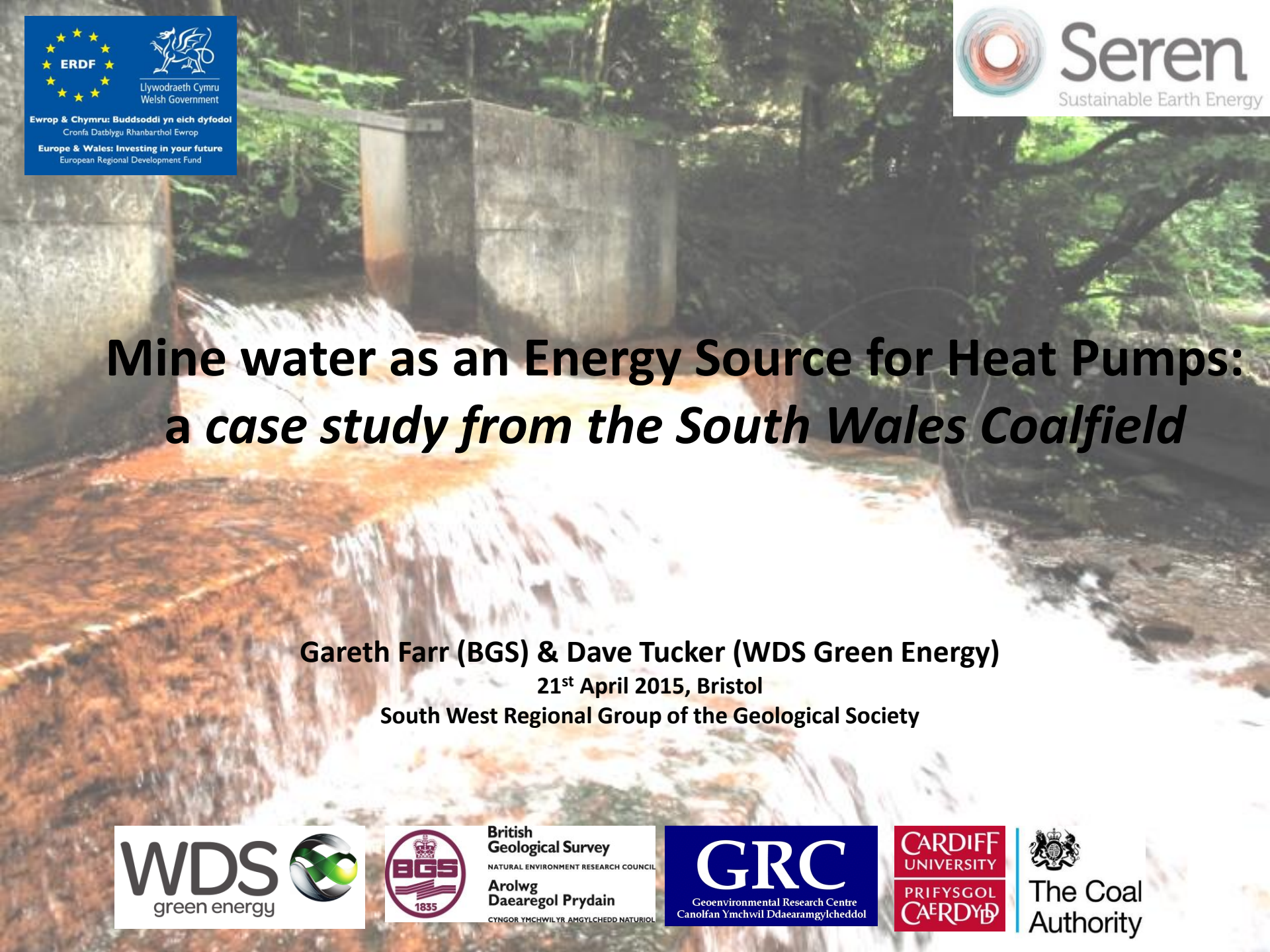


Mine water as an Energy Source for Heat Pumps: a *case study from the South Wales Coalfield*

Gareth Farr (BGS) & Dave Tucker (WDS Green Energy)

21st April 2015, Bristol

South West Regional Group of the Geological Society

Seren
Sustainable Earth Energy

Talk Outline:

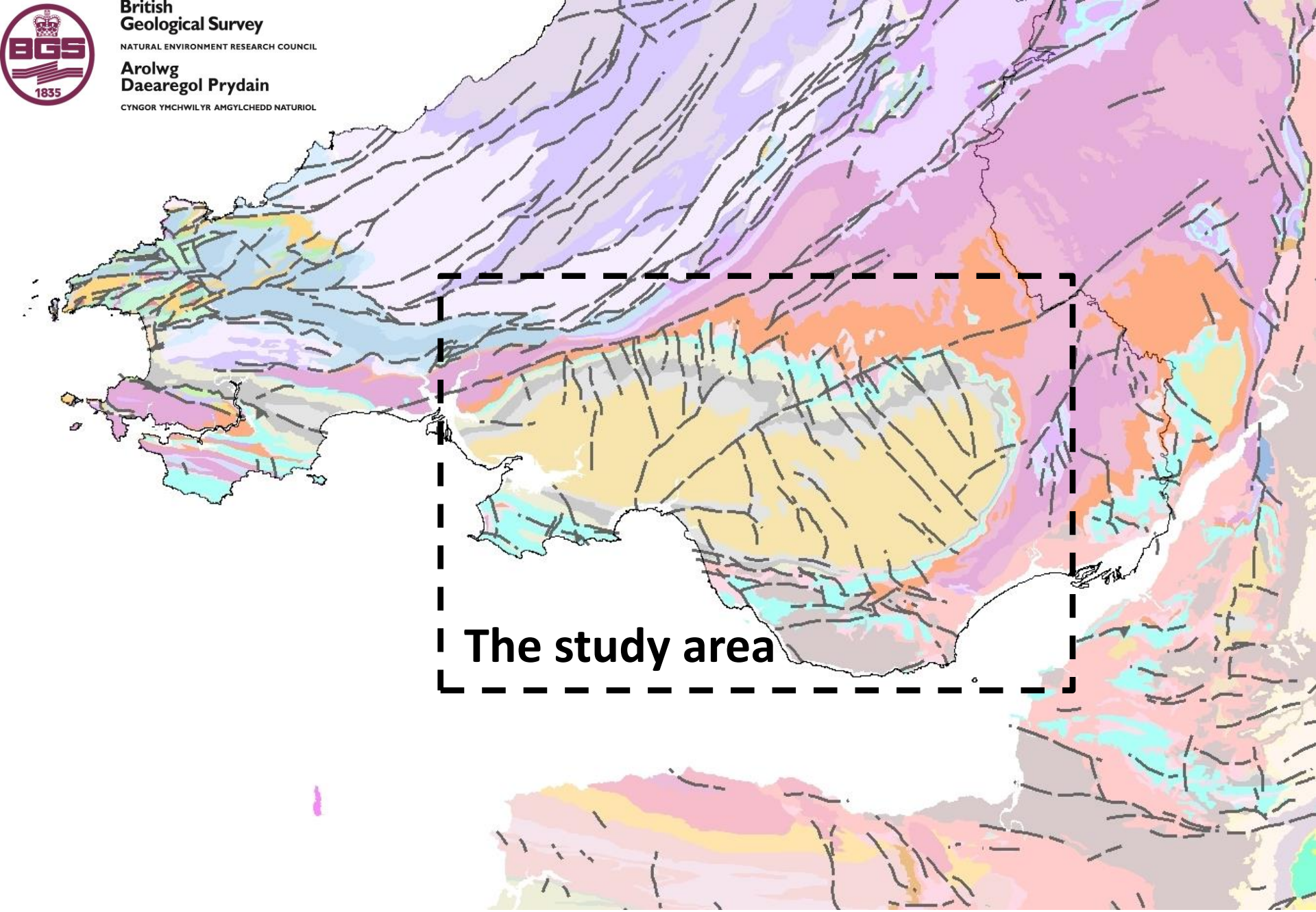
- The Seren Project
- Geology and setting of the South Wales Coalfield
- Establishing a network to monitor mine water temps
- Initial estimate of heating potential
- What are Ground Source Heat Pumps (GSHP) ?
- Why bother with green technology ?
- Crynant project: case study of GSHP system
- Benefits of using mine water for GSHP
- Conclusions and future challenges

The Seren Project (2010-2015)

- European Regional Development Fund (ERDF)
- Aim to develop innovative engineering technologies
- Ground Source Heat is one of the five work packages……
- BGS role to characterise temperatures & improve 3D model
- WDS role to install and monitor working system

South Wales during the Carboniferous

A Carboniferous Swamp as depicted by Loius Figuiler (1872) in his book titled ‘The World Before the Deluge’.

