heavier and more prolonged rainfall events on the surrounding slopes, and flows into the basin relatively diffusely around its edge. A number of springs and wells discharge into the basin along its eastern boundary.

The basin drains exclusively to the south, which is notable given the proximity of its north-western boundary to Porth Mellon beach. Drainage from the basin occurs firstly through a narrow, relatively straight open channel, and then through a culvert to and across Old Town beach.

2.2 Geology

Figure 2.2-1[4] shows the surface geology of the area. St Mary's island is composed of the Isles of Scilly granite (red in Figure 2.2-1), which therefore represents the bedrock

[4] Taken from the British Geological Survey's online viewer

beneath and within the vicinity of the site. There are a number of different superficial deposits, as follows (oldest first):

- Head; clay, silt, sand and gravel (purple). During the last Ice Age the Irish Sea Ice extended only to the northern parts of the Isles of Scilly. South of this, cold tundra conditions resulted in the accumulation of orange-brown slope and wind-blown deposits known locally as 'ram'. It is very likely that these deposits extend, perhaps continuously, beneath the site.
- Blown Sand (light yellow). These form slightly higher ground along the north-western and southern boundaries of the basin, separating it topographically from the coast, and they could extend beneath the site, above the ram deposits, to some extent.
- Alluvium (dirty yellow). These deposits are generically described as clay, silt, sand and gravel. These deposits form the immediately substrate within the basin and the SSSI.

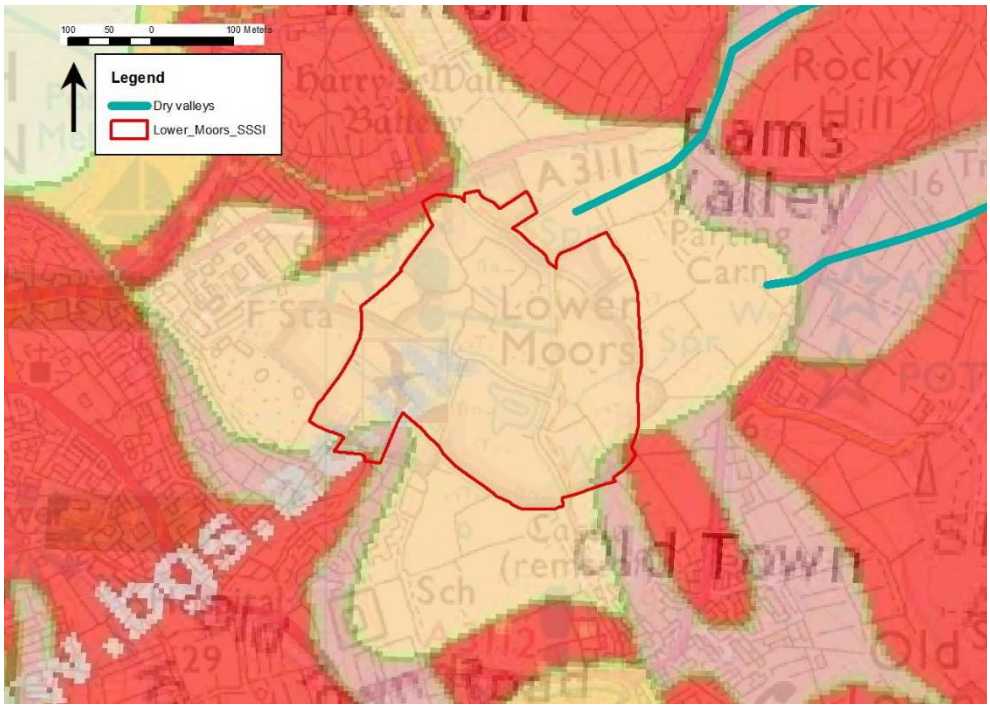

Figure 2.2-1 Surface geology (BGS on-line viewer); see text for geological key

2.3 Hydrogeology

There is unlikely to be significant groundwater flow within the bedrock granite.

