

Work Package 1-194
Improved use of information in Geotechnics
Final Report Part 1 - Overview and
recommendations

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Reviewer List

Name	Role
Savina Carluccio	Arup Project Manager
David Patterson	Client Package Sponsor

Signoff List

Name	Role
David Patterson	Client Package Sponsor

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1. Introduction

Task 1-194 'Improved use of information in geotechnics', was awarded by Highways England to Arup AECOM under the SPaTS research framework.

This report describes the findings of study undertaken for this task, including recommendations.

This report is presented in two parts:

- 'Part 1 - Overview and Recommendations' (this document) provides background, a summary of the task, a summary of the findings detailed in Part 2 and a list of recommendations for work to address the findings, (the 'Work Bank', included in Appendix B).
- 'Part 2 – Detailed Findings' (separate document) provides a detailed account of the assessment and analysis, and presents the findings of the study, including recommendations, presented in context.

Part 1 is intended to be a standalone document, which should be read in conjunction with Part 2 where further detail is required.

Work on this project commenced in January 2017 and reported in April 2018.

1.1. Purpose and scope of study

The task considered the use of geotechnical data and information throughout the asset lifecycle, including:

- site investigation
- monitoring
- inspections
- decision support systems
- design
- construction (including repairs, renewals and improvements)
- inspections
- maintenance
- disposal

The aim of the task was to investigate and identify data and information requirements that have been established from other research tasks, day-to-day activities and external initiatives. Also it was to look at the future regarding the likely technology landscape that will exist, to enable Highways England to make the best use of information and realise the potential benefits e.g. improved data management and data visualisation.

1.2. Outputs

A list of recommendations has been developed as an output of this study. The identified recommendations are aligned with the Highways England Asset Information Principles, see Section 2.2. Most of the recommendations are specific to Highways England however some are for Highways England to steer and/or be aware of rather than delivering directly.

The recommendations developed during this project form a prioritised Work Bank of proposed tasks (see Section 5 for further details on the prioritisation process) included in Appendix B. It is not within the scope of this project to determine

exactly how or when the recommended tasks are implemented, this should be planned separately as part of a programme of continual improvement spanning Road Periods 1 and 2. Planning should take into consideration other (cross-asset) initiatives/tasks that are underway, or have been planned so as not to duplicate effort. A cross-asset approach should always be preferred wherever possible.

It is recommended that this exercise be repeated/refreshed every five years to ensure that improvements in information are maintained and that digital technology advances are identified and exploited.

A vision and associated roadmap for improved use of geotechnical information within Highways England are proposed, see Section 6. The means of achieving the vision are set out in the Work Bank (Appendix B).

1.3. Anticipated benefits

This task will not deliver immediate benefits as it is limited to research and planning, however follow-on work and take up of the recommendations by the Highways England will help to provide efficiency savings in terms of time, quality and cost. As the recommendations are implemented, it will be important to undertake baseline assessments of the existing processes to be able to measure the benefits for reporting purposes. Highways England currently operates an efficiency register and benefits capture process, which should be used for this purpose. The register should be reviewed periodically to ensure that it is appropriate.

2. Background

2.1. Drivers

Highways England is committed to delivering value for money. As part of the Roads Investment Strategy (RIS) Highways England committed to deliver at least £1.2 billion in efficiencies over Road Period 1 (RP1) and to meet or exceed the expectations set out in the Delivery Plan. Highways England is committed to deliver total efficiency savings of over £2.6 billion over the next ten years¹.

The Office of Rail and Road (the “ORR”) monitors Highways England against the requirements set in Licence, RIS and the Delivery Plan. It monitors performance against all KPIs and PIs, including the efficiency KPI. The Operational Metrics Manual² sets out how the ORR measures efficiency performance “Achieving Real Efficiency”.

External drivers such as Digital Built Britain are pushing the civil engineering industry away from analogue methods to communicate throughout the supply chain. Some specific industries, such as nuclear, have a history of good data management, however in the highways and rail infrastructure sectors specifications, schedules and drawings have generally been paper-based and only recently been transferred to electronic form in still-analogue PDF files. There is a recognition that data-driven documents provide more value before, during and after the procurement phase of an asset.

Some construction disciplines e.g. geotechnical engineering and geoscience have used data in smarter ways, utilising common interchange formats, for example the AGS data format, which has been developed and maintained by the Association of Geotechnical and Geoenvironmental Specialists. More recently Building Information Modelling (BIM) has been a high profile initiative to increase the use of data throughout the construction industry.



Figure 1 Making sense of the initiatives

¹ [Efficiency and Inflation Monitoring Manual, September 2015](#)

² [Operational Metrics Manual](#)

However, the development of BIM has thus far not included geotechnical information (site investigation data, or asset modelling). Therefore each project is having to establish its own methods and schemas for delivering level 2 BIM, as required by the UK Government. This is causing confusion and duplication, and introduces unwanted costs and delays; the opposite of what was intended.

Technology, especially mobile technology and web services/applications, has advanced considerably in recent years providing opportunities for mobile data capture and consumption that were not possible, too unreliable or too expensive in the past.

There is a risk that the multitude of initiatives, formats and applications will lead to a fragmentation of the processes and actually result in a loss of efficiency. This may also impede the progress of realising the potential benefits within the delivery programme of the RIS.

This task involved researching and reviewing the current state of geotechnical data and information, looking at what opportunities exist for improved use and management of data that can deliver real financial benefits to Highways England, either directly, or through efficiencies that can be realised by its supply chain.

The work forms part of the Geotechnical Knowledge Development work stream within the 5-year Geotechnical Innovation Plan (2015-2020).

2.2. Information principles

The National Archives has set out a number of principles to govern the design and management of information, primarily intended for long-term storage and re-use. However, the principles can be used throughout the whole information lifecycle to ensure best-practice and that the end product complies with the principles.

The principles are set out below. Further information can be found on the [National Archives web site](#).



Figure 2: National Archives Principles

In addition to the principles set out by the National Archives, Highways England has its own set of information principles related to asset information set out in the Asset Data Management Manual.³

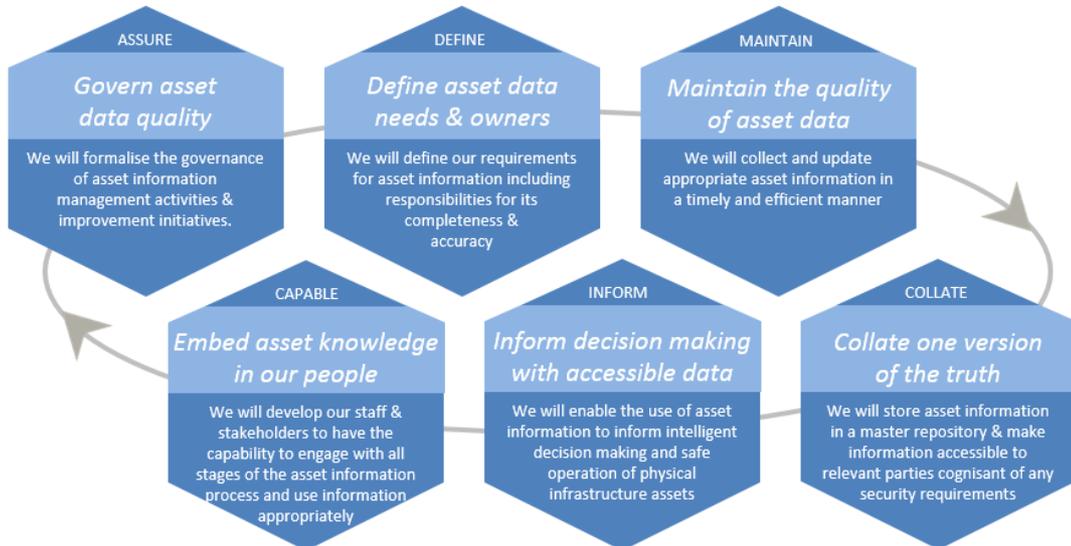


Figure 3: Highways England Asset Information Principles

Given the first principle set out by the National Archives, information is a valued asset, the Highways England Asset information principles apply not only to physical assets, but also to information itself.

The principles set out above have provided a framework against which the research and recommendations have been set.

³ Asset Data Management Manual, Highways England 2017 (unpublished)

3. Approach

This review was undertaken through a number of desktop reviews complemented by significant stakeholder inputs, as summarised below. A summary of the findings and analysis, and prioritisation of the recommendations are presented in Part 1 of this report (this document). Detailed findings and recommendations are presented in Part 2 (Sections 3 to 7).

3.1. Desktop reviews

A series of desktop reviews was carried out including:

- baseline review of current practice, including literature review of key Highways England documents and process mapping (Section 4.1)
- review of Highways England internal initiatives (Section 4.2)
- review of external initiatives (Section 4.3)
- technology review (Section 4.4)

A limited literature search was carried out with detailed reviews only undertaken where directly relevant to the study. The knowledge gained from publications, articles and websites seen during this study has also been useful as it is indicative of past, current and potential future trends in the industry.

- Other Highways England groups and studies were consulted, with meetings held with these groups 24 January and 12 July 2017.
- Handover of Geotechnical information from Major projects back to Highways England
- Asset Data Management Manual
- Highways England Asset Improvement Programme
- IAN 182/184, Employers Information Requirements (EIR)
- Highways England BIM initiatives

A bibliography of key sources consulted in this study is presented at the end of this report.

The above literature review has fed into the baseline review of practice. The core team first undertook analysis of current ways of working and current information flows on Highways England projects involving geotechnical activities. As well as providing early identification of the key issues to consider, this also helped to optimise the structure for subsequent consultations.

A review of relevant tasks and activities that have/are being carried out by Highways England was undertaken. The findings from task reports were reviewed and any outstanding, relevant recommendations collated and brought forward as recommendations from this task. Information on external initiatives was largely obtained from research of online and published sources, see Section 4.3 of this report. In addition:

- The core team members are active participants in the AGS Data Format Working Group.

- Information on Uniclass 2015 was presented to the project team by NBS⁴ at a meeting on 12 July 2017.
- Information on buildingSMART⁵ and Industry Foundation Classes⁶ was discussed during a telephone call with Nick Nisbet (vice chair of buildingSMART UK Chapter) with further information obtained from Arup's attendance at the buildingSMART Summit held in November-December 2017.
- A presentation on 'BIM⁷ for the subsurface' was given at an AGS Data Format Working Group meeting attended by the core team.

Lastly, a technology review looked at recent advances in smarter ways of capturing, storing, analysing and presenting data that could be adopted by Highways England and their supply chain.

3.2. Stakeholder activities

This study has been led by a core team from Arup AECOM, with feedback and opinion from a variety of stakeholders. This included designers and contractors from the supply chain as well as key stakeholders in Highways England. Information was gathered from a combination of meetings, interviews, informal discussions and exchange of correspondence.

Feedback and opinion has been sought from a variety of stakeholders, including:

- Highways England project sponsor David Patterson: initial meeting and a number of subsequent discussions and exchanges of information
- Interviews with Arup staff involved in Highways England projects
- Meetings, discussions and correspondence with lead participants in other Highways England groups including representatives from site investigation contractors, engineering consultants on the Smart Motorways Projects and Highways England Geotechnical Advisors.
- Informal discussions with colleagues and peers, both internally and at external meetings or events.