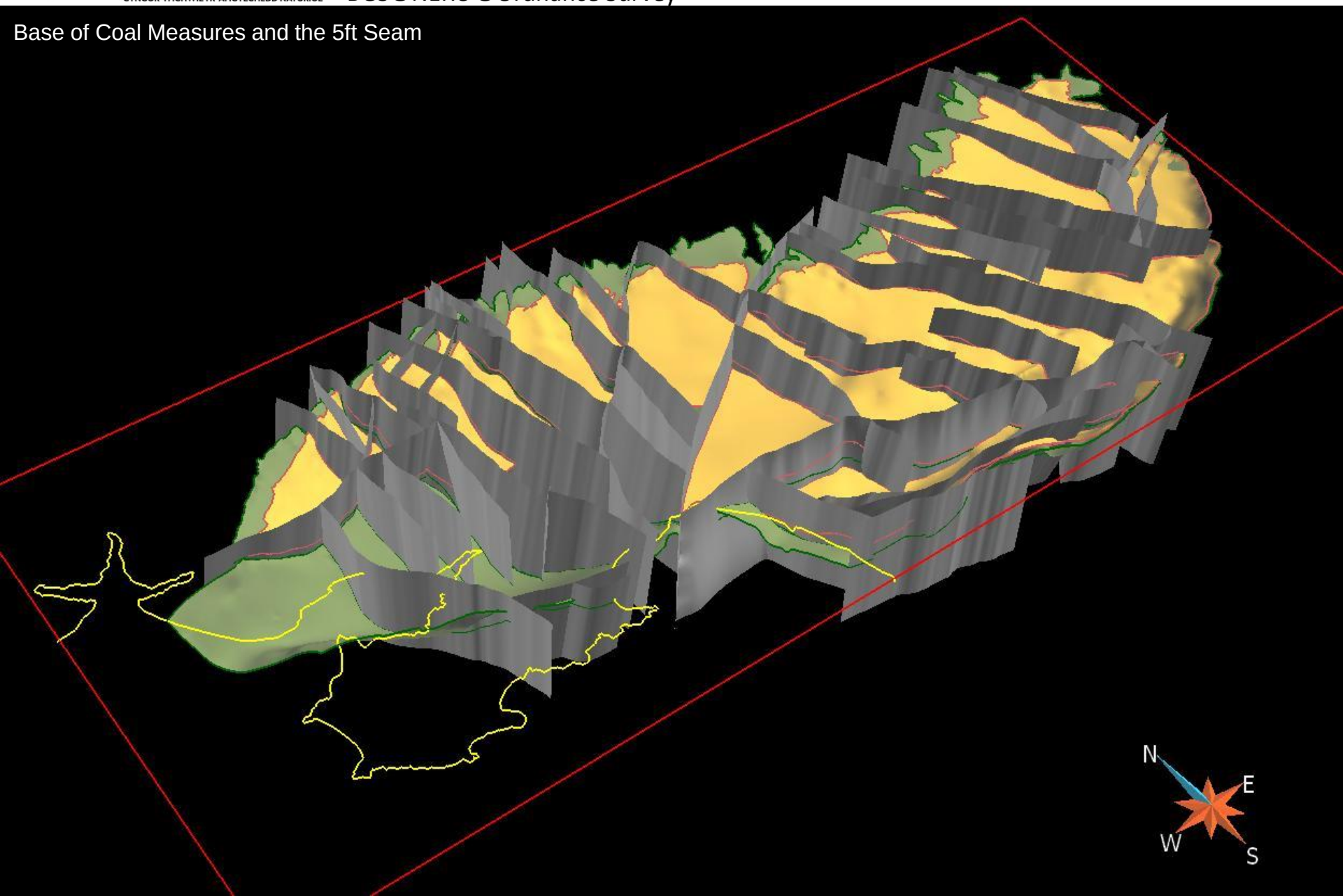


British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
Arolwg Daearegol Prydain
CYNGOR YMCHWILYR AMGYLCHEDD NATURIOL

Improved 3D Geological Model

Andy Hulbert (BGS)

Base of Coal Measures and the 5ft Seam



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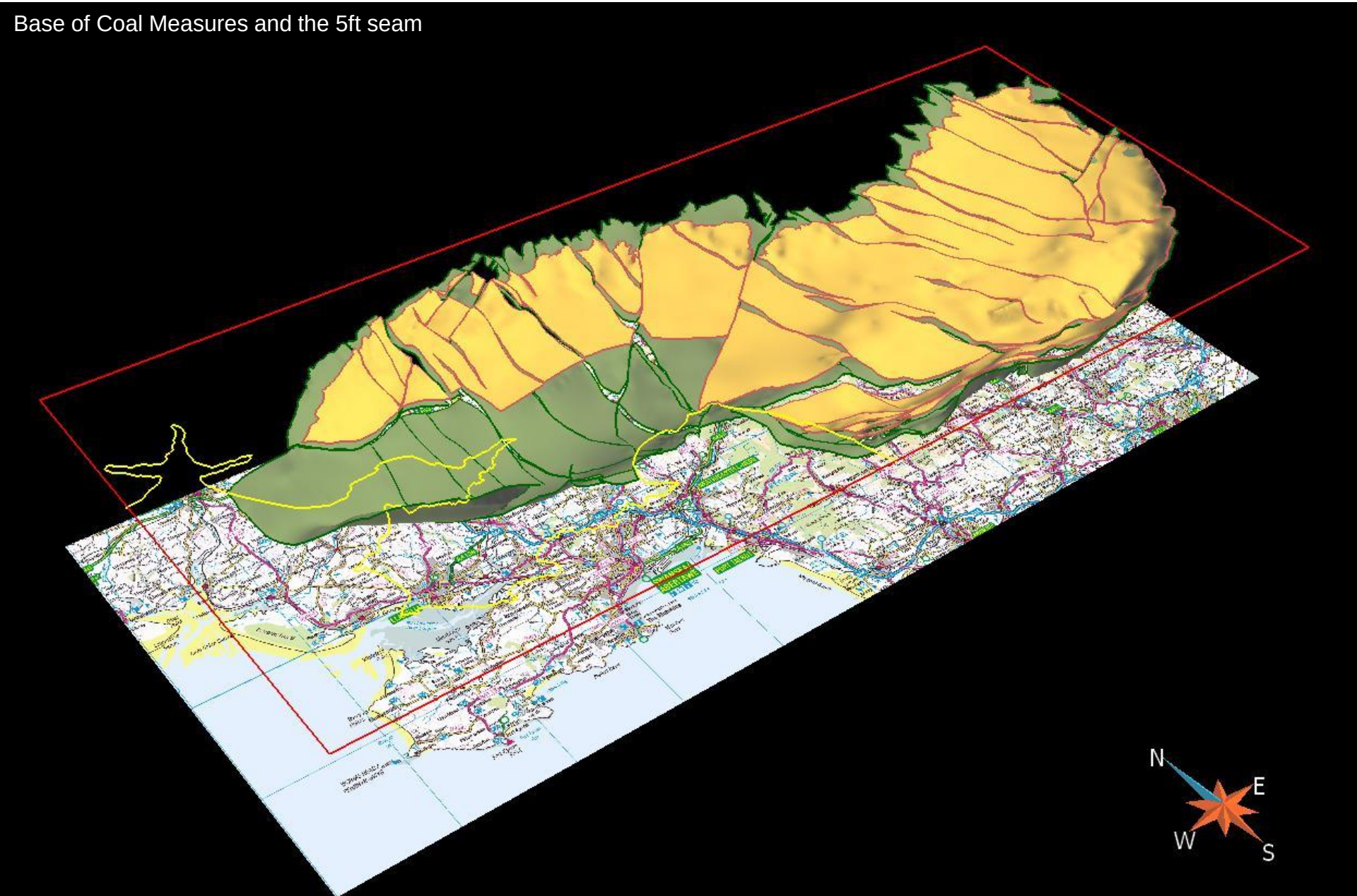