The hydrogeological properties of the ram deposits are unclear from their lithological description, given the range in permeabilities through clay, silt, sand and gravel. However the locations of the springs and wells around the eastern edge of the site imply strongly that they represent groundwater discharge from the ram deposits extending to the east within valleys, and the inclusion of springs on the 1:25,000 scale mapping implies that this discharge is significant and that it continues for most of the time, if not perennially. In turn this implies that the ram deposits in this area are relatively permeable, perhaps with significant sand and/or gravel components.

Further interpretation of the hydrogeology of the site is included below.

2.4 Land-use

Urban, suburban and industrial land-uses surround the Lower Moors basin on its southern, western and northern-eastern sides. Arable fields and pasture dominate to the east and north-east.

3 Field observations and interpretation

The field visit was carried out on 27th April 2014, during which the weather was warm with occasional light rain. The visit was conducted at the end of the summer when water levels would be expected to be low; the summer of 2014 was relatively warm and dry and therefore the water levels were probably also relatively low for the time of year. Physical water quality parameters (pH, electrical conductivity and temperature) were measured using a Hanna HI9812-5 meter, and substrate sampling was carried out using a hand-auger.

Illustrated field notes and a map showing sampling locations are included in Appendix A. References to observation points are given in brackets below.

3.1 Substrate

Peat was encountered in four of the five auger holes within the site, but with a maximum thickness of only 35 cm. The peat was generally crumbly and/or fibrous and poorly humified. No evidence of historical peat cutting was found. The relatively small thicknesses of peat on the site are surprising in the context of the topographic position in what probably used to be a closed basin, but it is likely that relatively low effective rainfall (rainfall minus evapotranspiration) means that near-continuous maintenance of near-surface water tables, a pre-requisite for peat growth, is unlikely.

The sediments underlying the peat, and in the auger hole in the western part of the site (9), predominantly consisted of silt and fine sand, sometimes with a definite black colouration indicating either a significant organic content or reducing conditions; the latter is considered more likely. The origin of this alluvium is thought to be fluvial (and perhaps aeolian) reworking of the adjacent ram and blown sand deposits.

Augering beyond 1.2 mbgl was precluded both by running sand and/or the stiffness of the alluvium, the latter indicating a surprisingly high density.

3.2 Water

The wider basin is drained by a relatively dense network of ditches. The boundary of the SSSI is coincident along all but its north-western segment with a ring ditch, the function of which historically would have been to intercept springflow and surface runoff from the surrounding ground, and conduct it directly to the drainage point to the south. The ring ditch around the eastern side of the SSSI was observed still to be performing this function (4, 5), with very low flows derived almost certainly from the springs around the eastern edge of the basin (Aunt Joaney's and Castle Rocks Wells, etc). The ring ditch will still be fulfilling its intended function elsewhere, although no flow was observed in the larger ditches[5].

The general drainage direction through the SSSI is clearly to the south, but the difficulties in identifying any flow (and therefore flow direction) and the fact that many of the ditches were dry during the visit meant that it was impossible to discern the directions of flow through the network.

Whilst the main ditch and tributaries in the southern and central part of the site contained water during the visit, ditches in the northern and north-western parts of the site, and the site away from ditches in these areas, were dry (3, 11). This implies that there is a significant (in hydrological terms) slope across the site, although this is not easily discernible by eye.

The site discharges through a relatively narrow channel and then by culvert, to the south and Old Town beach. There is a water control structure with the facility for

[5] In which a large cross-sectional area combined with a low flow give a very low flow velocity

installation of level control boards downstream of the site (1), but no boards were in place during the visit (or for some time previously, judging by the condition of the board slots).

