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GSNI Geological
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GEOLOGICAL SURVEY OF NORTHERN IRELAND

Annual Report 2022/23



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Director's statement:

Dr Marie Cowan

I am pleased to introduce the Geological Survey of Northern Ireland's (GSNI) 2022/23FY Annual Report for the Department for the Economy (DfE). This report summarises how GSNI performed and the impact of our work for Northern Ireland's economy, environment and society.

GSNI has had another very productive year. Some of the most significant and visible work includes GSNI's contribution to heat policy, specifically under Action 16 of DfE's Energy Action Plan 2022 to undertake feasibility studies to inform future decisions on suitable locations for accessing geothermal heat and to better understand the potential role that geothermal energy can play in Northern Ireland's energy mix to help catalyse growth in this sector.

This FY GSNI wrote the contract specifications, input to an extensive DfE pre-market engagement exercise, and responded to 128 clarifications before the contract was awarded and kick-off meeting held on 22nd February 2023. GSNI also conducted geological, hydrogeological, and together with Queens University Belfast and Aberdeen University, geophysical surveys on the Stormont Estate to refine the understanding of the bedrock and superficial geology.

The GSNI-chaired Geothermal Advisory Committee (GAC) which involves industry, academia, public

sector, and professional organisations based in UK and Ireland hosted Northern Ireland's inaugural #GeothermalWeekNI in June. This week comprised a series of events including an international conference session, launch of the DfE-Commissioned QUB report on building the geothermal sector here, social science research based on roundtable dialogues with key stakeholders, a fieldtrip for C-level decision makers, an online public lecture, and invited presentations at the Energy Institute NI Conference and to Antrim and Newtownabbey Borough Council.

GSNI scientists have been working with our British Geological Survey (BGS) colleagues in the UK Critical Minerals Intelligence Centre and contributed to a report entitled Potential for Critical Raw Material prospectivity in the UK published in April this year highlighting Northern Ireland locations with potential for minerals of global strategic interest.

The €13.5M Interreg VA-funded Catchment Care project, involving the construction of 50 new groundwater monitoring boreholes co-delivered

with the BGS and Geological Survey Ireland (GSI), concluded this FY. The aim was to improve understanding of the role groundwater plays in our river catchments. As part of this project, a groundwater visualisation work programme was developed using interactive 3-D Oculus Headsets which allow people to visualise groundwater systems; this innovative approach was highly commended by the CEO of Special EU Programmes Body.

GSNI scientists were part of a global group of experts selected to define and set the assessment criteria, evaluation and determination of the world's first 100 Geosites. This was under the auspices of the International Union of Geological Sciences. They were cited as authors in the published book and were invited to present at the international conference to launch the sites with Northern Ireland Giant's Causeway making it to the final list.

As well as delivering a geoscience work programme for our parent Department for the Economy, GSNI also worked on service level agreements for the Northern Ireland Environment Agency (NIEA), Newry, Mourne and Down District Council, NI Water, and the Department for Agriculture, Environment and Rural Affairs (DAERA). GSNI is also working to inform the Department for Infrastructure /DAERA's co-chaired Coastal Forum Working Group to identify the data gaps needed to inform climate change adaptation.

GSNI scientists are collaborating on research with scientists from Trinity College Dublin, Cambridge University, Camborne School of Mines and Brown University USA on critical minerals on the island of Ireland involving two PhD students.

GSNI provided scientific support and advice to DfE for its scoping of social science research for QUB on the Critical Minerals Value chain and a stakeholder event in February 2023.

Dr Marie Therese Cowan PGeo, MIOD MRIA
Director, Geological Survey of Northern Ireland





Introduction

The Geological Survey of Northern Ireland (GSNI) is an office of the Department for the Economy (DfE) in Northern Ireland staffed by scientists of the British Geological Survey (BGS). It was established under the Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959 and sits within the Energy Group of the DfE.

GSNI provides professional, technical and scientific research, data services and archive management to inform the development of NI's economy and to help protect its environment.

The work programme for DfE and associated terms and conditions are detailed in a service level agreement (SLA) between DfE and UK Research and Innovation (UKRI). The same applies to SLAs with NIEA and other public sector bodies.

UKRI is a non-departmental public body sponsored by the Department for Science, Innovation and Technology which governs the BGS and employs GSNI staff.

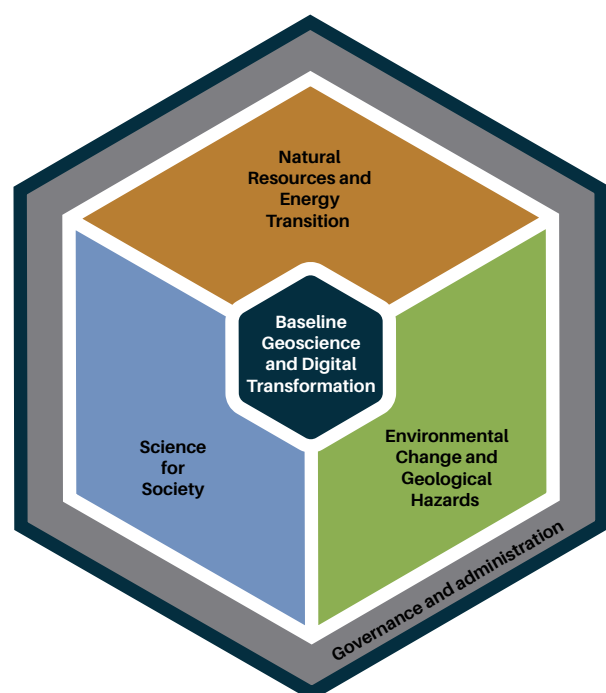
Governance and administration

The policies and processes framework for the operation and administration of GSNI are documented in the GSNI Procedures Manual, a key reference in any audit of GSNI. To provide an effective governance and assurance mechanism, DfE reviews progress on its SLA with GSNI at quarterly SLA review meetings.

The SLA review meetings are chaired by the DfE Director of Business, Gas, Minerals and Petroleum Division. The purpose of the meeting is to review

GSNI's SLA performance dashboards, monitor spend against budget, risk register information, and action points from previous meetings.

The GSNI Director chairs bi-monthly meetings of the GSNI Executive where monthly reports are reviewed,



issues and opportunities are considered, risks are escalated and health and safety items are managed.

As a result of work carried as part of the draft GSNI Science Strategy, the organisational structure of GSNI was changed in FY2022/23. This moved away from the siloed team structure and instead focused on science and innovation programmes to allow for a more coordinated approach to local, national and global challenges. A summary of each of these has been provided below.

Natural resources and energy transition

An essential part of GSNI's work is ensuring our geoscience knowledge and expertise helps Northern Ireland make best use of natural resources in a sustainable way and that policy decisions are informed by data and high-quality research. To this end, the Natural Resources and Energy Transition work programme supports the regulatory duties of DfE and wider government through the provision of technical expertise.

The green technology revolution relies on critical elements, sustainable use of groundwater resources and utilisation of low-carbon subsurface energy solutions. The Natural Resources and Energy Transition work programme increases the understanding of the distribution of these resources in Northern Ireland, and how subsurface properties and the modelling of geological processes can help in planning the resilient infrastructure required for the energy transition and sustainable uses of water resources.

Environmental change and geohazards

Climate change is the most pressing environmental issue we face, impacting our coastline, infrastructure, built environment and natural ecosystems. The Environmental Change and Geohazards work programme increases the understanding of changes to our natural and built environment, the vulnerability

of our environment to geological hazards how it is responding to climate-driven challenges.

Key tasks within the Environmental Change and Geohazards work programme include enhancing geological hazard characterisation by implementing new monitoring techniques, increasing knowledge of groundwater to help reduce groundwater vulnerability, assessing coastal change to reduce coastal vulnerability, and increasing the understanding of the urban and built environment to support climate resilient development.

Baseline geoscience and digital transformation

Good data underpins sound decision making and the expansion of our national baseline geoscience data is necessary to ensure we have the right data to address future challenges such as the supply of energy, raw materials and water. The demand for open access to data resources is increasing; data users want access to authoritative, modern, and increasingly, real time data. Our archives hold a wealth of information that must be accessible into order to be appraised against today's geoscience challenges.