DESIGN OF A MONITORING NETWORK

Available datasets

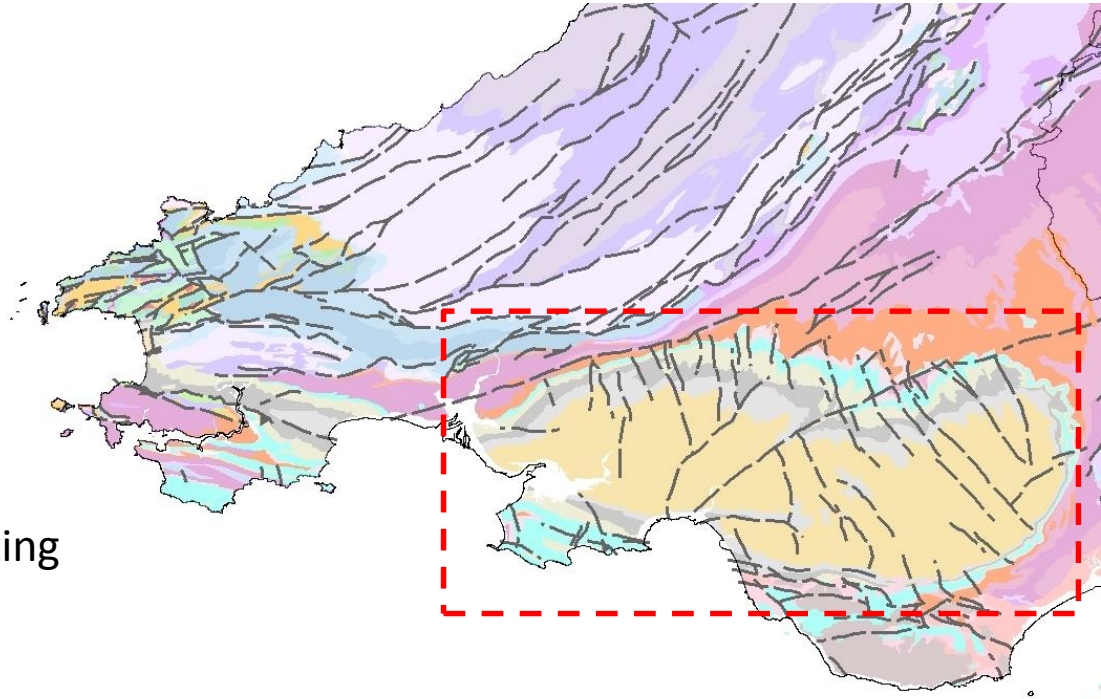
• Coal Authority Data	268 sites
• Natural Resources Wales	60 sites
• Priority Abandoned Coal Mine Discharges	29 sites
• BGS Borehole data	6563 sites
• Published and grey literature	

Consultation with:

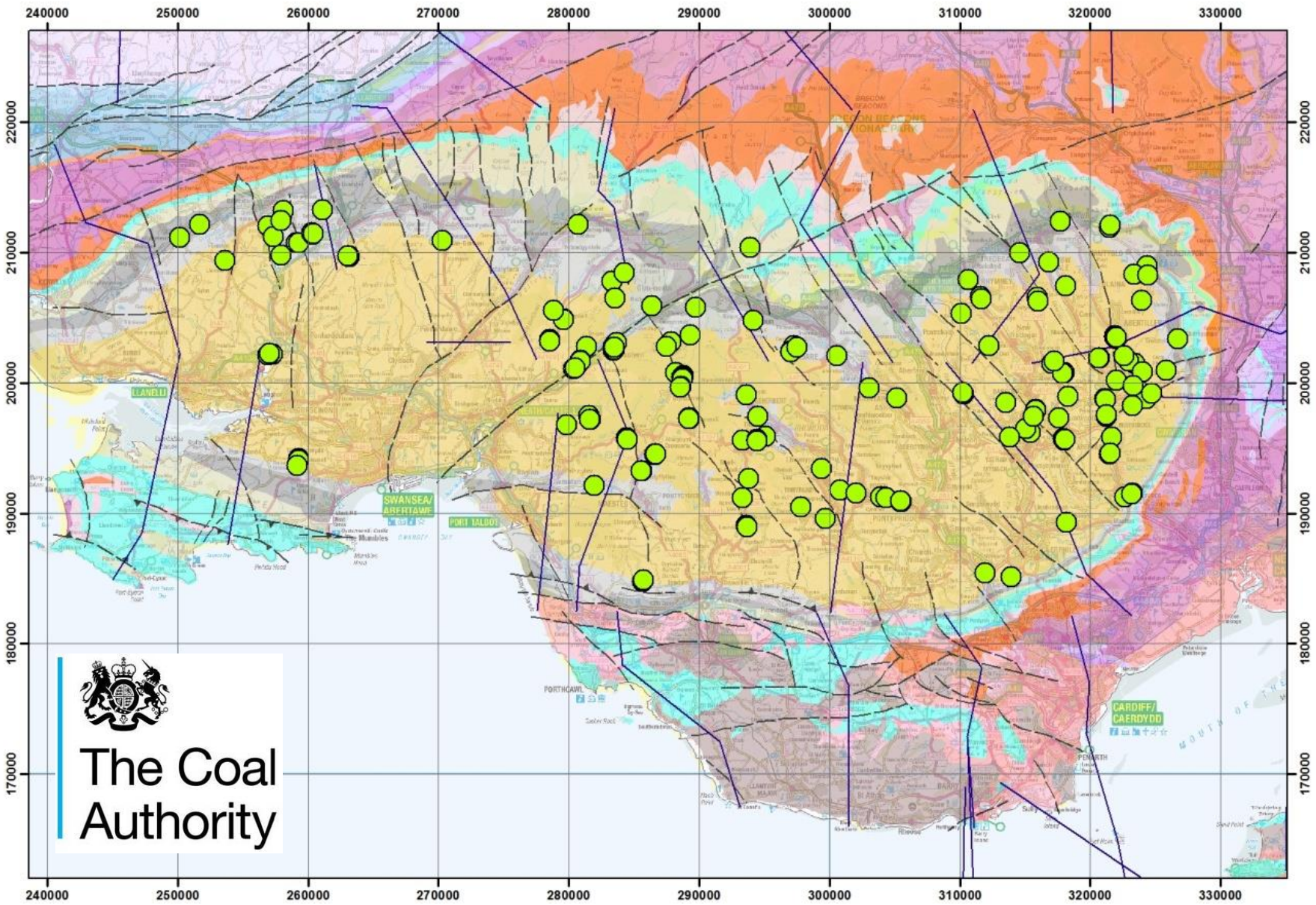
- Natural Resources Wales
- Local Authorities (x 6)
- Coal Authority and Tower Colliery

Consideration of:

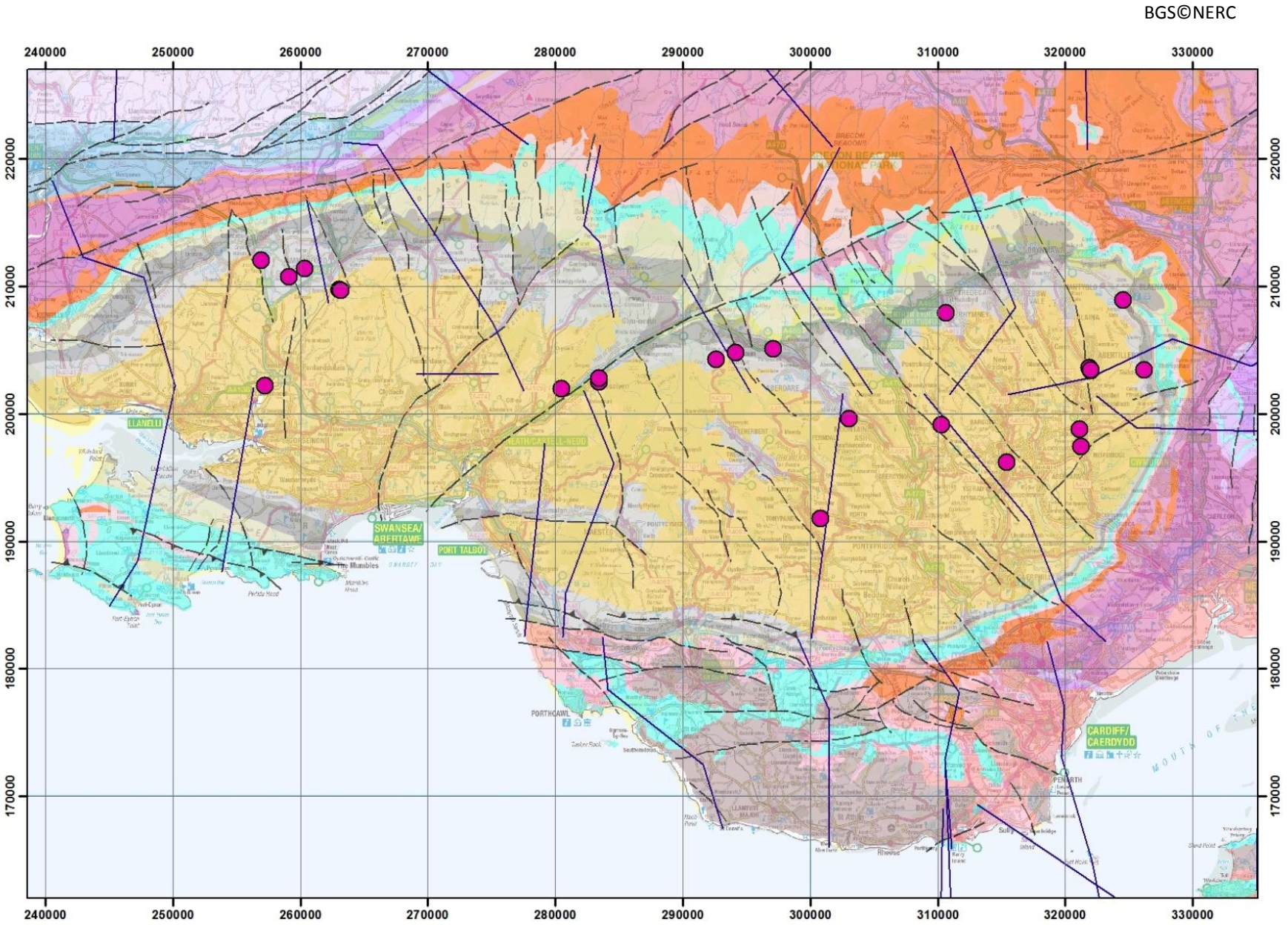
- Proximity to existing urban areas
- Local Development Plans (LDPs)
- Geological and hydrogeological setting



COAL AUTHORITY MONITORING POINTS



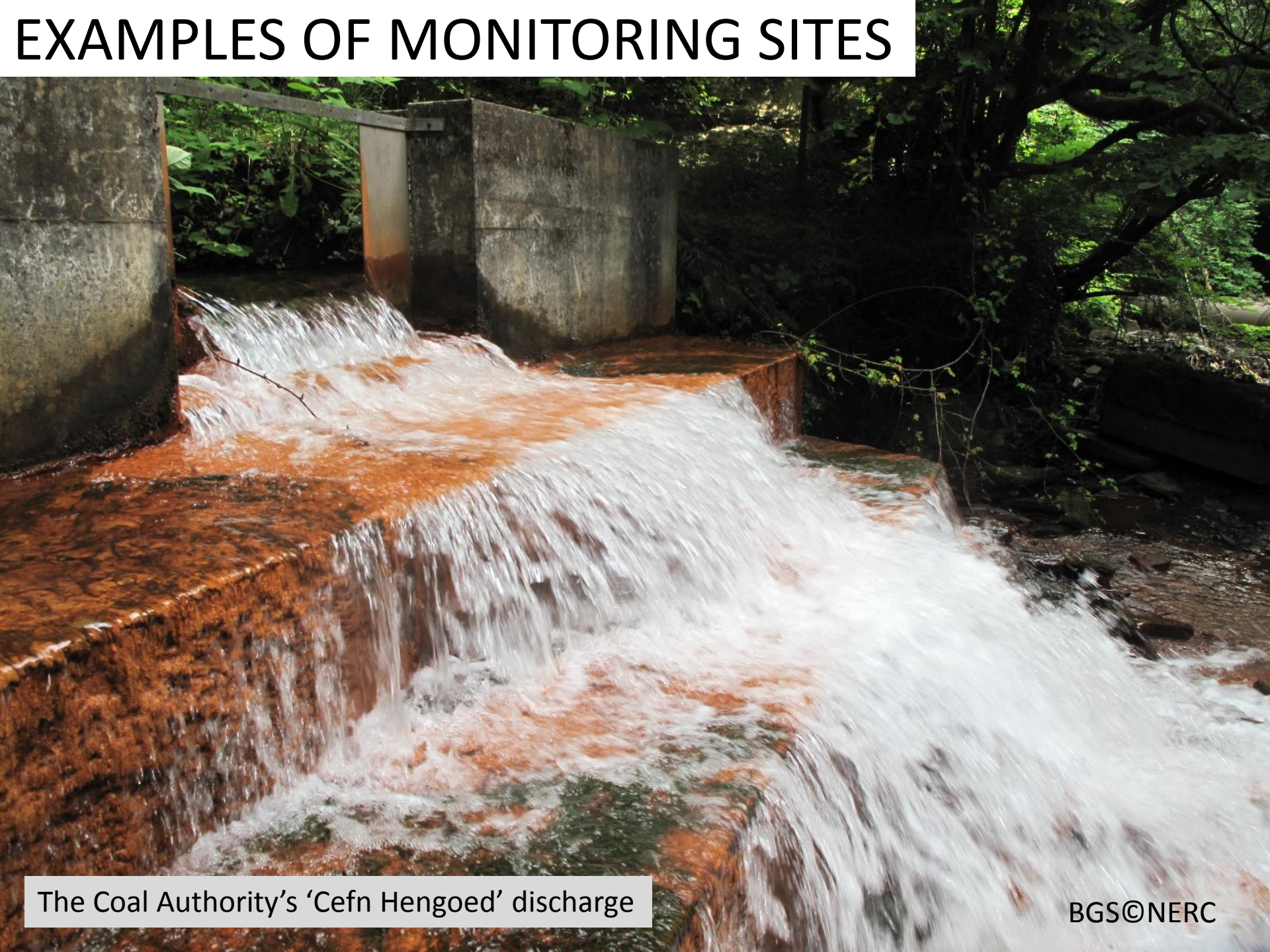
SEREN MONITORING NETWORK



Iron deposition on the temperature logger after just 3 months !