The main ditch towards the south of the site (15) contained > 1 m depth of water whilst the water in the outflow channel, at the level control structure around 100 m downstream, was generally 10-20 cm deep, with a flow estimated at 3 l/s during the visit. If it was assumed that the bed of the channel between these two points was flat, the implied hydraulic gradient would be very large, meaning that the flow would be much higher and the maintenance of > 1 m standing depth of water within the site would be unlikely. The implication is that the bed of the channel slopes upwards towards the point of discharge, confirming the description of the site as a topogenous mire within the citation.

An anonymous document was forwarded later in the project (Lower Moors.docx) which made reference to a series of dipwells monitored by the 'Council' and the Environment Agency. No other information has been seen on these dipwells, and none were encountered in the field.

3.3 Other

The waste dump for the island is notably close to the site on its western side. An observation borehole was discovered on the path adjacent to the dump (19), and it is possible that groundwater quality is tested regularly using this (and probably other) borehole(s), or at least that a risk assessment on groundwater contamination has been carried out.

Access to the site was (quite reasonably) denied during the visit, but it was possible to view the site from the public footpath (18).

4 Conceptual model and discussion

4.1 Conceptual hydrological model

The following is illustrated in the schematic diagrams provided as Figure 4.1-1 at the end of this section.

Water supply

Water is supplied to the site through:

- Direct rainfall
- Groundwater discharge from the ram (head) deposits. These deposits extend up the dry valleys to the east of the site, around the periphery of the larger basin, and probably beneath the basin. Groundwater recharge to the deposits is derived from direct rainfall and surface water runoff from adjacent hillsides. Groundwater discharges in springs around the periphery of the site, and possibly flows upwards into the alluvium from beneath the site.
- Direct surface water runoff from adjacent hillsides which will occur periodically, during heavy and/or prolonged rainfall.

Water flow and retention within the site

The site is relatively flat which imposes a low hydraulic gradient across the site. The immediate substrate of silt and fine sand will be relatively poorly permeable and this, combined with the low hydraulic gradient, means that the capacity for shallow subsurface flow through the site is limited, and the water table tends to rise to the ground surface; hence the site is a wetland.

Water retention derives from two mechanisms:

- The limited capacity for subsurface flow through the site means that it takes an appreciable time to drain down towards the south, the point of discharge. This means that water levels away from the central and southern portions of the site are dynamic, rising when greater amounts of water are provided by the various sources, and falling when discharge to the south and evapotranspiration dominate. The peripheral areas of the site are the first to dry out during such periods.
- Water retention, primarily in the central and southern areas of the site, behind the topographic barrier to the south, over which the outfall channel flows.

Water loss

Water is lost from the site by:

- Discharge to the south, via the channel and culvert, to Old Town beach.
- Evapotranspiration, the rate of which tends to be positively related to the size and vigour of the vegetation. The vigorous growth in the reedbeds and of the scrub and trees within the site suggests that evapotranspiration per unit area is relatively high from the site in the summer, and this could easily be a factor in any drying out of the site.

4.2 Discussion towards recommendations

4.2.1 Wetland hydrological management

At a basic level wetland hydrological management can be considered as a number of steps:

1. Determine the desired type and distribution of wetland plant communities. The current condition of the site has been described as an ecotone between

Phragmites australis swamp and *Juncus maritimus* salt marsh, but no information on the desired type and distribution of wetland plant communities has been available for the current project.

2. Decide relevant hydro-environmental supporting conditions (HSCs) for these communities. HSCs are defined in terms of aspects of behaviour of key variables, for example, water levels, flows or quality, and temporal and spatial distributions thereof. Information on HSCs for NVC S4 *Phragmites australis* reedbed is available in Wheeler *et al* (2004)[6].
3. Assess to what degree the required HSCs are present, preferably through direct measurement and monitoring (see below), or perhaps through interpretation of other evidence such as vegetation community distribution and condition, or anecdotal evidence.
4. If necessary, adapt the hydrological management of the site such that the required HSCs will result; adaptations should be informed by the conceptual hydrological model.
5. Continue monitoring and adaptive management, at least until the required HSCs are achieved.

