

**GEOTECHNICAL COURSE DATES:**  
 Rock Description Workshop  
 2nd Oct. 2014, 7th Nov. 2014  
 In Situ Testing  
 9th October 2014

**GEOTECHNICAL COURSE DATES:**  
 Geotechnical Foundation  
 Design - 6th November 2014  
 Soil Description Workshop  
 24th Sept' 2014  
 4th Dec' 2014

**H&S COURSE DATES:**  
 Avoiding Danger from  
 Underground Services  
 12th Sept' 2014, 24th Oct' 2014  
 Safe Supervision of  
 Geotechnical Sites:  
 15th - 17th Oct' 2014

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# SOUTH COAST CLIFF INSTABILITY

A look at a recent project at Barton on Sea examining erosion and cliff instability.

Also included in this month's issue:

- Digital Services and the Environmental Study Process
- Preparation for the next recession
- Arrow Geophysics look at geophysical techniques for locating and investigating subsidence and void development

Issue No.  
**33**

September 2014



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## SAFE SUPERVISION OF GEOTECHNICAL SITES - £450 + VAT

This three day course is certified by IOSH, is specifically focussed on the geotechnical industry and provides a totally unique and relevant Health and Safety course for managers and supervisors.

The course is aimed at anyone who is or will be expected to run sites where geotechnical works are carried out. The course meets all of the requirements of the UKCG and has been approved by The Environment Agency, Thames Water and The Association of Geotechnical and Geoenvironmental Specialists.

**NEXT COURSE DATES:** 15th - 17th October 2014  
10th - 12th December 2014

## AVOIDING DANGER FROM UNDERGROUND SERVICES - £150 + VAT

This one day course is aimed at anybody involved in specifying, instructing, managing, supervising or actually breaking ground. Important aspects include the use of real examples from the geotechnical industry and delivery by chartered advisors who are from within the industry.

This course is definitely not another CAT and Genny course and is the **only** externally verified course in the UK carrying the IOSH badge. The course is built around HSG47 and current industry best practice.

**NEXT COURSE DATES:** 12th September 2014  
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Writing for theGeotechnica this month is independent consultant and part-time lecturer at Brunel University Pete Reading. This month Pete provides details of the recent survey works carried out on the South Coast of England focussing on cliff instability at Barton on Sea. Pete worked as a consultant on the project on behalf of Brunel University who are assisting with the research of the landslide. This article particularly focuses on the work of Quarry Design and their Octocopter in carrying out an aerial survey of the affected area.

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# GEOTECHNICAL COURSES

## SOIL DESCRIPTION WORKSHOP - £265 + VAT

24th September 2014  
4th December 2014

## ROCK DESCRIPTION WORKSHOP - £265 + VAT

2nd October 2014  
27th November 2014

## GEOTECHNICAL FOUNDATION DESIGN - £225 + VAT

26th September 2014  
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## IN SITU TESTING - £225 + VAT

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30th October 2014

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# Welcome

Welcome to the 33rd Edition of **theGeotechnica** - the UK's fastest growing online geotechnically focussed e-magazine.

This month, once again, we have a fantastic line-up of insightful and informative articles that make for a must-read.

The first article of this month's issue comes from Mark Burnard, Senior Product Manager at Landmark® Information Group, a leading provider of property related environmental risk information and digital mapping since it launched in 1995. In this month's offering, Mark discusses the role that digital services today play in improving the environmental desk study process.

Writing our second article of this month's issue is one of our esteemed speakers from the Geotechnical Conference at Geotechnica 2014 - Tim Fitch of Invennt. Invennt is a business consultancy focussed on the construction sector that seeks to create value for clients and the supply chain through; strategic review, collaboration, relationship marketing, leadership and coaching. In this month's issue of theGeotechnica Tim writes about the best plans we can make to prepare ourselves for the next recession.

The third article is the second in a series of articles on geophysics from Tim Archer, Technical Director of Arrow Geophysics Limited, a geophysical consultancy established in 2004 that provides advice on geophysical risk reduction for UK construction projects. In this month's article Tim explains the usefulness of geophysical techniques for locating and investigating subsidence and void development.

