

Repurposing Mine Sites for the Well-being of Future Generations: Innovative Examples and Case Study of Developing Post Mining Remedial Work in Wales

Peter Stanley¹, Trystan James¹, Bob Vaughan¹, Steven Pearce²

¹Natural Resources Wales, Tŷ Cambria, Newport Rd., Cardiff, CF24 0TP, UK,
geoscience@cyfoethnaturiolcymru.gov.uk

²Mine Environment Management Ltd., 3A Vale Street, Denbigh, Denbighshire, LL16 3AD, UK,
spearse@memconsultants.co.uk

Abstract

The Well-being of Future Generations (Wales) Act 2015 introduced “sustainability” into legislation for the first time anywhere in the world aiming to improve the social, economic, environmental and cultural well-being of Wales. Seven case studies are described showing how Natural Resources Wales acted “in accordance with the sustainable development principle” revealing how public bodies must act in a manner seeking to ensure the needs of the present are met without compromising the ability of future generations to meet their own needs. Public bodies undertaking substantial capital spending have a duty to ensure they embrace community well-being by applying their Well-being objectives.

Keywords: sustainable, generations, wellbeing, legislation, community

Introduction

Mining has been an active industry in Wales since the Bronze Age, bringing much prosperity during the industrial revolution, however subsequent decline has left a legacy of scarred landscapes and societies. The last lead mine at Parc in the Gwydir Forest (North Wales) closed in 1958 and the copper precipitation ponds at Parys Mountain (Anglesey) were abandoned in 1956. Gold mining has endured and is still practiced at Clogau (North Wales) where processing of mine spoil continues. In relation to coal, only small private mines now exist as large collieries within the extensively worked South Wales Coalfield closed from the mid 1980's.

Many former mining communities that surround the now abandoned mines rank today as some of the poorest in western Europe. The legacy remaining from in excess of 1,300 metal mines, numerous collieries in the South Wales Valleys and those in North East Wales has been one where large reclamation schemes from the mid 1980's were encouraged to help restore impoverished environments and communities, attempting to inject new business opportunities. These

restoration schemes accommodated heavily industrialised areas such as Ebbw Vale (the Garden City), Merthyr Tydfil, Llanelli, Wrexham, also at Bwlch and Van lead mines in Mid Wales. Many areas have however, had little development since the cessation of mining, exemplified by the designated landscape of the Blaenavon World Heritage Site (South Wales Coalfield), which contains many original features of the previous mining landscape.

Given this long history of mining in Wales and numerous examples of resultant legacy sites, a valuable long-term opportunity to evaluate the practical application of “sustainability” with respect to mine site remediation has emerged in this Act. Examples of legacy mine site remedial actions are therefore identified and discussed as early stage case studies.

Private and Community Led Repurposing in Wales

Developments utilising former mining landscapes to regenerate local economies have recently used adventure tourism as its base. The development of tourism as an “end

use" at Welsh mines developed from decades of experience with traditional projects like interactive visitor centres, museums and walking trails. A small scale opportunity occurred at the Bedlinog recreation and climbing centre, a former colliery north of Caerphilly. Larger redevelopment of an open cast coal mine occurred at the Ffos Las Horse Racecourse, Carmarthenshire, plus the diversification of a sheep and cattle farm with a cart racing track at Abbey Consols mine, Ceredigion. More recent adventure tourism projects such as the downhill mountain bike center Antur 'Stiniog was established in former slate mines near Blaenau Ffestiniog as a not for profit social enterprise. This followed receipt of over 2,000 support pledges from local residents, each sharing the same vision "To develop the potential of the Outdoor Sector in a sustainable and innovative way for the benefit of local residents and economy". Other examples include aerial zip lines (Zip World) at Penrhyn Quarry near Bethesda, surfing lagoons (Surf Snowdonia) at the former Trefriw aluminium plant and at the Slate Caverns of the Llechwedd Deep Mine, Blaenau Ffestiniog with underground trampoline networks (Bounce Below), cavern exploring plus quarry tours offered. All provide positive community benefits, much needed employment and revenue generation.

