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Wales

# Macrophyte Survey of Welsh Lakes for Habitats Directive and Water Framework Directive Monitoring, 2014

Baxter, E. and Stewart, N.  
Ecus Ltd

NRW Evidence Report No. 52

## About Natural Resources Wales

Natural Resources Wales is the organisation responsible for the work carried out by the three former organisations, the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales. It is also responsible for some functions previously undertaken by Welsh Government.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future.

We work for the communities of Wales to protect people and their homes as much as possible from environmental incidents like flooding and pollution. We provide opportunities for people to learn, use and benefit from Wales' natural resources.

We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

We work to maintain and improve the quality of the environment for everyone and we work towards making the environment and our natural resources more resilient to climate change and other pressures.

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We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

This Evidence Report series serves as a record of work carried out or commissioned by Natural Resources Wales. It also helps us to share and promote use of our evidence by others and develop future collaborations. However, the views and recommendations presented in this report are not necessarily those of NRW and should, therefore, not be attributed to NRW.

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## 1. Crynodeb Gweithredol

Comisiynodd Cyfoeth Naturiol Cymru ECUS Ltd i gasglu a chyflwyno data ecolegol o bump ar hugain o lynnoedd, ar draws wyth ardal awdurdod lleol yng Nghymru. Roedd angen y data i gefnogi rhaglen fonitro integredig CNC ar gyfer safleoedd gwarchoddedig (Ardaloedd Cadwraeth Arbennig, Ardaloedd Gwarchodaeth Arbennig a Safleoedd o Ddiddordeb Gwyddonol Arbennig), y Gyfarwyddeb Fframwaith Dŵr, a sbardunau deddfwriaethol a pholisi eraill.

Cyflawnwyd arolygon macroffyt dyfrol ym mhob un o'r pump ar hugain o lynnoedd, gan ddilyn Canllawiau Safonau Cyffredin y Cydbwyllgor Cadwraeth Natur / dull Arolwg Leafpacs2 Y Gyfarwyddeb Fframwaith Dŵr. Cyfrifwyd metrig LEAFPACS o'r data. Casglwyd proffiliau dyfnder tymheredd ac ocsigen toddedig o un man ar bob llyn a nodwyd y ffactorau a welwyd yn effeithio ar y llyn. Cwblhawyd arolygon bathymetrig ar saith llyn na chafodd eu harolygu o'r blaen a dadansoddwyd y data gan ddefnyddio meddalwedd System Gwybodaeth Ddaearyddol.

Cyfrifwyd metrig Leafpacs2 y Gyfarwyddeb Fframwaith Dŵr gan ddefnyddio offer taenlen awtomataidd UKTAG. Roedd gan y mwyafrif o'r llynnoedd werthoedd Mynegai Maetholion Macroffyt y Llyn (LMNI) gweddol isel, sy'n adlewyrchu natur ucheldir llawer o'r safleoedd. Roedd gan y mwyafrif o'r safleoedd fflora gweddol amrywiol, yn nodweddiadol rhwng 10 a 20 o dacsonau. Dim ond un llyn (Llyn Isaf) oedd yn rhy brin o rywogaethau i amau canlyniadau Leafpacs2.

Nodwyd dwy rywogaeth nodedig yn ystod yr arolygon. Cofnodwyd Llyriad y-dŵr arnofiol *Luronium natans*, Rhywogaeth Dan Warchodaeth Ewropeaidd, mewn saith llyn (Llyn Egnant, Llyn Gynon, Llyn Teifi, Llyn Cerrigllwydion Isaf, Gwnllyn, Llyn Padarn a Llyn Tegid). Mae'r rhain i gyd yn lleoliadau hysbys ar gyfer y rhywogaeth. Rhestrir Rhawn-yr-ebol serennog, *Nitellopsis obtusa*, dan Fygythiad ar Restr Goch y DU (Cydbwyllgor Cadwraeth Natur 2014). Cofnodwyd Rhawn-yr-ebol serennog yn Llyn Llangors, sef yr ail safle yn unig yng Nghymru i'w gofnodi ac mae'n record newydd ar gyfer y llyn hwn sydd wedi cael ei astudio'n helaeth.

Cofnodwyd nifer o ffactorau a allai fod yn effeithio'n negyddol ar y llynnoedd, gan gynnwys amrywiadau'n lefel y dŵr yn Llyn Eigiau; maethynnau gormodol yn Llynnoedd Hanmer a Llygeirian; a siltio yn Llyn Glangors. Mae rhywogaethau goresgynnol yn broblem benodol yn Nhal-y-llyn (*Lagarosiphon major* a *Elodea nuttallii*), yn Llys Rhos-ddu (*Elodea nuttallii* ac ychydig o *Elodea canadensis*) ac yn Llyn Llangors (*Elodea nuttallii*, *Elodea canadensis* a *Nymphoides peltata*).



## 2. Executive Summary

Natural Resources Wales commissioned ECUS Ltd to collect and present ecological data from twenty-five lakes, across eight local authority areas in Wales. The data was needed to support NRW's integrated monitoring programme for protected sites (SACs, SPAs and SSSIs), the Water Framework Directive, and other legislative and policy drivers.

Aquatic macrophyte surveys were undertaken at all twenty five lakes, following the JNCC Common Standards Guidance / WFD Leafpacs2 Survey method. LEAFPACS metrics were calculated from the data. Depth profiles of temperature and dissolved oxygen were collected for a single point on each lake and observations on pressures impacting upon the lake were noted. Bathymetric surveys were completed on seven previously unsurveyed lakes and the data analysed using GIS software.

Leafpacs2 WFD metrics were calculated using the UKTAG automated spreadsheet tool. The majority of lakes generally had relatively low LMNI values, reflecting the upland nature of many sites. Most sites had a reasonably diverse flora with between 10 and 20 taxa being typical. Only one lake (Llyn Isaf) was too species-poor for Leafpacs2 results to be doubtful.

Two notable species that were recorded during the surveys. Floating water-plantain *Luronium natans*, a European Protected Species, was recorded at seven lakes (Llyn Egnant, Llyn Gynon, Llyn Teifi, Llyn Cerrigllwydion Isaf, Gwnllyn, Llyn Padarn and Llyn Tegid). All of these are known locations for the species. Starry stonewort, *Nitellopsis obtusa*, is listed as Vulnerable on the UK Red List (JNCC, 2014). Starry stonewort was recorded at Llangorse Lake, making it only the second recorded site in Wales and a new record for this well-studied lake.

A number of pressures that may be negatively impacting upon the lakes were recorded, including water level fluctuations at Llyn Eigiau; excessive nutrients at Hanmer Mere and Llyn Llygeirian; and siltation at Llyn Glangors. Invasive species are a particular issue at Tal-y-llyn (*Lagarosiphon major* and *Elodea nuttallii*), Llyn Rhos-ddu (*Elodea nuttallii* with some *Elodea canadensis*) and Llangorse Lake (*Elodea nuttallii*, *Elodea canadensis* and *Nymphoides peltata*).

### 3. Introduction

The EU Water Framework and Habitats Directives (WFD and HD respectively) require monitoring of freshwater habitats, both for reporting and to guide implementation of measures to achieve environmental objectives. In lakes, this data includes surveys of aquatic plants and supporting background data.

Aquatic plant survey data for both WFD and HD in the UK are collected using a common, shared survey method (WFD-UKTAG 2014a; JNCC 2015).

Ecus Ltd was commissioned by Natural Resources Wales (NRW) to collect ecological and limnological data from twenty-five lakes across Wales. This was to support NRW's integrated monitoring programme for protected sites (SACs and SSSIs), the Water Framework Directive, and other legislative and policy drivers. Aquatic plant communities were monitored and both physical and chemical data were collected at all twenty-five lakes, with bathymetric survey undertaken in addition at seven of the sites.

#### 3.1. Monitoring Sites

Table 1 lists the lakes surveyed in 2014. The lakes were selected for survey for a number of reasons:

- SAC: monitoring of a SAC feature (Natura 2000 site);
- SSSI: monitoring of a Site of Special Scientific Interest feature;
- WFD: Water Framework Directive surveillance network site; and
- ND: Nitrates Directive.

Table 1 List of Lakes and Drivers for Survey

UK Lakes Waterbody Identification	Central Grid Reference	Lake Name	Local Authority Area	Main Purpose of Monitoring
32435	SH346898	Llyn Llygeirian	Anglesey	SSSI / ND
33160	SH326739	Llyn Maelog	Anglesey	SSSI / ND
33627	SH424648	Llyn Rhos-ddu	Anglesey	SAC
33836	SH645595	Llyn Idwal	Snowdonia National Park	SAC / WFD
33803	SH659604	Llyn Ogwen	Snowdonia National Park	SAC / WFD
34039	SH641547	Llyn Teyrn	Snowdonia National Park	SAC
33807	SH772604	Llyn Glangors	Snowdonia National Park	SSSI
35561	SH648239	Llyn Bodlyn	Snowdonia National Park	WFD
36405	SH717099	Llyn Mwyngil (Tal-y-Llyn Lake)	Snowdonia National Park	WFD
34987	SH909334	Llyn Tegid	Snowdonia National Park	SAC / WFD

33571	SH720650	Llyn Eigiau	Snowdonia National Park	WFD
34400	SH780461	Llyn Conwy	Snowdonia National Park	SAC / WFD
33730	SH565614	Llyn Padarn	Gwynedd	WFD / SSSI
34780	SJ452392	Hanmer Mere	Wrexham	SSSI / WFD /ND
38163	SN838729	Llyn Gwngu	Ceredigion	SAC
38525	SN799646	Llyn Gynon	Ceredigion	SAC
38069	SN802757	Llyn Isaf	Ceredigion	SAC
38390	SN783675	Llyn Teifi	Ceredigion	SAC
38409	SN792671	Llyn Egnant	Ceredigion	WFD / SAC
33864	SH751593	Llyn Bychan	Conwy	SSSI
33855	SH760592	Llynnau Bodgynydd	Conwy	SSSI
38282	SN843699	Llyn Cerrigllwydion Isaf	Powys	SAC
38321	SN947689	Gwynllyn	Powys	SSSI
39267	SO119463	Llanbwchllyn Lake	Powys	SSSI / ND
40067	SO132264	Llangorse Lake	Brecon Beacons National Park	SAC / WFD

## 4. Methods

### 4.1. Access

Contact details for all relevant landowners and stakeholders were obtained following liaison with the local NRW operational teams.

Prior to survey visits, landowners were contacted by either the local NRW officer or Ecus Ltd. Where possible, landowners were contacted by telephone or email, but letters were used if other contact methods were unsuccessful. At one site, statutory access powers under Section 51 (1)(b) of the Wildlife and Countryside Act 1981 (as amended) had to be invoked.

Records of all contact made with landowners were kept, including details of any access problems or constraints, changes in ownership, or requests for further information or survey data. A record of landowner communication is provided as an electronic spreadsheet that accompanies this report. For data protection reasons, this record is confidential.

Most lakes had good access by road. A quad bike was used to transport survey equipment to more remote lakes with poor access. The use of a quad bike was dependent on permission from landowners and suitable terrain.

### 4.2. Fieldwork Preparation

A detailed risk assessment was produced and agreed by NRW's Project Officer prior to undertaking survey work. The risk assessment was provided to any landowners upon request. A work schedule and method was produced by Ecus Ltd and agreed with NRW's Project Officer. This was modified as the survey progressed in response to difficulties encountered during the survey.

For each water body, a map was produced displaying locations of previous CSM/WFD survey transects, where applicable. Previous survey information, provided by NRW, was consulted prior to survey, including:

- Bathymetric data (Turner *et al.*, 2010)
- Previous site condition assessments (Burgess *et al.*, 2006, 2009, 2013).
- Site Condition Assessment Database version 2.1

### 4.3. Macrophyte Survey

#### 4.3.1. Sectors

Survey teams comprised two members: A lead surveyor and an assistant, who supported the lead surveyor acting as a scribe and boat handler, whilst assisting with the perimeter survey and providing *in situ* verification of species identification. Macrophyte surveys were undertaken in accordance with the Common Standards Monitoring Guidance for Standing Waters (JNCC, 2015). A summary of this method is outlined below.

A number of sectors are selected that are intended to be representative of the habitats present in the lake. Typically, four sectors are surveyed per lake, but for large lakes up to eight sectors may be used, whilst two sectors is considered to be

sufficient for lakes less than 2 ha in area. The number of sectors surveyed per lake is shown in Table 2.

Where lakes had been surveyed previously, the sectors were repeated (with the same sector start points) unless otherwise specified by NRW. Transects were established on lakes that had not been previously surveyed, and the start and end points recorded using a GPS. A perimeter survey, wader transect and boat transect were completed as standard within each sector. The locations of the sectors are presented on maps A1-A25 in Appendix 1. Grid references for the sectors are provided in Appendix 2.

Macrophyte surveys were undertaken between August and November, with the majority undertaken in mid to late September. Lowland sites were prioritised for survey earlier, as many species likely to be encountered in lowland sites die back in autumn, resulting in species being missed and / or cover values being underestimated if surveys are too late.

#### 4.3.2. Perimeter Survey and Strandline Search

A sector represents a 100 m length of lake shore. The start and end points of the perimeter survey were recorded using GPS. Photographs were taken at each end of the sector looking towards the mid-point using digital cameras. These are supplied separately.

All emergent and marginal species were recorded, along with any rooted submerged or floating-leaved aquatic species present above or at the water-line. An indication of the abundance of each species within the overall 100 m stretch was given using the DAFOR scale. The extent of the strandline colonised was also scored on a DAFOR scale to provide an indication of the open water community.

The following physical and environmental characteristics were also noted:

- modifications to lakeshore, inflow or outflow;
- evidence of erosion,
- water level compared to the winter normal level,
- water quality,
- other issues that may impact upon the lake.

Table 2 Site Specific Survey Details.

Lake	SSSI Name	Survey Date	Surveyors	Number of Sectors	Type of Survey
Llyn Llygeirian	Llyn Llygeirian	26/09/2014	RH	4	Wader and boat
Llyn Maelog	Llyn Maelog	09/09/2014	DD/RH	4	Wader and boat
Llyn Rhos-ddu	Newborough	08/09/2014	DD/RH	2	Wader and boat <sup>1</sup>
Llyn Idwal	Eryri	05/11/2014	NS/LK	3 <sup>2</sup>	Wader and boat
Llyn Ogwen	Eryri	11/09/2014 & 26/09/2014	DD/RH/EB	4	Wader and boat
Llyn Teyrn	Eryri	12/09/2014	DD/RH	2	Wader and boat
Llyn Glangors	Pandora Reservoirs	25/09/2014	DD/EB	3	Wader and boat
Llyn Bodlyn	None	19/09/2014	DD/EB	4	Wader and boat
Llyn Mwyngil (Tal-y-Llyn Lake)	Cadair Idris	20/09/2014	DD/EB	4	Wader and boat
Llyn Tegid	River Dee & Llyn Tegid	22/09/2014 & 23/09/2014	DD/EB	6 <sup>3</sup>	Wader and boat
Llyn Eigiau	Eryri	21/11/2014	EB/DO	2 <sup>4</sup>	Wader only
Llyn Conwy	Migneint-Arenig-Dduallt	7/11/2014	NS/LK	4	Wader and boat
Llyn Padarn	Llyn Padarn	10/09/2014	DD/RH	4	Wader and boat
Hanmer Mere	Hanmer Mere	29/08/2014	DD/EB	4	Wader and boat
Llyn Gwngu	Elenydd	04/11/2014	NS/LK	3	Wader only
Llyn Gynon	Elenydd	22/09/2014	RH	4	Wader and boat
Llyn Isaf	Elenydd	28/09/2014	RH	2	Wader and boat
Llyn Teifi	Afon Teifi	19/9/2014 & 20/09/2014	RH	4	Wader and boat
Llyn Egnant	Afon Teifi	21/09/2014	RH	4	Wader and boat
Llyn Bychan	Llyn Bychan	23/09/2014	DD/EB	2	Wader and boat

<sup>1</sup> Wader only at T2.