BGS©NERC

EXAMPLES OF MONITORING SITES



The Coal Authority's 'Cefn Hengoed' discharge

BGS©NERC

The Coal Authority's Abercwmboi Shaft

BGS©NERC

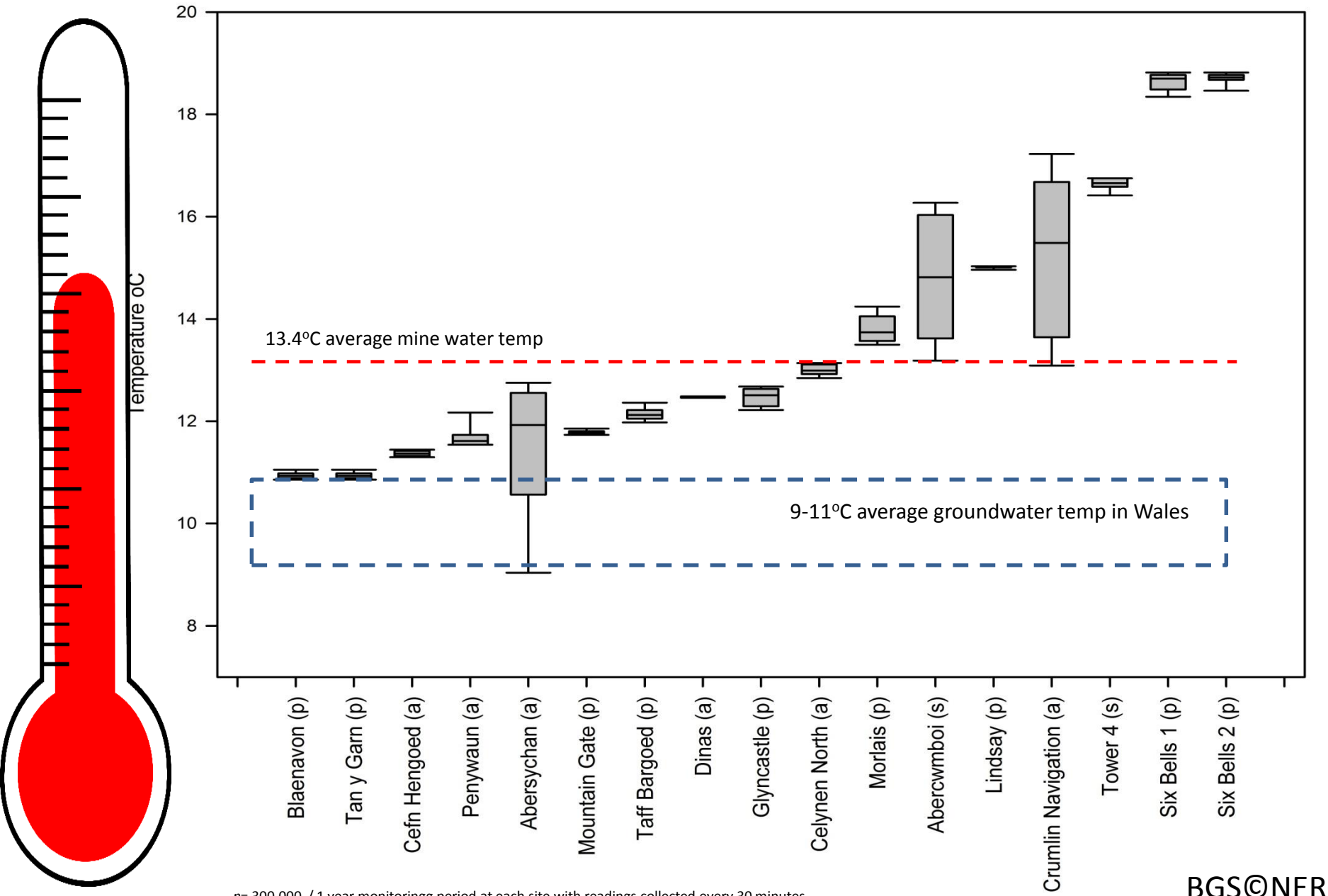
The Coal Authority's Celynen North discharge

BGS©NERC

The Coal Authority's Vivian Pumping Station

Crumlin Navigation: a friends group hope to restore the buildings and to incorporate ground source heating into their final design

RANGE OF MINE WATER TEMPERATURES



n= 300,000 / 1 year monitoringg period at each site with readings collected every 30 minutes

Initial estimate of resource*

- Outflow from abandoned mines =3000 l/s

  (likely to be significant underestimate of true value and does not represent water that could be abstracted via pumping from the coalfield)

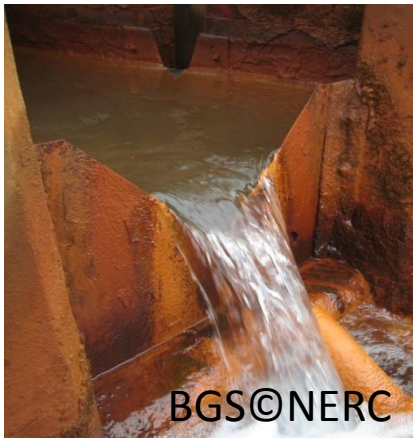
- average mine water temperature of 13.4°C
- removal of a maximum of 3°C by the GSHP
- disused mine waters could provide enough energy to heat ~~~20,000 homes (3 bed equivalents) in South Wales




RESULTS

- Currently no use for mine water
- Elevated temperatures
- 13.4˚C average temperature (range from ~8 -19˚C)
- >>3000 l/s pumped or discharged
- Potential to heat at least ~ 20,000 homes (based on standard 3 bed house)
- Further work needed to understand variation in geothermal gradient across the coal field



Talk Outline:

- The Seren Project
- Geology and setting of the South Wales Coalfield
- Establishing a monitoring network
- Mine water temperatures...are they hot ?
- What are Ground Source Heat Pumps (GSHP) ?
- Why bother with green technology ?
- Crynant project: case study of GSHP system
- Benefits of using mine water for GSHP
- Conclusions and future challenges

WDS GREEN ENERGY

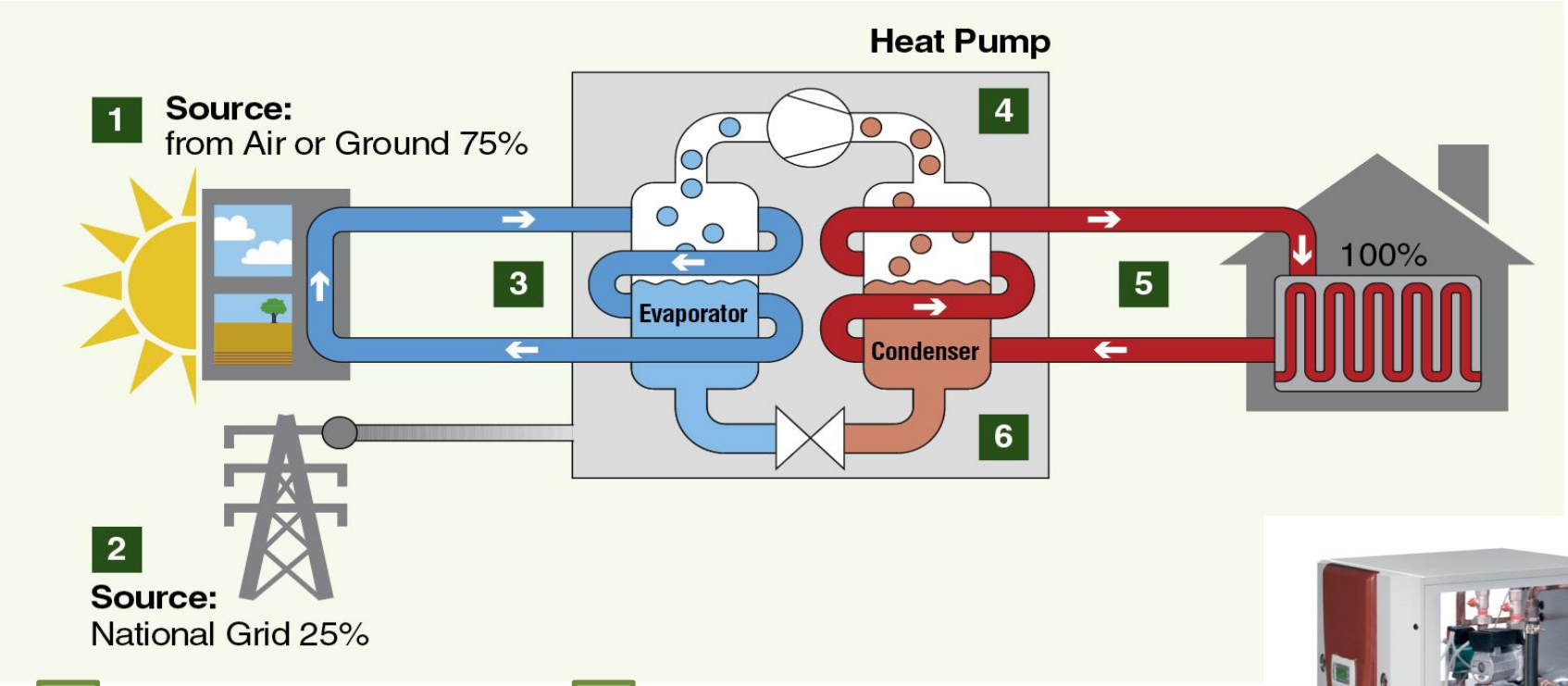
- A specialist renewable energy company trading for over 12 years
- Based in Cardiff serving clients in Wales and England
- Over 450 ground and air source heat pump systems installed in UK
- MCS accredited installers