Other Highways England task groups were consulted with the findings from other studies incorporated where relevant.

On two occasions presentations relating to this study were made at the Geotechnical Asset Owners Forum (GAOF), which is attended by the discipline leads of other asset owners such as Network Rail. A presentation was also given at the 'Geotechnical data conference 2017', organised by the Association of Geotechnical and Geoenvironmental Specialists (AGS).

⁴ [NBS-uniclass-2015](#)

⁵ www.buildingsmart.org

⁶ [ifc-introduction](#)

⁷ Building Information Modelling

4. Findings

The following presents a summary of the findings. The detail behind the findings are presented in Part 2 of this report.

4.1. Baseline review

The baseline review, which comprised document review and consultation considered current practice on how geotechnical information and data are used at each stage of geotechnical asset management. The key themes arising from the review are summarized in the following:

- The desk study process is considered to be of high value and it appears to be implemented reasonably well, with HAGDMS proving useful and GIS being used to good effect by some suppliers. However, it is felt that improvements can still be made, particularly in relation to the AGS format data acquired from legacy ground investigations and the presentation and subsequent exchange of the desk study information collected.
- Ground investigation data is critical to the delivery of projects, but typically the release of ground investigation data is slow and inefficient due to it requiring manual intervention. Many consultees and industry practitioners believe that the process could be improved, especially given the technology now at our disposal. There is currently a great opportunity for innovation.
- Use of the AGS format for exchange of ground investigation data is commonplace and this is generally perceived as a success story for the industry. However, implementation is still by no means perfect with some common problems and annoyances, such as inconsistent referencing of samples and specimens, when using 3rd party laboratories.
- Geotechnical reports are critical to the exchange of geotechnical information, especially knowledge related to interpretation that data alone may not convey. However, the method and style of reporting has changed little over decades with reports still predominantly text based and often very large. Today's reports are often difficult to use as reference documents and key messages about risk can get lost as found by the Atkins Special Geotechnical Measures tasks.
- Sharing of ground model information within the supply chain is becoming more common. These generally use mutually agreed proprietary software file formats for exchange in the absence of software neutral transfer formats. There are no established protocols for creating or sharing ground model data, and there is a concern from some that model information could be misinterpreted or used by uninformed users.
- Another important trend is the increasing use of automation in design, which is expected to continue in the coming years. This depends on data which has the appropriate level of quality as input.
- Full geotechnical information, in particular AGS format data, is not always finding its way down the supply chain to contractors at procurement or construction stage. Several contributory causes have been identified.
- During construction, there is a trend towards increasing use of field capture of data using mobile technologies or instrumentation. However, there is a

perception that the industry is not taking full advantage of this. Lack of industry standards for the transfer of construction data to as-built and/or asset information systems a key factor.

- There seems to be little direct linkage from design through to asset management, i.e. future assets or construction types are not explicitly identified at design or construction stage. Asset management considerations are typically only considered at handover. This is contrary to the vision for BIM which envisages seamless transfer of data through design, construction and on to asset management.

In addition, the baseline review looked in more detail at three specific issues, as follows:

- Formal documentation of processes for geotechnical data management is not common and there is a low level of implementation and awareness of BS8574 (Code of practice for the management of geotechnical data for ground engineering projects).
- As noted above, whilst use of AGS format data is well-established in Highways England, the review has identified that improvements could be made. Analysis of HAGDMS records shows that AGS data is missing for many projects that should have this data. The quality of data is also a concern with inconsistent specifications considered to be the main cause. Furthermore, parts of the existing (AGS4) data format are not being used to their full potential, namely laboratory test scheduling and monitoring.
- Access to Highways England standards is reported to be good, as these are all freely available online. However, access to knowledge, e.g. discovery of published work on a particular subject, can be more difficult. A review of the various current Highways England internal and external portals for information (presented in Part 2) has identified a number of problems that need to be addressed, such as the ability to search repositories for information.

4.1.1. Process mapping

The baseline review involved mapping the processes that make up the asset lifecycle in Highways England, as set out in the standards HD41/15 and HD22/08 together with site investigation best practice and existing ad-hoc processes. The processes were assessed in terms of the required types and formats of the information inputs and outputs (I/O maps). For example, a Preliminary Sources Study or Desk Study (HD22/08 Appendix C) requires information to be collected and assessed. The information used is typically:

- Old maps and plans
- Environmental reports
- Geological maps
- Previous reports etc.

The process map for desk study is presented in Figure 4 below:

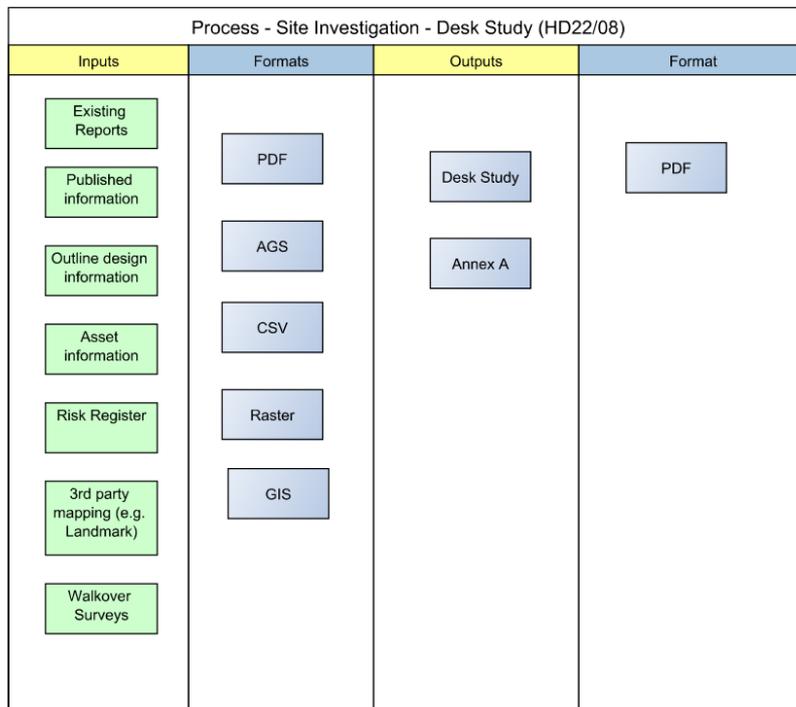


Figure 4 I/O process map for Desk Study

It shows the variety of formats that are used as inputs and the single output format (PDF), which is a requirement of HD22/08, such that Highways England can hold an official record of the report.

The I/O maps, which are presented in Appendix A demonstrate that at various stages of the asset lifecycle data is being collated in digital format, or analogue format that is subsequently digitised, but the output is almost always as PDF. Because PDF does not hold digital information in an accessible format it means that data is not provided to the next stage of the process.

If the data could be stored and transferred in a digital format, such as GIS data files or AGS data format files it would save time and money and most likely lead to better-informed decision making. The process maps should be used to target common information types and formats to maximise the impact of creating file formats that can help the transfer of digital information, starting with the Desk Study.

4.2. Highways England internal initiatives

The internal initiatives comprise previous tasks carried out, or currently being undertaken by Highways England where improvements in information and data requirements form part of the recommendations. This also includes asset information systems where data requirements have been identified, but not developed. The internal initiatives reviewed include:

- Special Geotechnical Measures
- Handback of geotechnical information task
- Geotechnical drainage information
- Review of ground investigation procurement

- Review of Employers' Information Requirements
- Resilience task
- Review of HD22/08
- Review of IAM IS Requirements
- Data Quality assessment task (summer 2017)
- Hazard Task Reviewer
- Geotechnical Performance Indicator task
- Asset information system (HAGDMS)
- Review of Asset Data Management Manual and HD41/15
- Access to information on Highways England's web site and portal
- Electronic Transfer of Desk Study Information Task 376(387)ARPS

A summary of the findings of the reviews are presented below, with the detailed discussion and findings presented in Part 2.

- Geotechnical Asset Information is held in the relevant asset information system (HAGDMS). This software system has several underlying relational databases, holding various structured information. It also holds report records, which have structured metadata. Although the report records are held as PDF files, they have been indexed for searching and specific topic searches have been implemented. The user interface of HAGDMS has an interactive GIS-style mapping interface. HAGDMS is very well aligned to the NA and Highways England information principles. Although it lacks some search tool and interoperability it is an exemplar of information management within and without the organisation.
- The procurement and provision of HAGDMS relies on the ability to demonstrate financial benefits. A recent benefits assessment showed that some of the data required to support the benefits was not being captured by the system. This included items such as the number of downloads of reports and AGS data files.
- Asset data requirements have been set out for the majority of the inventory properties for the geotechnical asset; however, at the time of writing none the asset condition and inspection items have been documented. This compromises the ability to have a seamless method of handover and handback of information. It will also hinder efforts to enable interoperability/data sharing between asset systems. Other data items are also not recorded as structured data, such as construction methods and materials, maintenance requirements etc.
- The primacy of geotechnical asset earthwork data is generally very good, with HAGDMS being the primary data set. Generally data is not held on other systems (the exception being some informal data on AVIS). However, the information held about the drainage associated with the geotechnical asset e.g. slope drains, cut-off drains is not held on HAGDMS. This tends to reside in the drainage asset information system HADDMS, however there is little or no oversight by the geotechnical asset managers.

- The current methods of procurement of ground investigations prevent information being captured in a timely manner and in some cases prevent the acquisition of all the data needed for efficient design. Procurement of ground investigations has been influenced by contractual arrangements, restrictions over network occupancy and constraints due to CDM legislation, namely responsibilities for the "Principal Contractor".
- The key finding from the interviews carried out with the stakeholders was that whilst Highways England is doing relatively well in managing information, the awareness of people within the supply chain is generally poor, especially at the outer limits of the supply chain, namely the site investigation contractors, who have little or no knowledge of HD22 and the data held in HAGDMS. Whilst Highways England is fulfilling its responsibility under the CDM regulations by making information available to its supply chain, the people who should be using it typically don't have access to it and aren't aware that they can have access.
- The output from site investigations takes the form of a PDF report and AGS data. This is specified in HD22/08. However, evidence shows that whilst there is reasonable population of the PDF reports on the HAGDMS reports database, there is a lack of AGS data, with only 40% of factual reports issued between 2007 and 2017 having associated data. AGS data is extremely useful when planning schemes and can save significant amounts of time and money. The specification of AGS in Highways England's documentation is quite vague and allows for inconsistencies, such as different versions of AGS to be used within the same project. The need for more detailed specification was also mentioned in the CON125 report (2006).
- The Smart Motorway Programme uses AGS data digitised from PDF reports. However, feedback from the interviews carried out with some of the members of the Smart Motorway team indicate that the scope of the digitisation was too limited to provide the data required.
- Highways England's Geotechnical Advisors have a responsibility to review and approve geotechnical submissions (PDF reports). When the information is presented as static graphs, logs and maps it can be quite difficult to assimilate the information and build up a ground model. This results in delays for checking and occasionally missed opportunities to spot anomalies in the data, or true outliers. Re-use of the AGS data at project level by Highways England staff is not possible due to a lack of software and/or skills to visualise the information interactively.
- Output from research tasks that have been undertaken over numerous years is often difficult to access. It is generally held in PDF format and stored on the web site, the Portal, SHARE, or on a local CD/DVD. The body of information cannot be searched. Valuable research is therefore not being made available to the supply chain and the opportunity to generate efficiencies through innovation are being lost. Work is also in danger of being repeated.