The Baseline Geoscience and Digital Transformation work package will expand our geoscience data holdings and deliver GSNI's data to end users by supplying the underlying infrastructure, applications and processes that will support all of the other work programmes.

Science for society

Northern Ireland faces several societal challenges that present an opportunity to highlight the key role that geoscience must play in addressing these. By communicating with the public and our stakeholders and by strategically informing and supporting relevant government policy we can raise awareness of and begin to address these challenges.

Increasing societal challenges will require an increased number of future geoscientists to enhance NI's sustainability and economic resilience which can be achieved by developing an inclusive geoscience education strategy. This will be complemented by supporting sustainable geological tourism and using

it as an effective and powerful means of bringing geoscience directly to society.

GeoEnergy NI

GSNI is supporting DfE in the delivery of two geothermal exploratory and feasibility studies that will be used to better understand the subsurface and to identify sites to drill and install one shallow geothermal system and one deep geothermal system in Northern Ireland. The project is formally known as GeoEnergy NI and the data and learning from this will be used to demonstrate that a viable geothermal heat resource is accessible at depth, to encourage private investment and to inform the development of a policy and regulatory framework that supports and promotes opportunities to unlock Northern Ireland’s geothermal energy potential.

Public science role

GSNI’S mission is to deliver high quality scientific evidence and expert knowledge to inform the sustainable use of natural resources and sound environmental governance whilst helping society transition to a low carbon economy and adapt to a changing world.

We achieve that through four overarching strategic objectives:

- Society, economy and environment: Delivering geoscience data and evidence to progress the economic and social ambitions of Northern Ireland while protecting and enhancing its natural environment.
- People and assets: Recruiting, developing and supporting our people and assets to provide high impact, innovative, efficient and effective public service.
- Partners and customers: Engaging with and listening to the public and stakeholders to inform our work and help build trust in, and understanding of, geoscience and the GSNI. Strategically informing and supporting key decisions and policies on national geological issues in Northern Ireland.
- Unlocking our data: Unlock the value of our paper records and physical collections in our archive through digital transformation of our data and delivery mechanisms.

Statutory responsibilities

GSNI was established under the Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959. As an office of DfE, GSNI has a number of statutory responsibilities as laid out in Northern Ireland legislation as indicated in the table below.

Northern Ireland legislation that determines GSNI’s statutory responsibilities

Theme	Legislation
Minerals	Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959
	Mineral Development Act (Northern Ireland) 1969
Planning	Planning Act (Northern Ireland) 2011
	The Planning (General Development Procedure) Order (Northern Ireland) 2015
	The Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 2015
Petroleum	Petroleum (Production) Act (Northern Ireland) 1964 and secondary legislation in 1987 & 2010
Abandoned Mines	Mineral Development Act (Northern Ireland) 1969
Information Requests	Freedom of Information Act 2000
	The Environmental Information (Amendment) Regulations (Northern Ireland) 1998
	The Environmental Information Regulations (Northern Ireland) 1993
National Core Repository	Minerals (Miscellaneous Provisions) Act (Northern Ireland) 1959
Climate Change	Climate Change Act (Northern Ireland) 2022



Section 1

Our public good science

Delivering the GSNI strategy

GSNI Science Advisory Committee

The role of the GSNI Science Advisory Committee (SAC) is to advise the GSNI Director and senior leadership team on the development and delivery of GSNI's science strategy. The SAC comprises just over 20 external members from all sectors, trade bodies and professional bodies in Northern Ireland, and representatives from Ireland and elsewhere in the UK. This SAC meets twice per year and the position of Chair rotates amongst the university representatives; this year the SAC met online in May and in-person with a few members joining online in November.

GSNI Science Task Force

The GSNI Science Task Force (STF) was established in September 2022 and has the following roles:

- Review current research science and ensure links into relevant Northern Ireland government policies.
- Prioritise future research that aligns with and meets the requirements of the GSNI science strategy
- Maximise the impact of our science; and ensure benefits for society.

The membership of the STF consists of 10 GSNI members of staff who meet quarterly. The first kick-off meeting was held face-to-face in October 2022.

The STF reports to the GSNI executive and will initially develop a research priority list for inclusion in the next DfE SLA, other SLAs and projects. The focus of the STF is to strategically prioritise our work programme with existing resources and to make the case for additional resources to respond to new research challenges.

Science into policy

GSNI's position as an office within DfE provides a valuable opportunity to inform and support public policy development right across Northern Ireland government, and to inform debates and decisions on relevant issues. Using this approach, it is providing the scope to identify policy trends and opportunities not just within Northern Ireland, but throughout the rest of the UK, Ireland and the rest of Europe.


GSNI staff have a wide range of expertise demonstrated through the breadth of science work programmes making it possible to provide valuable contributions to relevant policy consultations, calls for evidence and requests for information. Topics covered this year were centred around climate change, primarily as a result of the introduction of the Climate Change (Northern Ireland) Act 2022. There was also a strong emphasis on energy, with a particular focus on renewable energy including the facilitation of energy infrastructure.


Summary of science into policy

Specific examples of science into policy are provided in the next section and a list of all policy inputs has been provided in the table below.

Department / Organisation	Policy
DfE	Energy One Stop Shop Implementation Plan Consultation on Policy Options
DfE	Offshore Energy Renewable Action Plan Consultation
DfE	Draft Circular Economy Strategy Consultation
DfE	Phase 1: Departmental Return on Climate Action Plan
DfE	Phase 2: Departmental Return on Climate Action Plan
DAERA	NICCAP2 Mid-Programme Review
DAERA	Draft Marine Plan (policy papers) - government body consultation
Dfi	Public consultation on the Review of Permitted Development Rights for microgeneration equipment
DEFRA	Draft Consultation: Nature Recovery Green Paper: Protected Sites and Species
UK CCC	Climate Change Adaptation Conceptual Frameworks

Summary of outputs

9  Peer-review papers and books

12  Public webinars and invited talks

21  Conference abstracts

6  GSNI-led fieldtrips

11  Reports

9  Public in-person events

9  Magazine articles

2  TV / radio appearances

Summary of SLA objectives

A summary of the work programme delivered as part of the DfE SLA is provided in the table below.

WP	No.	Objective	Target Achieved in 2022/23
Governance	1	Governance and project evaluation	
	2	Coordination of scientific and technical activities	
	3	Strategic Communications and Business Development	
	4	Admin, finance and contract support to GSNI	
Natural Resources	1	Mineral licensing and policy support	
	2	CRMs Prospectivity	
	3	Geothermal prospectivity	
	4	Groundwater resources	
	5	Reservoir characterisation	
	6	Geological resource mapping	
Geohazards	1	Abandoned mines programme and emergency response planning	
	2	Coastal change and marine	
	3	Geological hazards	
	4	Groundwater catchment	
	5	Urban and built environment	
Digital	1	Provide data collection, storage and delivery mechanisms	
	2	Making our data Q-FAIR	
	3	Unlocking the GSNI archives by digitising our records and collections	
	4	Delivering new and innovative data products and services	
	5	Enquiries	
Science for Society	1	Spatial planning	
	2	Public policy	
	3	Internal communications	
	4	External communications	
	5	Education	
	6	Tourism and Sustainable Development	
Geothermal	1	Reconnaissance and Survey	
	2	Test Boreholes	
	3	Thermal response tests	
	4	Feasibility and design	
	5	Visualisation and engagement	
	6	Project support	



Science highlights

Natural resources and energy transition

Minerals licensing support

The provision of scientific advice in this area falls into two principal categories; operational support in the administration of mineral prospecting licences and policy support in the development of minerals policy. The former of these will be covered in this section.

Operational support is primarily delivered through the advice and monitoring of the mineral licensing system for which DfE has responsibility under the Mineral Development Act (Northern Ireland) 1969. GSNI supported DfE in pre application discussions with prospective licence applicants and through the provision of data to inform the application itself. There are currently 14 active prospecting licences across Northern Ireland and each of these has an annual reporting requirement which GSNI assesses.

Under Health and Safety legislation, DfE collects information on the annual production and employment figures from quarries across Northern Ireland. GSNI collates these data and produces the Annual Quarry Return statement for publication on the DfE website. In recent years in addition to this annual task, GSNI has been working to develop a supplementary document to sit alongside this publication to give more visual insight into aggregate production across Northern Ireland.