<sup>2</sup> Only three of four transects could be completed due to high winds.

<sup>3</sup> Six transects were specified compared to eight previously.

<sup>4</sup> Four transects are recommended for this site but bad weather restricted access.

Llynnau Bodgynydd	Llynnau Bodgynydd	24/09/2014	DD/EB	4	Wader and boat
Llyn Cerriglwydion Isaf	Elenydd	24/09/2014 & 25/09/2014	RH	3	Wader and boat
Gwynllyn	Cwm Gwynllyn	18/9/2014	DD/EB	3	Wader and boat
Llanbwchllyn Lake	Llan-bwch-Ilyn Lake	17/09/2014	DD/EB	4	Wader and boat
Llangorse Lake	Llyn Syfaddan / Llangorse Lake	16/09/2014	DD/EB	4	Wader and boat

#### 4.3.3. Wader Survey

The wader survey records plant species growing in shallow water (to approx. 1 m depth). In each sector, five transects were surveyed at 20 m intervals. Each transect was perpendicular to the shoreline, and contained four sampling points of 1 m<sup>2</sup> were selected for survey at 0.25 m, 0.5 m, 0.75 m and >0.75 m water depth. Each sample point was surveyed by bathyscope or grapnel (or both), depending on water clarity.

The species recorded within each sample points was recorded and a given a cover value using a four point scale:

- 0: absent
- 1: <25% cover;
- 2: 25-75% cover;
- 3: >75% cover.

The following additional information was recorded at each sample point:

- substrate type;
- filamentous algae cover (0-3 as above);
- floating and submerged vegetation cover (0-3 as above);
- emergent cover (0-3 as above);
- shade (0-3 as above); and
- survey method (e.g. bathyscope, grapnel, or both).

#### 4.3.4. Boat-based Survey

The mid-point of the sector was identified and used as the end point of the boat transect, where possible. Boat transects ran perpendicular to the shore mid-point, out into the lake. A bathyscope and grapnel were used to identify the depth limit of aquatic macrophyte colonisation, which marked the start point of the boat survey. Both ends of the transect were marked using a GPS and the bearing of the transect recorded.

The boat transect comprised 20 sample points, approximately equally spaced between the depth of maximum colonisation and the lake shore. Where the distance between the start and end point was too short to easily obtain 20 sample points, two parallel 10 point transects were completed. At each sample point, the vegetation within 1 m<sup>2</sup> was recorded by either bathyscope or grapnel.

The species recorded within sampling points were recorded and given a cover value, as described in 2.3.13.

The following additional information was recorded at each sample point:

- water depth;
- substrate type;
- shade (0-3 as above);
- floating and submerged vegetation cover (0-3 as above);
- emergent cover (0-3 as above);
- filamentous algae cover (0-3 as above); and
- survey method (e.g. bathyscope, grapnel, or both).



#### 4.3.5. Voucher Specimens

Specimens of species requiring microscopic examination for definitive identification, such as charophytes, *Callitriche*, *Potamogeton* and bryophyte species were collected and preserved for more detailed examination where necessary.

Identification of voucher specimens, including all those highlighted in the LEAFPACS species list (WFD-UKTAG, 2014), were checked by expert aquatic botanist Nick Stewart. Richard Lansdown was consulted for confirmation as necessary. Identification references used to support determinations included Stace (2010), Preston (1995), Moore (1985) and Jermy & Simpson (2007).

#### 4.3.6. Data Analysis

Data were entered into the Lakes LEAFPACS spreadsheet version 2.0, available from the UKTAG website (WFD-UKTAG, 2014b). Data input was checked by a senior surveyor to identify any anomalous species and cross-referenced with the field forms to ensure accurate data entry. The formulae used to automatically calculate the metrics were amended to provide compatibility with the DAFOR data collected during the lake survey.

The spreadsheet was amended by:

- Inserting additional rows in to the wader and boat sheets to record emergent vegetation cover and shade, and effectively limiting the “Aquatic Plant Volume Rating” to submerged and floating leaved vegetation only;
- Altering the formula within the perimeter transect sheet to enable input of locally modified DAFOR ratings e.g. FLA. The cover weighting was also adjusted for these categories. Where only local cover ratings have been given e.g. LF, the scoring has been adjusted with the assumptions LO = RLO, LF = OLF, LA = FLA and LD = FLD; and
- The wader and boat transect sheets have been modified from accepting only presence and absence (1/0) data, to accepting DAFOR, locally modified DAFOR or 1-3 abundance values. Cover calculations have not been altered, therefore, a species that is considered Rare will score the same cover value for that sample point as something that is Dominant. However, it should be possible to change this to reflect local abundance values in the future upon discussion with NRW if desired.

The following metrics/performance indicators were calculated:

- maximum depth of colonisation;
- percentage cover of individual macrophyte species
- Lake Macrophyte Nutrient Index (LMNI);
- Number of functional groups (NFG);
- Number of macrophyte taxa (NTAXA);
- percentage cover of hydrophytes (COV);
- relative percentage cover of filamentous algae (ALG); and
- relative percentage cover of non-native macrophytes.

In addition, the vegetation community within each lake was assigned to an indicative lake group as described in Duigan et al. (2006).

#### 4.3.7. Water Chemistry and Secchi Depth

General observations were made for the lake on the presence of surface algal blooms, water clarity and water colour. Secchi disk readings were taken at all lakes.

At the deepest point in the lake a water temperature and dissolved oxygen depth profile was taken. The position of the depth profile was recorded using a GPS. Where lakes had been surveyed previously, the approximate location of the previous depth profile was used. In previously surveyed lakes the location of the depth profile was informed by the bathymetry survey.

A multi-parameter probe (Hanna Instruments HI9828 or YSI Pro Quatro) with a 20 m cable was used to take temperature (°C) and dissolved oxygen (mg l<sup>-1</sup> or % saturation) readings at 0.5 m depth intervals to the lake bottom or the maximum length of the cable. The lake depth at the profile location was also measured using the depth markings on the probe cable.

### 4.4. Bathymetry Survey

#### 4.4.1. Data Collection

Bathymetric survey was undertaken from an inflatable boat equipped with a Lowrance Elite-4 HDI sonar device at the following seven, previously unsurveyed lakes:

- Llyn Llygeirian
- Llyn Teyrn
- Llyn Glangors
- Llyn Eigiau
- Llyn Isaf
- Llyn Teifi
- Llynnau Bodgynydd

For bathymetric data on other lakes in this survey, see Turner et al. (2010).

Each lake was systematically traversed at a constant speed of 4-5 km h<sup>-1</sup> to ensure a consistent coverage of the water body. A series of parallel east-west transects were undertaken along with a number of north-south orientated transects and a perimeter survey of the lake. This latter survey was undertaken by steering the boat to within the zone of safe operation and effective data collection (i.e. approximately 1 m depth).

#### 4.4.2. Data Processing and Analysis

Bathymetric data was recorded *in situ* as an .SL2 file format, which was subsequently converted to .CSV files, compatible for entry into ArcGIS v10.2, using SonarViewer 2.1.2. All files for each individual lake were compiled into single data files.

Depth contours were produced by combining the grid references and related depth measurements within the area studied. The contours were smoothed using Bezier curves and then clipped using a shapefile of the lake boundary to produce a view of the lake only.

Contours were colour coded to give a clear picture of the lake bathymetry; the colours were graduated with darker colours representing the deeper areas of lake.

#### 4.5. Survey limitations

A number of issues arose throughout the project, such as access difficulties, equipment failures, prolonged periods of poor weather and fluctuating water levels, which compounded with the letting of the contract late in the summer, resulted in some surveys being undertaken beyond the optimal macrophyte survey season. However, most vegetation surveys were undertaken in September. Three sites (Llyn Idwal, Llyn Gwngu and Llyn Conwy) were not surveyed until late October. However, due to the assemblage present at these sites it is not thought that this affected the results apart from a potential under-recording of *Utricularia* species which is likely to have died back to turions. Subsequent quality assurance (T. Hatton-Ellis, NRW) has confirmed that for lakes where previous data existed; the species assemblages were similar, suggesting that there was no systematic bias in species detection.

It was not possible to undertake boat surveys at Llyn Eigiau as it was considered unsafe due to poor weather on both occasions that it was attempted. Very high water levels were an additional problem during one of the visits. However, the two wader surveys undertaken at this site indicated that there is a mesotrophic element to the flora linked to the extensive basic igneous geology of the catchment. It was therefore thought better to postpone the survey of this site until 2015 due to the possible occurrence of deciduous aquatic species.

## 5. Results and Discussion

### 5.1. Macrophyte Survey

The raw macrophyte survey data is provided in the accompanying electronic spreadsheets within the Data Archive Appendix. Photographs that were taken of each sector are provided electronically in the Data Archive Appendix, a folder per lake. A catalogue was made of all photographs taken for the project detailing the lake, sector number, photo number, and a description of what the photo displays, which can be found in the Data Archive Appendix.

Table 3 below contains a summary of the Leafpacs2 metrics for each of the lakes surveys and Table 4 contains a summary of the total cover values of the submerged and floating leaved aquatic species recorded in each lake. Further details of Leafpacs2 metrics can be found in WFD-UKTAG (2014a).

Table 3. Summary table of LEAFPACS metrics.

Lake	LMNI	NTAXA	NFG	COV	ALG	Lake Type
Llyn Llygeirian	6.41	24	13	1.9	0.08	D
Llyn Maelog	7.15	13	9	1.64	0.68	G
Llyn Rhos-ddu	6.87	11	7	7.74	0.01	G
Llyn Idwal	3.57	13	8	6.02	0.24	C2
Llyn Ogwen	3.57	17	8	2.43	0.19	C2
Llyn Teyrn	2.94	9	4	6.23	0.38	C2
Llyn Glangors	3.9	9	5	4.47	0	C2
Llyn Bodlyn	3.38	14	7	4.08	0.31	C2
Llyn Mwyngil (Tal-y-Llyn Lake)	4.85	19	12	4.89	4.89	D
Llyn Tegid	4.98	20	11	1.27	0.24	D
Llyn Eigiau	3.91	15	8	2.82	0.17	C2
Llyn Conwy	3.28	8	3	3.91	0.16	C2
Llyn Padarn	4.35	13	9	3.08	0.31	D
Hanmer Mere	6.79	15	9	2.96	0	G
Llyn Gwngu	3.47	11	8	7.51	0.29	C2
Llyn Gynon	3.09	14	8	4.82	0.21	C2
Llyn Isaf	3.59	4	3	8.61	0.42	A
Llyn Teifi	3.35	13	7	2.32	0.33	C2
Llyn Egnant	3.23	10	6	5.49	0.21	C2
Llyn Bychan	3.84	12	6	1.65	0.01	C2
Llynnau Bodgynydd	3.40	15	9	1.82	0.03	C2
Llyn Cerrigllwydion Isaf	3.29	14	7	3.59	0.49	C2
Gwynllyn	4.26	15	11	3.94	0.56	D
Llanbwchllyn Lake	6.88	15	10	2.75	0	G
Llangorse Lake	6.77	23	10	3.06	0.2	F

Table 4. Summary table of submerged and floating leaved aquatic species, showing Leafpacs2 taxon-specific cover scores for each lake.

	Llyn Llygeirian	Llyn Maelog	Llyn Rhos-ddu	Llyn Idwal	Llyn Ogwen	Llyn Teyrn	Llyn Glangors	Llyn Bodlyn	Llyn Mwyngil (Tal-y-Llyn Lake)	Llyn Tegid	Llyn Eigiau	Llyn Conwy	Llyn Padarn	Hanner Mere	Llyn Gwngu	Llyn Gynon	Llyn Isaf	Llyn Teifi	Llyn Egnant	Llyn Bychan	Llynau Bodgynydd	Llyn Cerrigllwydion Isaf	Gwynlyn	Llanbwchllyn Lake	Llangorse Lake
<i>Batrachospermum</i> sp.						2.6		1.9		0.1		12.2			2.3	5.1			1.7			1.3			
<i>Butomus umbellatus</i>																									0.1
<i>Callitriche brutia</i> var. <i>hamulata</i>				1.7	0.6		0.1	3.7	3.3	1.4	2.2				0.9	1.3		2.6	1.4			0.8	0.1		
<i>Callitriche hermaphrodita</i>	<.1																								
<i>Callitriche</i> sp.					0.1					0.1															
<i>Callitriche stagnalis</i>									0.1					0.9											
<i>Callitriche truncata</i>		1.2																							
<i>Ceratophyllum demersum</i>	0.9													4.6										0.3	6.2
<i>Chara aspera</i>	0.8																								
<i>Chara contraria</i> var. <i>contraria</i>																									0.3
<i>Chara globularis</i>																								0.1	0.3
<i>Chara virgata</i>											2.0									0.5	0.5				
<i>Elatine hexandra</i>		0.9		0.4	0.2				0.1	3.8	3.1		0.5	0.5				2.3			0.3				
<i>Elatine hydropiper</i>	2.5																								
<i>Eleocharis acicularis</i>	0.3	1.4							0.1	0.5															
<i>Eleocharis multicaulis</i>																					0.4				
<i>Eleogiton (Isolepis) fluitans</i>															6.1						0.5				
<i>Elodea canadensis</i>	15.7		1.5											9.6											0.8
<i>Elodea nuttallii</i>			53.3						4.0	0.5			0.7												16.9
Filamentous algae	3.3	11.9	0.6	19.1	7.8	21.1	0.1	17.9	16.3	6.2	7.2	5.1	12.3	0.1	23.6	14.3	14.4	9.8	11.7	0.3	0.8	24.4	33.2	0.1	13.5

	Llyn Llygeirian	Llyn Maelog	Llyn Rhos-ddu	Llyn Idwal	Llyn Ogwen	Llyn Teyrn	Llyn Glangors	Llyn Bodlyn	Llyn Mwyngil (Tal-y-Llyn Lake)	Llyn Tegid	Llyn Eigiau	Llyn Conwy	Llyn Padarn	Hanmer Mere	Llyn Gwngu	Llyn Gynon	Llyn Isaf	Llyn Teifi	Llyn Egnant	Llyn Bychan	Llynnau Bodgynydd	Llyn Cerrigllwydion Isaf	Gwynllyn	Llanbwchllyn Lake	Llangorse Lake
<i>Fontinalis antipyretica</i>	0.1				0.8			0.8	0.3	1.1	0.2	0.3	0.1									2.6	0.1		
<i>Fontinalis squamosa</i>													0.3			1.0									
<i>Hippuris vulgaris</i>			2.6																						
<i>Hottonia palustris</i>														0.1											
<i>Hydrocharis morsus-ranae</i>	1.0																								
<i>Hydrodictyon reticulatum</i>	0.1	2.3																						0.1	0.4
<i>Hypericum elodes</i>																							0.8		
<i>Isoetes echinospora</i>							0.2	0.1										0.1							
<i>Isoetes lacustris</i>				24.1	14.3	1.9	7.7	13.7	2.4	5.1	3.8	3.8	9.8			5.0		0.6		0.3	1.9	0.7			
<i>Isoetes sp.</i>					0.48																				
<i>Juncus bulbosus</i>				17.0	2.5	3.3	14.8	1.2			2.9	3.5	0.1		3.9	6.4	3.9	9.6	10.0	1.5	8.1	4.3	5.0		0.3
<i>Lagarosiphon major</i>									52.6																
<i>Lemna minor</i>	0.8	1.3	4.7						0.1					7.1										0.5	0.7
<i>Lemna trisulca</i>	1.9													1.6										1.2	5.0
<i>Leptodyction riparium</i>										0.1															
<i>Limosella aquatica</i>										0.1															
<i>Littorella uniflora</i>	2.8	0.3		2.0	4.6	9.2	16.6	11.7	4.8	3.6	10.7	2.2	9.5		7.5	15.7		1.2	1.5	2.6	3.4	8.3	5.8		
<i>Lobelia dortmanna</i>				4.9	5.6	10.3		4.3			2.9					9.9				2.0	0.5	1.2			
<i>Luronium natans</i>										1.0			0.4			5.7		2.7	10.8			2.2	0.9		
<i>Lythrum portula</i>									0.1		0.4			0.1				0.1							
<i>Menyanthes trifoliata</i>	2.4		4.0	1.1					2.9												0.7	1.0	0.7	2.6	0.3
<i>Myriophyllum alterniflorum</i>	3.3			2.5	1.4			1.1	0.1		0.1	0.5	3.3		6.6	1.4		0.7	16.7	5.5	6.3	2.3	7.7		