Recommendations arising are set out in the Work Bank table in Appendix 1. Typically the recommendations from the internal initiative reviews are within the capacity and capability of Highways England to action.

4.3. External initiatives

External initiatives comprise those activities or programmes that are not within the direct control of Highways England.

This project should be viewed in the context of the general direction of travel towards adoption of BIM and digital technologies within the UK construction industry as a whole. With this in mind, the review has looked at the most relevant external initiatives relating to BIM, including some not necessarily directly connected with geotechnics, highways or asset management. Key findings from this part of the review are as follows (further details in Part 2):

- Over the last few years, the UK Government has been active in promoting BIM with the current vision out in described in [Digital Built Britain - Level 3 Building Information Modelling – Strategic Plan \(HM Government, 2015\)](#). The key organisations tasked with promoting BIM in the UK are UK BIM Alliance and the Centre for Digital Built Britain (due to formally launch in early 2018).
- There are some general BIM related initiatives that are considered to warrant further attention from Highways England, the foremost of which is the work of buildingSMART on Industry Foundation Classes (IFC). IFC is an open-standards based software-neutral format for viewing, exchange and storage of design and construction information that is commonly used for exchanging BIM models on buildings sector projects. The IFC data schema is less well developed for infrastructure applications but there are a number of ongoing projects at buildingSMART that aim to address this. The current version of IFC does not explicitly cater for ground investigation or ground monitoring, and the schema for some geotechnical assets is inadequate. BuildingSMART is keen to obtain expert input from infrastructure owners, such as Highways England.
- BuildingSMART works closely with the Open Geospatial Consortium (OGC) who develop open standards for the geospatial domain. OGC is developing InfraGML which is a schema optimised for linear infrastructure.
- Also relevant is Uniclass 2015 which is a unified classification for the UK covering all construction sectors, developed and maintained by the National Building Specification (NBS). This is also commonly used on BIM-based projects. Highways England is a key stakeholder in the development of Uniclass.
- Other initiatives have been identified that are potentially relevant to Highways England but the review concludes that these would bring limited benefits to Highways England. These include COBie (Construction Operations Building Information Exchange), the Infrastructure Asset Dictionary for the UK (IADD4UK) and COINS (Construction Objects and the Integration of processes and Systems). With respect to COBie, it is acknowledged that this is well established and promoted in the buildings sector, but it is not considered to be well suited to Highways England requirements.

Some geotechnics-focused external groups and initiatives have been reviewed, as follows:

- CON125 'Review of Electronic File Formats for the Exchange of Geotechnical Information used in Transportation Schemes' (CIRIA, 2006) is a consultancy report authored by Mott MacDonald for CIRIA with support from Highways England. Despite being written over 10 years ago, most of the findings of the CON125 report are as relevant today as they were when they were written, and some of the recommendations, or similar, have been incorporated in this report. An exception is the recommendation to adopt DIGGS; reasons for this are further described below.
- The AGS Data Format Working Group continues to maintain and improve the AGS data transfer format. Current work includes extending the format to cover advanced laboratory testing, interpretative information (including ground models) and construction data, in particular piling and grouting. An early objective for the next major revision (AGS5) is that it should be capable of being the primary means of providing the investigation data, with the factual report being a secondary view of that data.
- BIM for the subsurface is a recently completed research project funded by Innovate UK. The main outputs were tools added to proprietary software providing to access to BGS datasets (including a newly formed BGS store of AGS data), sharing of data via the cloud and manipulation of 3D fence diagrams.
- DIGGS is a data transfer protocol for transfer of geotechnical and geoenvironmental data developed in the USA that was originally supported by AGS and the Highways Agency. A DIGGS schema exists but it is not well used or supported. The reasons for the lack of support relate to the complexity of the format and the lack of need/demand for an XML data interchange format (in the UK).

Recommendations arising are set out in the Work Bank table in Part 1. The recommendations from the external initiative reviews generally require Highways England to support the relevant initiatives in appropriate ways.

4.4. Technology review

A general review of the emerging technologies that will provide opportunities for advances in the capture, transfer and visualisation of information was also carried out.

Over the last 20 years the paradigm for the use of IT in geotechnical engineering has been:

- collect/obtain data,
- input (import or manually enter) into desktop software application,
- analyse and report to an analogue format,
- provide digital data (AGS) format

Whilst the media of reporting is now typically digital (PDF format) the report itself is static and a facsimile of a paper equivalent, such that if the report is printed it is identical. (See 4.1.1)

The digital (AGS) data is generally, but not always issued at the end of a site investigation.

Whilst desktop applications have worked well, there are advances in technologies that will drive an alternative model to the method of working in the near future.

Mobile Hardware and Software

Mobile devices (tablets) will become more prevalent in the work-place as they become cheaper, and engineering and asset information becomes available in ways that can be consumed by mobile technology. e.g. 3D models, virtual reality etc.

Mobile devices are increasingly being used for data capture. Whilst this has been the case for geotechnical asset management in Highways England for a number of years the rest of the workflow, i.e. site investigation and monitoring have not adopted the technology widely. It has been used successfully for borehole logging (drillers' data) and in some cases engineering logs, but the wider adoption of mobile technology for general data capture e.g. insitu tests, site diaries, laboratory testing has not taken place.

Browser-based applications

The PDF rendering of a document is intentionally fixed to represent the printed page, which has the advantage of preserving the document in exactly the same format in which it was published. This is of course very useful for records and documents which have a legal or quasi-legal status.

Web technology, especially HTML5 and JavaScript offers opportunities to improve the communication of information. For example exploratory hole logs could be represented as a single, continuous entity, rather than being split over many pages.

Other benefits of using an interactive interface to communicate information include:

- access to web services such as BGS, Landmark and the Coal Authority.
- interactive maps: zoom, toggle visibility of layers, show information about locations etc.
- interactive tables, searchable data, drill down etc.
- interactive charts, zoom, toggle visibility of points etc.
- interactive 3D models, zoom rotate, toggle visibility of objects etc.

Document databases and JSON

Document databases, sometimes referred to as NoSQL databases, are a new technology that provide an alternative way of storing data to a conventional relational database (RDBMS). Instead of holding the data in tables connected by common fields, document databases store data in discrete packages of information, usually in JSON format.

The key advantage of a document database over an RDBMS is that the data structure does not need to be defined and maintained. It is very useful for storing data which is similar but does not have exactly the same schema.

Whilst document databases do have their limitations, especially where data is being changed very frequently, the appropriate scenario for Highways England would be the storage of AGS data for subsequent analysis and visualisation.

Wireless technology

Although wireless technology has been available for some years and has been used effectively on distinct projects to monitor soil and groundwater parameters to control construction methods (e.g. A419 Blunsdon Bypass). It has not been implemented at a national level to monitor the “health” of the geotechnical asset. Opportunities to standardise the type and method of data transfer and storage should be considered. Possibly using the document database mentioned above to provide the flexibility of data schema, at least until methods are established.

5. Task Prioritisation

The tasks identified as part of the Work Bank have been prioritised to enable the business to determine the order in which they should be implemented. Note that the prioritisation should only be used as a guide, since some tasks could be implemented ahead of their ranking, if the delivery route is available e.g. via a task undertaken by another part of the business.

The prioritisation is based on the relevant sections of a typical business case i.e. value for money and business need and follows four steps:

Step 1 - Rank the tasks in order of benefit vs cost (value-for-money score)

Step 2 - Apply an urgency weighting

Step 3 - Derive the priority score

Step 4 - Report the priority rating and description.

A description of each stage is given below.

Step 1

The benefit vs cost ranking uses the matrix shown in Figure 5.

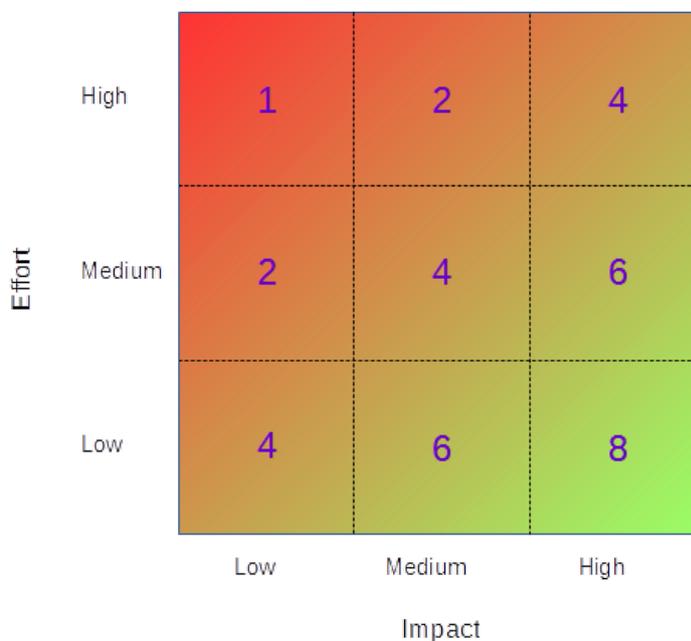


Figure 5 Effort vs Impact matrix

The matrix typically represents the value-for-money aspect of a business case for initiating the tasks. The exception being those tasks which have low impact

and low effect. These tasks don't really require a business case, they are typically filler tasks in business-as-usual activities.

Steps 2 & 3

An urgency weighting is applied to represent the business need element of the business case decision making process. A simple approach of classing the task as “urgent” or “not urgent” has been adopted. The urgency is primarily based on the feedback from consultations and business policy and strategy. A more sophisticated scale of urgency was not considered appropriate at this stage, however it could be developed if required.

The method of applying the urgency weighting is to simply multiply the value-for-money score of those tasks designated as urgent task by 2. The non-urgent tasks have a weighting of 1. The application of the urgency weighting to the value-for-money score provides the overall priority score.

Steps 3

The derivation of the priority rating is based on the distribution of numbers of tasks, such that the implementation can be managed within the business, i.e. the majority of the tasks have an average priority. Note that this does not consider the scale or scope of each individual task; that assessment should be done as and when the tasks are considered for implementation.