Given the history of mining in Wales and the decades of resulting negative socio-economic impact, the developing adventure tourism concept offers an alternative view on what "sustainable" means from the perspective of mine closure.

The Well-being of Future Generations (Wales) Act 2015 (WbFGA)

To maximise the opportunities to progress mine remedial work NRW is looking at recently introduced legislation. The enacting of the WbFGA introduced "sustainability" into legislation for the first time anywhere in the world. This adopts the Gro Harlem Brundtland sustainable development principles (World Commission 1987); and aims to improve the social, economic, environmental and cultural well-being of Wales. This puts in place the following seven goals

1. **A prosperous Wales:** An innovative,

productive and low carbon society which recognises the limits of the global environment and therefore uses resources efficiently and proportionately (including acting on climate change); and which develops a skilled and well-educated population in an economy which generates wealth and provides employment opportunities, allowing people to take advantage of the wealth generated through securing decent work.

2. **A resilient Wales:** A nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change (for example climate change).
3. **A healthier Wales:** A society in which people's physical and mental well-being is maximised and in which choices and behaviours that benefit future health are understood.
4. **A more equal Wales:** A society that enables people to fulfil their potential no matter what their background or circumstances (including their socio-economic background and circumstances).
5. **A Wales of cohesive communities:** Attractive, viable, safe and well-connected communities.
6. **A Wales of vibrant culture and thriving Welsh language:** A society that promotes and protects culture, heritage and the Welsh language, and which encourages people to participate in the arts, and sports and recreation.
7. **A globally responsible Wales:** A nation which, when doing anything to improve the economic, social, environmental and cultural well-being of Wales, takes account of whether doing such a thing may make a positive contribution to global well-being.

"In this Act, any reference to a public body doing something "in accordance with the sustainable development principle" means that the body must act in a manner which seeks to ensure that the needs of the present are met without compromising the ability of future generations to meet their own needs." A public body like NRW must

consider and balance the short-term needs with those of the long term, particularly if these have a detrimental effect on the long-term effect. This accommodates other public bodies objectives and therefore their involvement or collaboration to enhance well-being deliverables and goals. Thus, for large capital remedial schemes, stakeholder dialogue will accommodate the designated range of national and local public bodies via the Public Services Board (PSB). A Future Generations Commissioner ensures the PSBs fulfill their duties.

This duty requires public bodies to work together with PSBs to enable greater public participation with funded work. For example, by working with the Sports Council of Wales and Public Health Wales NHS Trust, opportunities to encourage enhanced healthy lifestyles can be incorporated into new planning. Similarly, by linking with the Arts Council of Wales, National Museum of Wales or the Higher Education Funding Council for Wales, planned development may leverage additional funds delivering enhanced cultural opportunity for intuitive sensitive public art with communities and schools engaged in design development to educate via nature or social history.

Public bodies undertaking substantial capital spending have a duty to ensure they embrace community well-being and apply their objectives. NRW's objectives link the State of Natural Resources Report (SoNaRR), Natural Resources Policy (NRP) and Area Statements. The NRP, produced by Welsh Government, identifies that NRW will secure nature based solutions, increase resource efficiency to decarbonise and take a place based approach. The NRP focuses upon reversing the decline in biodiversity, reducing pollution and flooding, improving ecological resilience, soil quality and biosecurity, increasing renewables, carbon storage, healthy fish, woodlands, recycling, recovery, maximising recycled aggregate, ensuring sustainable mineral extraction and adapting to climate change. NRW has seven Area Statements, one marine and six land-based that take a place based approach focusing on collaborative working, building on evidence that communities will better

deliver behavioural changes to tackle the challenges and priorities. The SoNaRR collates evidence from Area Statements and elsewhere, providing the prime national scale evidence base for Welsh Government to produce the NRP, which develops national priorities where taking action at the right scale will maximise or multiply benefits.

Llynfi Valley Sustainable Redevelopment Case Study

This case study highlights the importance of the socio-economic aspects of mine closure, and how innovation is vital for success. At the former Coegnant colliery and Maesteg Washery in the upper Llynfi Valley (ULV) South Wales, one of the most socially and economically deprived communities in Wales, Welsh Government funded in 2015 a reclamation woodland scheme for community benefit. Although preparatory work preceded the Act, the outputs promoted the principles.