	Llyn Llygeirian	Llyn Maelog	Llyn Rhos-ddu	Llyn Idwal	Llyn Ogwen	Llyn Teyrn	Llyn Glangors	Llyn Bodlyn	Llyn Mwyngil (Tal-y-Llyn Lake)	Llyn Tegid	Llyn Eigiau	Llyn Conwy	Llyn Padarn	Hanner Mere	Llyn Gwngu	Llyn Gynon	Llyn Isaf	Llyn Teifi	Llyn Egnant	Llyn Bychan	Llynau Bodgynydd	Llyn Cerrigllwydion Isaf	Gwynllyn	Llanbwchllyn Lake	Llangorse Lake
<i>Myriophyllum spicatum</i>																								<.1	7.0
<i>Najas flexilis sensu stricto</i>													2.3												
<i>Nitella flexilis</i> agg. (includes <i>N. opaca</i> )					1.2			0.1	4.4	0.8	4.9									1.6	2.2		2.3		
<i>Nitella gracilis</i>																0.1							0.4		
<i>Nitella opaca</i>	3.5																								
<i>Nitella translucens</i>									0.5	0.7															
<i>Nitellopsis obtusa</i>																								0.5	
<i>Nuphar lutea</i>	1.29									0.1				8.8	7.6								0.9	11.5	9.3
<i>Nymphaea alba</i>		0.1							0.4					3.6						3.3				11.8	1.3
<i>Nymphoides peltata</i>																									3.2
<i>Persicaria amphibia</i>	3.4	0.4												1.3										7.6	0.6
<i>Potamogeton berchtoldii</i>	0.3			0.3						0.2			0.1	0.7									0.2		
<i>Potamogeton crispus</i>	0.3		2.0											4.1											
<i>Potamogeton lucens</i>																									1.2
<i>Potamogeton natans</i>					0.6		0.1	<.1	0.3	0.1	1									1.5				0.9	
<i>Potamogeton obtusifolius</i>	0.3																							3.7	
<i>Potamogeton pectinatus</i>	0.3		2.9																					0.4	0.2
<i>Potamogeton perfoliatus</i>	0.1	0.3	4.8																						0.7
<i>Potamogeton polygonifolius</i>				1.2	0.3	0.6				0.1					0.7	0.2		0.1	0.1	0.1	0.1	0.6	0.2	0.1	
<i>Potamogeton praelongus</i>																									0.6
<i>Potamogeton pusillus</i>	0.2	0.8	7.5																						
<i>Potamogeton trichoides</i>														1.3											

	Llyn Llygeirian	Llyn Maelog	Llyn Rhos-ddu	Llyn Idwal	Llyn Ogwen	Llyn Teyrn	Llyn Glangors	Llyn Bodlyn	Llyn Mwyngil (Tal-y-Llyn Lake)	Llyn Tegid	Llyn Eigiau	Llyn Conwy	Llyn Padarn	Hanmer Mere	Llyn Gwngu	Llyn Gynon	Llyn Isaf	Llyn Teifi	Llyn Egnant	Llyn Bychan	Llynnau Bodgynydd	Llyn Cerrigllwydion Isaf	Gwynllyn	Llanbwchllyn Lake	Llangorse Lake
<i>Ranunculus aquatilis</i> agg.										0.1	0.2		0.8												
<i>Sparganium angustifolium</i>					0.6	6.4		0.4	0.2								0.1	0.4	0.5		1.8	0.6			
<i>Sparganium emersum</i>							0.2																		
<i>Sphagnum</i> (aquatic indet.)				2.7	0.4	0.6	0.5	0.3				3.7			23.1	1.1	16.1	0.1	0.5	0.6	0.3	0.4	1		
<i>Spirodela polyrhiza</i>			1.4																						0.4
<i>Subularia aquatica</i>				1.4	<.1						0.8														
<i>Ulva (Enteromorpha) flexuosa</i>		0.2																							
<i>Utricularia minor</i>															0.3	0.3									
<i>Zannichellia palustris</i>		0.1																							1.4



### 5.1.1. Rare and Notable Species

Details of nationally threatened, rare and scarce species recorded during the survey are given in Table 5. Previous records for these species were extracted from the Botanical Society of the British Isles's Distribution Database (DDB).

Starry stonewort, *Nitellopsis obtusa*, a species listed as Vulnerable on the UK Red List (JNCC, 2014), was recorded at Llangorse Lake. This species has been identified from a number of new sites in recent years, suggesting that it is increasing, but this is only the second site in Wales.

Records of other species of local interest are given in Table 6. Most of these are previously well known at these sites except *Spirodela polyrhiza* at Llyn Rhos-ddu which may be new to Anglesey and *Hottonia palustris* at Hanmer Mere.

### 5.1.2. Invasive Plants

Details of invasive aquatic plants are given in Table 7. Invasive species are a particular issue at Tal-y-llyn (*Lagarosiphon major* and *Elodea nuttallii*), Llyn Rhos-ddu (*Elodea nuttallii* with some *Elodea canadensis*) and Llangorse Lake (*Elodea nuttallii*, *Elodea canadensis* and *Nymphoides peltata*).

## 5.2. Water Chemistry and Secchi Depth

The raw data for the depth profiles for temperature and dissolved oxygen are provided in the Data Archive Appendix. Each lake is included as a different tab/sheet within the Excel document. A graphical representation of the depth profile is included within the spreadsheets and presented in Figures 1 to 6. The depth of the lake at the point where the depth profile was taken is presented.

If collected, a full suite of *in-situ* water quality parameters are included in this spreadsheet and a Secchi depth.

Table 5. Locations of Nationally Threatened, Rare and Scarce Species Recorded

Species	Status	Site	Cover value (%)	DAFOR	Previous records	Comments
<i>Luronium natans</i>	Habitats Directive Annexes II, IV; GB Nationally Scarce; UKBAP Priority; W&C Act Schedule 8.	Egnant	10.83	FLA	Yes	
		Gynon	5.74	F	Yes	
		Teifi	2.70	F	Yes	Sectors 1 (SN780670), 2 (SN785675)
		Cerrigllwydion Isaf	2.24	OLF	Yes	
		Gwynllyn	0.87	O	Yes	Sectors 1 (SN948960), 3 (SN946690)
		Padarn	0.38	R	Yes	Sector 1 (SH582602)
		Tegid	0.98	RLO	Yes	Sector 1 (SH890311)
<i>Nitella gracilis</i>	UKBAP Priority; GB Red Data Book Vulnerable.	Gynon	0.14	R	Yes	Sector 1 (SN795645)
		Gwynllyn	0.36	R	Yes	Sector 2 (SN948689)
<i>Nitellopsis obtusa</i>	UKBAP Priority; GB Red Data Book Vulnerable.	Llangorse	0.47	R	No	Sector 4 (SO125266) in 0.75 to 1.5 m.
<i>Elatine hydropiper</i>	GB Nationally Scarce.	Llygeirian	2.46	OLF	Yes	
<i>Hydrocharis morsus-ranae</i>	GB Red Data Book Vulnerable.	Llygeirian	1.01	RLA	Yes	Sector 1 (SH347896). More frequent there than on recent surveys
<i>Limosella aquatica</i>	GB Nationally Scarce.	Tegid	0.05	R	Yes	Sector 1 (SH890311)
<i>Lycopodiella inundata</i>	UKBAP Priority; GB Nationally Scarce; GB Red Data Book Endangered.	Bodgynydd	-	R	No	Sector 3 (SH76225934 to SH76275941). Needs further survey and confirmation. Although known from nearby, this is apparently a new population.
<i>Callitriche truncata</i>	GB Nationally Scarce.	Maelog	1.17	O	Yes	

Table 6. Locally Rare Species Recorded

Species	Site	Cover value (%)	DAFOR	Previous records	Comments
<i>Butomus umbellatus</i>	Llangorse	0.14	R	Yes	
<i>Chara aspera</i>	Rhos-ddu	0.83	O	No	There are nearby records from Newborough Warren and other Anglesey Lakes.
<i>Chara contraria</i>	Llangorse	0.32	R	Yes	One previous record (1995).
<i>Hottonia palustris</i>	Hanmer	0.07	R	No	Sector 1 (SJ450388). There are other records in the area.
<i>Potamogeton lucens</i>	Llangorse	1.18	O	Yes	Key species for Habitats Directive Eutrophic Lake feature
<i>Potamogeton praelongus</i>	Llanbwchllyn	0.61	O	Yes	One of only three extant Welsh localities for this rare species.
<i>Potamogeton trichoides</i>	Hanmer	1.25	OLF	Yes	One previous record (2009). Likely to be under-recorded.
<i>Spirodela polyrhiza</i>	Rhos-ddu	1.40	R	No	Only the second record for Anglesey.
	Llangorse	0.35	R	Yes	

Table 7. Details of invasive aquatic species recorded during the survey.

Species	Site	Cover value (%)	DAFOR	Previous records	Comments
<i>Lagarosiphon major</i>	Tal-y-llyn	52.60	ALD	Yes	Recorded in previous Leafpacs survey.
<i>Elodea nuttallii</i>	Llangorse	16.90	A	Yes	First recorded mid 1990s.
	Padarn	0.65	O	Yes	First recorded 1994
	Rhos-ddu	53.30	ALD	Yes	First recorded 1994
	Tal-y-llyn	3.98	O	Yes	Recorded in previous Leafpacs survey.
	Tegid	0.47	R	Yes	Recorded in previous Leafpacs survey.
<i>Elodea canadensis</i>	Hanmer	9.64	FLA	Yes	Recorded 2011.
	Llangorse	0.83	O	Yes	Recorded since the 19 <sup>th</sup> century. Now much less frequent than <i>E.nuttallii</i>
	Llygeirian	15.73	FLA	Yes	Recorded since 1964.
	Rhos-ddu	1.45	O	Yes	Recorded in 1996 and probably present well before. Now much less frequent than <i>E.nuttallii</i>
<i>Nymphoides peltata</i>	Llangorse	3.20	O	Yes	Established in the lake since at least 1936.

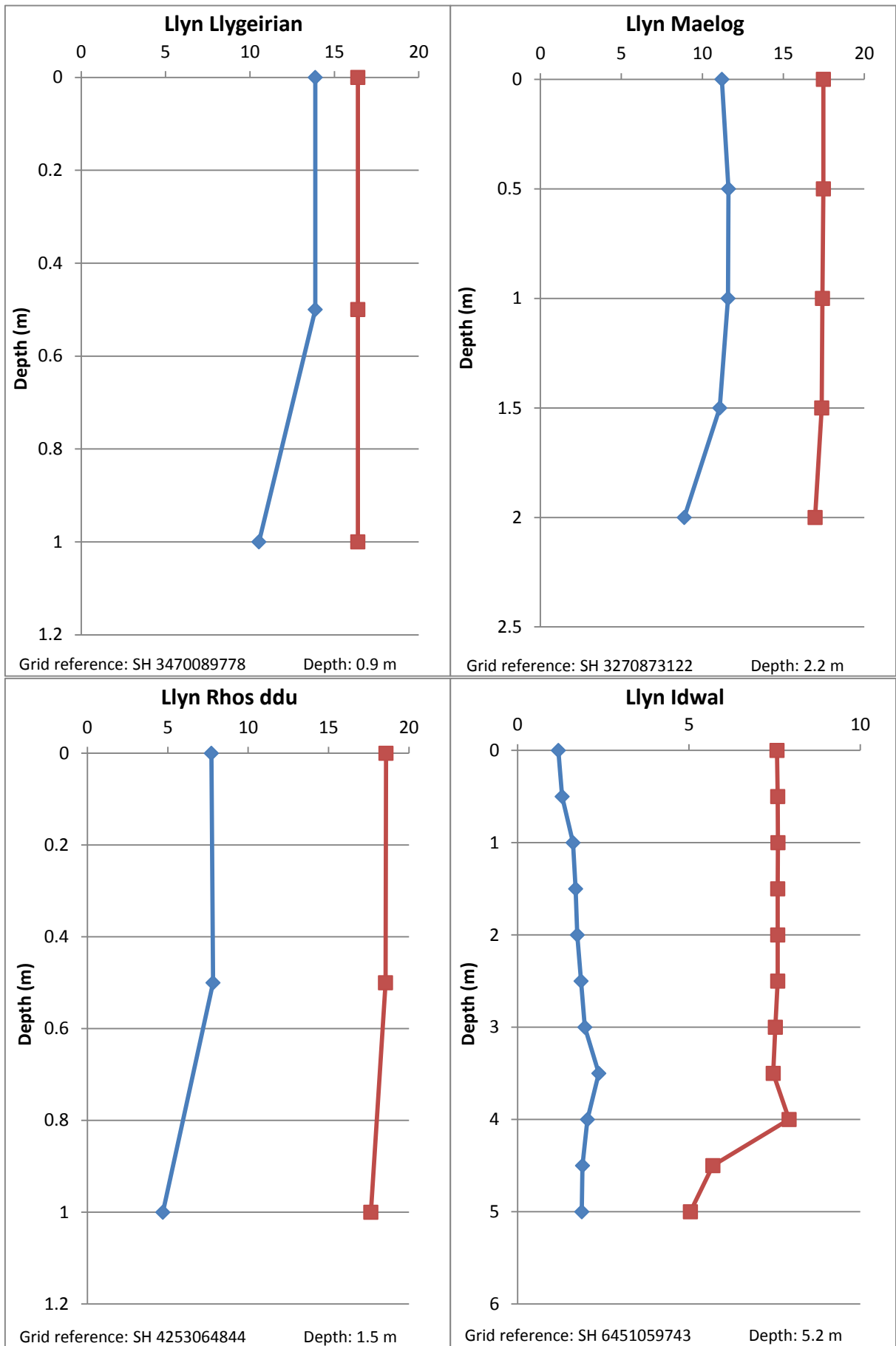


Figure 1. Depth profiles for temperature °C (red) and dissolved oxygen mg/l (blue)