Our final article this month is also our cover article. and comes from independent consultant and part-time lecturer at Brunel University Pete Reading. This month Pete provides details of the recent survey works carried out on the South Coast of England focussing on cliff instability at

Barton on Sea. Pete worked as a consultant on the project on behalf of Brunel University who are assisting with the research of the landslide. This article particularly focuses on the work of Quarry Design and their Octocopter in carrying out an aerial survey of the affected area.

As with every new edition of the magazine, the Editorial Team here at **theGeotechnica** will be on the lookout for even more new, original and interesting content from all corners of the sector, and would actively encourage all readers to come forward with any appropriate and relevant content - whether it be a small news item or a detailed case study of works recently completed or being undertaken. If this content is media rich and interactive, then all the better. We are looking to increase the already large readership of the magazine through better social media integration and promotion, as well as improving content month on month.

Finally, for any content that is submitted we will ensure that an advertising space, proportionate to the quality of content provided, is reserved should you wish to place an advert in that single edition of the magazine. We hope you enjoy this month's edition of the magazine and are inspired to contribute your own content for the coming editions of **theGeotechnica**.

**Editorial Team,  
theGeotechnica**

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# Geotechnical Applications Course

## 22nd - 26th September 2014

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### Monday 22nd September 2014 - Specifying Site Investigations

This one day course will look at the various methods available to carry out intrusive and non intrusive investigation. Whilst the course will concentrate on geotechnical methods some geo-environmental methods will be briefly discussed. The course will look at the aims of SI and categorise the various stages in an investigation.

**Trainers: Julian Lovell & Keith Spires, Managing & Operations Directors, Equipe Group**



### Tuesday 23rd September 2014 - Geotechnical Laboratory Testing Awareness

The course comprises a comprehensive one day overview of the complete process involved in Geotechnical Laboratory Testing from sampling through to interpretation. The course provides guidance on sampling requirements including sample types and sizes and revised regimes to comply with Eurocode 7 and BS 1377. During the day some typical laboratory testing equipment will be used to carry out tests and to give a greater understanding of how the tests are conducted. Practical examples will be carried out to enhance understanding.

**Trainer: Pete Reading, Consultant, Equipe Group**

### Wednesday 24th September 2014 - Soil Description Workshop

From 2007 new European Standards have started replacing the British Standards (Codes) under which investigations in the UK have been carried out. UK working practice will have to change to meet these new requirements but few practitioners are aware of the changes or the timetable. The workshop will comprise a series of lectures on the changes, and lectures on soil description followed by practical sessions describing soil samples.

**Trainer: Professor David Norbury, Director, David Norbury Limited**

### Thursday 25th September 2014 - Geotechnical Field Instrumentation, Monitoring and Reporting

The course comprises a comprehensive one day appreciation of the complete process involved in Instrumentation and Monitoring in the geotechnical environment. The course provides an overview of the current guidance documents and their requirements. The course will consider the design of both individual installations and the installation of suites of instruments in the wider site context.

**Trainer: Dr Andrew Ridley, Managing Director, Geotechnical Observations**

### Friday 26th September 2014 - Geotechnical Foundation Design

This one day course will provide a general overview of foundation design. It will include an assessment of the use and choice of shallow foundations and piles. It will cover the derivation of bearing capacity formula and their use. Exercises will be carried out to calculate the working loads and settlement of simple foundations. The methods used to calculate these will be in accordance with those described in Eurocode.

**Trainer: Pete Reading, Consultant, Equipe Group**



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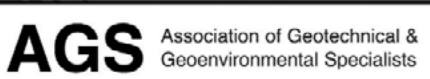
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# HOW CAN DIGITAL SERVICES IMPROVE THE ENVIRONMENTAL STUDY PROCESS?

Writing for **theGeotechnica** this month is Mark Burnard, Senior Product Manager at [Landmark@ Information Group](#), a leading provider of property related environmental risk information and digital mapping since it launched in 1995. Mark discusses the role that digital services today play in improving the environmental desk study process.