Project initiation of GeoEnergy NI

The Northern Ireland Energy Strategy - Path to Net Zero, published in December 2021, recognised that geothermal energy has a role to play in decarbonising how we heat and cool our homes hospitals, schools, universities, businesses, and offices. The DfE's 2022 Energy Strategy Action Plan committed to develop and commence delivery of a geothermal demonstrator project as part of its pathway to reach net-zero targets with GSNI providing scientific support.

In June 2022, the then DfE Minister, Gordon Lyons, recognising the importance of ensuring that there is a secure supply of locally available energy, announced £3 million of funding for a geothermal demonstrator project. This project is designed in a phased approach to evaluate the feasibility of harnessing geothermal energy at two locations – a shallow geothermal system for heating and cooling of buildings on the Stormont Estate in Belfast, and a deep geothermal system at the College of Agriculture Food & Rural Enterprise (CAFRE) Greenmount Campus in Antrim. The objectives are to showcase the potential of geothermal energy to provide heating and cooling, and to encourage future private sector investment in geothermal technology in Northern Ireland.

This FY GSNI scoped the project, drafted the contract specifications, input to an extensive DfE pre-market engagement exercise, and responded to a number of clarifications before the contract was awarded and kick-off meeting held on 22nd February 2023. In addition, GSNI conducted geological,



Geophysical and geological surveys of the Stormont Estate

hydrogeological, and together with Queens University Belfast and Aberdeen University, geophysical surveys on the Stormont Estate to refine the understanding of the bedrock and superficial geology

Geophysical and geological surveys of the Stormont Estate

In preparation for the GeoEnergy NI project, DfE funded a series of research projects that were managed or carried out by GSNI scientists. These included a geological survey and a series of shallow geophysical surveys on the Stormont Estate.

A geological survey of the bedrock and superficial deposits of the Stormont Estate was conducted by in June and July 2022. Work was completed at 1:2000 scale and was done to inform the drawing of cross sections used for construction of 3D models of the site and a conceptual model for outreach purposes. Information from the mapping was combined with that previously reported from the Newtownards geological map and memoir and provided as a geological report for the Estate and surrounding area.

In October 2022, a team including researchers from Queen's University Belfast and the University of Aberdeen undertook magnetic, seismic refraction,

and electrical resistivity tomography (ERT) surveys, coordinated by GSNI. The aim of this work was to characterise the shallow geology and aquifers of the Stormont Estate, with the objective to identify suitable sites for shallow geothermal test boreholes and to assist in building a 3D model to better understand the site.

Critical Minerals Intelligence Centre

The UK Critical Minerals Intelligence Centre (CMIC) supports the UK in securing adequate, timely and sustainable supplies of the minerals and metals it requires to transition its economy in the coming decades to net-zero emissions. CMIC is led by BGS with support from the Department for Business & Trade (DBT) and brings together universities and private and public sector partners to gather and analyse intelligence on the supply and demand of critical minerals, their global value chains and use by UK industry.

GSNI has contributed to two publications released by CMIC in these areas. In the first paper, "Sustainable supply of critical raw materials for the UK: good practice and recommendations for improvement", GSNI provided a case study considering the benefits of a central repository for mineral exploration data, the



GSNI stand at the IAH conference with the publication Northern Ireland's Groundwater Environment

system adopted in Northern Ireland. In the second paper "Potential for Critical Raw Material Prospectivity in the UK", GSNI worked alongside BGS colleagues to identify areas of the UK that available data suggest are the most prospective for critical minerals. One area of Northern Ireland, mid County Tyrone, was one of the eight identified as being potentially prospective for critical raw materials.

GSNI staff will continue to be involved in the assessment of all eight areas as this work by CMIC is progressed.

Critical Ireland research

Due to their essential role in green technologies and concerns over supply security, platinum group elements (PGEs) constitute 'critical raw materials' and require innovative research to identify new deposits. Palaeogene igneous intrusions in Northern Ireland have been suggested as one of the most prospective regions for Ni-Cu-PGE-(Au) mineralisation in Europe and have been the subject of limited PGE exploration. This Science Fund Ireland project is supporting two PhDs and a postdoctoral researcher to investigate the Palaeogene geology of the region to look for

signs of PGE mineralisation and understanding their conditions of formation.

The supervisory group includes expert researchers from Trinity College Dublin, University College Dublin, Camborne School of Mines, Cambridge University and Brown University in America. A highly successful 'kick-off' workshop hosted by GSNI, and a fieldtrip was held in August 2022 across prospective parts of the region to welcome the two PhD students. The students have commenced their studies and fieldwork and have presented their initial findings at the iCrag and Irish Geological Research meetings.

NI's Groundwater Environment

GSNI published a new book and digital map dataset title 'Northern Ireland's Groundwater Environment'. They are the culmination of over eight years work starting with the development of a Groundwater Data Repository that has allowed a new digital map dataset of the aquifers to be developed and been attributed with relevant summary statistics for key aquifer properties and chemistry. This will de-risk groundwater resource development projects and make it easier for groundwater to be managed and regulated making Northern Ireland a more attractive location for businesses that require a reliable private



Underground investigations at Rathkenny as part of the abandoned mine programme

water supply and will help NI Water Ltd. with their groundwater development programme.

The book is a guide to this digital dataset and is written as an introduction to the valuable groundwater resources in Northern Ireland. It also contains relevant information for anyone looking to develop or use groundwater resources in Northern Ireland including what regulatory requirements there are and other tools and resources useful for developing groundwater resources.

This new book uses an aquifer conceptual model approach to provide a common platform by which all groundwater projects can be based. This will make it easier for all practitioners when developing new projects and will help regulators reviewing applications for permissions and licenses. This will lead to an exciting new age of groundwater development in Northern Ireland.

Environmental change and geological hazards

Abandoned mine programme

GSNI continued its Abandoned Mine Monitoring Programme encompassing Northern Ireland's 2,400 recorded historic mine workings. A total of 112 inspections were conducted during the year with mitigation measures carried out at three sites. One of these included the monitoring of a newly discovered mine shaft in County Antrim.

After an initial review of historic literature, investigations were carried out to determine the geometry and condition of the mine working including its horizontal tunnels and evaluate how it related to the nearby Rathkenny Iron Mine which operated from 1875 to 1922. Following a geological and topographic survey a series of geophysical investigations was conducted including electromagnetic conductivity mapping, electrical resistivity tomography and ground penetrating radar to evaluate the extent of the underlying mine works. As the mine shaft contained flowing water, a water-trace survey was completed to trace the pathway and located the outlet source. Finally, a confined space internal inspection was



Platform for Atlantic Geohazards Observatories

completed to evaluate the condition of the shaft and tunnels. The results revealed limited public risk to the wider area and treatment of the shaft was completed in October 2022 with the installation of a 4 metre diameter reinforced concrete cover slab with an inspection hatch for future inspections.

Throughout 2022/23FY GSNI continued to deliver its abandoned mine 24/7 emergency response service.

Platform for Atlantic Geohazards Observatories

GSNI continued its work on the Platform for Atlantic Geohazard Management (AGEO) project. This is a project funded through the EU Interreg Atlantic Area and includes 13 partners from five countries across the Atlantic Area; Portugal, Spain, France, Ireland and UK.

Focused on geohazard risk management the partners developed citizen observatories in Lisbon, Madeira, Canary Islands, and Brittany with GSNI responsible for delivering the Northern Ireland Causeway Coast Observatory.

The project team visited each pilot site to understand the geohazard risk, observe citizen participation in

monitoring and learn from the key stakeholders their information needs in managing the risk.

- The team visited Gran Canaria, an island prone to major rockfalls, and La Palma to witness first-hand the devastating impact of the Cumbre Vieja volcanic eruption of 2021 and meet with the emergency service personnel and local communities.
- In Lisbon, which is under threat from a number of geohazards including landslide, subsidence, flooding and tsunami threat, the team gained a better understanding of local municipality actions in communicating with the public and risk management planning.
- The team also visited Madeira, an area where large-scale landslides have led to devastating loss of life, and who are working with local schools to deliver disaster risk reduction education.