Sustainable woodland planting occurred in ULV that has, based on socioeconomic metrics, higher degrees of limiting long term illness and "General Health Not Good" than those in the nearby communities of Maesteg, Bridgend (14 km away) or Wales as a whole (Powell Dobson Urbanists 2010). Incapacity benefit in the ULV communities is also higher than in both Bridgend and Wales. These socio-economic factors directly effect economic activity within communities as more illness or poor health are an impediment to achieving sustainable positive economic outcomes. For example, there are twice as many people who have never worked here than in Bridgend. Economic mobility is also impaired, comparative analysis revealing car ownership reduced by half in the ULV, resulting in more people traveling to work by bus or taxi and fewer by bike.

Sustainability can be "encapsulated" when development achieves economic, social, environmental and cultural well-being. The planting of 30 ha with 60,000 trees created the Spirit of Llynfi Woodland in an area of 75 ha that demonstrably promotes health and well-being. When initially assessing mine hazards at the site, NRW reviewed typical constraints like crown holes, habitat, drainage and also

the opportunities, for example identifying the potential to exploit mine water enthalpy for community benefit (AECOM 2015). The planting scheme incorporates an off-road cycle route connecting ULV, Maesteg and the national network that provides an obvious improvement to cycle mobility and connectivity. Additional footpaths were introduced, green exercise areas plus trails for people and dogs, a geocache trail. Diversity of habitats was achieved with ponds, marshland, fruit tree orchard, stream bridges with school inspired designs and a lasting artwork was established through the sculpture of Keeper of the Collieries, one of the last working colliers.

Bridgend County Borough Council also introduced the Caerau Construction Skills Centre that linked with the Green Skills Centre at Tredegar to stimulate training in the green economy and increased economic activity in microgeneration and renewable energy installation. Subsequent major Welsh Government investment for community heating from the mine water has occurred.

The Metal (Non Coal) Mine Programme

Following the EU Water Framework Directive (WFD) in 2000, Environment Agency Wales a predecessor body to NRW published the Metal Mines Strategy in 2002 prior to the WFD being implemented into UK law in 2003. This gave an objective to focus on the fifty most polluting metal mines leading to several catchment led assessments of polluting pressures on surface waterbodies.

Studies became more site focused leading to remedial intervention actions redirecting surface water away from open cast sites and shafts as entry points.

As part of a review of priority sites, The Coal Authority reviewed monitoring and assessment at ten mines and three Blow Out Potential (BOP) sites (Coal Authority 2016). Prioritisation (Table 1) ranked them according to completeness of monitoring, treatability of the discharges, physical site attributes, constraints of heritage, habitat and landscape, land ownership issues and cost benefit. This review resulted in the least technically complex site at Abbey Consols being ranked top priority, leading to the Teifi Mines of Abbey Consols and Esgair Mwyn progressing to detailed design for treatment and sediment arrest infrastructure to maximise benefits to the Afon Teifi. Feasibility studies are completed at Cwm Rheidol, Cwmystwyth, Dylife and Frongoch-Wemyss mines, whilst at Parys Mountain a cost benefit assessment progresses.

Abbey Consols is located on the opposite side of the river to the 12th century Strata Florida Abbey, whose Cistercian monks were also interested in the mineral resources in the area. Notably the church at the Abbey had been built with a lead roof until a fire attributed to a lightning strike in 1284, caused it to melt and roll off. Culturally the Abbey is nationally important, whilst the mine is the largest contributor of zinc to the River Teifi and impacts some 40 km. NRW used this evidence to pursue design of the

Table 1 Metal Mine Prioritisation Site Scoring Matrix (from Coal Authority 2016).