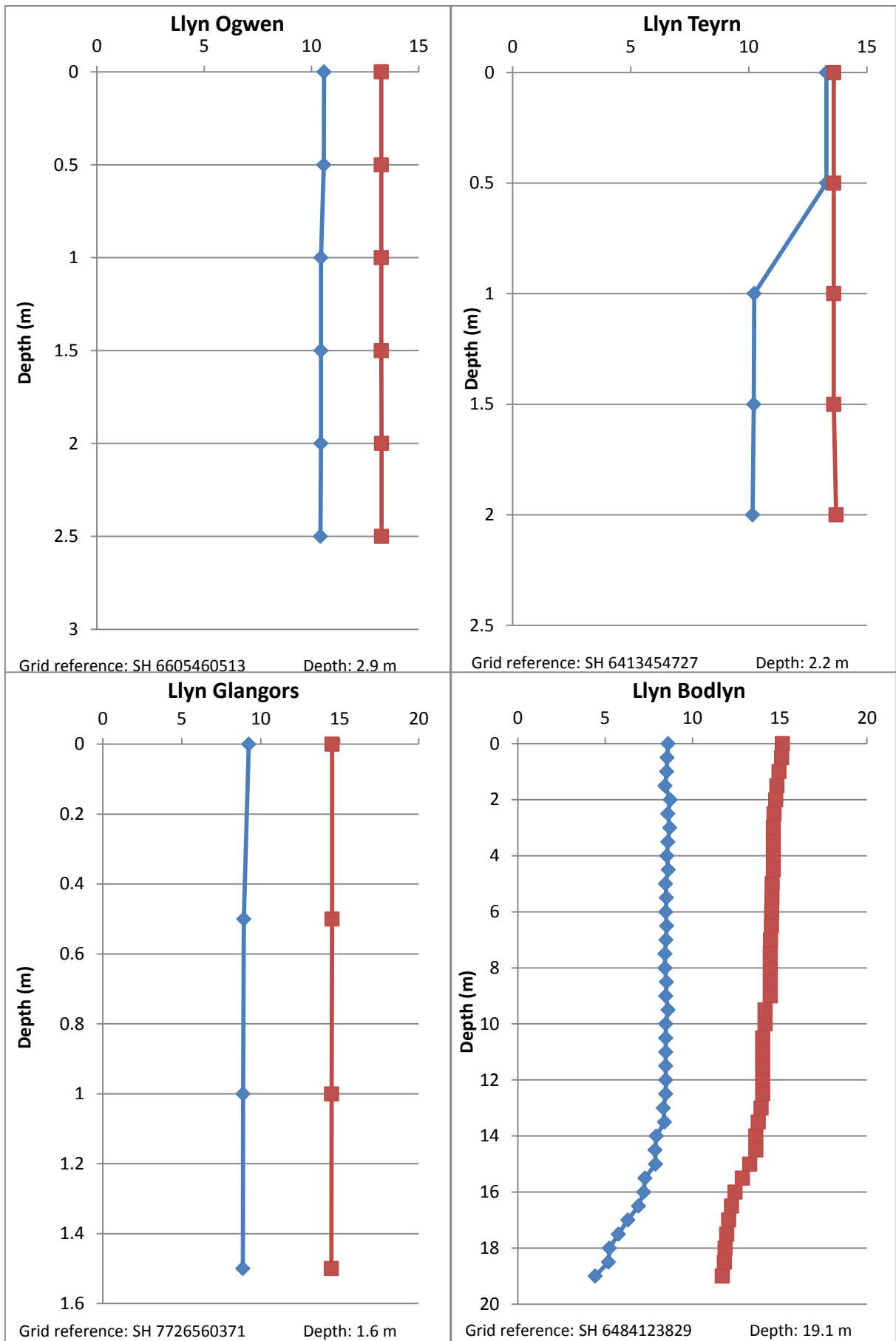
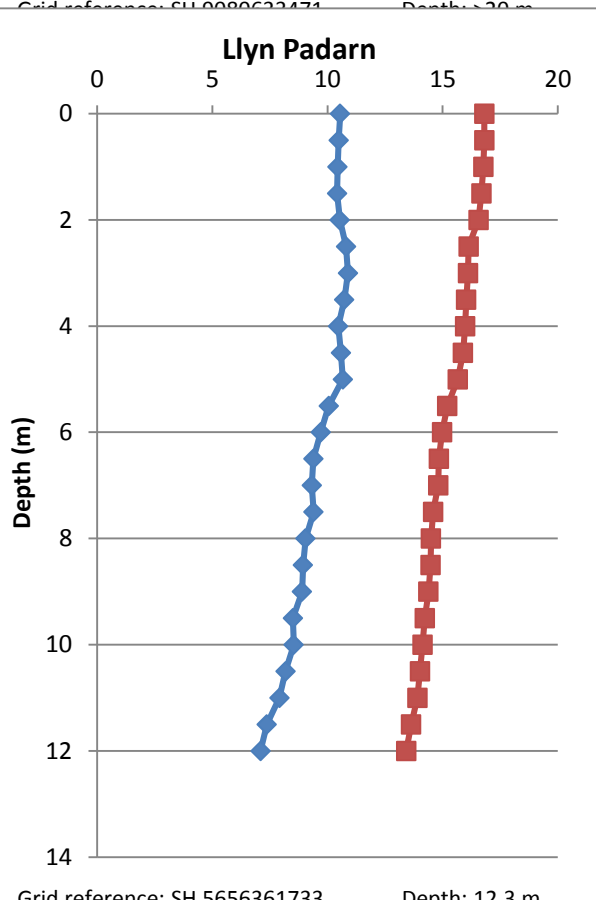
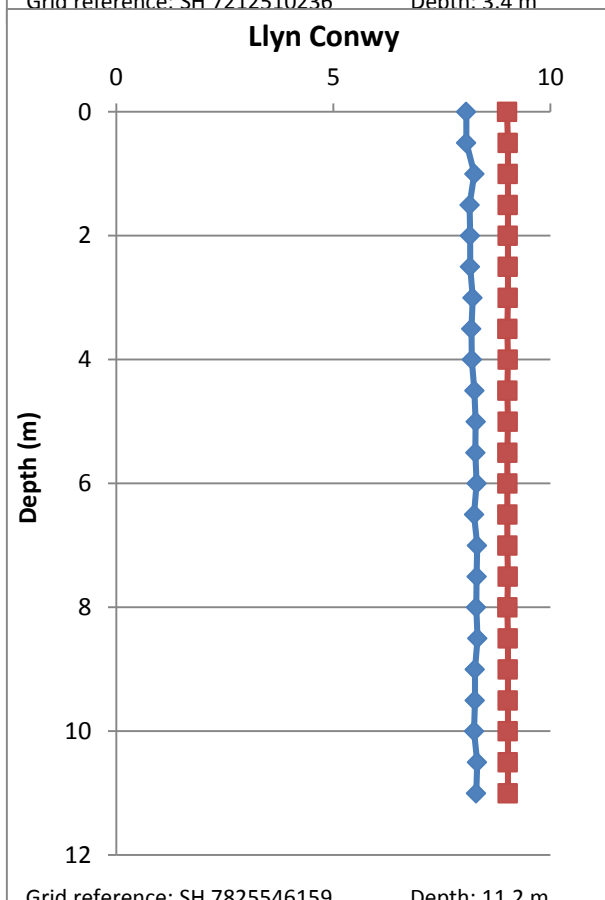
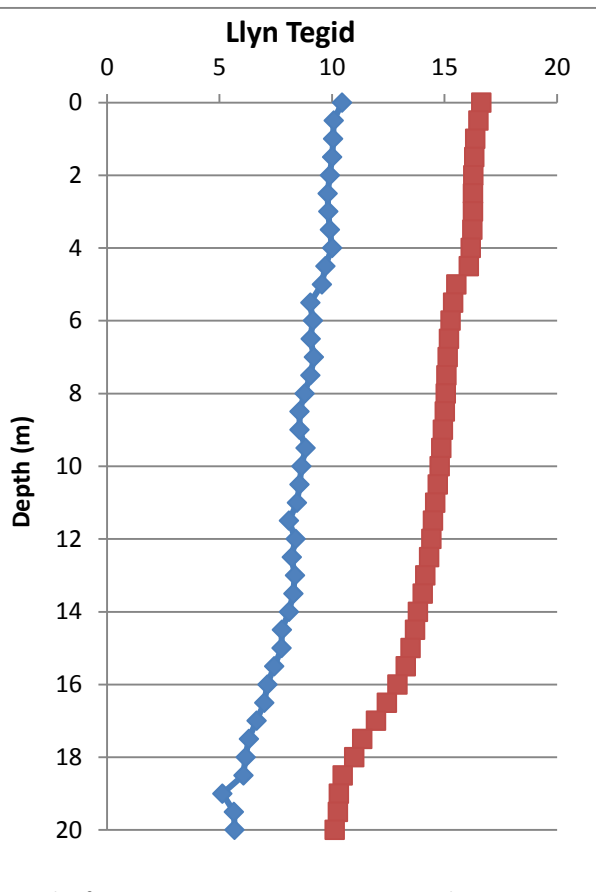
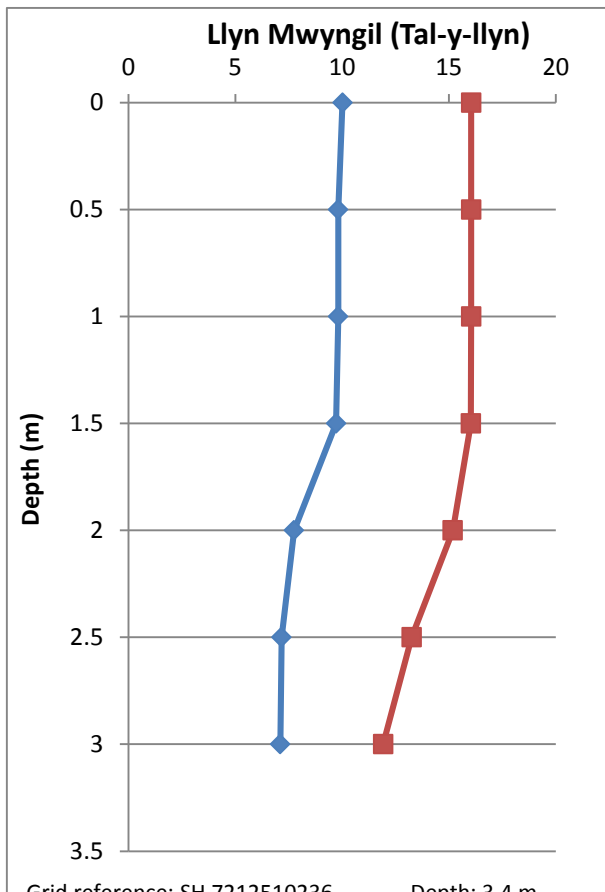
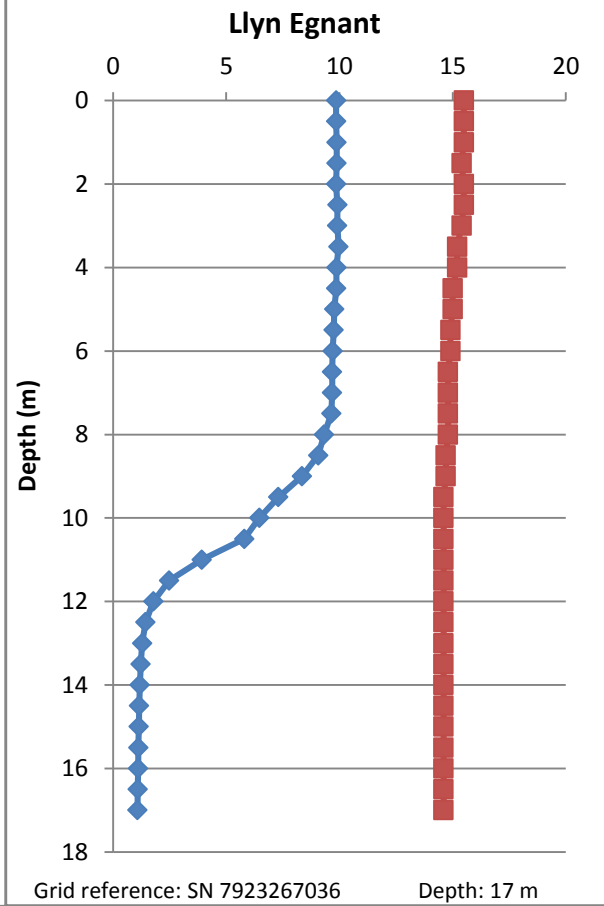
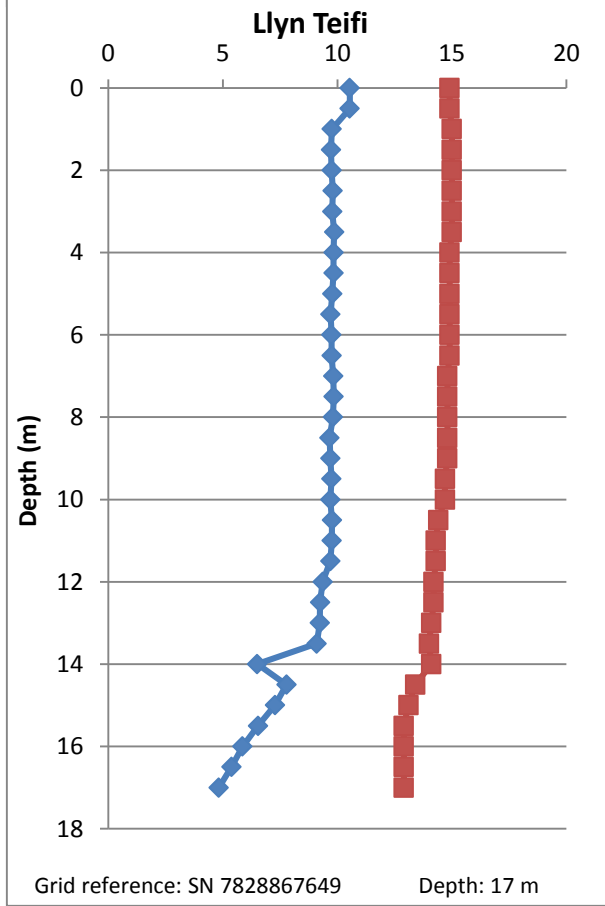
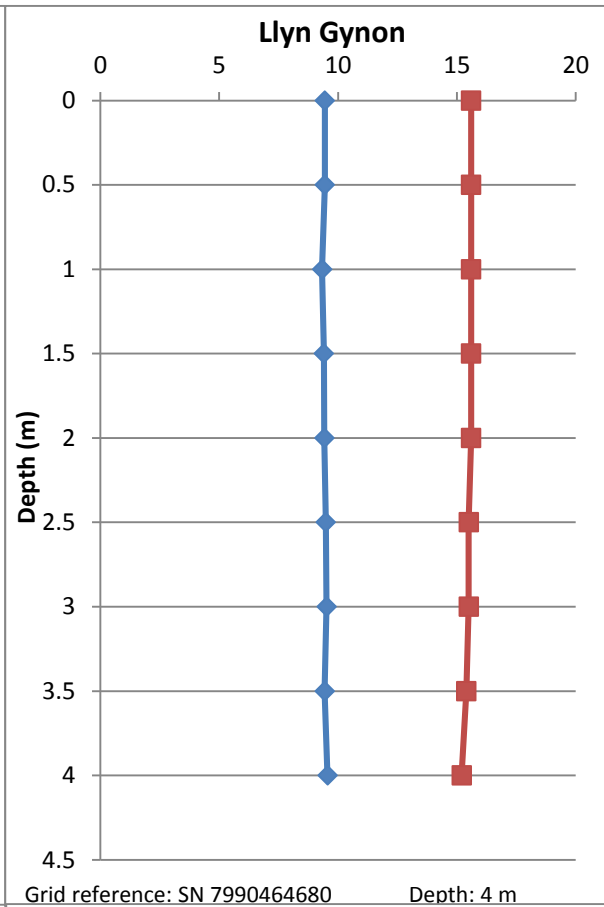
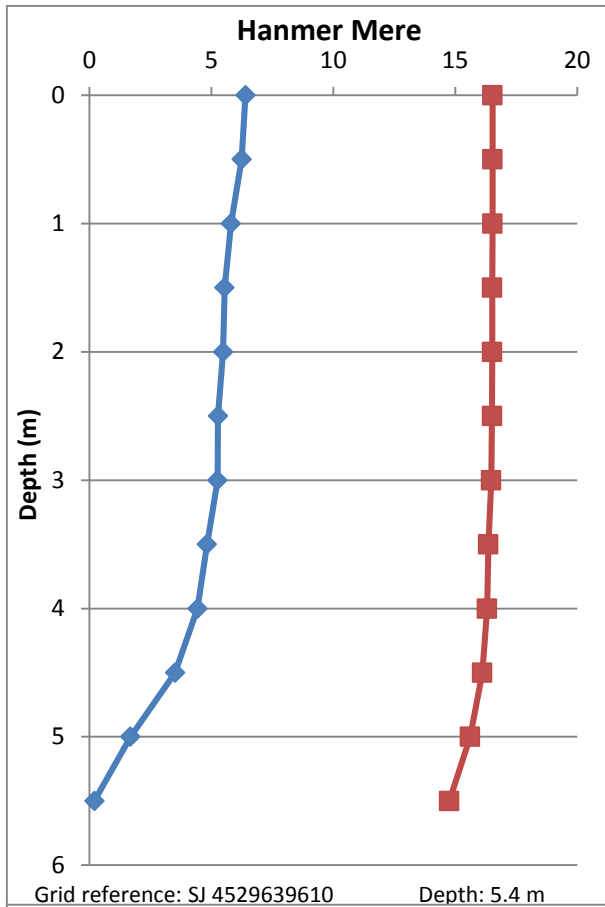
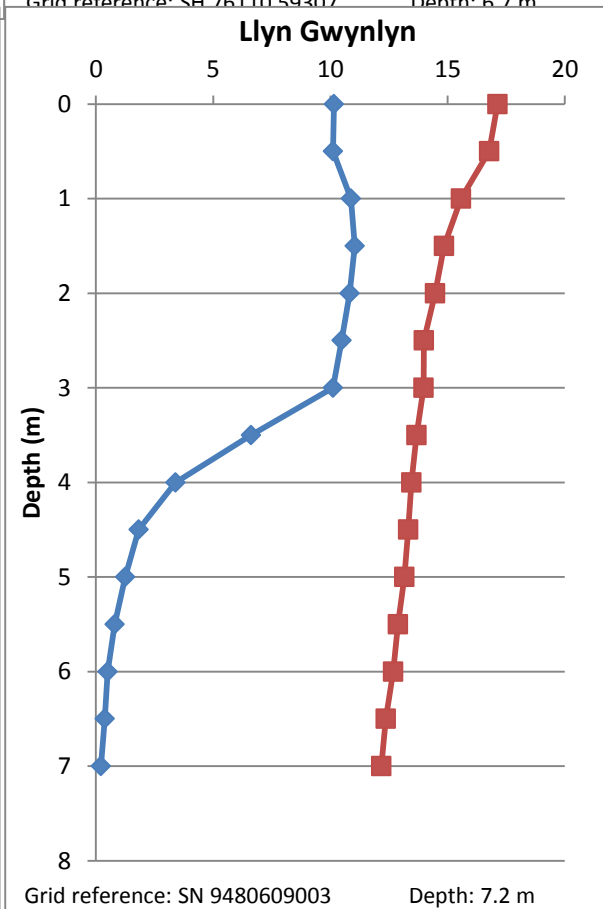
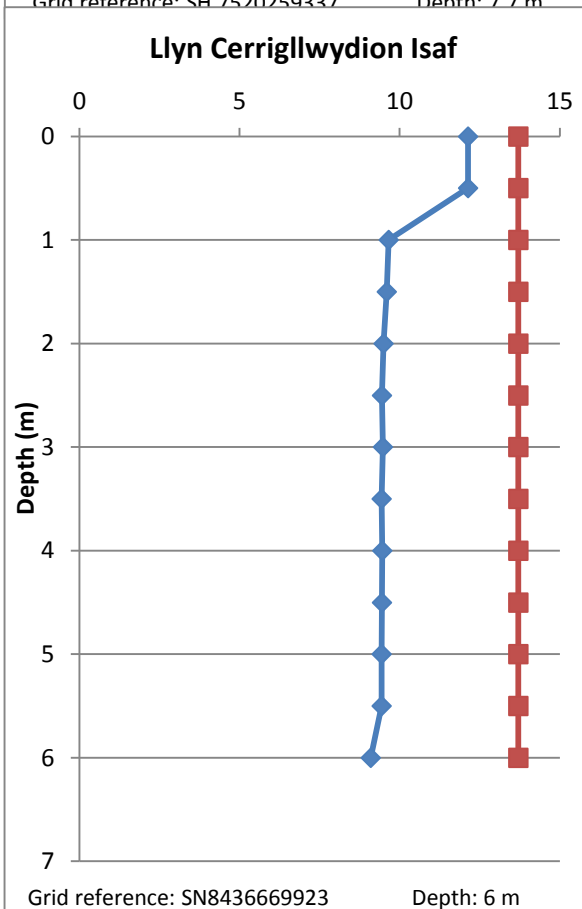
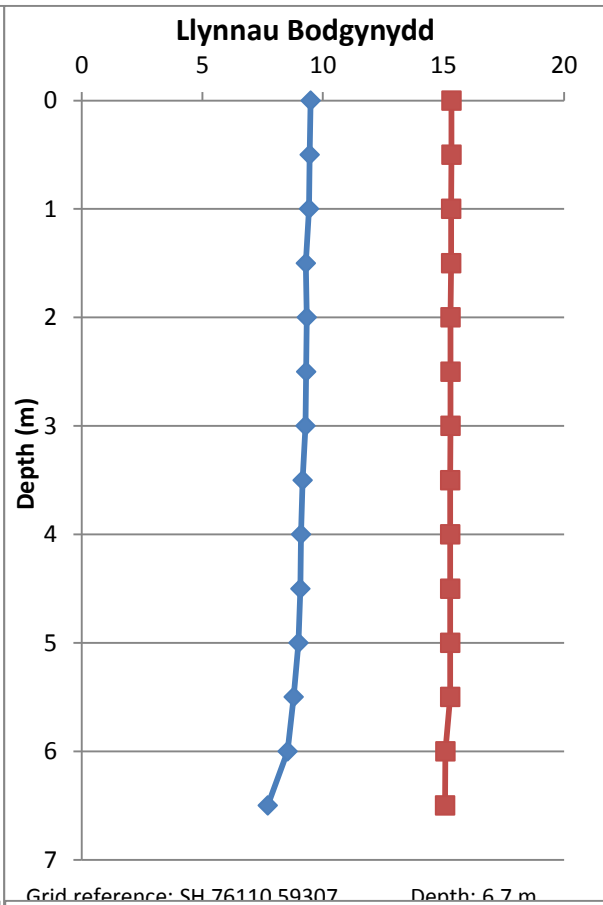
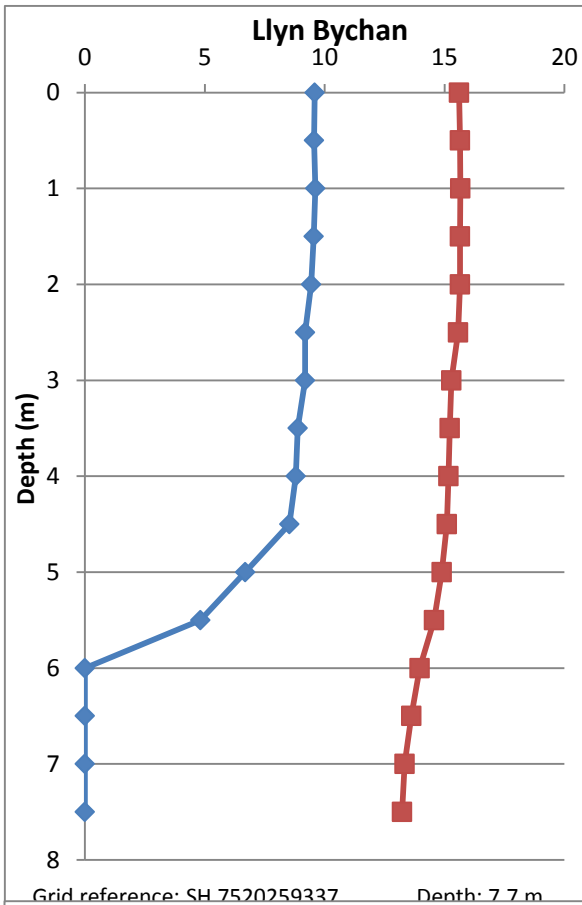