4.2.2 Hydrological monitoring

Inception of some hydrological monitoring at the site, the results from which could inform future hydrological management, would be very useful. The amount of hydrological monitoring which can be undertaken is related directly to the resources available; it is assumed that there are relatively few resources available for the current site, and in this context the following are suggested:

- Installation of a small number of shallow dipwells and stilling wells in the fen and ditches respectively, to facilitate measurement of water table and ditch water levels.
- Manual water level measurements; these could be carried out by Wildlife Trust staff or volunteers using simple equipment.
- Maintain a site hydrological diary, for example recording the spatial extent and duration of flooding and other notable events.

Results from the above could be used to develop a more quantitative understanding of the hydrological functioning of the site, which in turn could be used to both refine the conceptual hydrological understanding and inform hydrological management of the site (see above).

4.2.3 Perceived drying of the site

It was noted in the 2012 SSSI condition assessment that the presence of negative indicator species indicated drying of the site, as does the absence of positive indicator species. No evidence has been found during the current study for recent changes to the water supply or water retention mechanisms of the site which would result in drying. The most likely cause is enhanced evapotranspiration from the vigorous reed, scrub and tree growth which should be countered by continued appropriate vegetation management, as also suggested in the comments in the 2012 condition assessment.

The potential for raising water levels locally within the site using small dams in ditches is questionable because the fine sand substrate would almost certainly allow a

[6] Provided digitally with this report

significant amount of flow to take place beneath and to the sides of any dam, making it difficult to maintain a higher water level upstream of the dam for any length of time.

4.2.4 Flooding of the industrial estate

This was raised as a problem during the introduction to the site. Since the industrial estate drains south-eastwards, through the SSSI, it is possible that low efficiency of water movement through the SSSI during critical periods could be a contributory cause of the flooding. Any improvement in the efficiency of water movement through the SSSI would probably involve deepening and/or widening of channels, and possibly significant clearance of vegetation. For the former it might be necessary to deepen the outflow channel in order to increase its flow capacity. The results of this type of work on the ditch and water level regimes within the site are difficult to predict in detail, but on first consideration it would be surprising if they didn't cause a lowering of levels, which would almost certainly be undesirable from a conservation viewpoint.

A possible solution to this conflict of interest in hydrological management of the SSSI could be installation of a flood relief culvert from the industrial estate to the Porth Mellon beach to the north. Any further scoping or design work on this topic should be carried out by a surface water hydrologist/engineer.

4.2.5 Waste dump

The location of the waste dump, upstream of the SSSI, is obviously of concern in terms of potential groundwater- and surface water-borne contamination of the site. The following are recommended:

- The results and reporting from any risk assessments or ongoing monitoring are obtained from relevant authorities (the local council and/or the Environment Agency). The presence of an observation borehole downstream of the waste dump suggests that there is taking, or has taken, place.
- Water quality samples are taken from critical locations within the site, for example from the ditches leading from the area of the waste dump. The samples should be analysed for a full suite of waste-related determinands.