- Projects include:
  - Schools
  - Arts centres
  - Offices
  - Leisure centres
  - Swimming pools
  - District heating system
  - Social houses
  - New homes
  - Village halls
  - Retrofits

- Award winning installer for Zoar Chapel Project in Merthyr
- Industrial Partner with the Seren Team at Cardiff University

Seren
Sustainable Earth Energy

HEAT PUMP OPERATION



1 Heat source

2 Electricity supply

3 Heat onto refrigerant in evaporator - liquid/gas conversion

4 Gas compressed to high temperature

5 Heat transferred to water in heat exchanger/ condenser

6 Gas back returns to liquid through Expansion valve

GROUND SOURCE HEAT PUMP

GROUND COLLECTORS

APPLICATIONS

- New housing
- Visitor Centres
- Existing housing
- Apartments
- Offices
- Self Build
- Schools
- Commercial
- Swimming pools
- Leisure Centres
- Farm Buildings

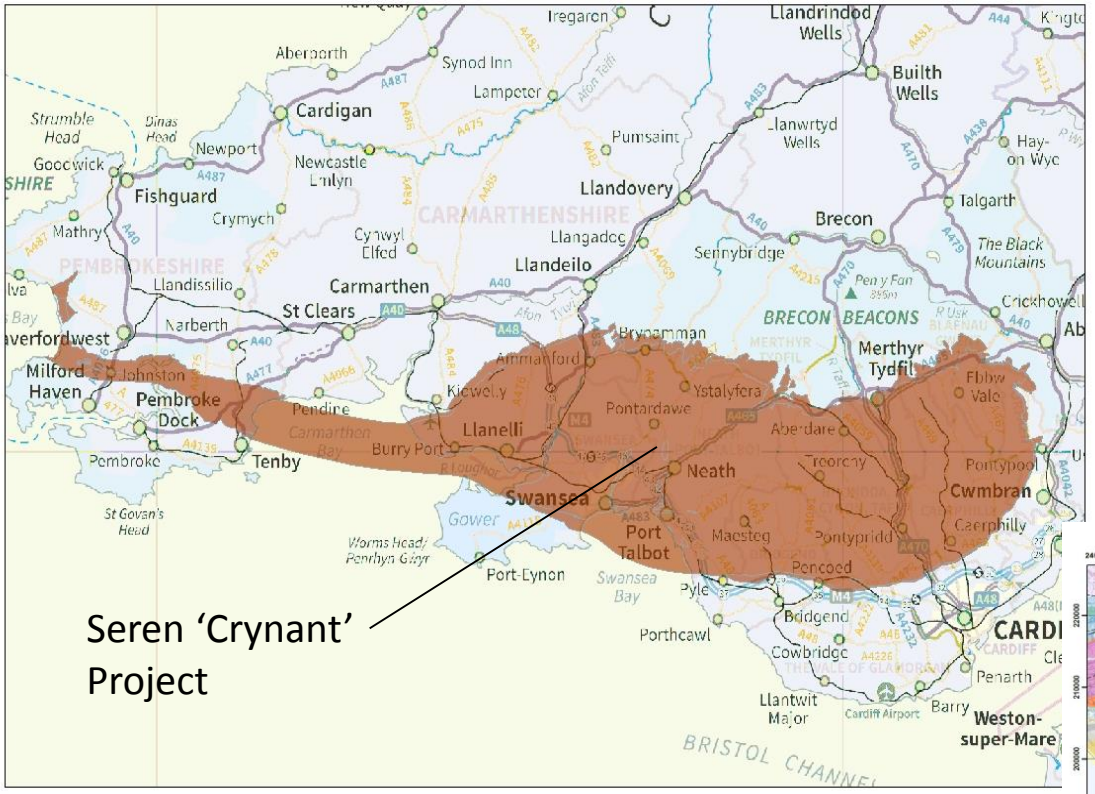
GROUND ENERGY- WHY MINE WATER ?

WDS green energy

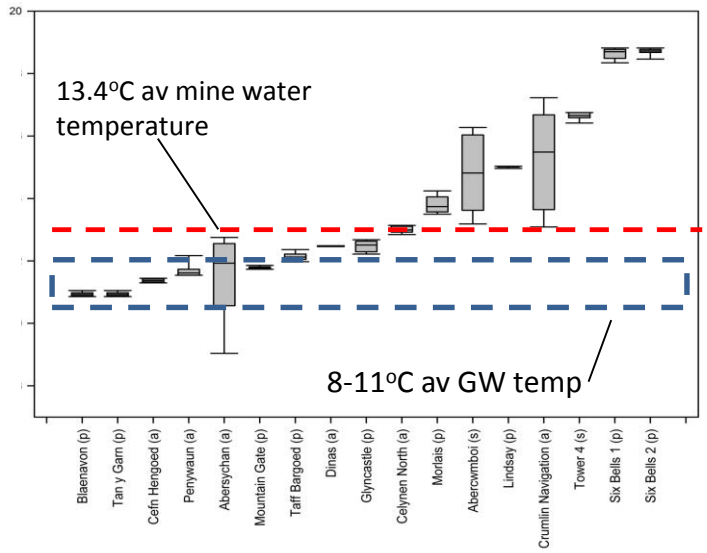
Planet earth is a large source of stored renewable solar energy:

Source	**Advantages**	**Disadvantages**
Ground (horizontal loops)	- Easy to construct	- Large land area needed - Land sterilised for building
Ground (boreholes)	- Need small land area - Heat abstraction is reliable	- Costly to drill - Numbers increase with capacity
River and streams	- Easy source for abstraction	- Varying seasonal temperatures - Delta T can effects ecology
Mine workings	**- Large volumes of warm water** **- Pollution restricts other usage** **- Only two boreholes required** **- Stable / elevated water temperatures** **- No loss of water to surface**	**- Depth of workings critical** **- Location related to demand**