Figure 2. Depth profiles for temperature °C (red) and dissolved oxygen mg/l (blue)









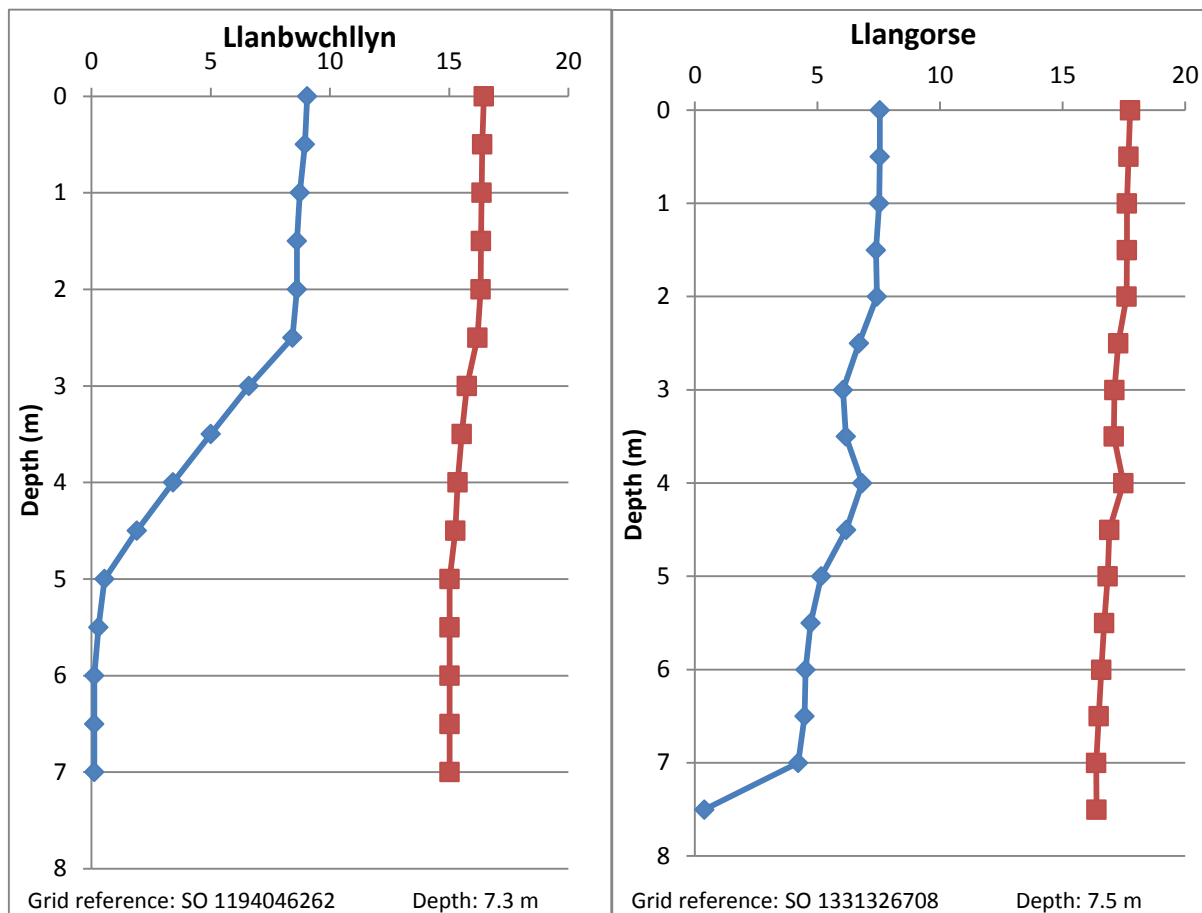


Figure 6. Depth profiles for temperature °C (red) and dissolved oxygen mg/l (blue)

### 5.3. Bathymetry

Raw XYZ bathymetric data and the GIS shapefiles including depth mapping, are provided in the Data Archive Appendix. Mapped outputs from the GIS are presented in Figures 7-12.

Table 8. Summary bathymetry metrics for the lakes.

Lake	Volume (m <sup>3</sup> )	Max. Depth (m)	Mean Depth (m)
Llyn Isaf	12,657	2.00	0.85
Llynnau Bodgynydd	334,389	15.48	4.37
Llyn Elgiau	51,5062	6.12	1.82
Llyn Glangors	38338	2.49	1.32
Llyn Llygeirian (large)	97,483	1.47	0.83
Llyn Llygeirian (small)	12,559	1.76	0.86
Llyn Teifi	1,101,229	14.90	4.29
Llyn Teryn	30,039	1.48	4.81