Key outputs from the year included the acquisition of LiDAR scans of the Giant's Causeway, and landslide reporting data acquired through the AGEO mobile application and an increased understanding of risk exposure at the Northern Ireland observatory.



Peat slide risk assessment training with NIEA

Peat slide risk assessments

As a statutory consultee within the Northern Ireland planning system, GSNI is frequently asked to comment on peat slide risk assessments (PSRAs), especially in relation to wind farm development. This is an important issue and one that needs to be considered carefully in the context of renewable energy development if we are to continue to contribute to climate change mitigation measures.

Staff at GSNI have been engaging with a knowledge exchange programme with the Northern Ireland Environment Agency (NIEA) with an aim to bring about an improved understanding of each body's statutory responsibilities with regards to planning applications that deal with PSRAs. These are a compulsory aspect of an environmental impact assessment whenever a proposed development is likely to encounter a significant amount of peat, usually deeper than half a metre. The ubiquity of blanket and raised peat in Northern Ireland means that wind farms are by far the most common type of development associated with PSRAs, but they are also frequently linked to the installation of energy

networks, houses, aggregate extraction, and road developments.

GSNI have provided NIEA with training on PSRAs in both office and field-based scenarios. This has ranged from the geotechnical properties of peat, to what to look for during an on-site walkover survey, as well as how consultants go about constructing a risk register and managing extracted peat during the construction phase of a wind farm.

Coastal geology datasets

GSNI has continued to work with the Department for Agriculture, Environment and Rural Affairs (DAERA) on the acquisition of relevant coastal data to support coastal management and climate change adaptation measures.

Following on from a coastal geology bedrock geology dataset, and the pilot study to develop a methodology to produce a similar dataset for superficial geology, GSNI was commissioned by DAERA to update the NiDigMap superficial



Coastal geology datasets produced for DAERA

coastal geology database started in January 2023, continuing into the 2023/24 financial year.

Most of the work focuses on refining and updating existing data within 200m of the coast, using high resolution LiDAR-derived elevation models. Field checking later in the year will focus on characterising areas covered by the Mass Movement database. These areas are likely to account for the majority of future changes, given that they are already susceptible to movement. Currently no specific data exist pertaining to their sedimentary or genetic composition.

Depth to bedrock for Belfast

As a result of engagement with the geotechnical community and other relevant stakeholders, GSNI has been working on the Belfast depth to bedrock model. This will integrate borehole records and bedrock outcrop locations to predict rockhead elevation for the Belfast City area. Integrating these geotechnical data with expert geological interpretations has been a challenge.

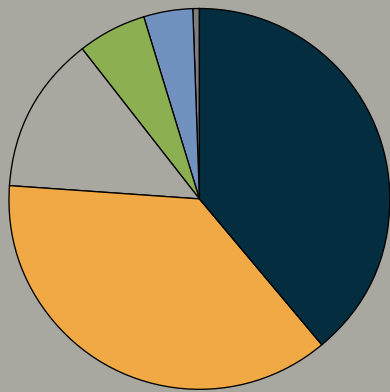
In this new model the positional accuracy of the input data are calculated from multi-scale standard deviation scores derived from a high-resolution digital

elevation model. Hand-drawn geological cross-sections are integrated allowing for expert geological insights to be encoded explicitly into the model. In the final step, predicted bedrock depths are checked against borehole records where bedrock is not encountered and adjusts the minimum thickness of superficial deposits. The end product is a bedrock surface map accompanied by a map of prediction uncertainty.

Stakeholder engagement has shown that there is demand for depth to bedrock maps from civil engineering, academic and renewable energy sectors. The parameterization of future climate change scenarios, incorporating groundwater flooding and the geotechnical properties of coastal areas will also rely heavily on an understanding of the location of different strata. Furthermore, this body of work represents the first stage of a new release of the pioneering Belfast Engineering map.

453 ENQUIRIES

168 PLANNING CONSULTATIONS



The Planning (General Development Procedure) Order (Northern Ireland) 2015

59%

Statutory Consultee

mineral applications
hydrocarbon exploration

41%

Non-statutory consultee

applications that may be impacted upon by geological issues including but not limited to:

abandoned mines, compressible ground, and geological hazards

92% responded to within the statutory response period.

Average response: 14 days

Enquiries and planning consultations

Catchment Care

This Interreg VA funded project involved the construction of 50 new groundwater monitoring boreholes and was a joint work package between BGS and GSI. The aim was to improve the understanding of the role groundwater plays in our river catchments.

In its last year, the focus was on the gathering of monitoring data from the new boreholes to characterise each groundwater monitoring station and on development of tools that would ensure a legacy from the project. NIEA has now included the new boreholes as part of the regional groundwater monitoring network. This means that awareness of the pressures on groundwater in catchments across Northern Ireland has improved. Data packs were collated and will be available for download by anyone interested in studying groundwater or developing a relevant project which will address some of the knowledge gaps of how groundwater interacts with surface waters in our catchments.

A groundwater visualisation programme was developed as part of this project. This is an interactive 3D viewing platform that allows people to better

visualise groundwater using Oculus Headsets. It is designed to mainly be used by children but will be relevant for any stakeholder and is an excellent way of raising the awareness and understanding of groundwater across Northern Ireland.

Science into policy

Planning development management

GSNI, through DfE, is a statutory consultee for planning applications in the development management process as stipulated in The Planning (General Development Procedure) Order (Northern Ireland) 2015. This is for all mineral applications and for all applications for hydrocarbon exploration or extraction. In addition, GSNI is a non-statutory consultee for planning applications that may be impacted upon by geological issues including but not limited to abandoned mines, compressible ground, and geological hazards. In 2022/2023FY, there were 168 planning consultations, with 59% being statutory.

As part of the development management process, GSNI supports Planning Officials through the provision of expert advice including recommending necessary site investigations needed for specific sites



Geothermal Week was held in June 2022.

and reviewing a wide range of assessments including, but not limited to, Environmental Statements, slope stability reports, landslide risk assessments and mine risk assessments.

Geothermal Advisory Committee

The Geothermal Advisory Committee (GAC) for Northern Ireland was established in July 2021 bringing together experts from industry, academia, public sector, and professional organisations based in the UK and Ireland. This group provides independent advice to the Department for the Economy (DfE) aimed at informing, supporting, and developing public policy on geothermal energy for NI as part of the new Energy Strategy for Northern Ireland

In 2022/23FY, the committee had nine meetings to advise and input to the following outputs:-

- DfE-QUB Commissioned Report: - Net Zero pathways: Building the geothermal energy sector in Northern Ireland
- Set the agenda and host Northern Ireland's inaugural #GeothermalWeekNI
- DfE-QUB Commissioned Report: - #NIGeothermalWeek: Defining the vision for geothermal energy in Northern Ireland

- Scoping of commissioned research, and review of report from ARUP-BGS Report Research into the Geothermal Energy Sector of Northern Ireland; Technology and Policy Review
- Consultation response to Department for Infrastructure on Permitted Development.
- Survey responses, representation at DfE Green Skills for the Energy Transition workshop and significant input to the final contractor's report.

Geothermal Week

The GSNI-chaired Geothermal Advisory Committee (GAC) which involves industry, academia, public sector, and professional organisations based in the UK and Ireland hosted Northern Ireland's inaugural #NIGeothermalWeek in June.

This week comprised a series of events including an international conference session, launch of the DfE-commissioned Queen's University Belfast School of Management report on building the geothermal sector here, social science research based on feedback from roundtable dialogues with geothermal stakeholders, a fieldtrip for C-level decision makers, an online public lecture, and invited presentations at



Critical raw materials workshop at Queen's University Belfast

the Energy Institute NI Conference, and to Antrim and Newtownabbey Borough Council.

The QUB School of Management published a report from #NIGeothermalWeek in October 2022; DfE commissioned this research to provide evidence and to inform geothermal policy development. The report entitled *Defining the Vision for Geothermal Energy in Northern Ireland* was presented to the GAC before it was finalised.

Informing critical raw materials policy development

An aspect of the service that GSNI provides to DfE covers the provision of advice and support in relation to critical minerals and emerging policy development required to support this vital area.