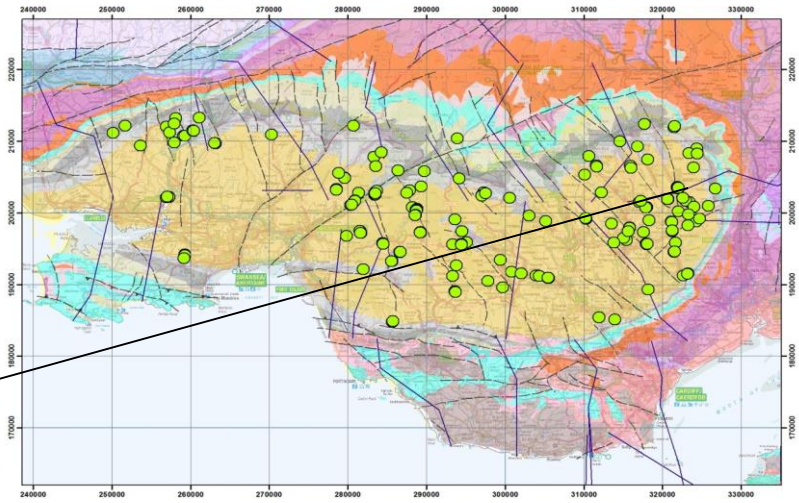
MINE WATER POTENTIAL



South Wales coalfield

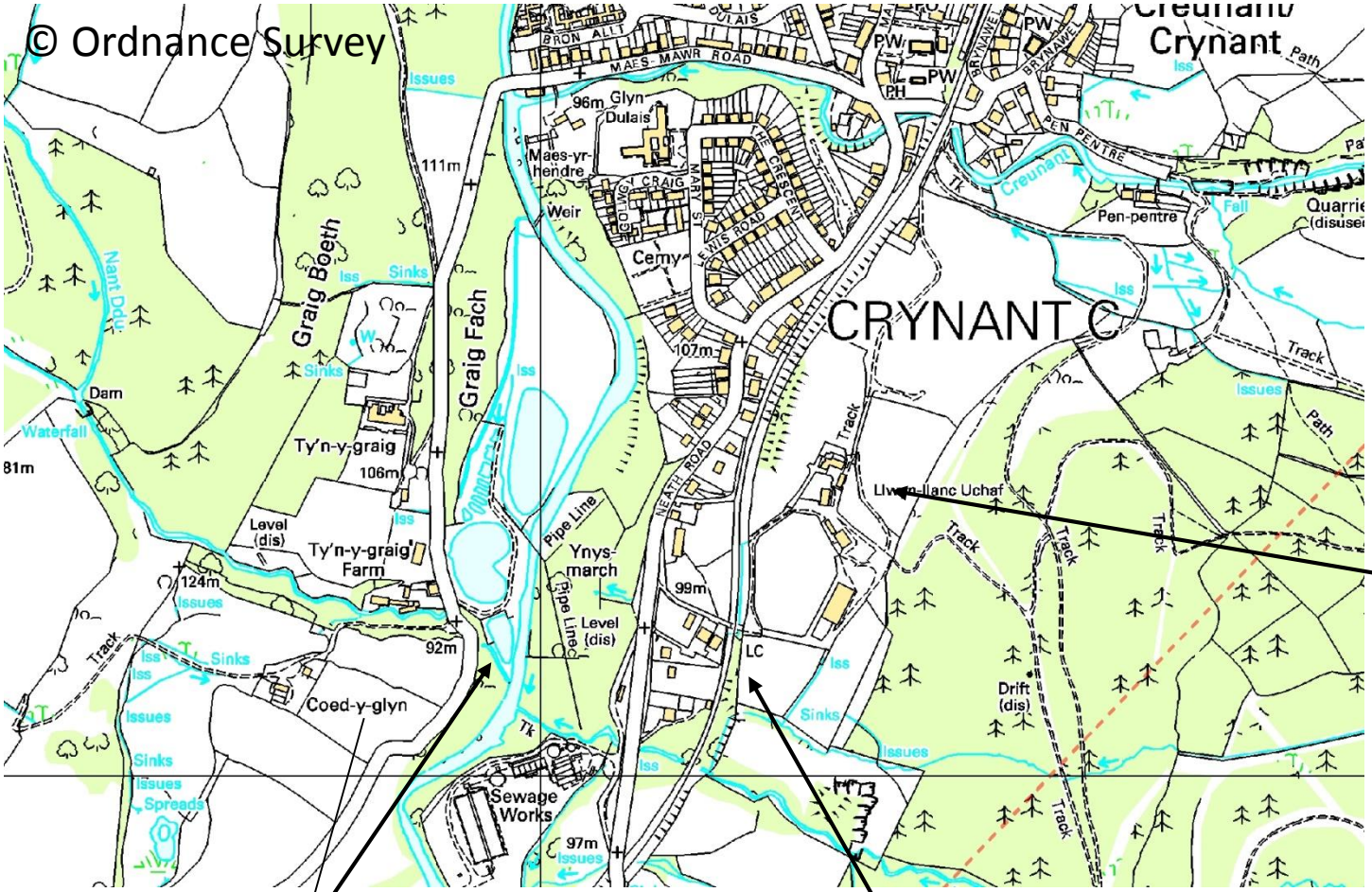


Water Temperatures Recorded by BGS



Mine Water Discharge Sites monitored by the Coal Authority and British Geological Survey

CRYNANT: SITE LOCATION



Crynant site

Cefn Coed Colliery

Dulais Valley

CRYNANT PROJECT: THE DRIVERS

- The client already uses ground source heat pumps on his other properties and enjoys the benefits of low running costs < 50% of oil
- His farmhouse, workshops and family physiotherapy business on the site are all heated by either oil or directly by electricity with a total demand of 30KW's
- Client owns land which overlies old mine workings from the Cefn Coed Colliery which closed in 1985
- Keen to unify his heating systems, save money and gain RHI payments
- Willing to participate in an 'experimental project' using mine water as the source of energy for a heat pump system
- Cardiff University, Seren Team, keen to gain data on heat transfer etc

CRYNANT: INVESTIGATORY WORKS

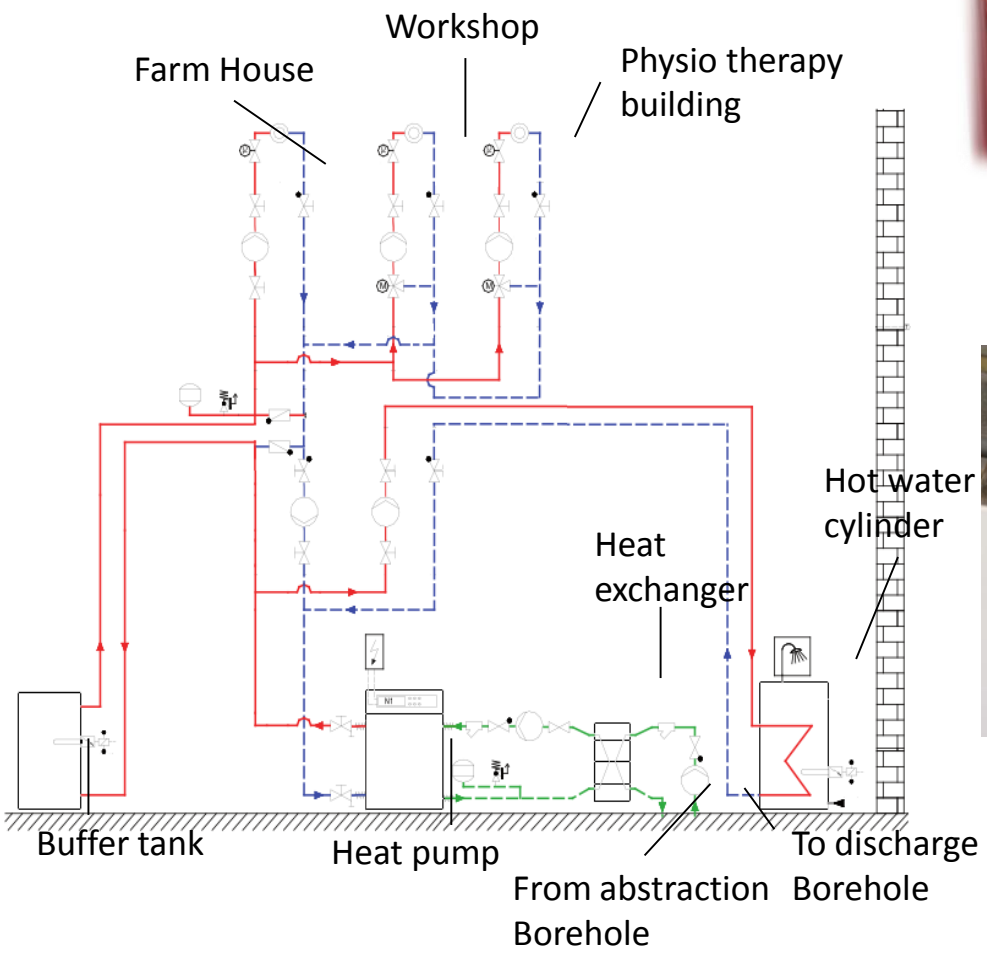
- Project requirements and cost analyses/benefit
- Site evaluation for borehole locations and mine working options
- Discussions with **Coal Authority** leading to a ‘Minewater Heat Recovery Access Agreement’
- Approval to investigate ground water source (borehole drilling) from **NRW**
- Seren requirements for comprehensive monitoring and water quality testing
- Exploratory drilling, test pumping and water quality analysis