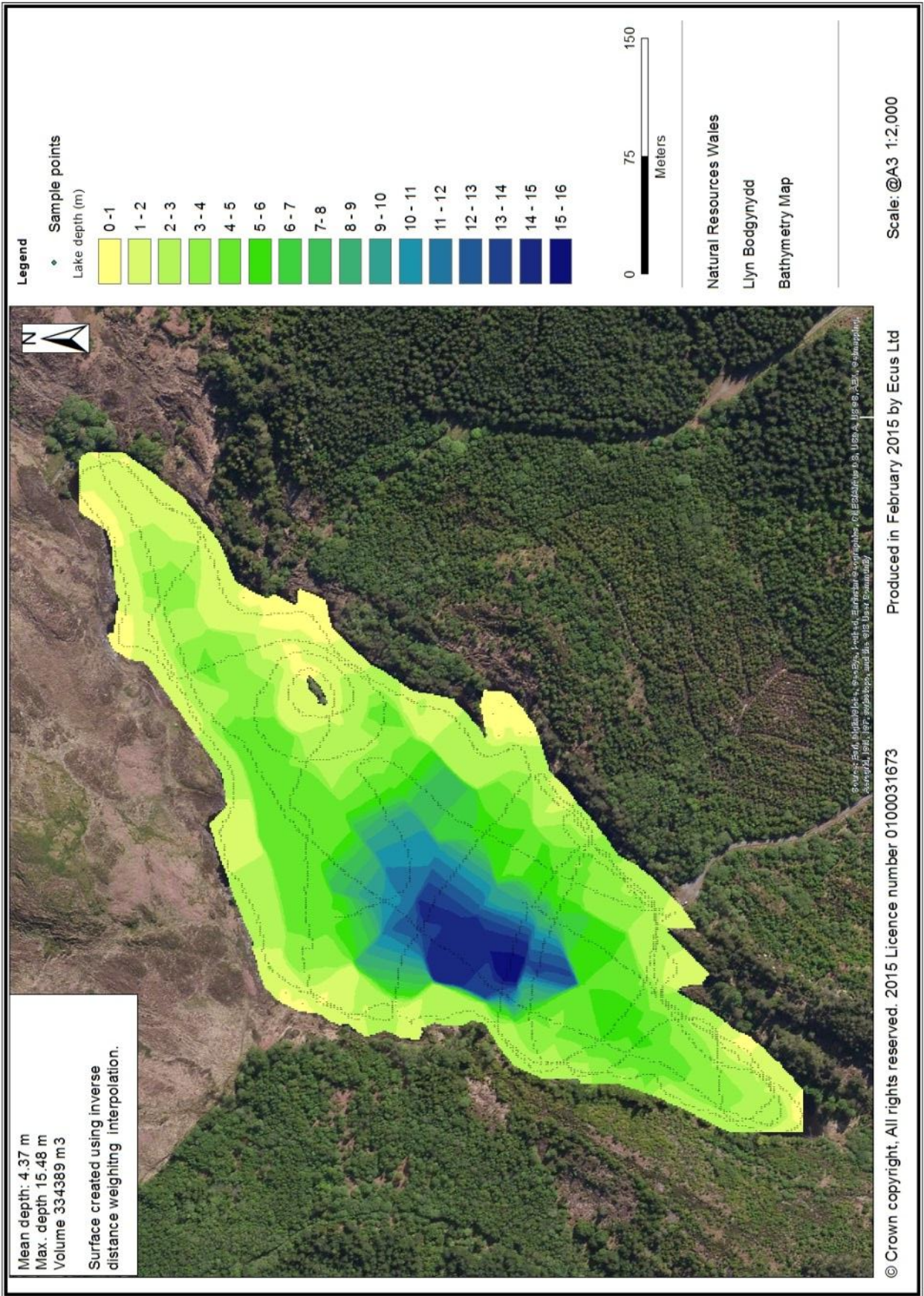


Figure 7. Bathymetry map for Llynau Bodgynydd



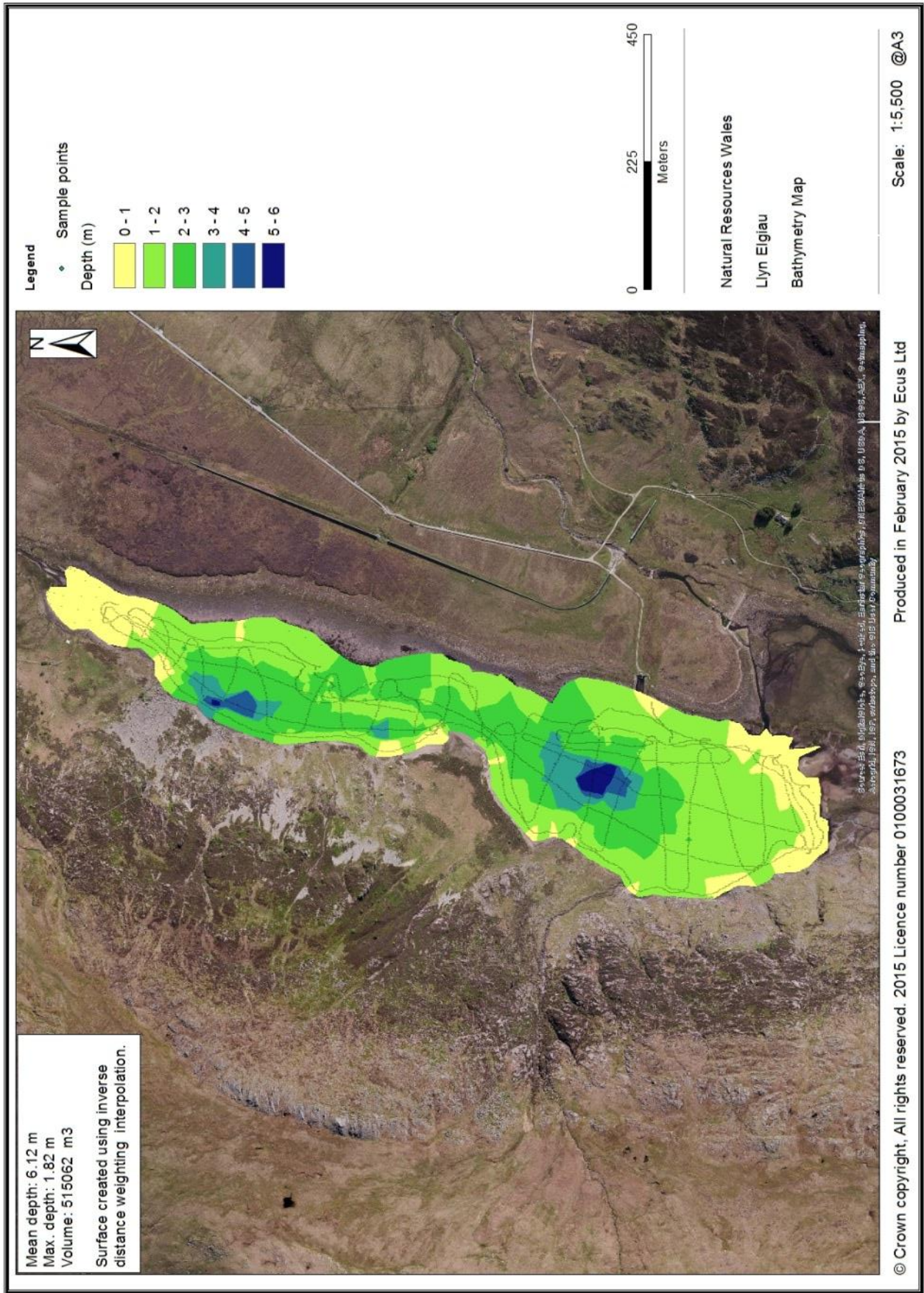


Figure 8. Bathymetry map for Llyn Eigiau



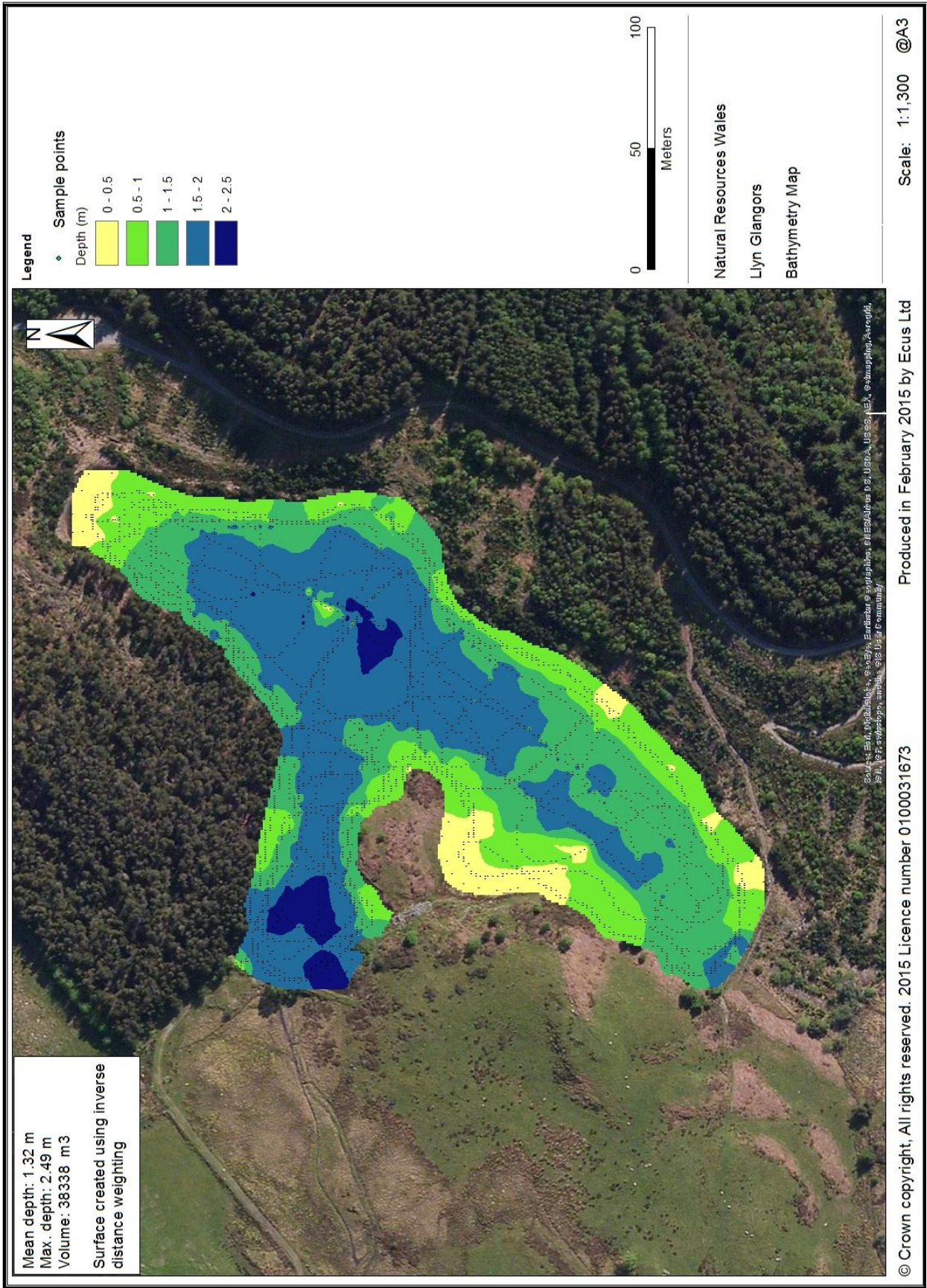


Figure 9. Bathymetry map for Llyn Glangors



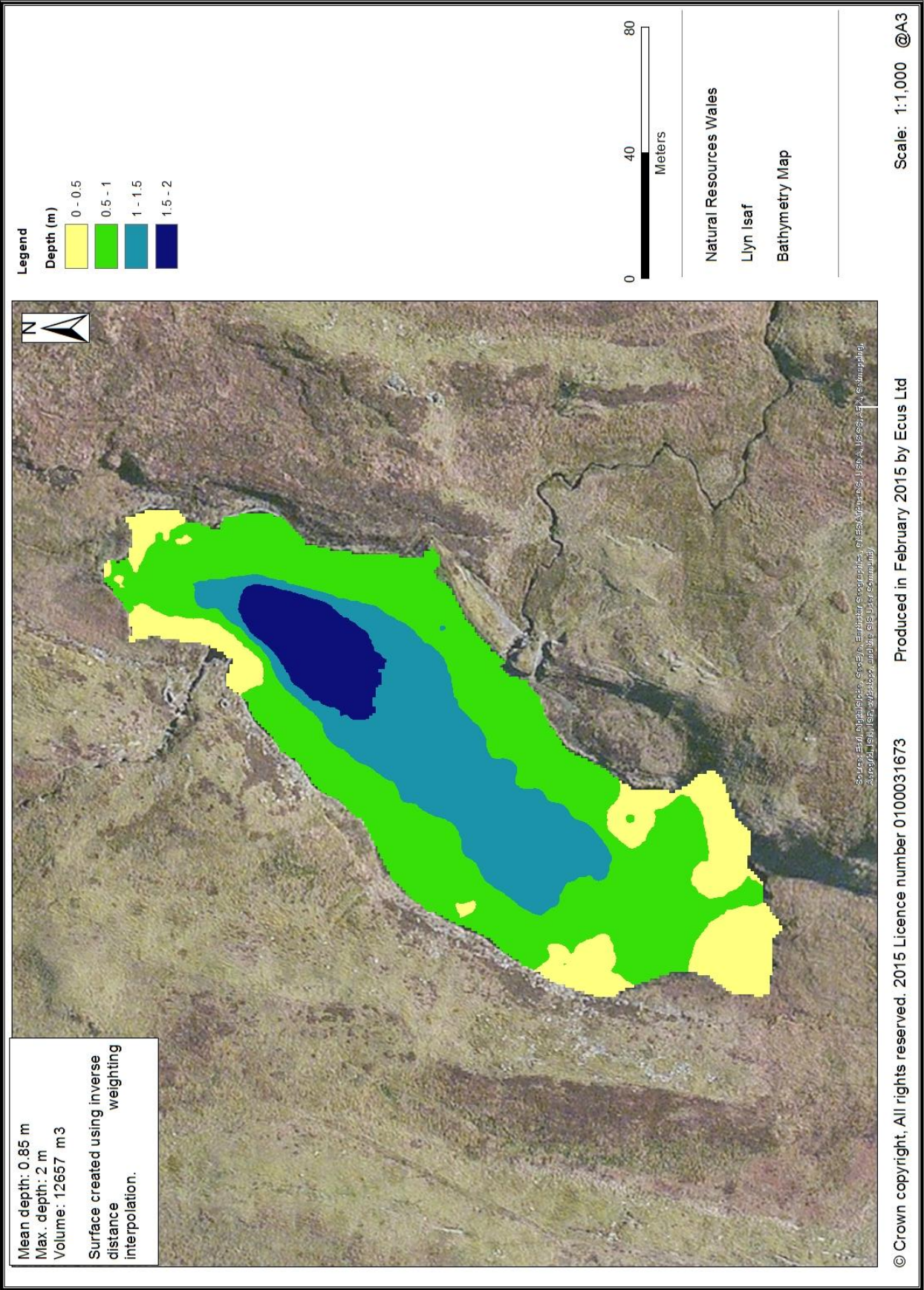


Figure 10. Bathymetry map for Llyn Isaf



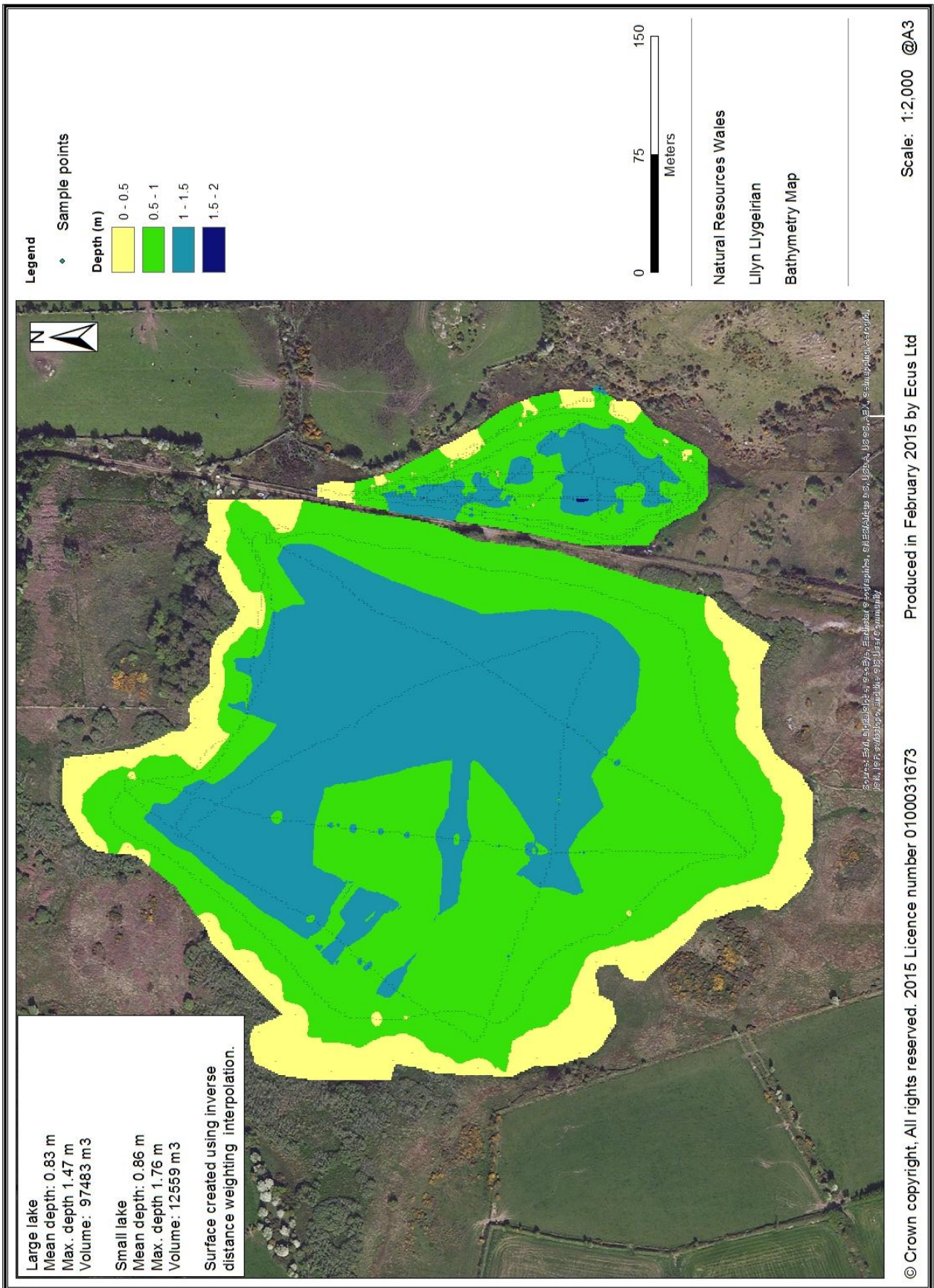


Figure 11. Bathymetry map for Llyn Llygeirian



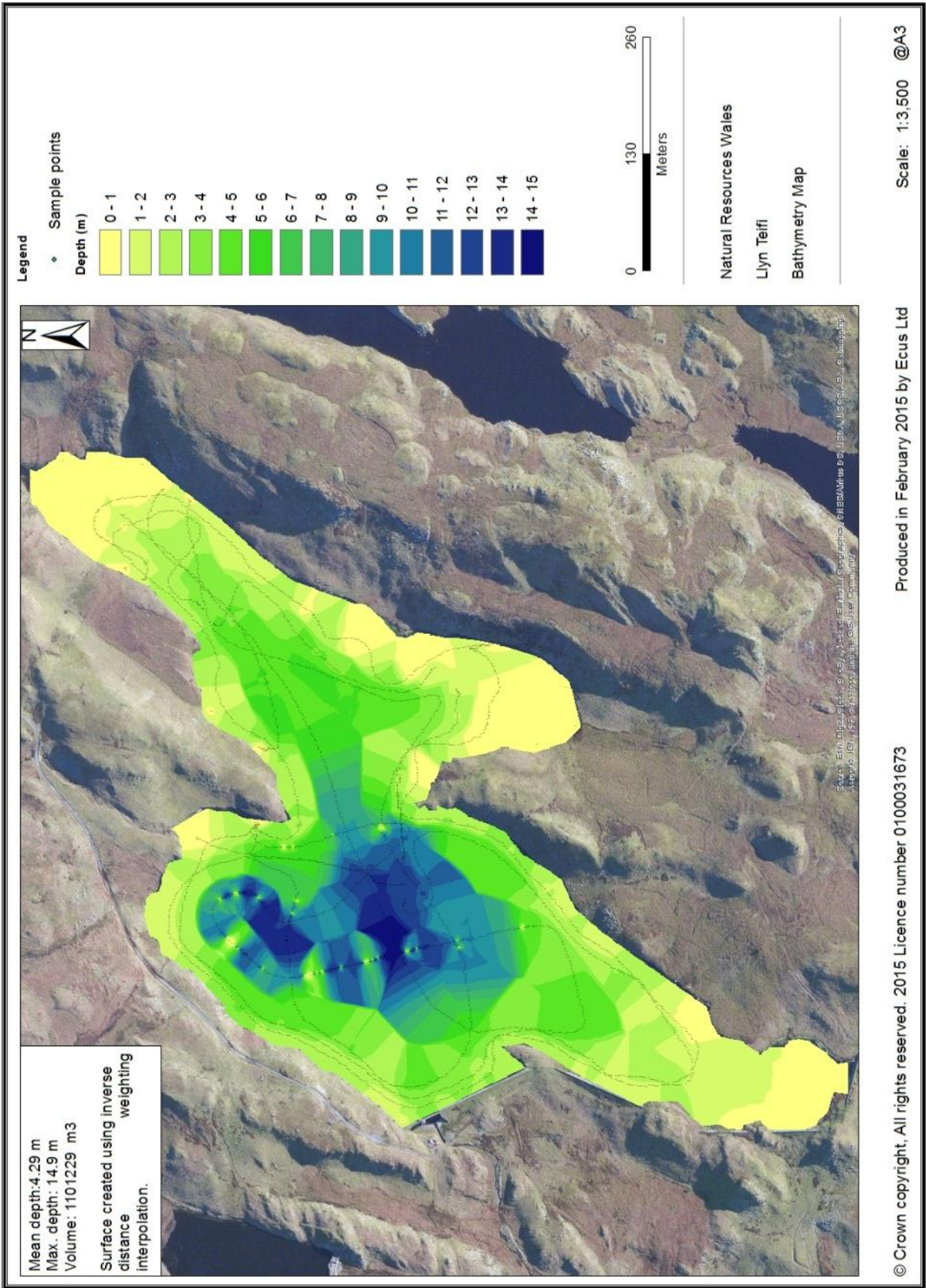


Figure 11. Bathymetry map for Llyn Teifi



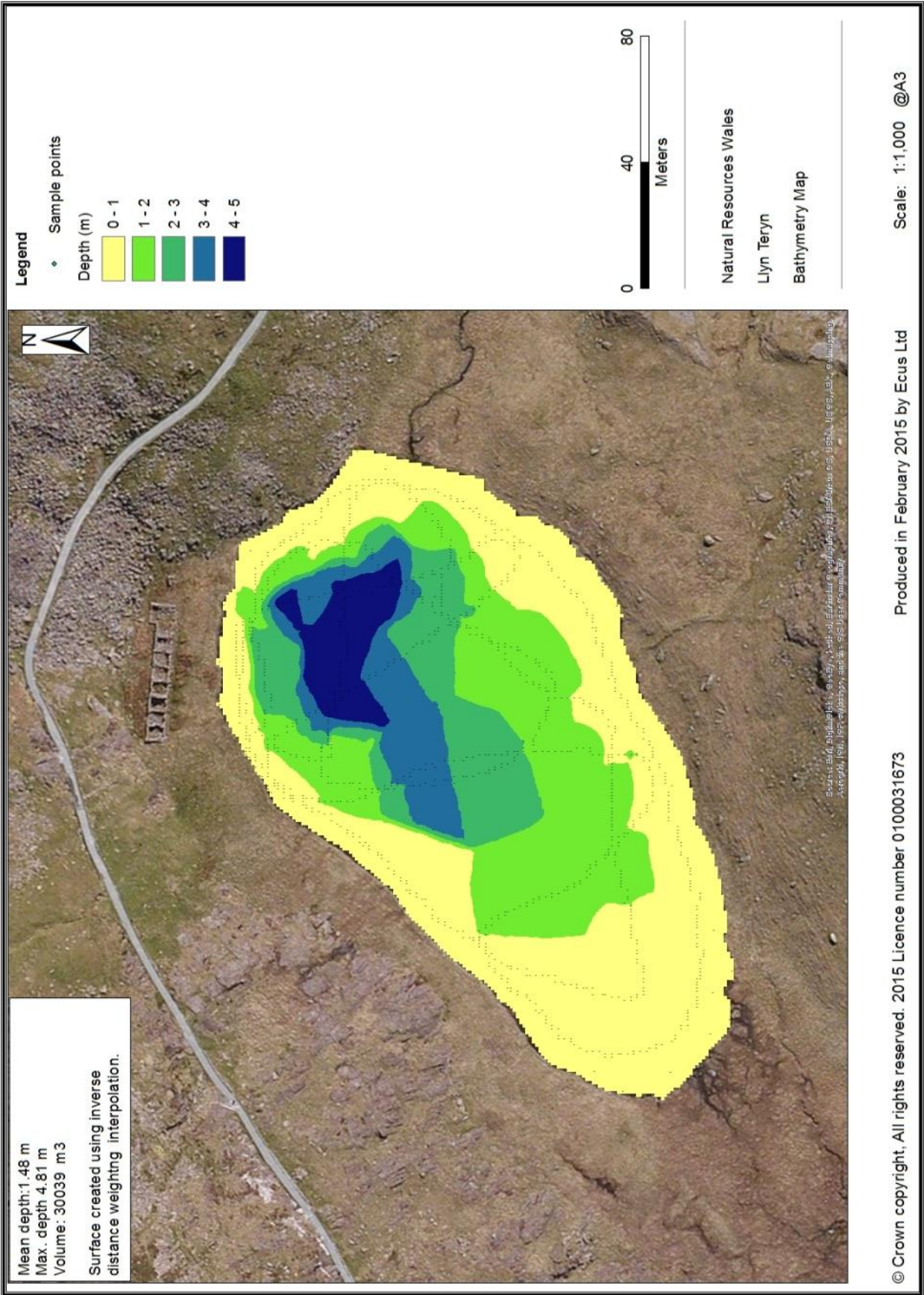


Figure 12. Bathymetry map for Llyn Teryn

#### 5.4. Considerations for Condition Assessment (SSSI Lakes)

Detailed data analysis to assess site condition was beyond the remit of this contract. However, a record of potential pressures on site condition and site management requirements was made on site and is provided in Table 9.

Table 9. Notable Pressures and Management Requirements

Site	Comments
Llyn Llygeirian	Water greyish and turbid. Plant assemblage consists of a number of nutrient tolerant species. Site is surrounded by farmland.
Llyn Maelog	Water green-brown and turbid potentially due to algal bloom, with the potential to impact upon vegetation.
Llyn Rhos-ddu	Dense <i>Elodea nuttallii</i> and water turbid.
Llyn Idwal	Factors such as recreational pressure or exposure may be impacting shoreline vegetation on northern shore.
Llyn Ogwen	No particular issues of concern noted.
Llyn Teyrn	No particular issues of concern noted.
Llyn Glangors	Surrounded by coniferous forestry on 3 sides with needle drop into the lake and siltation from surrounding land use
Llyn Bodlyn	Water supply reservoir but appeared to be limited water extraction, Significant algal cover on two of the wader sectors.
Llyn Mwyngil (Tal-y-Llyn Lake)	Abundant <i>Lagarosiphon major</i> .
Llyn Tegid	Slight blue-green algal bloom, suggesting nutrient issues. Surrounded by farmland and possible urban inputs.
Llyn Eigiau	RWE npower reservoir, resulting in strong and irregular water level fluctuations.
Llyn Conwy	Water supply reservoir but appeared to be limited water extraction.
Llyn Padarn	Low levels of <i>Elodea nuttallii</i> . Potential, but uncertain, impact caused by recreation (water sports).
Hanmer Mere	Nutrient issues causing algal blooms over submerged vegetation. Also significant <i>Elodea canadensis</i> .
Llyn Gwngu	<i>Utricularia</i> under-recorded due to late season of survey. However, an area of <i>Littorelletea</i> was discovered (not found on previous survey) and a sector added to survey to cover this
Llyn Gynon	No particular issues of concern noted.
Llyn Isaf	No particular issues of concern noted.
Llyn Teifi	Welsh Water reservoir. Otherwise no particular issues of concern noted.
Llyn Egnant	Welsh Water reservoir. Local sheep erosion.
Llyn Bychan	No particular issues of concern noted.

Llynnau Bodgynydd	No particular issues of concern noted.
Llyn Cerrigllwydion Isaf	Significant algae present but no obvious cause.
Gwynllyn	Local sheep erosion. Adjacent fields to the south are limed.
Llanbwchllyn Lake	Water turbid due to algal bloom.
Llangorse Lake	Weak algal bloom. Significant <i>Nymphoides peltata</i> and <i>Elodea</i> spp. <i>Nitellopsis obtusa</i> newly recorded. Lake has heavy recreation use.

## 6. References

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## 7. Appendix 1. Macrophyte Sector Maps