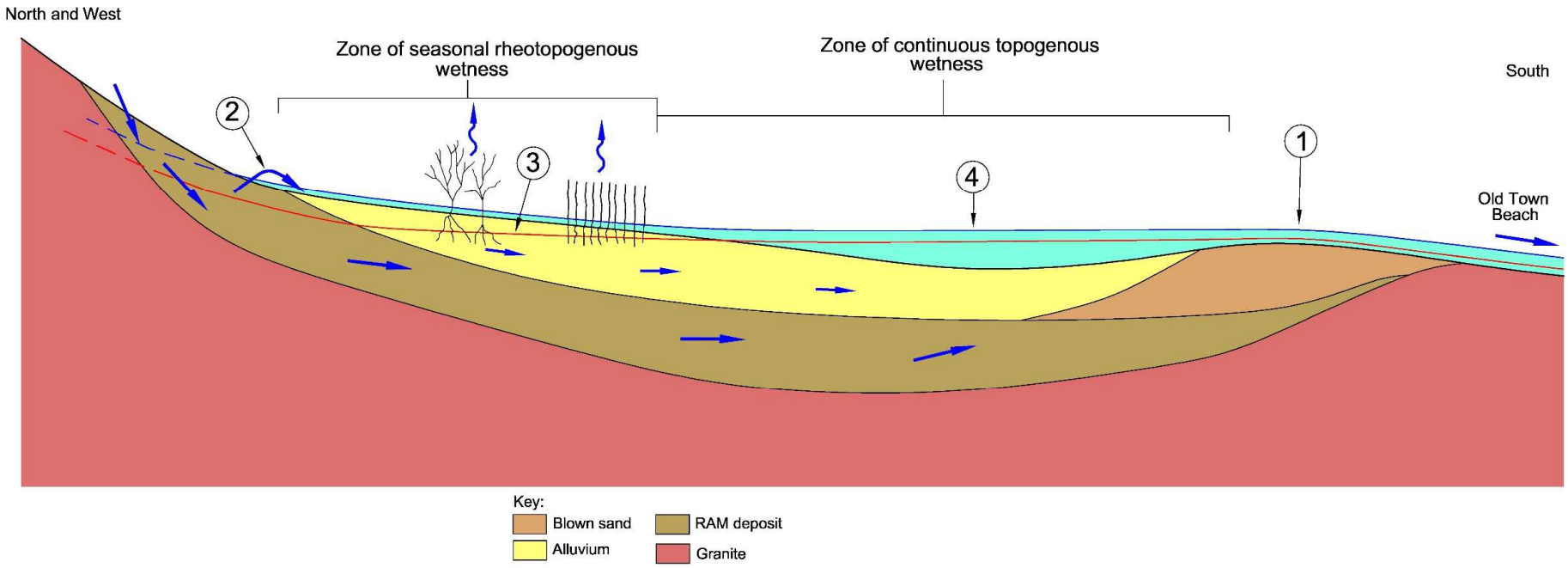

Figure 4.1-1 Schematic diagram of the hydrological conceptual model. The higher winter water levels are shown in blue whilst the lower summer water levels are shown in red. A topographic barrier at the southern end of the site (1) retains water at a similar level in the central and southern area of the site, resulting in an area of topogenous wetness. Further north and west within the site, water levels are high when maintained by rainfall, groundwater (from peripheral springs (2)) and surface water flow during the colder months, but have a tendency to fall below the surface (3) when not supported. Relatively high transpiration from vigorous reedbeds, scrub and willow will exascerbate lowering of the water table during the warmer months. The expressions of topogenous wetness in the central and southern areas of the site (4) are deeper water-filled ditches and episodic more extensive flooding.

5 Conclusions and recommendations

5.1 Conclusions

- Hydrological and other relevant information from desk study and a field visit have been combined and analysed to develop a conceptual understanding of the hydrological functioning of Lower Moors SSSI (see Section 4.1). A generic approach to wetland hydrological management has also been outlined (see Section 4.2.1)
- The most likely cause of the drying of the site noted in the 2012 SSSI condition assessment is enhanced evapotranspiration from the vigorous reed, scrub and tree growth. The potential for using dams to raise water levels locally within the site is almost certainly very limited because of the nature of the substrate.
- Since the industrial estate drains south-eastwards, through the SSSI, it is possible that low efficiency of water movement through the SSSI during critical periods could be a contributory cause of flooding. Any improvement in the efficiency of water movement through the SSSI would probably involve deepening and/or widening of channels, and possibly significant clearance of vegetation; on first consideration it would be surprising if the former didn't cause a lowering of levels, which would almost certainly be undesirable from a conservation viewpoint.
- The location of the waste dump, upstream of the SSSI, is of concern in terms of potential groundwater- and surface water-borne contamination of the site.