Two key projects were commissioned by DfE towards the end of 2022. The first of these addressed a potential critical mineral supply opportunity and was carried out by researchers from the University of Edinburgh. This has resulted in a vital increase in the understanding of Northern Ireland's potential to be part of the UK critical mineral supply infrastructure.

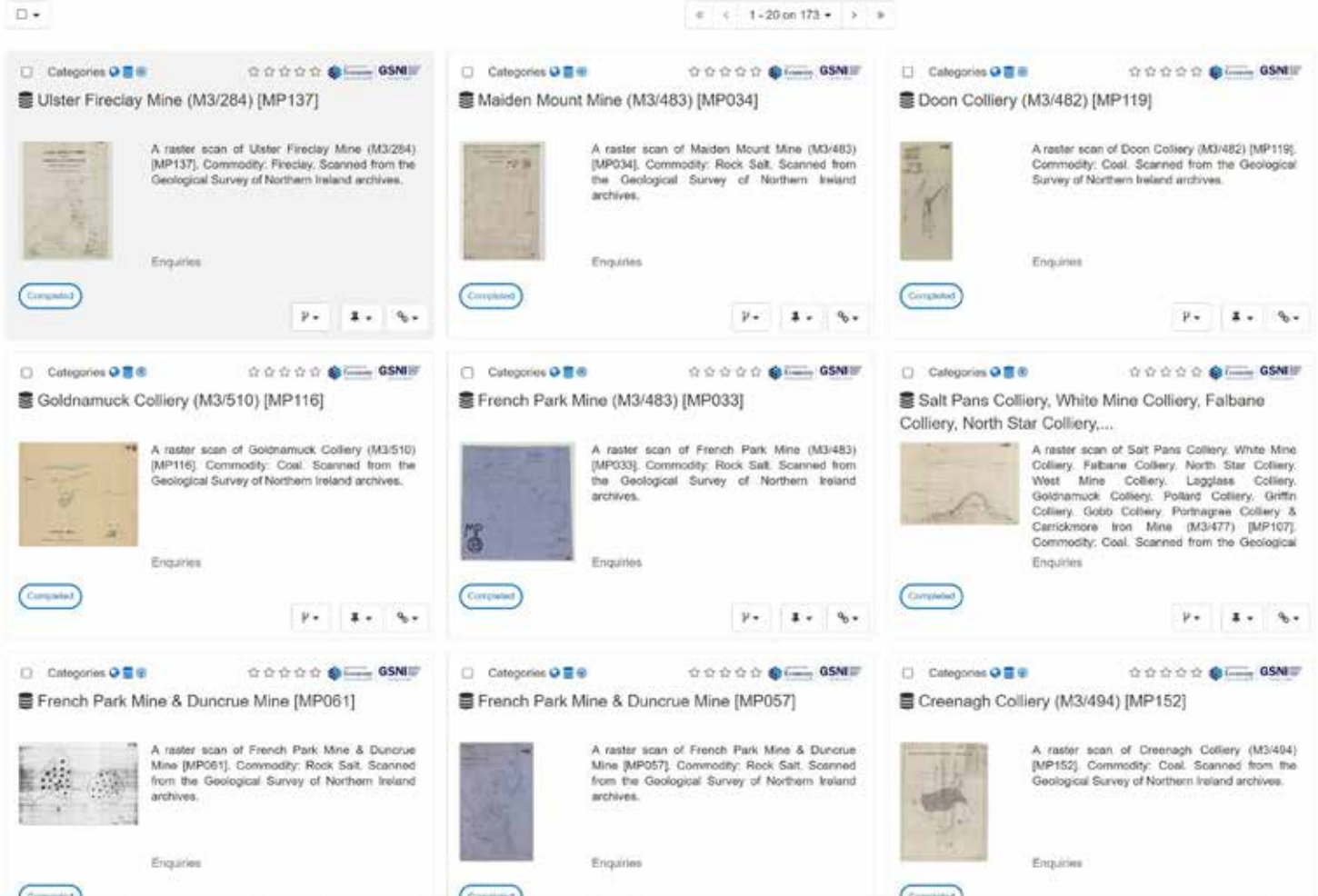
The second research strand was carried out by Queen's University looking at responsible critical

mineral sourcing. Stakeholder analysis sessions took input from two separate groups that might have an interest in the development in the extraction of minerals in Northern Ireland. The research aims were guided by GSNI, and the events were supported by GSNI staff working alongside DfE and Queen's University. The findings of this research are due in the first quarter of 2024 and are likely to have direct impact on the approach that DfE takes in the drafting of new minerals policy.

DfE Climate Action Plan

With the Climate Change Act (Northern Ireland) 2022, receiving Royal Assent in June 2022, a number of legislative responsibilities were required to be fulfilled by all government departments in Northern Ireland, including DfE. One of these was the compilation of a Departmental Climate Action Plan (CAP) that would feed into the Northern Ireland CAP produced by DAERA.

GSNI contributed to the development of the DfE CAP by firstly providing basic information on all of our relevant work areas that support the reduction of emissions alongside protection of the environment and the ability to minimise, mitigate or remedy the



Historic mine abandonment plans in the GSNI data catalogue

effects of climate change. This was then followed up in Phase 2 with much more detailed information.

Policies and proposals that were presented included:

- geothermal demonstrator project
- research proposals on enhanced rock weathering
- coastal vulnerability dataset development in support of climate change adaptation
- peat slide risk assessment work and its role in supporting renewable energy development
- increased water security through groundwater abstraction to boost public water supply

DfE skills audit research

As part of the Energy Strategy Action Plan there was a commitment to carry out a Skills Audit to support the energy transition. The purpose of the audit was to identify gaps and the skills needed from the education and training sectors in Northern Ireland in the short, medium and long term.

GSNI staff provided extensive input to a request for information from stakeholders across multiple areas. GSNI's diverse work programme provides access to a wealth of stakeholders across the water, energy,

industrial and critical minerals sectors. These contacts cover business and academia across the UK and Ireland and in some cases even further afield.

The contributions that GSNI made to the skills audit provided a considerable addition to the information available DfE to draw down as part of the gap analysis.

Digital data access and products

Data catalogue

The GSNI data catalogue has continued to deliver GSNI data to our end-users. Dedicated sub-portals have been created to collate data on a number of themes including Historic Mine Plans, Tellus Surveys and Geothermal. Work began to populate the Geothermal portal with data extracted from historic exploration wells. This sub-portal will also be used to deliver the outputs of GeoEnergy NI.

Enquiries

GSNI responded to 453 enquiries with an average time to completion of nine days. The sector represented and enquiry type have been collated

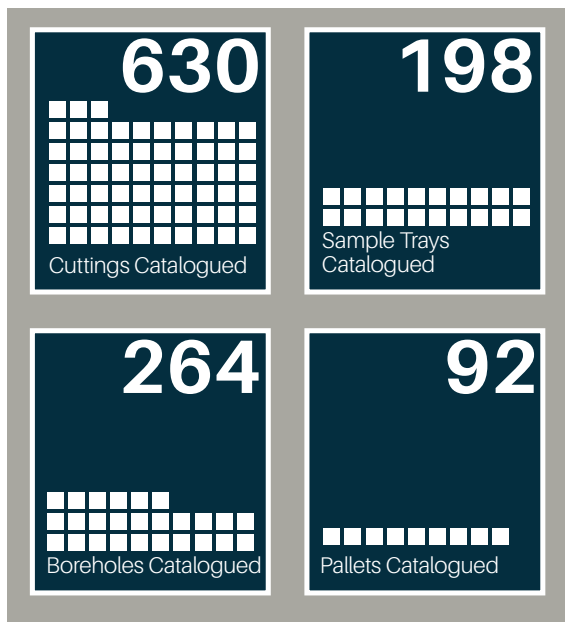


Digital images of the core-store collection

from the enquiries database and are shown in the chart on page 22.

GSNI Core store

Work began on a database to manage the physical samples held in the core store. Equipment, such as roller conveyors, lighting and camera supplies, was purchased to enable the imaging of the collections.