## 8. Appendix 2. Macrophyte Sector Grid References

Name	Transect	NGR	Bearing	Distance (m)
Bodgynydd	T1 Boat start	SH 76009 59179	216	165
Bodgynydd	T1 Boat end	SH 75913 59045		
Bodgynydd	T2 Boat start	SH 76051 59370	291	48
Bodgynydd	T2 Boat end	SH 76006 59387		
Bodgynydd	T3 Boat start	SH 76199 59404	148	55
Bodgynydd	T3 Boat end	SH 76228 59357		
Bodgynydd	T4 Boat start	SH 76247 59461	58	52
Bodgynydd	T4 Boat end	SH 76291 59488		
Bodgynydd	T1 Start	SH 75899 59033		
Bodgynydd	T1 End	SH 75960 59073		
Bodgynydd	T2 Start	SH 75981 59366		
Bodgynydd	T2 End	SH 76071 59418		
Bodgynydd	T3 Start	SH 76224 59341		
Bodgynydd	T3 End	SH 76275 59415		
Bodgynydd	T4 Start	SH 76321 59510		
Bodgynydd	T4 End	SH 76219 59489		
Bodlyn	T1 Boat start	SH 64698 24218	142	121
Bodlyn	T1 Boat end	SH 64772 24122		
Bodlyn	T2 Boat start	SH 64883 24109	102	98
Bodlyn	T2 Boat end	SH 64979 24088		
Bodlyn	T3 Boat start	SH 64810 23715	304	22
Bodlyn	T3 Boat end	SH 64792 23727		
Bodlyn	T4 Boat start	SH 64690 23905	111	19
Bodlyn	T4 Boat end	SH 64708 23898		
Bodlyn	T1 Start	SH 64676 24180		
Bodlyn	T1 End	SH 64704 24264		
Bodlyn	T2 Start	SH 64928 24167		
Bodlyn	T2 End	SH 64965 24094		
Bodlyn	T3 Start	SH 64859 23683		
Bodlyn	T3 End	SH 64758 23701		
Bodlyn	T4 Start	SH 64668 23868		
Bodlyn	T4 End	SH 64695 23960		
Bychan	T2 Boat start	SH 75160 59286	93	51
Bychan	T2 Boat end	SH 75211 59283		
Bychan	T3 Boat start	SH 75215 59362	298	47
Bychan	T3 Boat end	SH 75173 59384		
Bychan	T2 Start	SH 75238 59316		
Bychan	T2 End	SH 75164 59248		
Bychan	T3 Start	SH 75214 59406		
Bychan	T3 End	SH 75147 59335		
Cerrigllwydion Isaf	T1 Boat start	SN 84327 69901	176	56
Cerrigllwydion Isaf	T1 Boat end	SN 84331 69845		

Name	Transect	NGR	Bearing	Distance (m)
Cerrigllwydion Isaf	T2 Boat start	SN 84361 70020	13	44
Cerrigllwydion Isaf	T2 Boat end	SN 84371 70063		
Cerrigllwydion Isaf	T3 Boat start	SN 84437 69975	234	88
Cerrigllwydion Isaf	T3 Boat end	SN 84366 69923		
Cerrigllwydion Isaf	T1 Start	SN 84257 69823		
Cerrigllwydion Isaf	T1 End	SN 84345 69819		
Cerrigllwydion Isaf	T2 Start	SN 84316 70024		
Cerrigllwydion Isaf	T2 End	SN 84374 70092		
Cerrigllwydion Isaf	T3 Start	SN 84467 70015		
Cerrigllwydion Isaf	T3 End	SN 84438 69940		
Conwy	T1 Boat start	SH 77763 46019	183	64
Conwy	T1 Boat end	SH 77760 45955		
Conwy	T2 Boat start	SH 77903 46521	54	17
Conwy	T2 Boat end	SH 77917 46531		
Conwy	T3 Boat start	SH 78361 46210	104	45
Conwy	T3 Boat end	SH 78405 46199		
Conwy	T4 Boat start	SH 78183 45891	105	30
Conwy	T4 Boat end	SH 78212 45883		
Conwy	T1 Start	SH 77784 45942		
Conwy	T1 End	SH 77711 45985		
Conwy	T2 Start	SH 77857 46536		
Conwy	T2 End	SH 77937 46532		
Conwy	T3 Start	SH 78429 46240		
Conwy	T3 End	SH 78392 46153		
Conwy	T4 Start	SH 78226 45921		
Conwy	T4 End	SH 78211 45835		
Eigau	T1 Start	SH 72067 64876		
Eigau	T1 End	SH 72043 64796		
Eigau	T2 Start	SH 72247 65940		
Eigau	T2 End	SH 72195 65907		
Egnant	T1 Boat start	SN 79145 66892	305	58
Egnant	T1 Boat end	SN 79097 66925		
Egnant	T2 Boat start	SN 79257 67430	132	13
Egnant	T2 Boat end	SN 79267 67421		
Egnant	T3 Boat start	SN 79370 67204	103	35
Egnant	T3 Boat end	SN 79404 67196		
Egnant	T4 Boat start	SN 79254 66844	353	193
Egnant	T4 Boat end	SN 79232 67036		
Egnant	T1 Start	SN 79097 66926		
Egnant	T1 End	SN 79102 66834		
Egnant	T2 Start	SN 79187 67486		
Egnant	T2 End	SN 79271 67486		
Egnant	T3 Start	SN 79419 67245		
Egnant	T3 End	SN 79389 67155		