5.2 Recommendations

- It is recommended that the approach to site hydrological management described in Section 4.2.1 is adopted, and the following are specific steps towards this:
    - It would be useful to develop an explicit vision for the site in terms of the type and distribution of wetland vegetation communities. This should take into account the current functioning and the opportunities and constraints of the site in terms of its hydrology.
    - It would be very useful to initiate some resource-appropriate hydrological monitoring within the site, as detailed in Section 4.2.2. It is important to note that a minimum of well-designed and executed monitoring would be useful in this case, given the current complete absence of quantitative hydrological data for the site.
- Clearance of scrub and trees, and cutting of reeds, should be continued in order to reduce evapotranspirative water losses from the site as much as possible.
- The causes of flooding within the industrial estate should be investigated, initially at a scoping level, by a surface water hydrologist/engineer. The possibility of installing a flood relief culvert from the industrial estate to the Porth Mellon beach to the north should form a part of this investigation.
- Regarding the potential for contamination of the site by the adjacent (upstream) waste dump, the following are recommended:
    - The results and reporting from any risk assessments or ongoing monitoring are obtained from relevant authorities (the local council and/or the Environment Agency).
    - Water quality samples are taken from critical locations within the site, for example from the ditches leading from the area of the waste dump. The samples should be analysed for a full suite of waste-related determinands.

References

B.D. Wheeler, D.J.G. Gowing, S.C. Shaw, J.O. Mountford, and R.P. Money, 2004. Ecohydrological Guidelines for Lowland Wetland Plant Communities (Eds. A.W. Brooks, P.V. Jose, and M.I. Whiteman,). Environment Agency (Anglian Region).