The distribution of tasks is shown in Figure 6

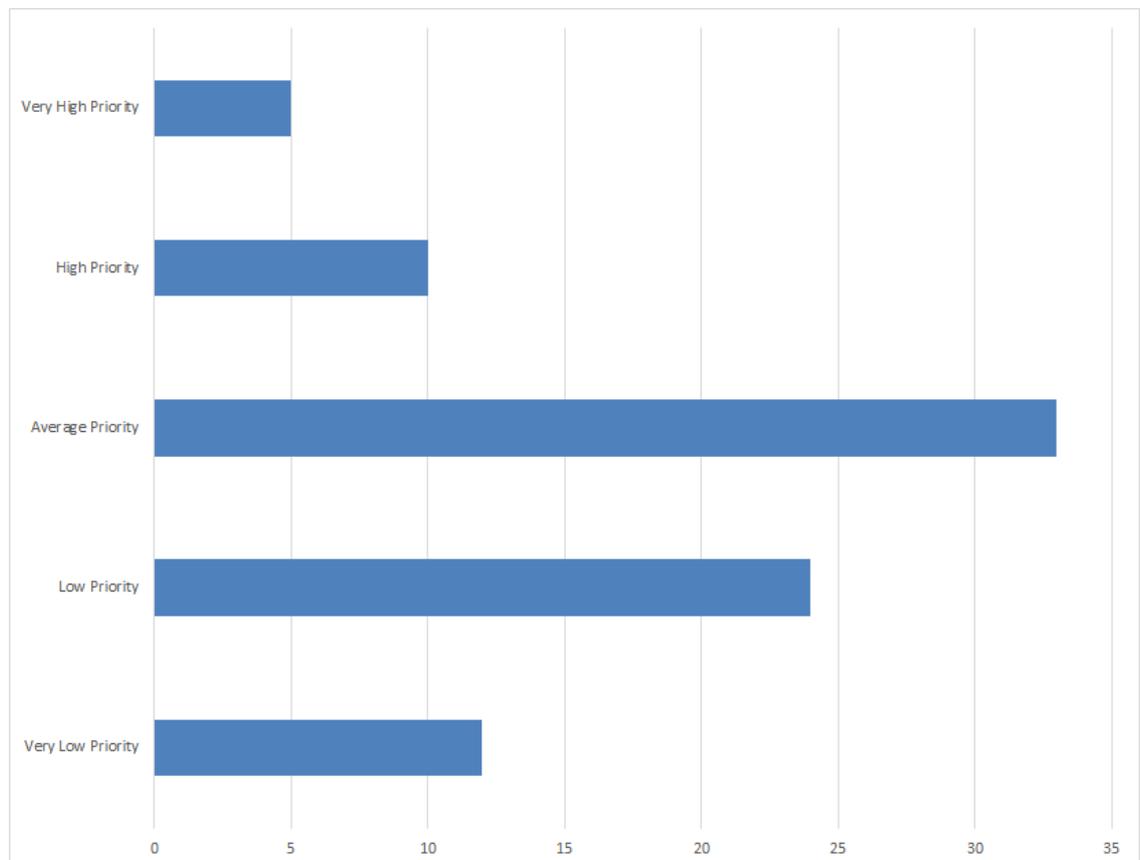


Figure 6 Task distribution by priority

The assignment of prioritisation is based on divisions of the priority score as shown below:

Priority description	Numeric scale	Time-frame for delivery
Very High Priority	>12	<6 months
High Priority	=12	6-24 months
Average Priority	<=8	24-60 months
Low Priority	<=4	≈5 years
Very Low Priority	<=2	indefinite

Table 1 Priority scale

The application of the numeric scale is applied (logically) bottom to top.

6. Vision and roadmap

Having carried out the research, it is useful to communicate a proposed vision of where Highways England should be in the medium to long-term, with respect to geotechnical information.

The vision is for *Highways England to be a leading organisation in the management and provision of geotechnical information* by establishing the following:

Goal	Benefit description	Highways England Information principle	Time to implement
Informed and trained staff and suppliers who understand the importance of geotechnical data and information	An appropriate skill level of people is a critical success factor in delivering geotechnical information improvements.	Capable	short to medium term
Documented geotechnical information and data management system	Forms the bedrock of decision making and informs stakeholders of the requirements and processes. Regular audits should be undertaken to ensure awareness is maintained.	Assure and Define	medium term
Geotechnical data stored and visualised in a way that allows easy access for analysis	Being able to rapidly assimilate geotechnical information is crucial for the efficient delivery of schemes	Inform	medium to long term
Leaders in geotechnical information management	Highways England should be at the forefront of geotechnical information management to drive productivity in the sector through the use of mobile data capture, interoperability, re-use of data and visualisation of information	Capable	medium to long term

Goal	Benefit description	Highways England Information principle	Time to implement
Easy transfer of geotechnical information and data between schemes and the maintenance environment	Technology currently exists to enable easy transfer of data however it is not being used. Interoperability between software systems will greatly reduce time spent importing/exporting - support to BIM goals	Collate and Maintain	long term

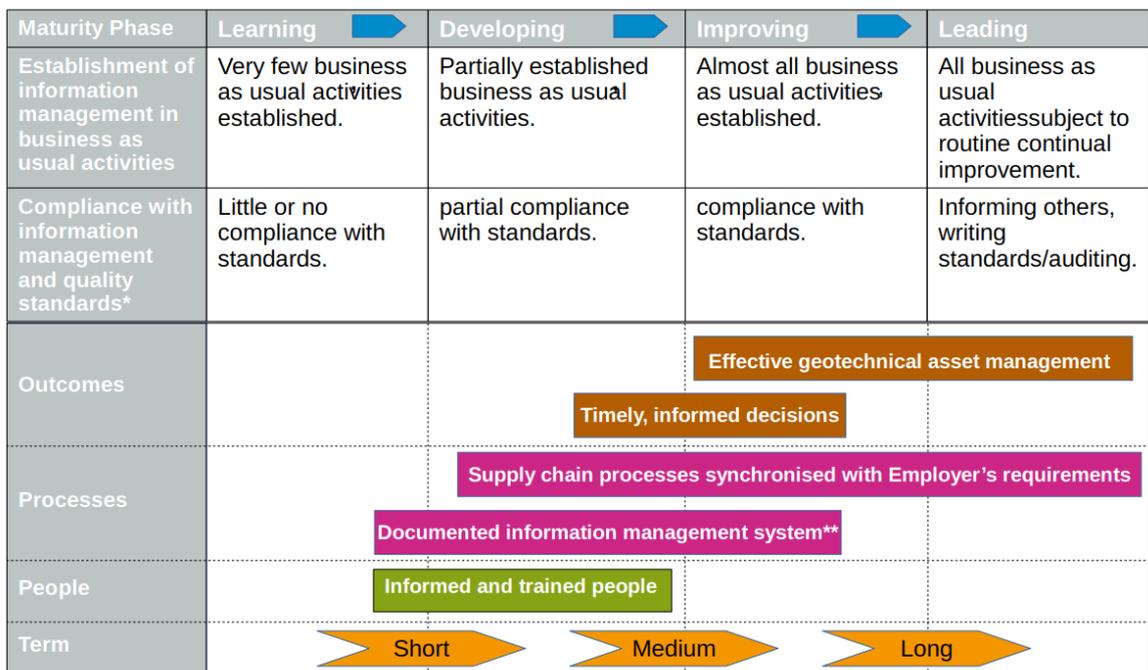
Table 2 Vision for geotechnical information in Highways England

The combined elements of the vision will provide Highways England with the tools to align to the principles of ISO 8000⁸, ISO5 5000⁹, BS8574¹⁰, BS1192¹¹ and general best practice in information management. The means of achieving the vision are set out in the task list (Work Bank, included in Appendix B) presented in the Recommendations section below.

The above vision has been translated into a roadmap shown in Figure 7 overleaf.

Geotechnical Information as an Asset - Maturity Roadmap

V1.0



Notes: * relevant standards include HD22/08, ADMM, BS8574, ISO9001, PAS1192 and AGS data transfer format
 ** "system" refers to a management system, not a computer system

Figure 7 Roadmap for improved use of information in geotechnics

⁸ ISO 8000-8:2015 Data quality

⁹ ISO 55000:2014 Asset Management Standards

¹⁰ BS8574: 2014 Code of practice for the management of geotechnical data for ground engineering projects

¹¹ BS1192: 2007 Collaborative production of architectural, engineering and construction information – Code of practice

7. Conclusions and recommendations

The review of has identified where improvements can be made, through a desktop review of key sources, internal and external initiatives and stakeholder consultation. These have been collated in a prioritised 'Work Bank', included in Appendix B.

In summary, most of the recommendations made fall within one or more of the following subject areas:

- **Data management systems and processes** including implementation of BS8574 and training initiatives
- **Access to information and knowledge**, including improvements to HAGDMS
- **Ground investigation processes**, primarily information flows during investigations but also considering procurement
- **Geotechnical reporting**, aiming to better reflect user needs with more prominence given to data, metadata and map based presentations
- **Continuous improvement of the AGS format**, and its implementation within Highways England, including its extension into construction data and interpretation
- **Interoperability**, considering both BIM and geospatial (GIS) domains, including developing the use of IFC and Uniclass
- **Asset definition and information**, including flow of information from design and construction through to asset management

In the full schedule, the improvement items have been categorised and tagged with keywords to enable searching and sorting. In addition, each of the identified improvement items has been prioritised on the basis of benefit, ease of delivery and urgency to the business.

It is recommended that the list be reviewed at six-monthly intervals and at key stages in the delivery of associated projects to ensure that it is kept up-to-date. A full refresh should be carried out every five years. Version control should be applied to the table to track changes.

In some instances, for example where initiatives have stalled or ceased, the research has concluded that there should be no further action. The qualitative benefits of each of the tasks have been included to justify their inclusion in the Work Bank.

All recommendations are underpinned by the principle that that *any data and information improvements must be aligned with business requirements*. The 'very high priority' tasks identified include:

- Review the information requirements and extend the ADMM data dictionary to include the new asset-related information, link with Uniclass 2015 and aligned with business requirements.

- Use the output from recent research tasks (e.g. identification and classification of SGMs) to inform the supply chain about asset construction methods, hazards and risks.
- Create a best-practice guidance note for the procurement of ground investigations (in lieu of a framework contract).
- Update standards and guidance to ensure that the correct data is being collected at the right time (e.g. AGS4 is specified and is a primary deliverable).
- Provide ground investigation contractors with direct access to HAGDMS to fulfil the client's requirements under CDM and to engage with the outer reaches of the supply chain.
- Use Employer Information Requirements on small schemes as well as the larger projects to ensure completeness and consistency of information.
- Roll out training to the supply chain as necessary and implement a training register (for asset information training initially).

The complete task list should be reviewed when planning follow on work to ensure that linked tasks are considered. It may be preferable to implement linked tasks, even if they are not high priority.

When starting a task, a baseline assessment should be carried out so that and financial benefits can be captured.