Score	Monitoring	Treatment	Physical Site Attributes	Designations	Land Ownership	Cost v Benefit	Total
Site							
AC	9	7	7	7	5	9	44
F-W	7	7	7	7	3	7	38
CRh	9	5	7	7	1	7	36
CY	7	7	3	5	7	7	36
Dylife	7	7	7	5	3	7	36
PMtn	9	7	7	5	5	3	36
EM	5	5	3	7	5	7	32

AC=Abbey Consols. F-W=Frongoch-Wemyss. CRh=Cwm Rheidol. CY=Cwmystwyth. PMtn=Parys Mountain. EM=Esgair Mwyn.

Surface Water Management System (SWMS), treatability trials and detailed design with WSP in collaboration with Cardiff University. The favoured treatment design is a semi passive system incorporating NaCO_3 dosing and settlement ponds. The discharge rate of 1 L/sec means the footprint of the treatment scheme will be relatively small and capital costs of this scheme are expected to be low circa £1M. The scheme design will transform improvements in water quality using innovative water treatment technology that delivers Public Goods benefitting nationally important cultural heritage, community well-being and offering applied learning opportunities.

Frongoch-Wemyss is in upland Ceredigion on private land located about 3 km from the former mining community of Pont-rhyd-y-groes. Some of the mine buildings are designated Scheduled Monuments (SM's) and of particular note with regard to perception of mine waste, an area of mine spoil is designated a geological Special Site of Scientific Interest (SSSI) for possessing rare supergene mineral formation. Latterly from 1899 to 1903 the site was operated by Belgian company Société Anonyme Minière. The site now benefits a SWMS and has three distinct discharges, one from Frongoch adit that enters the Nant (stream) Cwmnewydion and two much smaller, but concentrated discharges that enter Frongoch stream. NRW pursued innovative sustainable research of contained low energy demand water treatment solutions. Electrochemical coagulation pilot trials on the two concentrated discharges successfully removed the majority of metals and collaboration with Swansea University investigated membrane nanofiltration improving precipitate harvesting to 15–20% solids (Elentec 2019). The electrochemistry trials continue with collaborating partners of LIFE Demine. This site continues to provide opportunities to study the possibilities, and practicality of incorporating sustainable mine water treatment technologies in a remote upland environment that is also a culturally sensitive heritage site.

Cwm Rheidol is in the steep sided Rheidol valley that on the north side of the valley has two adit discharges conveyed

to limestone filter beds constructed in the 1960's to address the highly concentrated and ochreous acidic discharges. The filter beds soon passivated, stopped working and now some 9 T/yr of metals enter the Rheidol. The Cwm Rheidol hydro power station, operated by Statkraft UK Ltd, is located downstream where they have a visitor centre and butterfly house. The Rheidol steam railway and Special Area of Conservation (SAC) provide attraction on the valley's southern side. There is no immediate associated community and the location lends itself to incorporation of an active treatment system with a low footprint, which could stimulate economic enterprise. NRW supported Power & Water carrying out sono-electrochemistry trials using the ©soneco process, which proved successful in substantially reducing metal loading and demonstrates the options to utilise renewable energy for mine water treatment (Rose 2019). Trials of Dispersed Alkaline Substrate are planned to provide comparative assessment.

Cwmystwyth has been exploited since the Bronze Age. The stunning landscape setting is located on a steep sided mountain valley 7 km west of Pont-rhyd-y-groes. Treatment of the main discharge, Pugh's adit ochreous discharge, would significantly reduce metal loads to the river by up to 8 T/yr of non iron metals, but not recover the river to good status. It is noted that there are designations for SM's, SSSI and SAC's present identifying a highly sensitive site setting. The Coal Authority has attributed costs of £3M to address discharges from Pugh's adit. Use of onsite hydropower for an active treatment system has been recognised as a potential opportunity and it would be viewed as an exemplar scheme with multiple benefits decarbonising the programme.

Dylife is on the headwaters of the Afon Twymyn and Nant Dropyns about 4 km from the small community of Staylittie in Powys. The Roman fortlet Penycrocbren is situated above the workings and the area has been exploited since Romano British times. The watercourses are intermittent due to loss of water to the mineral workings on the lodes, which strike across the waterbodies. Accordingly, an integrated hydro-scheme to convey water from above the mine workings

to a turbine house beneath the spoil tips is considered favourable. Toe drainage and active treatment of spoil tip discharges will be required as will protection/capping of the dressing floor at the confluence of the tributaries. There are habitat, heritage and biosphere constraints. Costs for the hydro scheme to completion of detailed design are estimated at £700K. Remedial work to convey water over the mine workings would ensure a substantial reduction in metal loading to the river.