Engaging stakeholders and the public with our science

All-Ireland Sustainability Summit

GSNI was delighted to be a main partner in the All-Ireland Sustainability Summit, held in the Europa Hotel, Belfast in March 2023. This seminal event for sustainability across the island of Ireland was hosted by Triterra with the intention of inspiring individuals and organisations to drive and accelerate positive change towards sustainability and net-zero.

GSNI were one of the main speakers at the event and gave a summary on the forthcoming GeoEnergy NI project and how this will contribute to Northern Ireland's net zero targets whilst helping to improve energy security and enhance economic development. There was also GSNI representation on one of the panel discussions including how businesses should consider climate change adaptation in their drive towards sustainability. GSNI took the opportunity to facilitate an interactive display associated with geothermal energy to demonstrate



All-Ireland Sustainability Summit

what it is, how it works and why Northern Ireland is the ideal location for its development.

Attended by well over 200 people, those present were from a diverse range of sector including business, industry, government (central and local), community and voluntary. It was a great opportunity to network with audiences that would not typically be aware of GSNI's outputs and activities and how they contribute to sustainability.

Irish Geological Research Meeting

The first post-Covid, face-to-face meeting of the Irish Geological Research Meeting (IGRM) was organised jointly by GSNI, the Ulster Museum and Queen's University and held in the Ulster Museum in March 2023. The aim was to revitalise this important geological event for the research community across the island of Ireland.

The meeting was a great success with over 100 delegates, 45 oral and 39 poster presentations. GSNI staff contributed to over 15 of these giving an indication of the level of collaboration with academic institutions across the island of Ireland and further afield. This statistic also demonstrates the value and

impact of GSNI knowledge and data to the broader earth science community.

Subject areas covered by GSNI involvement included Palaeogene stratigraphy and geochemistry particularly related to platinum group elements, rare earth elements in the Mourne Mountains natural laboratory, glacial geomorphology of the Antrim Plateau and the new BGS Quaternary map of the UK, the Triassic-Jurassic boundary, reservoir and aquifer properties of the Sherwood Sandstone related to geothermal and groundwater.

Geothermal webinar series

In the FY, GSNI worked with Queen's University Belfast, Geothermal Association of Ireland and GSI to host 11 webinars on geothermal energy which are all available on the GSNI YouTube channel. In total, the webinars attracted 1580 registrants from 86 countries.



IUGS 100 Geosites

IUGS First 100 Geosites

GSNI participated in the selection of the International Union of Geoscience's First 100 Geosites. The aim of this project was to identify sites from around the world that demonstrated internationally important geological heritage and that were seen as some of the best examples of their kind.

GSNI were fully involved in this international project from the outset and contributed to the development of criteria for site selection, was on the expert panel for site assessment, and were named editors in the project 'coffee table' publication that highlight all of the 100 sites chosen.

At a UK level, due to our level of expertise in geological heritage, GSNI was the national contact point and worked with representatives from across the UK to select four nominations. One of these nominations was the Giant's Causeway which was ultimately selected as one of the First 100 Geosites and was presented at the IUGS 60th anniversary celebration event in Zumaia, Spain.

GSNI was delighted to be able to welcome the IUGS Executive Board in February 2023 who had their annual meeting in Belfast. They asked GSNI to lead

a fieldtrip to the Giant's Causeway as a result of the 100 First Geosites nomination. In addition, GSNI also hosted a prestigious IUGS panel discussion on the 'Future of Geoscience on the island of Ireland' in the Ulster Museum, attended by all Executive Board members and subsidiary meeting representatives.

International Geodiversity Day

October 2022 saw the celebration of first ever International Geodiversity Day, having been approved by the UNESCO General Assembly the previous year. GSNI organised an event at our core store to mark this special occasion called "A Story Through Time" showcasing the incredible geodiversity found within Northern Ireland. International Geodiversity Day is aimed at promoting the many aspects of geodiversity which not only shapes the natural and built environment but also has a major influence on our biodiversity and historical and cultural heritage.

The event was aimed at the general public and was attended by over 40 visitors. The GSNI core store is a wonderful venue due to its wealth of geological material and specimens. With samples on display spanning the whole of what Northern Ireland's geology has to offer, the guests truly got to appreciate why Northern Ireland is considered for its size to be



AGEO Community Geohazard Workshop

one of the most geologically diverse places in the world and how that impacts our daily lives.

AGEO Community Geohazard Workshops

As part of the AGEO project, GSNI organised a series of community geohazard workshops on the Antrim Coast. The aim of the workshops was to raise awareness of the AGEO project but also to help local communities gain a better understanding of what geohazards are and what geohazards are relevant to the area that they live. It also gave GSNI staff the opportunity to showcase the AGEO application that can be used for community geohazard monitoring.

Three workshops were held in total: one in Carnlough, one in Portballintrae and one in Ballycastle. Approximately 50 people attended and included a variety of backgrounds such as retired teachers, local council staff, National Trust staff, mountain rescue teams, hill walkers and local residents. Each of the workshops was very engaging and all of the attendees expressed a huge interest in

the geohazards that were a potential hazard in the areas that they lived or worked in.

The workshops also provided GSNI with a huge amount of additional information, advice and suggestions for further projects and highlighted the need to engage further with local communities in this area.

Section 2

Our People

GSNI staff

At the end of FY, GSNI had 13 members of staff.

New staff

GSNI has been able to add one new member of staff to the team in FY reflecting the growing demand on GSNI skills and expertise. Michelle O’Grady originally joined BGS as an Enquiries and Retail Officer in the London office at the Natural History Museum and has spent time on secondment as an Equality, Diversity and Inclusion (EDI) Officer. She joined GSNI in October 2022 as the Deputy Project Manager for GeoEnergy NI and will also contribute towards social media and EDI initiatives.

Learning and development

Learning and Development (L&D) is primarily managed by the L&D team at BGS who provide and support training in leadership and management, behavioural / soft skills, IT, science, Health and Safety, bespoke coaching, mentoring and other training opportunities as they arise.

Mandatory training

All staff completed BGS mandatory training on:

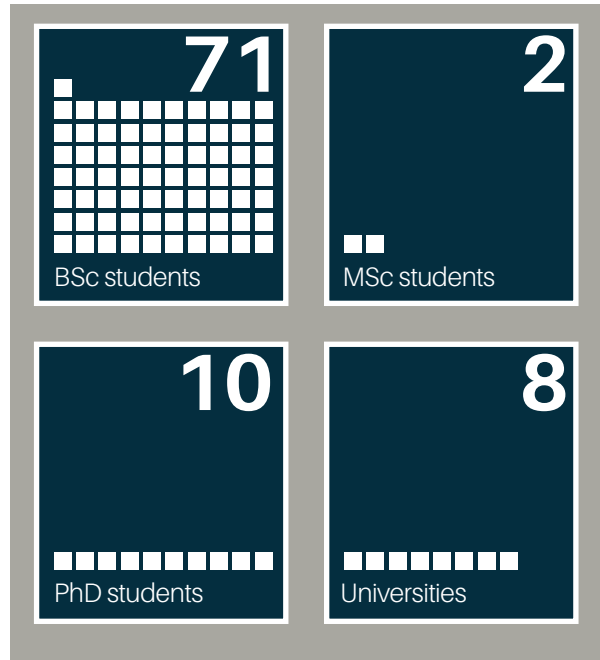
- Preventing Harm (Safeguarding)
- Risk and Counter Fraud (BGS)
- Modern Slavery and Human Trafficking (BGS)
- Information Handling and Governance
- Trusted Research and Innovative Awareness Training
- Manual Handling
- Fraud and Anti-Bribery
- The Inside Man – Cybersecurity Training
- Information Handling and Governance

All staff completed NICS mandatory training on:

- Data Protection Essentials
- Freedom of Information and Environmental Regs: Essentials (NICS)
- Introduction to Diversity and Inclusion
- Equality and Diversity Essentials
- Fire Warden Training
- Fire Safety
- Display Screen Equipment



Breakdown of staff by gender



Supporting the next generation of geoscientists

Continuing Professional Development

Continuing Professional Development is encouraged and supported at all levels. The CPD highlights for FY are as follows:

- One staff member has graduated from SOAS with a distinction in MSc in Climate Change and Development.
- One staff member has been accredited as a Professional Geologist (PGeo) by the Institute of Geologists of Ireland.
- One staff member has been gained an Association for Project Management 'Project Management Qualification'.
- Environment Impact Assessment training
- Developing One DfE (leadership) Programme for G6/G7

Equality, Diversity and Inclusion

The addition of a new member of staff who is on the BGS EDI Steering Group, a UKRI EDI Advocate and a member of a number of associated staff networks, is providing much needed insight into wider organisational initiatives and providing advice on how they can be applied at GSNI. It is anticipated that this will be strong focus for future years as this issue is further embedded into the GSNI work programme.