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Appendix A – I/O process maps

Process - Site Investigation - Statement of Intent (HD22/08)

Inputs	Formats	Outputs	Format
<p data-bbox="147 363 439 496">Existing Reports</p> <p data-bbox="147 547 439 679">Published information</p> <p data-bbox="147 754 439 887">Outline design information</p> <p data-bbox="147 962 439 1134">Asset information (e.g. HAGDMS)</p> <p data-bbox="147 1217 439 1350">Risk Register</p>	<p data-bbox="607 456 875 592">PDF</p> <p data-bbox="607 687 875 823">AGS</p> <p data-bbox="607 919 875 1054">Raster images</p>	<p data-bbox="1151 504 1420 639">Statement of Intent</p>	<p data-bbox="1664 480 1933 616">PDF</p>

Process - Site Investigation - Desk Study (HD22/08)

Inputs	Formats	Outputs	Format
Existing Reports	PDF	Desk Study	PDF
Published information	AGS	Annex A	
Outline design information	CSV		
Asset information	Raster		
Risk Register	GIS		
3rd party mapping (e.g. Landmark)			
Walkover Surveys			

Process - Site Investigation - Risk Assessment (HD22/08)

Inputs	Formats	Outputs	Format
<p data-bbox="194 304 483 432">Existing Reports</p> <p data-bbox="194 483 483 611">Published information</p> <p data-bbox="194 687 483 815">Outline design information</p> <p data-bbox="194 892 483 1019">Asset information</p> <p data-bbox="194 1096 483 1224">Hazard maps</p>	<p data-bbox="647 394 909 521">PDF</p> <p data-bbox="647 624 909 751">AGS</p> <p data-bbox="647 834 909 962">CSV</p> <p data-bbox="647 1064 909 1192">HAGDMS</p> <p data-bbox="647 1256 909 1383">Raster images</p>	<p data-bbox="1182 442 1444 569">Risk Assessment</p>	<p data-bbox="1686 416 1948 544">PDF</p> <p data-bbox="1686 646 1948 774">Spreadsheet</p>

Process - Site Investigation - Design (HD22/08 GDR & EC7)

Inputs	Formats	Outputs	Format
<p data-bbox="376 300 591 408">GIR</p> <p data-bbox="376 456 591 564">Design Information</p> <p data-bbox="376 612 613 721">Risk Register</p>	<p data-bbox="734 300 949 408">PDF</p> <p data-bbox="734 472 949 580">AGS</p> <p data-bbox="734 644 949 753">Drawings</p> <p data-bbox="734 823 949 932">Database</p> <p data-bbox="734 1015 949 1123">Spreadsheet</p> <p data-bbox="734 1174 949 1283">GIS</p> <p data-bbox="734 1334 949 1442">CSV</p>	<p data-bbox="1173 370 1384 529">Geotechnical Design Report</p> <p data-bbox="1173 612 1384 721">SEAF?</p>	<p data-bbox="1581 347 1796 456">PDF</p> <p data-bbox="1581 536 1796 644">Drawings</p>

Process - Site Investigation - Ground Investigation (EC7)

Inputs	Formats	Outputs	Format
Specifications	Paper		PDF
Exploratory hole data	PDF	Ground Investigation Report	
Lab Data	AGS	Factual report	AGS
Test schedules	CSV		
Risk Register	Database		
Site diary	Spreadsheet		
Photographs	Raster images		
Site Instructions	email?		
3rd party information (e.g. services)	Drawings GIS		

Process - Construction (SHW/ADMM/IAN182/IAN184)

Inputs	Formats	Outputs	Format
<p data-bbox="152 368 439 467">GDR</p> <p data-bbox="152 536 439 635">GIR</p> <p data-bbox="152 703 439 831">Design Drawings</p> <p data-bbox="152 900 439 1027">Design Specifications</p> <p data-bbox="152 1096 439 1224">Temporary works design</p> <p data-bbox="152 1292 439 1420">Risk Register</p>	<p data-bbox="629 395 891 526">PDF</p> <p data-bbox="629 601 891 732">Drawings</p> <p data-bbox="629 807 891 938">Spreadsheet</p> <p data-bbox="629 1013 891 1144">CSV</p> <p data-bbox="629 1219 891 1350">AGS</p>	<p data-bbox="1151 501 1413 667">Compliance test approvals</p> <p data-bbox="1151 756 1413 960">Geotechnical Feedback report</p>	<p data-bbox="1677 451 1939 633">Data in accordance with ADMM</p> <p data-bbox="1677 681 1939 879">Drawings in accordance with IAN184</p> <p data-bbox="1677 948 1939 1027">AGS</p>

Process - Construction Monitoring (SHW)

Inputs

Site readings
(insitu tests)

Laboratory
tests

Risk Register

Specifications

Instrumentation
results

Formats

PDF

Drawings

Spreadsheet

CSV

Outputs

Compliance
test approvals

Geotechnical
Feedback
report

Format

PDF

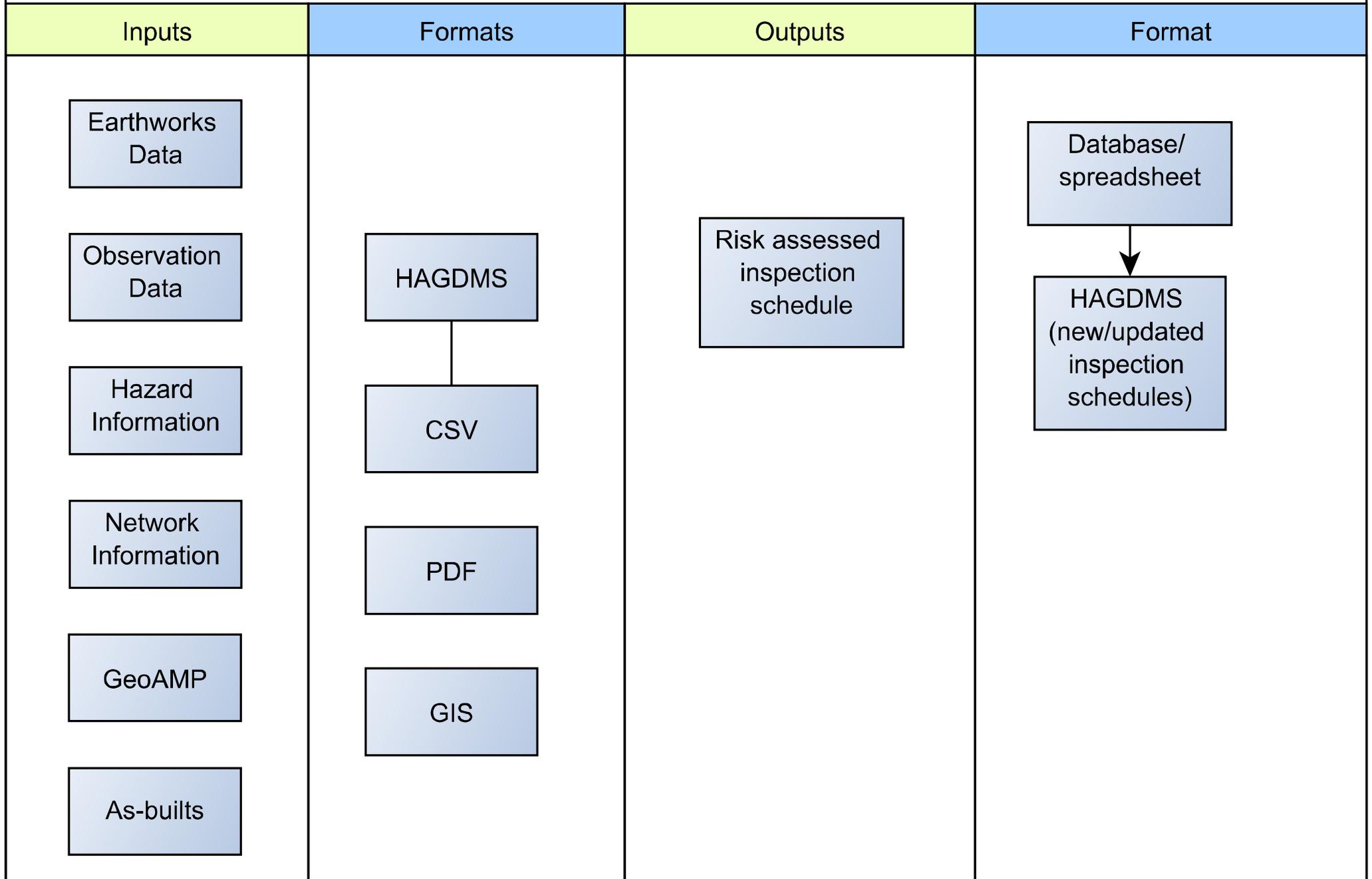
Drawings

AGS data
(monitoring)

Process - Maintenance Monitoring

Inputs	Formats	Outputs	Format
<p data-bbox="389 300 600 405">GIR</p> <p data-bbox="389 453 600 558">Design Information</p> <p data-bbox="389 606 600 711">Risk Register</p> <p data-bbox="398 759 609 865">As-builts</p>	<p data-bbox="741 300 952 405">PDF</p> <p data-bbox="741 469 952 574">AGS</p> <p data-bbox="741 638 952 743">Drawings</p> <p data-bbox="741 823 952 928">Database</p> <p data-bbox="741 1008 952 1114">Spreadsheet</p> <p data-bbox="741 1161 952 1267">GIS</p> <p data-bbox="741 1324 952 1430">CSV</p>	<p data-bbox="1173 363 1384 526">Geotechnical Design Report</p> <p data-bbox="1173 603 1384 708">SEAF?</p>	<p data-bbox="1579 347 1789 453">PDF</p> <p data-bbox="1579 533 1789 638">Drawings</p>

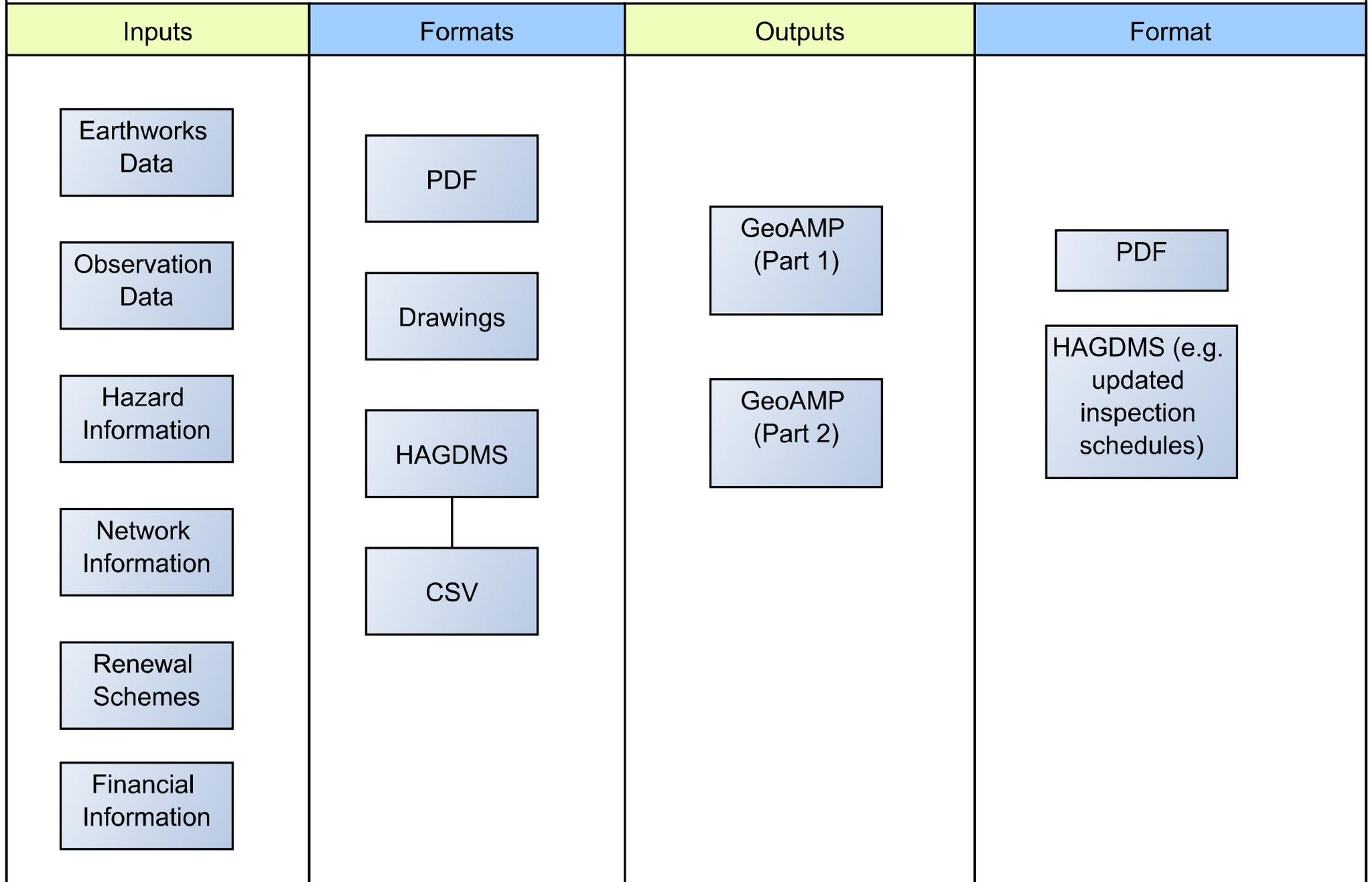
Inspection Risk Assessment (HD41/15)