Appendix A Illustrated field notes

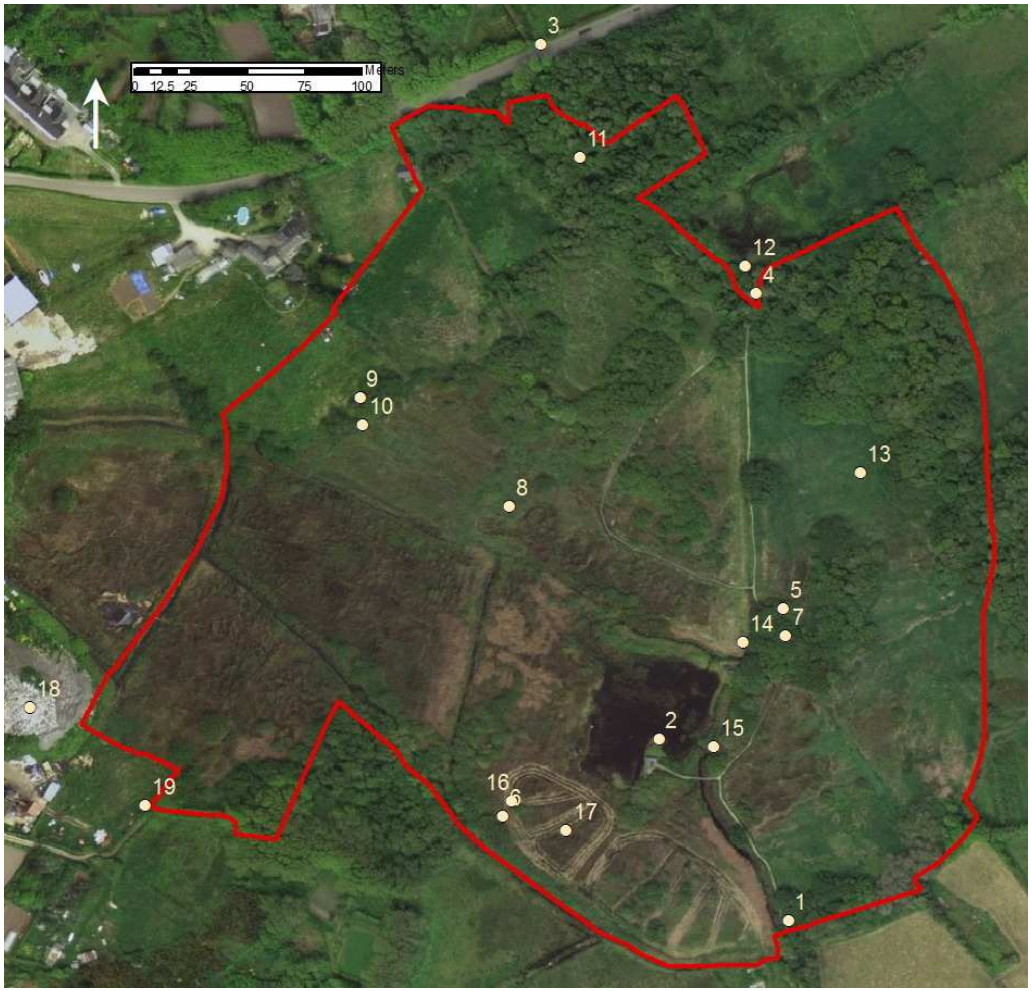

Figure A1-1 Site map over aerial photograph showing observation points

#	Easting	Northing	Feature/comment	pH	EC (µS/cm)	Temp (deg C)	Photo
1	91293	10443	Water control structure on outlet channel. Facility for stop-logs, but none in place. No channel restriction.	6.9	o/s	17	
2	91236	10523	Bird hide and photograph of bird scrape.				
3	91184	10830	Inflow channel at N end of site. Dry and overgrown.				
4	91279	10720	Confluence of eastern peripheral ring ditch with axial channel - springflow. Very small flow observed.	6.9	780	15	

5	91291	10581	Confluence of eastern peripheral ring ditch with axial channel - springflow. Very small flow observed under one footbridge, but not others.	7.2	780	15	
6	91167	10489	Deep/wide boundary ditch, uncrossable.				
7	91292	10569	Auger hole #1 0-30 cm Wet, brown, crumbly, granular PEAT. H2 30-40 cm Moist, brown, moderately soft SILT Wet, grey, fine SAND Hole collapsing, running sand				
8	91170	10626	Auger hole #2 0-35 cm Wet, mid-brown, crumbly, fibrous PEAT. H3 35-110 cm Damp, black-brown, soft organic-rich, silty fine SAND				

9	91104	10674	Dry channel bed, sloping to W? Very overgrown.				
10	91105	10662	Auger hole #2 0-10 cm Damp, brown SILT 10-40 cm Damp, black-brown, dense, silty coarse SAND Area generally dry, water table @ 40 cmbgl 40-120 cm Damp, brown, soft organic-rich SILT				
11	91201	10780	Northern area of site dry, with areas which are clearly routinely wet (wide channels, swales, etc)				
12	91274	10732	Ditch under footbridge from NE - v small flow observed.	7.1	740	15	

13	91325	10641	Auger hole #4 0-20 cm Damp, brown, crumbly PEAT with abundant roots. H2 20-65 cm Wet, mid-grey, fine SAND Hole collapsing, running sand				
13	91273	10566	Tributary from W part of site past northern hide. 2 m wide, no flow apparent. Potential sign of oil pollution on surface - doesn't break into platelets.	7	o/s	17	
14	91260	10520	Main ditch, occluded with weed (and algae?)				
15	91171	10496	Boundary ditch passing waste dump upstream. Very low flow. 2 m wide x 1 m deep.	7.3	o/s	16	
16	91195	10483	Auger hole #3 0-30 cm Damp, light-brown, v fibrous PEAT. H2 30-50 cm Damp, mid-brown, med. soft SILT with abundant roots 50-55 cm Damp, grey, stiff, silty fine SAND 55-65 cm Damp, light-grey/white, loose fine SAND. Hole collapsing, running sand				

17	90958	10537	Waste dump					
	91009	10494	Observation borehole on path. For groundwater monitoring of waste dump?