Name	Transect	NGR	Bearing	Distance (m)
Egnant	T4 Start	SN 79284 66853		
Egnant	T4 End	SN 79232 66799		
Glangors	T1 Boat start	SH 77299 60447	273	126
Glangors	T1 Boat end	SH 77173 60454		
Glangors	T2 Boat start	SH 77265 60371	197	75
Glangors	T2 Boat end	SH 77243 60299		
Glangors	T3 Boat start	SH 77320 60480	117	44
Glangors	T3 Boat end	SH 77359 60460		
Glangors	T1 Start	SH 77204 60430		
Glangors	T1 End	SH 77194 60483		
Glangors	T2 Start	SH 77196 60273		
Glangors	T2 End	SH 77276 60321		
Glangors	T3 Start	SH 77367 60502		
Glangors	T3 End	SH 77360 60417		
Gwngu	T1 Start	SN 83918 72848		
Gwngu	T1 End	SN 83799 72888		
Gwngu	T2 Start	SN 83892 73020		
Gwngu	T2 End	SN 83973 72979		
Gwngu	T3 Start	SN 83978 72973		
Gwngu	T3 End	SN 83999 72883		
Gwynllyn	T1 Boat end	SN 94687 69073	307	10
Gwynllyn	T1 Boat start	SN 94679 69079		
Gwynllyn	T2 Boat end	SN 94802 68945	204	20
Gwynllyn	T2 Boat start	SN 94794 68927		
Gwynllyn	T3 Boat end	SN 94833 69003	75	28
Gwynllyn	T3 Boat start	SN 94860 69010		
Gwynllyn	T1 Start	SN 94738 69108		
Gwynllyn	T1 End	SN 94647 69044		
Gwynllyn	T2 Start	SN 94749 68943		
Gwynllyn	T2 End	SN 94850 68918		
Gwynllyn	T3 Start	SN 94892 68953		
Gwynllyn	T3 End	SN 94819 69039		
Gynon	T1 Boat start	SN 79591 64540	55	90
Gynon	T1 Boat end	SN 79664 64592		
Gynon	T2 Boat start	SN 80001 64874	215	218
Gynon	T2 Boat end	SN 79877 64695		
Gynon	T3 Boat start	SN 80118 64573	60	270
Gynon	T3 Boat end	SN 80351 64710		
Gynon	T4 Boat start	SN 80114 64399	277	39
Gynon	T4 Boat end	SN 80075 64404		
Gynon	T1 Start	SN 79588 64548		
Gynon	T1 End	SN 79659 64493		
Gynon	T2 Start	SN 79951 64942		
Gynon	T2 End	SN 80020 64888		

Name	Transect	NGR	Bearing	Distance (m)
Gynon	T3 Start	SN 80332 64803		
Gynon	T3 End	SN 80371 64742		
Gynon	T4 Start	SN 80064 64374		
Gynon	T4 End	SN 80114 64398		
Hanmer Mere	T1 Boat start	SJ 45187 39001	207	195
Hanmer Mere	T1 Boat end	SJ 45099 38827		
Hanmer Mere	T2 Boat end	SJ 45321 39076	318	48
Hanmer Mere	T2 Boat start	SJ 45289 39112		
Hanmer Mere	T3 Boat end	SJ 45209 39244	101	46
Hanmer Mere	T3 Boat start	SJ 45254 39235		
Hanmer Mere	T4 Boat end	SJ 45296 39610	129	134
Hanmer Mere	T4 Boat start	SJ 45401 39526		
Hanmer Mere	T1 Start	SJ 45078 38812		
Hanmer Mere	T1 End	SJ 45123 38747		
Hanmer Mere	T2 Start	SJ 45340 39129		
Hanmer Mere	T2 End	SJ 45311 39039		
Hanmer Mere	T3 Start	SJ 45187 39201		
Hanmer Mere	T3 End	SJ 45222 39287		
Hanmer Mere	T4 Start	SJ 45391 39615		
Hanmer Mere	T4 End	SJ 45256 39604		
Idwal	T1 Boat start	SH 64453 59782	217	79
Idwal	T1 Boat end	SH 64406 59719		
Idwal	T2 Boat start	SH 64390 59219	69	60
Idwal	T2 Boat end	SH 64446 59240		
Idwal	T4 Boat start	SH 64562 59779	18	82
Idwal	T4 Boat end	SH 64587 59857		
Idwal	T1 Start	SH 64403 59739		
Idwal	T1 End	SH 64439 59615		
Idwal	T2 Start	SH 64444 59256		
Idwal	T2 End	SH 64429 59175		
Idwal	T4 Start	SH 64615 59858		
Idwal	T4 End	SH 64539 59898		
Isaf	T1 Boat start	SN 80279 75768	277	26
Isaf	T1 Boat end	SN 80253 75771		
Isaf	T2 Boat start	SN 80222 75692	219	59
Isaf	T2 Boat end	SN 80185 75646		
Isaf	T1 Start	SN 80278 75802		
Isaf	T1 End	SN 80252 75773		
Isaf	T2 Start	SN 80208 75737		
Isaf	T2 End	SN 80182 75643		
Llanbwchllyn	T1 Boat start	SO 12173 46241	113	33
Llanbwchllyn	T1 Boat end	SO 12203 46228		
Llanbwchllyn	T2 Boat start	SO 11940 46262	254	106
Llanbwchllyn	T2 Boat end	SO 11838 46233		

Name	Transect	NGR	Bearing	Distance (m)
Llanbwchllyn	T3 Boat start	SO 11784 46447	349	16
Llanbwchllyn	T3 Boat end	SO 11781 46463		
Llanbwchllyn	T4 Boat start	SO 11692 46421	243	40
Llanbwchllyn	T4 Boat end	SO 11656 46403		
Llanbwchllyn	T1 Start	SO 12198 46259		
Llanbwchllyn	T1 End	SO 12161 46210		
Llanbwchllyn	T2 Start	SO 11903 46225		
Llanbwchllyn	T2 End	SO 11803 46219		
Llanbwchllyn	T3 Start	SO 11849 46453		
Llanbwchllyn	T3 End	SO 11737 46482		
Llanbwchllyn	T4 Start	SO 11652 46453		
Llanbwchllyn	T4 End	SO 11679 46358		
Llangorse	T1 Boat start	SO 12934 26475	174	224
Llangorse	T1 Boat end	SO 12959 26252		
Llangorse	T2 Boat start	SO 13779 25877	273	19
Llangorse	T2 Boat end	SO 13760 25878		
Llangorse	T3 Boat end	SO 13828 26649	236	75
Llangorse	T3 Boat start	SO 13766 26607		
Llangorse	T4 Boat start	SO 12701 26655	282	258
Llangorse	T4 Boat end	SO 12449 26709		
Llangorse	T1 Start	SO 12919 26241		
Llangorse	T1 End	SO 13023 26245		
Llangorse	T2 Start	SO 13730 25959		
Llangorse	T2 End	SO 13761 25852		
Llangorse	T3 Start	SO 13778 26716		
Llangorse	T3 End	SO 13874 26686		
Llangorse	T4 Start	SO 12420 26702		
Llangorse	T4 End	SO 12446 26803		
Llygeirian	T1 Boat start	SH 34664 89709	179	47
Llygeirian	T1 Boat end	SH 34665 89662		
Llygeirian	T2 Boat start	SH 34596 89965	319	50
Llygeirian	T2 Boat end	SH 34569 89998		
Llygeirian	T3 Boat start	SH 34801 89977	12	29
Llygeirian	T3 Boat end	SH 34807 90005		
Llygeirian	T4 Boat start	SH 34785 89822	77	44
Llygeirian	T4 Boat end	SH 34828 89832		
Llygeirian	T1 Start	SH 34708 89678		
Llygeirian	T1 End	SH 34609 89683		
Llygeirian	T2 Start	SH 34612 90041		
Llygeirian	T2 End	SH 34525 89992		
Llygeirian	T3 Start	SH 34718 90052		
Llygeirian	T3 End	SH 34809 90018		
Llygeirian	T4 Start	SH 34829 89801		
Llygeirian	T4 End	SH 34858 89908		

Name	Transect	NGR	Bearing	Distance (m)
Maelog	T1 Boat end	SH 32366 73060	151	26
Maelog	T1 Boat start	SH 32379 73037		
Maelog	T2 Boat start	SH 32905 73346	347	27
Maelog	T2 Boat end	SH 32899 73372		
Maelog	T3 Boat start	SH 32540 72795	185	43
Maelog	T3 Boat end	SH 32536 72752		
Maelog	T4 Boat start	SH 32762 73029	120	20
Maelog	T4 Boat end	SH 32779 73019		
Maelog	T1 Start	SH 32341 73022		
Maelog	T1 End	SH 32391 73079		
Maelog	T2 Start	SH 32923 73394		
Maelog	T2 End	SH 32856 73360		
Maelog	T3 Start	SH 32475 72769		
Maelog	T3 End	SH 32553 72743		
Maelog	T4 Start	SH 32855 73050		
Maelog	T4 End	SH 32791 72992		
Mwyngi	T1 Boat start	SH 72166 10268	139	155
Mwyngi	T1 Boat end	SH 72268 10151		
Mwyngi	T2 Boat start	SH 71961 10128	276	135
Mwyngi	T2 Boat end	SH 71827 10143		
Mwyngi	T3 Boat start	SH 71382 09743	317	169
Mwyngi	T3 Boat end	SH 71266 09866		
Mwyngi	T4 Boat start	SH 71401 09703	140	167
Mwyngi	T4 Boat end	SH 71509 09575		
Mwyngi	T1 Start	SH 72207 10138		
Mwyngi	T1 End	SH 72307 10148		
Mwyngi	T2 Start	SH 71860 10191		
Mwyngi	T2 End	SH 71794 10114		
Mwyngi	T3 Start	SH 71297 09886		
Mwyngi	T3 End	SH 71219 09823		
Mwyngi	T4 Start	SH 71473 09523		
Mwyngi	T4 End	SH 71546 09599		
Ogwen	T1 Start	SH 66089 60305		
Ogwen	T1 End	SH 66017 60276		
Ogwen	T2 Start	SH 66590 60560		
Ogwen	T2 End	SH 66578 60637		
Ogwen	T3 Start	SH 65606 60474		
Ogwen	T3 End	SH 65688 60475		
Ogwen	T4 Start	SH 65324 60342		
Ogwen	T4 End	SH 65364 60297		
Ogwen	T2 Boat start	SH 66338 60580	91	221
Ogwen	T2 Boat end	SH 66559 60578		
Ogwen	T1 Boat start	SH 66125 60456	214	202
Ogwen	T1 Boat end	SH 66013 60288		

Name	Transect	NGR	Bearing	Distance (m)
Ogwen	T4 Boat start	SH 65388 60398	215	75
Ogwen	T4 Boat end	SH 65345 60336		
Ogwen	T3 Boat start	SH 65677 60378	337	98
Ogwen	T3 Boat end	SH 65638 60468		
Padarn	T1 Boat end	SH 58202 60245	357	33
Padarn	T1 Boat start	SH 58200 60278		
Padarn	T2 Boat end	SH 58082 60781	214	7
Padarn	T2 Boat start	SH 58078 60775		
Padarn	T3 Boat start	SH 56516 61559	166	12
Padarn	T3 Boat end	SH 56519 61547		
Padarn	T4 Boat start	SH 56055 62269	245	38
Padarn	T4 Boat end	SH 56021 62253		
Padarn	T1 Start	SH 58240 60241		
Padarn	T1 End	SH 58145 60232		
Padarn	T2 Start	SH 58107 60772		
Padarn	T2 End	SH 58044 60805		
Padarn	T3 Start	SH 56471 61603		
Padarn	T3 End	SH 56527 61535		
Padarn	T4 Start	SH 56009 62288		
Padarn	T4 End	SH 56055 62209		
Rhos-ddu	T1 Boat start	SH 42581 64882	233	64
Rhos-ddu	T1 Boat End	SH 42530 64844		
Rhos-ddu	T1 Start	SH 42619 64935		
Rhos-ddu	T1 End	SH 42633 64891		
Rhos-ddu	T2 Start	SH 42442 64774		
Rhos-ddu	T2 End	SH 42517 64807		
Tegid	T1 Boat end	SH 89083 31165	277	38
Tegid	T1 Boat start	SH 89045 31170		
Tegid	T2 Boat start	SH 89696 31598	174	18
Tegid	T2 Boat end	SH 89698 31580		
Tegid	T3 Boat start	SH 90202 33259	304	37
Tegid	T3 Boat end	SH 90171 33280		
Tegid	T4 Boat start	SH 92483 35261	354	143
Tegid	T4 Boat end	SH 92467 35403		
Tegid	T5 Boat start	SH 89202 31930	344	41
Tegid	T5 Boat end	SH 89191 31969		
Tegid	T6 Boat start	SH 90829 32839	117	33
Tegid	T6 Boat end	SH 90858 32824		
Tegid	T1 Start	SH 89056 31107		
Tegid	T1 End	SH 88998 31194		
Tegid	T2 Start	SH 89752 31557		
Tegid	T2 End	SH 89649 31576		
Tegid	T3 End	SH 90202 33317		
Tegid	T3 Start	SH 90135 33245		

Name	Transect	NGR	Bearing	Distance (m)
Tegid	T4 Start	SH 92515 35412		
Tegid	T4 End	SH 92408 35373		
Tegid	T5 Start	SH 89232 31976		
Tegid	T5 End	SH 89127 31980		
Tegid	T6 Start	SH 90817 32777		
Tegid	T6 End	SH 90892 32847		
Teifi	T1 Boat start	SN 78070 67191	131	41
Teifi	T1 Boat end	SN 78101 67164		
Teifi	T2 Boat start	SN 78536 67566	110	40
Teifi	T2 Boat end	SN 78574 67552		
Teifi	T3 Boat start	SN 78446 67667	329	12
Teifi	T3 Boat end	SN 78440 67677		
Teifi	T4 Boat start	SN 78191 67737	337	8
Teifi	T4 Boat end	SN 78188 67744		
Teifi	T1 Start	SN 78093 67052		
Teifi	T1 End	SN 78095 67131		
Teifi	T2 Start	SN 78568 67544		
Teifi	T2 End	SN 78611 67626		
Teifi	T3 Start	SN 78463 67730		
Teifi	T3 End	SN 78404 67654		
Teifi	T4 Start	SN 78115 67695		
Teifi	T4 End	SN 78075 67600		
Teyrn	T1 Boat start	SH 64110 54734	237	97
Teyrn	T1 Boat end	SH 64029 54681		
Teyrn	T2 Boat start	SH 64153 54753	72	56
Teyrn	T2 Boat end	SH 64206 54770		
Teyrn	T1 Start	SH 64052 54730		
Teyrn	T1 End	SH 64042 54658		
Teyrn	T2 Start	SH 64224 54768		
Teyrn	T2 End	SH 64171 54817		

## 9. Data Archive Appendix

Data outputs associated with this project are archived as project 463, media 1524 on server-based storage at Natural Resources Wales.

The data archive contains:

- [A] A full set of maps (25) of the macrophyte sector locations produced in PDF format.
- [B] A spreadsheet in Microsoft Excel format containing the grid references of the macrophyte survey locations.
- [C] A full set of LEAFPACS spreadsheets (25) in Microsoft Excel format.
- [D] A full set of images of the macrophyte sectors produced in JPEG format with an accompanying catalogue in Microsoft Excel format.
- [E] A spreadsheet in Microsoft Excel format containing the water quality depth profiles.
- [F] A series of GIS layers on which the bathymetry maps in the report are based.
- [G] A full set of maps (7) of the bathymetry survey produced in PDF format.
- [H] A confidential spreadsheet containing update landowner information.
- [I] The final report in Microsoft Word and Adobe PDF formats.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue <http://libcat.naturalresources.wales/webview/> by searching 'Dataset Titles'. The metadata is held as record no [115898](#).



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