Two other members of staff are involved in the Mental Health and Wellbeing group which involves the

development and implementation of a mental health strategy. This also includes the organisation of events to promote social and physical wellbeing in our office. A wellbeing conversation has been introduced in the mid-year and annual review stages.

Supporting the next generation of geoscientists

GSNI are committed to supporting the next generation of geoscientists through engagement including work experience, provision of internships, school talks and MSc/PhD student supervision.

Health, safety and well-being

Health, safety and well-being has continued to be a high priority as staff adopted a hybrid working arrangement.

Procedures manual

All aspects of GSNI governance are detailed in the "Procedures Manual", an internal organisational document, which is updated as required, reviewed and signed by all staff annually and is also audited cyclically by DfE.

Section 3

Financial summary

Income 2022/23.

Income type	£*	%
NI Public Service Level Agreement	857,619	78.5%
BGS Teams (UKRI)	86,241	7.9%
Personal Development (UKRI)	12,085	1.1%
Research	136,322	12.5%
Total income	1,092,266	100%

*excludes overheads

Northern Ireland Public Science

GSNI predominantly provides public science research services to government departments and Northern Ireland councils, primarily for DfE as part of its three-year recurrent work programme managed under a service level agreement (SLA).

Additional research

GSNI also has funding from UKRI via BGS and EU programmes. GSNI-based staff work on BGS Teams (UKRI) either on external research or internal 'national-capability' or operational projects.

Professional development

As GSNI staff are UKRI employees, BGS (UKRI) is responsible for their continuing professional development (CPD), mandatory training including health and safety.



Ring of Gullion, part of the Mourne Gullion Strangford Global Geopark © Tony Pleavin. Courtesy Tourism NI

Summary of external SLAs

In addition to the main SLA with DfE, GSNI staff also work with a number of public sector organisations through other SLAs.

NIEA

GSNI has been operating under an SLA with the NIEA to deliver key actions under the Water Management Unit and Natural Heritage Directorates within NIEA. The current SLA is renewed annually with a work programme being established to deliver a number of key tasks.

Newry Mourne and Down District Council

GSNI has been operating under an SLA with Newry Mourne and Down District Council to deliver key actions to obtain UNESCO Global Geopark status for the region. The current SLA is for a three-year period from 2020 to 2023, during which time there are a number of key deliverables.

NI Water

GSNI has been operating under an SLA with NI Water to provide hydrogeological oversight for the development of groundwater resources to supplement the Northern Irish drinking water supply. GSNI's main role is to scope relevant work required from external hydrogeological consultants, as well as the assessment and review of such work, and to present this internally to NI Water.

DAERA coastal datasets

GSNI has been operating under an SLA with DAERA for the provision of a superficial bedrock geology dataset for the Northern Ireland supported by the methodology to produce a coastal superficial geology dataset produced in the previous FY.

Section 4

Forward look

GeoEnergy NI

DfE, with scientific support from GSNI, is leading on this geothermal demonstrator project delivered by a contractor team lead by Tetra Tech Europe.

DfE is leading on a geothermal demonstrator project named GeoEnergy NI which is being delivered by a contractor team led by Tetra Tech Europe with scientific support from GSNI. The data and learnings from the GeoEnergy NI project will help refine our understanding of the subsurface in Northern Ireland, which will be essential to help us unearth geothermal heat. It will also aim to support the development of a geothermal industry here, which would produce many high value jobs and skills through direct employment and the supply chain.

In the new FY, tasks involving GSNI support and advice include the Stormont Estate Environmental Impact Assessment and planning application, conducting geophysical surveys in County Antrim, producing educational modules for use in the virtual reality headsets, a communications campaign

including surveys to engage the public, and deep well core analyses and digital image production.

BGS science strategy

BGS has been developing the new BGS Strategy for 2023 to 2028, 'Understanding our Earth'. This document sets out the priority science areas for the next five years including maps and models for the 21st century, a more secure energy transition, improved water security and living with geological hazards. Launched early in the 2023-24 FY, this document will provide an overarching framework for GSNI to deliver its science programme and in the delivery and communication of our data and knowledge.

Peaceplus – Geothermal and Coastal

GSNI, together with strategic project partners, is preparing to submit significant bids to the EU Peace Plus Programme designed to support peace and prosperity across Northern Ireland and the border



GeoEnergy NI launch

counties of Ireland. GSNI will submit bids under Theme 5: Supporting a Better-Connected and Sustainable Future as part of Investment Areas 5.2 (Marine and Coastal Management) and 5.5 (Geothermal Energy). These calls are expected to open in Autumn 2023 and if successful, this funding would help platform and deliver GSNI's strategic science ambitions for these topics in Northern Ireland.

GSNI strategy refresh

GSNI's Draft Science Strategy for 2021-2031, 'Geoscience for a Brighter Future', was developed prior to the Climate Change Act (Northern Ireland) 2022 gaining Royal Assent. As a result, there have been a significant number of policy developments that now need to be taken into consideration and incorporated within the document. As a result, a review and refresh will be carried out for GSNI's

Draft Science Strategy to ensure that it remains fit-for-purpose and continues to meet the needs of Northern Ireland government and society.

Outputs

Peer-reviewed papers and books

Jaud, M., Le Dantec, N., **Parker, K., Lemon, K., Lendre, S., Delacourt, C., Gomes, R.C.** (2022). How to include crowd-sourced photogrammetry in a Geohazards Observatory – case study of the Giant’s Causeway coastal cliffs. *Remote Sensing*, 14 (14), 3243. <https://doi.org/10.3390/rs14143243>

Krabbendam, M., Dioguardi, F., Arnhardt, C., **Roberson, S.** & Hall, A.M. (2022). Drag forces at the ice-sheet bed and resistance of hard-rock obstacles: the physics of glacial ripping. *Journal of Glaciology*, 69 (273), 103-119. <https://doi.org/10.1017/jog.2022.49>

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Molyneux, S.G., Harper, D.A.T., **Cooper, M.R., Hollis, S.P., Raine, R.J., Rushton, W.A., Smith, M.P., Stone, P., Williams, M., Woodcock, N.H. & Zalasiewicz, J.A.** (2022). A synopsis of the Ordovician System in its birthplace – Britain and Ireland. Geological Society, London, Special Publication Vol. 532, 191-266. <https://doi.org/10.1144/SP532-2022/235>

Shaw, J.I., Torvela, T., **Cooper, M.R., Leslie, A.G. & Chapman, R.J.** (2023). A progressive model for the development of the Cavanacaw Au-Ag-Pb vein deposit, Northern Ireland, and implications for the evolution and metallogeny of the Grampian Terrane. *Journal of Structural Geology*, 161, 104367. <https://doi.org/10.1016/j.jsg.2022.104637>

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(2022). Exploration indicators of the Jiama porphyry-skarn deposit, southern Tibet, China. *Journal of Geochemical Exploration*, 236, 106982.

Meju, M.A., Kulesa, B., Gallardo, L., Thompson, S., Ruffell, A. & **Parker, K.** (2022). Improved imaging of ground deformation and brine seepage around abandoned flooded salt mines by joint inversion of Multiphysics data. *Journal of Applied Geophysics*.

English, J.M., English, K.L., Dunphy, R.B., Blake, S, Walsh, J., **Raine, R., Vafeas, N.A. & Rodriguez Salgado, P.** (2023). An Overview of Deep Geothermal Energy and Its Potential on the Island of Ireland. *First Break*, 41 (2), 33-43. <https://www.earthdoc.org/content/journals/10.3997/1365-2397.fb2023009?crawler=true>

Conference abstracts (talks and posters)

Beckwith, J., Stock, M.J., **Cooper, M.R., Holness, M.B., Andersen, J.C.O., Huber, C., Chew, D.C. & Carter, E.J.** (2023). Geochemical characterisation of a Classic Palaeogene layered intrusion: the Carlingford Complex, Ireland. *Volcanic and Magmatic Studies Group Annual Meeting*, London, 4-6 January.