Parys Mountain is 3 km from Amlwch and is unique to the UK, being at one time the world's largest copper mine now discharging 231 T/yr of harmful metals into the Irish Sea. Mineral exploitation stretches back to the Bronze Age but huge interest sprang from 1760. Precipitation ponds were also used to extract the copper and a Copper Kingdom visitor centre is based at Amlwch port. There would be interest in mimicking the former cementation method of copper extraction, providing employment with artisanal scale jewellery and manufacture of cookery implements. It could yield educational and tourist interest, particularly if dashboards are made available to schools/institutions with live daily water quality data available. Interest would trigger heritage research at the precipitation ponds and reverberatory furnace. The Coal Authority is undertaking a comprehensive Benefits Assessment considering the newly created North Anglesey Marine SAC and will ensure a recognition of the Natural Capital. Pilot trials of the Dispersed Alkaline Substrate system are planned that may lead to a full scale system, which is currently considered cost disproportionate and provide a test bed for plug and play treatment systems.

NRW has further developed the programme to clean up and restore the 700 km of failing waterbodies impacted by metal mining (Coal Authority 2020). This accommodates the above sites, but also focuses on sites where BOP and mine hazards have been considered. The BOP assessments included Parc, Coed Mawr Pool and Pandora lead mines in the Gwydir Forest on the Welsh Government Woodland Estate. Welsh

Government has provided £4.5M capital funding for this financial year 2020–2021 to restore their health and habitat. These mines are centred primarily around Pont-rhyd-y-groes, Gwydir Forest, Llanrwst and Amlwch in Anglesey.

Capital funding received may be used as "match" contribution for other funding mechanisms, like Heritage or Lottery, leveraging more capital delivering well-being betterment to reverse negative socio-economic impacts. Cardiff University has been successful in a SMARTExpertise bid using NRW and Coal Authority remedial programme funds for further collaborative metal mine research, development and innovation. This will focus on Abbey Consols but extend to communications, monitoring devices, stabilisation or valorisation of sediments and precipitates.

Conclusion

The duties imposed by the WbFGA ensure that public bodies like NRW will have to adhere to their well-being objectives enshrined in their Corporate Plans and consider other associated public body interests with a view to collaborating if well-being goals are to be enhanced. The examples described here demonstrate how innovation from private sector led tourism regeneration has empowered communities to utilise former mining landscapes stimulating local economies and developing healthier outdoor lifestyle activities as its base. Furthermore, the case studies highlight opportunities for development of mine water treatment systems as part of remedial works to achieve positive ecological, environmental and economic outcomes. With regard to remedial works that incorporate metal mine water treatment systems, it is recognised that these typically as a minimum will have relatively low capital cost of £1-6M. Whilst this incentivising Act remains in it's infancy, given the setting of the sites, the scale of work with even modest capital outlay can still assist with sustainable area based community benefits, cultural heritage preservation and provide immediate term economic benefit.

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References

- World Commission (1987) Report of the World Commission on Environment and Development: Our Common Future.
- Powell Dobson Urbanists (2010) Llynfi Valley VARP (Valley Area Regeneration Plan) Baseline Report.
- AECOM (2015) Llynfi Woodland Creation Scheme.
- Coal Authority (2016) A Review of Priority Metal Mine Sites in Wales.
- Elentec (2019) ETEC 17008 – Frongoch Final Project Report.
- Rose SA, Matthews Z, Morgan G, Bullen C, Stanley P (2019) Sono-electrochemistry (Electrolysis with assisted Power Ultrasound) Treatment Trials of discharges from Cwm Rheidol - Ystumtuen mines, Ceredigion, Mid Wales.
- Coal Authority (2020) Metal Mine Failing Waterbodies Assessment - Overview Report.