Process - Inspections (includes during construction) (HD41/15)

Inputs	Formats	Outputs	Format
<p>GAD data</p> <p>Inspection data incl. schedule</p> <p>Design Drawings (for initial PI)</p> <p>GeoAMP</p> <p>Hazard assessment</p> <p>Raster images (photos & sketches)</p> <p>Spreadsheets (monitoring info)</p>	<p>PDF</p> <p>Drawings</p> <p>Spreadsheet</p> <p>CSV</p> <p>Paper</p>	<p>Data on HAGDMS</p>	<p>Data in accordance with ADMM</p> <p>Data in accordance with HD41/15</p> <p>AGS data (monitoring)</p>

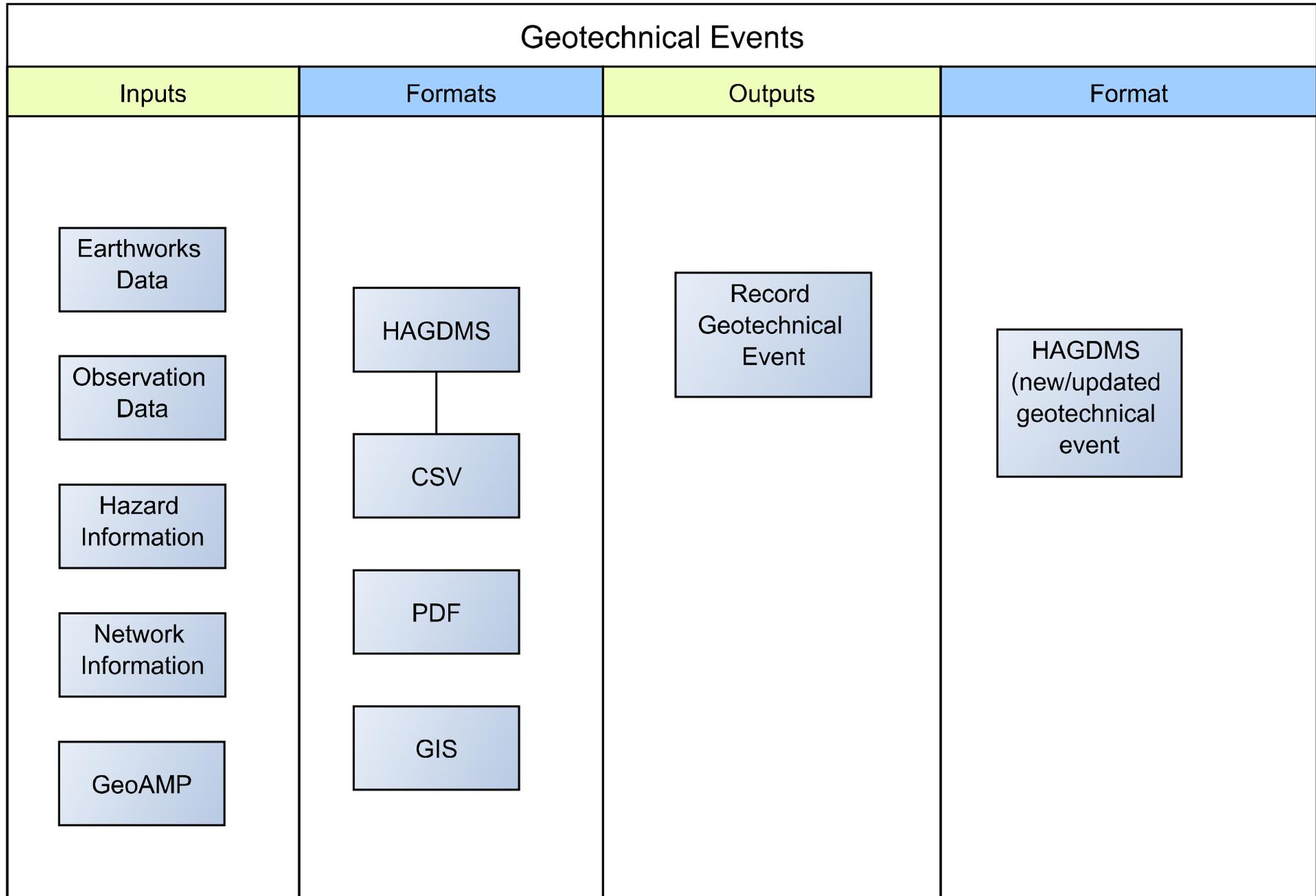
Prepare GeoAMP (HD41/15)



Performance Reporting, incl. monthly report (OMM)

Inputs	Formats	Outputs	Format
<p data-bbox="237 437 474 555">Earthworks Data</p> <p data-bbox="237 619 474 737">Observation Data</p> <p data-bbox="237 849 474 967">Inspection Data</p> <p data-bbox="237 1056 474 1174">Records Data</p> <p data-bbox="237 1264 474 1382">GeoAMP reports</p>	<p data-bbox="656 695 893 813">HAGDMS</p> <p data-bbox="674 1248 911 1366">PDF</p>	<p data-bbox="1115 501 1395 587">Monthly Report</p> <p data-bbox="1115 695 1395 782">PI report to S&P</p> <p data-bbox="1115 880 1395 967">Ad-hoc reporting</p> <p data-bbox="1115 1069 1395 1209">Annual Report to AIG/ S&P</p>	<p data-bbox="1565 437 1845 587">PDF (semi automated)</p> <p data-bbox="1565 673 1845 743">email</p> <p data-bbox="1565 829 1845 967">Spreadsheet template</p>

Geotechnical Events



Records Management

Inputs	Formats	Outputs	Format
<p data-bbox="152 703 407 831">Report Metadata</p> <p data-bbox="152 927 407 1054">PDF</p> <p data-bbox="152 1150 407 1278">AGS</p>	<p data-bbox="618 703 873 831">HAGDMS</p>	<p data-bbox="1115 491 1417 587">Monthly Report</p> <p data-bbox="1115 703 1417 799">PI report to S&P</p> <p data-bbox="1115 900 1417 995">Ad-hoc reporting</p> <p data-bbox="1115 1102 1417 1198">Annual Report to AIG/ S&P</p>	<p data-bbox="1603 421 1906 587">PDF (semi automated)</p> <p data-bbox="1603 676 1906 756">email</p> <p data-bbox="1603 847 1906 995">Spreadsheet template</p>

Appendix B – Prioritised ‘Work Bank’ of recommendations

Recommended actions - task list work bank.