Beckwith, J., Stock, M.J., **Cooper, M.R., Holness, M.B., Andersen, J.C.O., Huber, C., Chew, D.C. & Carter, E.J.** (2023) The dynamics of carbonate assimilation in layered mafic intrusions. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

Beresford-Browne, A., Jolley, D., **Raine, R., Stevenson, C.T. & Watt, S.** (2023). The discovery of new sedimentary interbeds within the Antrim Lava Group suggest temperate not sub-tropical palaeoclimate in the Palaeogene of Northern Ireland. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

Boomer, I., Copestake, R. & **Raine, R.** (2023). Pristine preservation of Pliensbachian (Early Jurassic), calcareous microfossils from Whitepark Bay, Co.

Antrim. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

Burke, S. & Wilson, P. (2023). Protecting the groundwater resource. CatchmentCare Final Conference, Ballybofey, Ireland, 20 April.

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Carter, E.J., Stock, M.J., Talbot, H., Beresford-Browne, A., **Cooper, M.R., Raine, R.,** Holland, G. & Burgess, R. (2023). Geochemical evolution of large igneous province volcanism in the Antrim Lava Group (North Atlantic Igneous Province), Northern Ireland. Volcanic and Magmatic Studies Group Annual Meeting, London, 4-6 January.

Clark, A.M., **Roberson, S.,** Blockley, S.P.E., Palmer, A.P., Damaschke, M. & Davies, B.J. (2023). High-resolution glacial geomorphology of the Antrim Plateau, northeast Ireland. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

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Geifman E., Stock M.J., **Cooper M.,** Carter E., Holness M.B., Andersen J.C., Chew D.M., & Huber C. (2023). The Temporal Evolution of LIP Magmatism in Northern Ireland. Volcanic and Magmatic Studies Group Annual Meeting, London, 4-6 January.

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Gluyas, J., **Raine, R.** & Moscardini, R. (2023). Red Beds Decarbonising the health service heating systems. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

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McConvey, P., McIntyre, T., Lydon, C., Vucinic, L. Hare, T. & **Ní Conchubhair, R.** (2023). A Hydrogeological Assessment of the Sherwood Sandstone aquifer within the Moneymore region of Mid-Ulster, Northern Ireland. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

Moscardini, R., English, K.L., Houghton, P., **Raine, R., Cooper, M.** & English, J.M. (2023). Impact of Triassic reservoir quality on geothermal and geostorage potential of the Kish Bank Basin: a new multidisciplinary study of coeval basins in Northern

Ireland, Ireland and Great Britain. 66th Irish Geological Research Meeting, Belfast, 3-5 March.

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Patton, M. (2023). Falkland Islands Government Mineral Exploration Licence Application Review - Warrar Resources Limited. British Geological Survey Confidential Report CR/22/135.

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Magazine articles

Cowan, M. (2022). A science-led approach to the development of geothermal energy in Northern Ireland. AgendaNi, May 2022. Available from: <https://www.agendani.com/a-science-led-approach-to-the-development-of-geothermal-energy-in-northern-ireland/>

Cowan, M. (2022). Interview for Geothermal Association Ireland, Autumn Newsletter.

Lemon, K. (2022). Environmental science delivers benefits across the UK: Northern Ireland. Available from: <https://www.ukri.org/who-we-are/how-we-are-doing/research-outcomes-and-impact/nerc/environmental-science-delivers-benefits-across-the-uk/>

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Geothermal Association Ireland, Autumn Newsletter 2022; Interview with **Marie Cowan**

Public Webinars and Talks

Cooper, M., **Lemon, K.** & Dempster, M. (2023). Geodiversity of Northern Ireland. Webinar delivered

to promote Northern Ireland's Geodiversity Charter, January 2023.

Cooper, M. (2022). Introduction to Northern Ireland bedrock types and structure. In-person talk for Belfast Metropolitan College, April 2022.

Cooper, M. (2023). Impacts of faults and dykes on fluid flow in Permo-Triassic aquifers and reservoirs. Harold Wilson Memorial Lecture for Belfast Geologists Society, March 2023.

Cowan, M. & Raine, R. (2022). Northern Ireland's Geothermal Journey - One Step at a Time. Webinar delivered as part of GSNI Geothermal Webinar Series, December 2022.

Lemon, K. (2022). Cultural heritage and climate change in the UK's UNESCO Global Geopark. Webinar delivered for the Institute for Environmental Sciences, April 2022.

Lemon, K. (2023). Geology and you: careers in geoscience. In-person talk for A-Level students at Our Lady and St. Patrick's College, Knock, Belfast, February 2023.

Lemon, K. (2023). Geology and you: careers in geoscience. In-person talk for MSc students at Leeds University, February 2023.

Lemon, K., Cooper, M. & Dempster, M. (2023). Geodiversity of Armagh City, Banbridge and Craigavon District Council. Webinar delivered for Armagh City, Banbridge and Craigavon Borough Council to promote Northern Ireland's Geodiversity Charter, January 2023.

Lemon, K. Cooper, M. & Dempster, M. (2023). Geodiversity of Newry Mourne and Down District Council. Webinar delivered for Newry Mourne and Down District Council to promote Northern Ireland's Geodiversity Charter, March 2023.

Lemon, K. & Dempster, M. (2023). Geodiversity of Fermanagh and Omagh District Council. Webinar delivered for Fermanagh and Omagh District Council

to promote Northern Ireland's Geodiversity Charter, March 2023.

Lemon, K. & Dempster, M. (2023). Quarries, mines and geodiversity. Webinar delivered for the MPANI to promote Northern Ireland's Geodiversity Charter, January 2023.

Wilson, P. & White, D. (2022). Sand Dune Groundwater Monitoring. In-person talk for NIEA, June 2022.

Glossary

AGEO	Atlantic Geohazard Management
ASIR	Advanced Seismic Instrumentation & Research
Au	Gold
Ag	Silver
BGS	British Geological Survey
BSc	Bachelor of Science
CAP	Climate Action Plan
CMIC	Critical Minerals Intelligence Centre
CPD	Continuing Professional Development
CR	Commissioned Report
CRM	Critical Raw Materials
Cu	Copper
DAERA	Department of Agriculture, Environment and Rural Affairs
DEFRA	Department for Environment, Food & Rural Affairs
DfE	Department for the Economy
Dfi	Department for Infrastructure
EDI	Equality, Diversity and Inclusion
ERT	Electrical Resistivity Tomography
EU	European Union
FY	Financial Year
GAC	Geothermal Advisory Committee
GSNI	Geological Survey of Northern Ireland
IAH	International Association of Hydrogeologists
iCRAG	Science Foundation Ireland Research Centre in Applied Geosciences
IGRM	Irish Geological Research Meeting
IT	Information Technology
IUGS	International Union of Geosciences
L&D	Learning and Development
LiDAR	Light Detection and Ranging
LIP	Large Igneous Province
Ltd	Limited
MPANI	Mineral Products Association Northern Ireland
MSc	Master of Sciences
NGO	Non-Governmental Organization
Ni	Nickel

NI	Northern Ireland
NICCAP2	Northern Ireland's second Climate Change Adaptation Programme
NICS	Northern Ireland Civil Service
NIDigMap	Digital Geological Map of Northern Ireland
NIEA	Northern Ireland Environment Agency
Pb	Lead
PGE	Platinum Group Elements
PGeo	Professional Geologist
PhD	Doctorate of Philosophy
PSRA	Peat Slide Risk Assessment
Q-FAIR	Quality - Findable, Accessible, Interoperable, Reusable
QUB	Queens University Belfast
SAC	Science Advisory Committee
SLA	Service Level Agreement
SOAS	The School of Oriental and African Studies
STF	Science Task Force
UK	United Kingdom
UK CCC	Climate Change Committee
UKRI	UK Research and Innovation
UNESCO	United Nations Educational Scientific and Cultural Organization



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