CRYNANT: SYSTEM DETAILS

Building control modules

Buffer tank and hot water tank

Hydraulic diagram

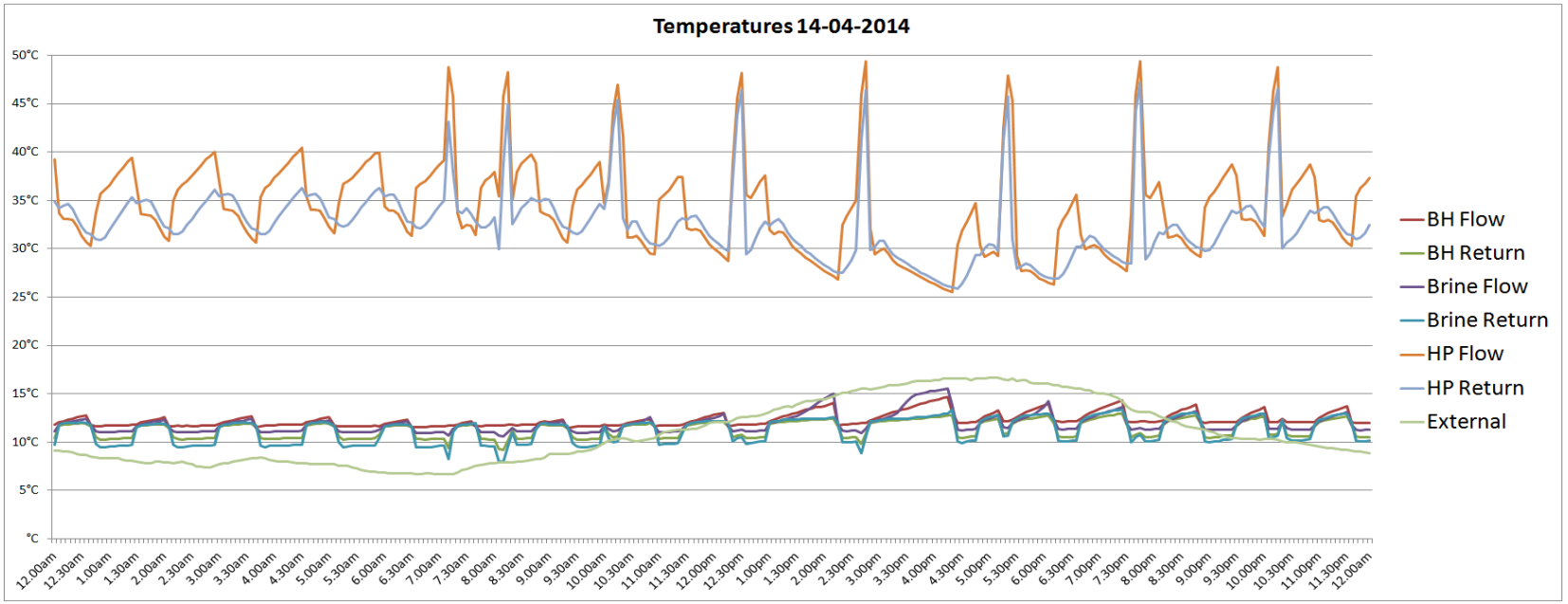


Heat pump with data collection and logger system

System data acquisition at site

CRYNANT: INITIAL FINDINGS

- Mine water at Crynant is stable at 11.5^{o}C
- Some water temperature gain from ground (1^{o} to 2^{o}C)
- Borehole water levels constant at 25m below gl, (mine workings are at 65m)
- Heat transfer to heat pump > 10^{o}C (<1.5^{o} C loss)
- Heat output recorded at 19KW & 38kW's for 1 & 2 compressors (manufacturers test data shows 14 & 30 kW's at brine or ground zero)



CRYNANT: BENEFITS SO FAR

- Fully instrumented for performance monitoring across all seasons
- Data loggers and meters show running costs are < 50% of oil system
- Approved for 20 year RHI funding under commercial tariff scheme
- Proved retrofitting of house possible without changing radiators
- Created a bench mark project for demonstration of heat pump technology using mine water
- Purpose built housing for visits by interested parties
- Proved warm mine water has a new future as a low cost renewable energy source for heat pumps
- Our collaboration with Cardiff University Seren Team has proved benefit of industry/ academy partnerships

WHY USE LOW CARBON HEATING?

The UK government tells us that:

- 80% of heating comes from natural gas: **this is not sustainable**

Welsh Government want to:

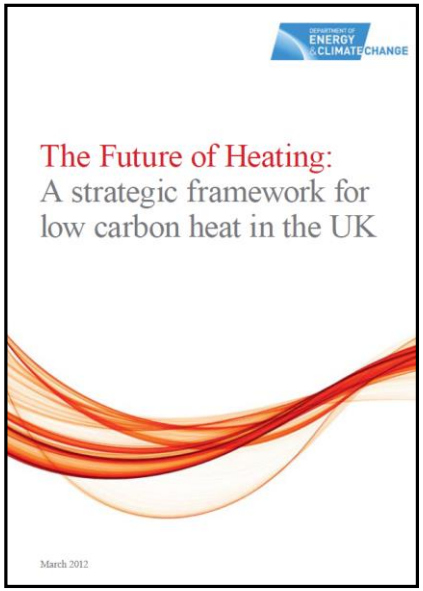
- Reduce greenhouse emissions by 3% every year and 40% by 2020

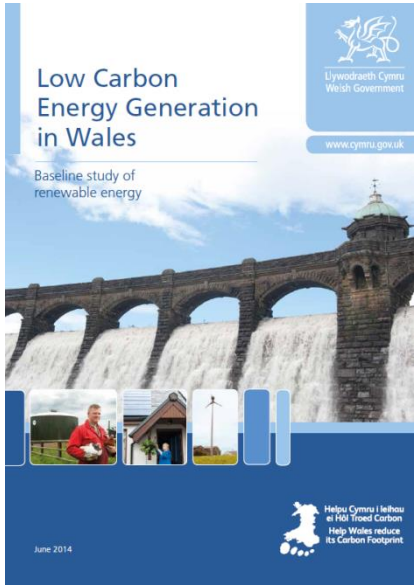
We need to:

- cut emissions of carbon dioxide
- replace fossil fuels with low carbon alternatives

In order to address:

- climate change
- energy security
- affordability of energy





CONCLUSIONS & FUTURE CHALLENGES

Mine water usage potential for GSH is considerable

- Currently there is > 10,000m^3/hr of mine waters in South Wales; the Crynant project uses only 7m^3/hr = 35kW from heat pump, average 3 bedroom house needs 16kW)
- Mine water elevated temperatures make heat pumps more efficient by >20%
- Excellent alternative to the use of LPG, oil and biomass and helps with CO_2 reductions
- Provides low cost heating for new houses, schools, hospitals and district heating systems
- With RHI tariff income project paybacks are circa 3 to 9 years

Regulation

We need to work together with NRW and the EA to address potential issues with the permitting and licensing requirements from abandoned mines.

THANK YOU

Thanks are also given to many other people involved in this project including:

- Professor Hwyel Thomas, Dr Manju Mishra & Dr Siva Sadasivams, (Cardiff University)
- Dr David Schofield (British Geological Survey) & Andy Hulbert (BGS)
- Dr Ian Watson, Matt Bailey & Dr Leigh Sharp (The Coal Authority)
- Lee Williams & Stephen Cross (Tower Colliery Ltd) and The friends of Crumlin Navigation
- Gareth and Keith at Integrated Water Services for facilitating access to the sites.
- Mr Phillip Hopkins, Llwyn Lanc Uchaf Farm, Crynant