Ref	Category/ key words	Life-cycle stage	Title	Description/Opportunity	Benefit Description	Effort	Benefit	Effort/ Benefit index	Urgency	Priority	Priority Description	Delivery Route
22	data, dictionary	All	Asset Data Dictionary	Review the data dictionary to derive a complete data set. The dictionary should be derived from the questions that need to be asked.	To provide the current and future reporting requirements.	Low	High	8	Urgent	16	Very High Priority	Follow on task
28	AGS, data, quality	Acquisition	AGS Version 4	Ensure that all data is provided in AGS v4 to comply with Eurocodes & associated ISO standards. Updates to Standards, IANs and EIR required.	To improve data quality and comply with current best practice.	Low	High	8	Urgent	16	Very High Priority	Follow on task
33	accessibility, CDM, legal	Acquisition, Maintenance	GI contractors & CDM	Provide GI contractors direct access to HAGDMS	To fulfil Client's duties under CDM and obtain more focussed/cheaper ground investigations.	Low	High	8	Urgent	16	Very High Priority	BaU
35	specifications, projects	Acquisition, Maintenance	EIR - small schemes - including Health & Safety File requirements	Provide EIRs for all schemes, not just large ones. (links to Data Management System)	To improve data quality and speed up project delivery.	Low	High	8	Urgent	16	Very High Priority	Follow on task
51	AGS, consistency, dataset	Acquisition	Specification of AGS data	Improve HE specification requirements for AGS data. Incorporate findings from the abbreviations/soil material codes review and address concerns relating to inconsistencies on referencing. Consider incorporating existing AGS guidance and/or create new guidance.	Consistent specification helps everyone in the supply chain, especially GI contractors. Also facilitates easier use of AGS data across projects or in the future when retrieved from archive (HAGDMS).	Low	High	8	Urgent	16	Very High Priority	Follow on task
85	data primacy, data quality	Knowledge	Data Primacy	Determine data primacy for geotechnical asset information in Highways England	Data quality improvement. Reporting assurance	Low	High	8	Urgent	16	Very High Priority	Follow on task - link with AIG
86	knowledge, accessibility	Knowledge	List web site information	Create a list of relevant internal and external web sites relevant to geotechnical information and host on the Portal.	Inform the supply chain and other stakeholders about previous and current schemes/best practice etc.	Low	High	8	Urgent	16	Very High Priority	Follow on task
5	skills, training	All	Data training	To raise the skill level of the supply chain, by supporting training initiatives or provide training materials	The quality, provision and use of data will be improved	Medium	High	6	Urgent	12	High Priority	Follow on task
14	SGM, map layers	Operation	Production of static SGM map layer	Details in the SGM report	To display the spatial location of SGMs to service providers	Low	Medium	6	Urgent	12	High Priority	HAGDMS Phase 11
23	BS8574, data, management	All	Compliance with BS8574	Raise the profile of BS8574 within the supply chain & implement and HE-specific Data Management System.	Improve data quality throughout the supply chain. Improves the likelihood of data being provided at the right time and to the right quality.	Medium	High	6	Urgent	12	High Priority	Follow on task
25	ground, investigation, procurement, guidance	Acquisition, Maintenance	Ground Investigation Procurement - Best Practice	Create a best practice guidance note for the supply chain to use when procuring ground investigations. Targeted at the lay-person (e.g. procurement manager)	To avoid problems such as contracts being let as lump sum and the designer not being involved at the right times.	Low	Medium	6	Urgent	12	High Priority	Follow on task
26	AGS, data, quality, timeliness, completeness	Acquisition	Manage the process of AGS data upload.	AGS data is frequently not uploaded to the asset information system in a timely manner. Implement processes for audit and improvement. Links with Data Management System	To ensure the correct level of data quality wrt the reports database.	Medium	High	6	Urgent	12	High Priority	Follow on task
27	AGS, interoperability, geology codes	Operation, Maintenance	Common abbreviation and geology codes	Review HE use of abbreviation codes, including soil material codes. Aim for a consistent specification that is fully aligned with AGS and, preferably, also aligned with BGS and other asset owners.	To future-proof the use of digital data.	Medium	High	6	Urgent	12	High Priority	Follow on task
45	training, data maturity	Knowledge	Training register	A training record register should be established	To support data quality maturity (ISO55000)	Low	Medium	6	Urgent	12	High Priority	Follow on task
47	data, hierarchy, dictionary	All	Asset Data Hierarchy	To review the current asset data hierarchy and compare against a logical model and the data dictionary. The links between inventory, construction and condition should be established. Other asset groups should be referred to in order to ensure compatibility of cross-asset reporting etc.	To ensure the correct level of reporting and granularity of data.	Medium	High	6	Urgent	12	High Priority	Follow on task
48	ADMM, data dictionary	All	ADMM	The ADMM should be updated to include data other than inventory.	To support data quality maturity (ISO55000)	Low	Medium	6	Urgent	12	High Priority	Follow on task
82	BIM	Acquisition, Maintenance	Input to high level BIM and digital construction initiatives in the UK	HE should keep track of and, where appropriate, participate in national BIM initiatives, e.g. taking a lead in the relevant BIM 4 groups, or offering support to UK BIM Alliance. Geotechnical matters are only a small part of the BIM picture and any such support would best be led from the BIM/AIG team within HE.	Opportunity to ensure that UK BIM practice evolves in a manner compatible with its needs	Low	Medium	6	Urgent	12	High Priority	Follow on task
24	ground, investigation, framework	Acquisition, Maintenance	Ground Investigation Framework	Create a framework contract for ground investigation works.	To speed up design and construction.	High	High	4	Urgent	8	Average Priority	Specific task
32	AGS, data, accessibility, knowledge, research	Knowledge	Research	Provide access to AGS data for research purposes to provide information that will help design (under & post-graduate)	To improve designs and help modular construction. (e.g. sign-post foundations)	Low	High	8	Not Urgent	8	Average Priority	Follow on task

Recommended actions - task list work bank.

Ref	Category/ key words	Life-cycle stage	Title	Description/Opportunity	Benefit Description	Effort	Benefit	Effort/ Benefit index	Urgency	Priority	Priority Description	Delivery Route
37	resilience, interoperability	Operation	Resilience mapping (simple)	Weather data from HA WIS to be presented on HAGDMS.	To enable smarter resilience planning	Medium	Medium	4	Urgent	8	Average Priority	HAGDMS Phase 12
39	information, accessibility, risk management	Operation	Network restrictions	Information regarding network restrictions such as diversion routs, traffic counts, capacity etc. should be collated to be used in risk modelling.	To enable network criticality and hence serviceability to be determined in a smarter way.	Low	High	8	Not Urgent	8	Average Priority	HAGDMS Phase 12
41	knowledge, accessibility	Knowledge	Review web site information	Collate information contained on the Archived HA web site and present on new HE web pages. Include research reports, The way we work, toolkits etc.	Inform the supply chain and other stakeholders about previous and current schemes/best practice etc.	Low	High	8	Not Urgent	8	Average Priority	Follow on task
46	data maturity	All	Documentation	Data management processes should be documented (links with Data Management System)	To support data quality maturity (ISO55000)	Medium	Medium	4	Urgent	8	Average Priority	Follow on task
52	AGS, data, quality	Acquisition	AGS/GI data quality grading	Create simple system for assessing the quality of GI data, including AGS data, primarily based on the verification regime adopted at the time. Assess legacy data in PSSR to inform later use.	Consistent basis for assessing reliability of legacy data. Future users of graded 'new' data will immediately be able to take an view on its reliability. May lead to reduced scope of future GIs.	Low	High	8	Not Urgent	8	Average Priority	Follow on task
65	BIM, IFC, modelling, continuity	Acquisition, Maintenance	Use IFC for archive models	Handover of full detailed model as IFC at end of project for archive purposes	Using a future proof software neutral format will make it easier for future users who need to have the	Low	High	8	Not Urgent	8	Average Priority	Follow on task
1	mobile, data, capture, investigation, productivity, innovation	Acquisition	Field data capture (site investigation & construction)	Promote field data capture for ground investigation through specifications/involvement with awards etc. Includes use of mobile technologies as well as electronic capture of field test data to replace current manual methods.	To reduce costs in the supply chain and to promote improved data quality	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
2	mobile, data, capture, monitoring, inspections, productivity	Operation	Mobile Data capture (monitoring)	Expand the use of mobile data capture to monitoring data in ad-hoc and principal inspections	To enable use of data to derive deterioration rates (factual/objective) and to promote consistency. To maximise the use of mobile technology being proposed (tabletGAD)	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
7	taxonomy, SGM, accessibility	All	Define Report Keywords	Create a taxonomy for report keywords Include hazard/SGM existing terms where possible. Implement in HAGDMS.	To enable searching and re-use of reports.	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
12	SGM, update	Acquisition	Update SGM data	The SGM task (594) was completed in Summer 2017 and used data from 2015. The exercise needs to be applied to the data loaded onto HAGDMS since 2015.	To provide a complete data set wrt SGMS	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
13	SGM, structured data	Operation	Incorporation of SGM Types into GAD data	Details in the SGM report	To ensure relevant data is captured	Medium	High	6	Not Urgent	6	Low Priority	HAGDMS Phase 11
20	SGM, mobile, data, capture	Operation	Update mobile data capture to include SGMS	Details in the SGM report	To ensure relevant data quality	Medium	High	6	Not Urgent	6	Low Priority	HAGDMS Phase 12
21	SGM, taxonomy, hierarchy, interoperability	Operation	Review SGM taxonomy wrt inventory, condition & cross asset data (e.g. structures & drainage)	Details in the SGM report	To ensure that SGMS are being recorded at the correct level of asset hierarchy. (e.g. where there are a principal component of the earthwork or a secondary feature)	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
29	AGS, data, quality	Acquisition	Digitised AGS data	When AGS data is digitised from PDF reports the complete data set should be digitised, not just logging data.	To improve the speed of delivery of projects.	Medium	High	6	Not Urgent	6	Low Priority	BaU
34	training, knowledge	Knowledge	Training materials	Ensure that all relevant parties have access to training materials, including HE staff (difficulty accessing webinars)	To improve awareness and skills.	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
36	accessibility, knowledge	Knowledge	Research reports	Require research reports to be provided in HTML format. (consider technology used for DMRB)	To allow easy access to research reports, including searching.	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
42	data, hierarchy	Operation, Maintenance	Drainage	Define geotechnical drainage, specify data requirements and provide inspection guidance	To improve asset information quality.	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
43	data, quality, completeness, reporting	Acquisition	Geotechnical Certification	Provide structured data to manage the geotechnical certification process in a smarter way	To improve asset information quality.	Medium	High	6	Not Urgent	6	Low Priority	HAGDMS Phase 12
44	records management	Records Management	Records management metadata	Provide structured data to enable librarianship of the report records, i.e. include review dates, disposal dates & reasons etc.	To better align with the records management requirements.	Medium	High	6	Not Urgent	6	Low Priority	HAGDMS Phase 12
49	AGS, primary deliverable	Acquisition	AGS data as primary deliverable	Improve AGS format so that is capable of being the primary deliverable from a GI (instead of the factual report). To include improved guidance.	GI process improvement. Puts focus on to accurate and timely provision of data instead of production of paper logs and reports.	Medium	High	6	Not Urgent	6	Low Priority	AGS Data Format Working Group
50	AGS, test, scheduling	Acquisition	AGS data for GI schedules	Develop use of AGS format for GI scheduling information. Requires revision of AGS format as this is not included at present, albeit it can be done with some imagination.	GI process improvement. Promotes importance of data exchange over paper schedules. Ensures consistent hole referencing.	Low	Medium	6	Not Urgent	6	Low Priority	AGS Data Format Working Group

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59	productivity, reporting, AGS	Acquisition	Early/incremental issue of final GI data/report	On long duration GIs, data/report to be finalised and delivered as it become available, instead of waiting until completion of whole of GI. Links to recommendation for new factual report format and AGS as primary deliverable	Reduces risk of problems arising during design due to late or slow delivery of data.	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
63	BIM, IFC, modelling, continuity	Acquisition, Maintenance	Use IFC exchange for collaboration	Encourage use of IFC for collaboration on projects, e.g. handover of model to contractor as IFC. Dependent on development of IFC schema.	Use of a standardised and common software neutral format (that most modelling software can export to) allows suppliers to collaborate more efficiently whilst still using their preferred authoring software.	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
68	AGS, BIM, Uniclass, hierarchy, continuity	Acquisition, Maintenance	Uniclass for geotechnical assets	Develop Uniclass 2015 geotechnical asset codes to provide better fit with HE asset management needs. Requires models and asset data provided to include Uniclass codes.	Uniclass codes could eventually supplant HAGDMS in-built coding as main method of searching for particular asset types. Using Uniclass would allow HE to share data with other asset owners in common format.	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
70	AGS, data accessibility	Acquisition, Maintenance	Provision of AGS and source data for procurement and construction	Investigate reasons for AGS data not reaching contractors. Develop system to ensure that AGS data, and other key data such as PSSR source data, is made available and easily discoverable during procurement, and at construction stage	This should be happening now but there is evidence to suggest it is not always the case, especially AGS data. Potential costs savings for supply chain, and reduced risk to all.	Medium	High	6	Not Urgent	6	Low Priority	Follow on task
72	project, AGS, data, completeness	Acquisition, Maintenance	AGS format for piling data	Support current AGS work on format for piling data (current part of HE structures remit, but of interest to geotechnical engineers)	Potential for improving data review process on site. In future, data could be analysed to benefit design, construction and/or asset management.	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
74	asset, identification, continuity	Acquisition, Maintenance	Asset identification at design stage	Identification of (future) asset at design and construction stage. Consider concept similar to COBie data drops.	HE asset management needs considered from and early stage, making eventual data drop for HAGDMS input much more straightforward. Also could allow 'under construction' assets to be incorporated in HAGDMS if desired.	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
76	project, AGS, monitoring	Acquisition, Maintenance	Use of AGS format for construction monitoring	Construction monitoring data (from instrumentation) to be routinely made available in AGS format	Potential for improving data review process on site. Easier to back-analyse large data sets data to benefit future design, construction and/or asset management.	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
77	operation, AGS, monitoring	Acquisition, Maintenance	Use of AGS format for asset monitoring	Asset monitoring data (from instrumentation) to be made available in AGS format	Easier to back-analyse large data sets data to benefit future design, construction and/or asset management.	Low	Medium	6	Not Urgent	6	Low Priority	Monitoring task
75	AGS, monitoring	Acquisition, Maintenance	AGS format for monitoring data	Review suitability of current AGS format and, if necessary, recommend improvements to AGS	Take up likely to be improved	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
84		Acquisition, Maintenance	SHW fill class in HAGDMS	Consider adding SHW fill class to HAGDMS. Preferably as-built as design may allow options.	Improves linkage through from design, and provides more opportunities for analysis of data.	Low	Medium	6	Not Urgent	6	Low Priority	Follow on task
4	data, exchange, formats, interoperability	All	Common Web-friendly formats	Develop or adopt web-friendly (JSON) data interchange formats for general data transfer, including AGS format	To enable interchange of data through the supply chain and across software products	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
8	keywords, reports, searches, accessibility	All	Extract Report Keywords	Extract keywords from reports using search software and populate data	To enable searching and re-use of reports.	High	High	4	Not Urgent	4	Low Priority	Follow on task
15	SGM, structure data, hierarchy	Operation	Creation of SGM-specific "observations"	Details in the SGM report	To ensure relevant data quality	Medium	Medium	4	Not Urgent	4	Low Priority	HAGDMS Phase 12
16	SGM, searches	Operation	Creation of SGM topic searches	Details in the SGM report	To ensure the data can be accessed	Medium	Medium	4	Not Urgent	4	Low Priority	HAGDMS Phase 12
17	SGM, hierarchy, searches	Operation	Creation of links between observations and reports	Details in the SGM report	To ensure the data can be accessed	Medium	Medium	4	Not Urgent	4	Low Priority	HAGDMS Phase 12
18	SGM, reports, metadata, keywords	Operation	Incorporation of SGM Types into Report record metadata	Details in the SGM report	To ensure the data can be accessed	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
19	SGM, searches	Operation	Creation of SGM GAD searches	Details in the SGM report	To ensure the data can be accessed	Medium	Medium	4	Not Urgent	4	Low Priority	HAGDMS Phase 12
31	AGS, data, completeness	Acquisition	AGS for construction	To extend the AGS data format for use in earthworks compliance testing and other geotechnical construction activities.	To provide as-built data in a digital format.	Medium	Medium	4	Not Urgent	4	Low Priority	AGS Data Format Working Group
40	information, accessibility, risk management	Operation	Traffic counts	Traffic counts to be presented at a mapping layer	To enable network criticality and hence serviceability to be determined in a smarter way.	Medium	Medium	4	Not Urgent	4	Low Priority	HAGDMS Phase 12
53	GIS, accessibility, continuity	Acquisition	PSSR as a live document	Live version of PSSR, with links to data sources, that evolves with project. Linked to development of web enabled GIS and alternative report formats.	Ensures desk study type information discovered after PSSR issue is shared in a more visible way.	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
54	report, formats, accessibility	Acquisition	Map based PSSR	PSSR report to include map based presentation (web enabled) to accompany a more concise text based report and risk register.	Early establishment of map based (using GIS)	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
55	project, continuity	Acquisition	Investigation Supervisor Report on GI	Report on site observations by GI Investigation Supervisor to be required when interpretation is to be delayed, or done by another supplier	Ensure key observations and knowledge gained from site are not lost in cases where GIR does not follow directly on.	Low	Low	4	Not Urgent	4	Low Priority	Follow on task

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56	project, continuity, BIM, CDE	Acquisition	Use of CDE at GI stage	Promote use of CDE at GI stage, including establishing a CDE specific to the GI if none already in place	GI process improvement	Low	Low	4	Not Urgent	4	Low Priority	Follow on task
57	AGS, test, scheduling	Acquisition	Lab test scheduling using AGS format	Promote exchange of lab test schedule information as AGS data (format already exists)	GI process improvement	Low	Low	4	Not Urgent	4	Low Priority	Follow on task
58	accessibility	Acquisition	New format for GI factual report	More user focused format for factual report. May be linked to development of AGS data as primary deliverable.	Designers and other users will save time as it will be easier to access desired information	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
62	BIM, IFC, modelling	Acquisition, Maintenance	IFC schema for earthworks and other geotechnical assets	Work with buildingSMART on development of IFC schema to make it suitable for use on highways projects.	Enabler for other recommendation on use of IFC. HE involvement in process should lead to schema better suited to HE needs. Facilitates better integration with other HE discipline who should also be moving towards IFC. integration with other	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
64	BIM, IFC, modelling, continuity	Acquisition, Maintenance	IFC MVD for asset management	Model View Definition for IFC that can create HE asset management subset of model, e.g. for input to HAGDMS	Provides stronger links between design/construction and asset modelling, reducing risk of inconsistency, and saving on potential rework	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
73	project, AGS, data, completeness	Acquisition, Maintenance	AGS format for other geotechnical construction activities	Support current AGS work on format for grouting data. Identify other processes that may benefit from AGS format data	Potential for improving data review process on site. In future, data could be analysed to benefit design, construction and/or asset management.	Low	Low	4	Not Urgent	4	Low Priority	Follow on task
78	knowledge, accessibility	Knowledge	HE geotechnical knowledge base	Set up a website collating existing HE published reports, papers and documents. Could be similar to Crossrail Learning Legacy site.	Ensures that all relevant published work is easily discovered by the supply chain, benefitting future design and construction.	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
79	knowledge, accessibility	Knowledge	Capture future learning points into knowledge base	In addition to Feedback Reports, large and/or complex projects to be require to produce publications on relevant topics for the knowledge base	Promotes dissemination of learning points	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
80	reporting	Knowledge	Parameters reported in GIR	Clarify what design parameters should be reported in GIR/GDR respectively. HD22 is current unclear and EC7 difficult to interpret	More consistent reporting and interpretation of EC7	Low	Low	4	Not Urgent	4	Low Priority	Follow on task
81	project, BIM, BS8574	Knowledge	Data Management Plans for projects	Require formal plans for data management on projects, including ground investigations, to comply with BS8574 and PAS 1192-2, effectively BIM Execution Plan (or part of the main BEP)	Efficiency through better data management and BIM compliance.	Medium	Medium	4	Not Urgent	4	Low Priority	ADMM
9	reports, desk study, data, formats	Acquisition	Source data for desk study reports.	Source data for (future) desk study reports made available as well as the PDF version of the report. Links with common data formats.	To speed up processes within the supply chain.	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
83	AGS	Acquisition	HE support to AGS Data Format Working Group	Drafting proposals for improvements/additions to AGS as part of HE projects, then taking them to AGS for adoption.	This would considerably speed up the process of change given that AGS often lacks the resources to work up major changes in a timely manner.	Medium	Medium	4	Not Urgent	4	Low Priority	Follow on task
3	report, formats, accessibility	All	Report Formats	Enable alternative report formats	To enable increased interactivity and accessibility of information contained in reports. The reporting will be simplified (data driven) and the reviewer will be able to visualise the data in a smarter way.	Medium	Low	2	Not Urgent	2	Very Low Priority	Follow on task
6	risk, register	Operation	Risk Register	Enabling the capture of the final risk register and possibly all previous versions. Set the risk register at the asset level.	The visibility of the risk register will help inform the maintenance requirements. Highlighting the use of the risk register throughout the asset lifecycle will help inform decision making.	High	Medium	2	Not Urgent	2	Very Low Priority	Follow on task
10	data, GIS, formats, interoperability	Acquisition	Use of web-based GIS	Present and consume data in a GIS format. This relies on having common data formats and an accessible GIS platform.	To enhance visualisation of data and speed up reporting/design approvals.	High	Medium	2	Not Urgent	2	Very Low Priority	Follow on task
11	GIS, WMS, interoperability, hazards	Acquisition	Provision of WMS	Provide HE geotechnical mapping (e.g. hazard maps) as WMS data to allow other systems to consume it.	To enable designers and other stakeholders access to up-to-date data and reduce the administrative costs of providing and consuming data.	High	Medium	2	Not Urgent	2	Very Low Priority	HAGDMS Phase 12
30	AGS, data, accessibility	Acquisition, Maintenance	Access to AGS data	AGS data to be made easier to access by combining all data sets and enabling user to download data from selected exploratory holes, rather than on a project-by-project basis.	To improve the speed of delivery of projects.	High	Medium	2	Not Urgent	2	Very Low Priority	HAGDMS Phase 12
38	resilience, interoperability	Operation	Resilience mapping (developed)	Integrate HA WIS information with hazard mapping/GAD data on HAGDMS such that automated "hot spots" can be viewed in real time	To enable smarter resilience planning	High	Medium	2	Not Urgent	2	Very Low Priority	HAGDMS Phase 12
60	project, accessibility,	Acquisition	Ground model exchange protocol	Establish protocol for exchange of ground model data, with focus on the metadata describing what the surface represents and how it was created.	Facilitates a consistent approach across the supply chain, which should encourage such exchanges. Reduces risk of inappropriate use of data.	Medium	Low	2	Not Urgent	2	Very Low Priority	Follow on task

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61	AGS, accessibility	Acquisition	AGS for interpretative data	Work with AGS on their creation of data transfer format for interpretative GI data. Links with ground model protocol work.	A structured format could facilitate cross project analysis of archive data, with benefits for design and asset management.	Medium	Low	2	Not Urgent	2	Very Low Priority	Follow on task
66	AGS, BIM, IFC, modelling, continuity	Acquisition, Maintenance	IFC for ground investigation	Create IFC schema for ground investigation that complements AGS format	Makes it easier to incorporate basic GI information in BIM models	Medium	Low	2	Not Urgent	2	Very Low Priority	Follow on task
67	AGS, BIM, IFC, modelling, continuity	Acquisition, Maintenance	IFC for ground models	Create IFC scheme for ground models. Likely to be done in conjunction with AGSi development	Facilitate exchange of ground model information in software neutral format.	Medium	Low	2	Not Urgent	2	Very Low Priority	Follow on task
69	AGS, BIM, Uniclass, hierarchy, continuity	Acquisition, Maintenance	Uniclass for ground investigation	Develop Uniclass 2015 GI related codes to better fit GI practice, including reporting, and AGS data structure.	Provides potentially more robust system for identifying different exploratory hole types when analysing data sets	Medium	Low	2	Not Urgent	2	Very Low Priority	Follow on task
71	project, data, completeness	Acquisition, Maintenance	CCR data	Collect data from Compaction Continuous Recording (CCR) on earthworks construction.	Data could in future be analysed to benefit design, construction and/or asset management.	High	Medium	2	Not Urgent	2	Very Low Priority	Follow on task