Today, there are more tools than ever before to help support the environmental site investigation process. The days of juggling PDF print-outs of site maps, historical maps and environmental data should be a thing of the past... but are they?

Many firms are continuing to scan through stacks of paper and maps, use light boxes, sticky tape, scale rulers and highlighter pens when preparing a Phase 1 Environmental Site Assessment. Not only is this

time consuming, but open to manual errors. With the advancement of technology, software tools and mobile devices, this way of working should be confined to the history books and, instead, new innovations embraced.

If you look back to the enactment of the Environmental Protection Act 1990 and the Environment Act 1995, here at Landmark, we saw an opportunity to start providing the industry with access to specialist mapping and environmental

data, served in a bundled package. At the time, we had entered into a joint venture with Ordnance Survey in 1995; capturing county series and post-war national grid mapping and geo-referencing them in to a single seamless

**“With the inclusion of data from local authorities and national datasets in 1996, Envirocheck® was born...”**

database. With the inclusion of data from local authorities and national datasets in 1996, Envirocheck® was born, which provided site-centred packages of paper maps and database information that

could be analysed for site investigation purposes.

Since 1996, additional data and mapping has been added to the Envirocheck software, including historical mapping from the Ordnance Survey's unpublished records; Survey of Information on Microfiche (SIM) and Supply of Unpublished Survey Information (SUSI) along with more recent SuperPlan mapping doubled the size of the historical collection to be well in excess of one million tiles. Subsequently, historical aerial photographs from the British Library and Fire Insurance Plans by Charles E. Goad were added, providing valuable additional detail as to an individual site's history.

**“With the additional historical mapping, a new advancement launched that offered a basic facility to overlay historical maps of various ages with current maps...”**

With the additional historical mapping, a new advancement was launched that offered a basic facility to overlay historical maps of various ages with current maps and aerial photography on screen. This enabled consultants to track and analyse changes in land use over time on and around the site, and to compare, accurately measure and ultimately create images

to include in Phase 1 Reports.

## An Evolving Industry

The crash in the financial markets in 2008 impacted heavily on contaminated land consultants. Fees charged were cut and the human resources to actually undertake work had to be scaled back to the bare minimum. Costs and, most significantly, time had to be cut on jobs without compromising upon quality. At the same time, major publicly funded infrastructure schemes were employing greater use of technology to improve accuracy and facilitate the easier dissemination of information. As a result of all of these factors, technology has advanced further

still to provide specialists with access to even more electronic data, which not only saves valuable time, but improves accuracy.

In fact the adoption and usage of online, digital services has become much more common-place and advances are continuing to support land specialists in accurately identifying potential risks before land or development

**“Digital land due-diligence data is now more accessible and cost effective than ever before...”**

projects commence. Digital land due-diligence data is now more accessible and cost effective than ever before, meaning that everything from historic maps, unexploded ordnance risk, environmental reports or geological data through to historic or current planning information can be quickly sourced, making the risk analysis and decision making process more streamlined.

This year, Landmark released its new Envirocheck Analysis, which now provides historical mapping, environmental and sensitivity data. It heralds the exciting adaptation of an already innovative idea, which takes material previously supplied in the paper Envirocheck Report (environmental and site sensitivity data) and transports it in to a digital environment, meaning professionals can now systematically review all

environmental risk datasets and mapping in one online application.

This process provides instant on-screen access to information, greatly reducing the risk of errors being made whilst at the same time reducing the amount of time it takes to review historical mapping and data.

From within the platform, professionals can overlay

digital environmental data onto current or historical maps to determine potential contamination risks. A range of aerial photography and drawing / measuring tools make it simple to mark-up Phase 1 assessments.

For a permanent record of features and findings, the platform enables a consultant to extract visual and tabular output, which can be readily incorporated in to a standard

**“Envirocheck Analysis is reducing the time it takes to analyse historical mapping and environmental data...”**

Phase 1 desk study report.

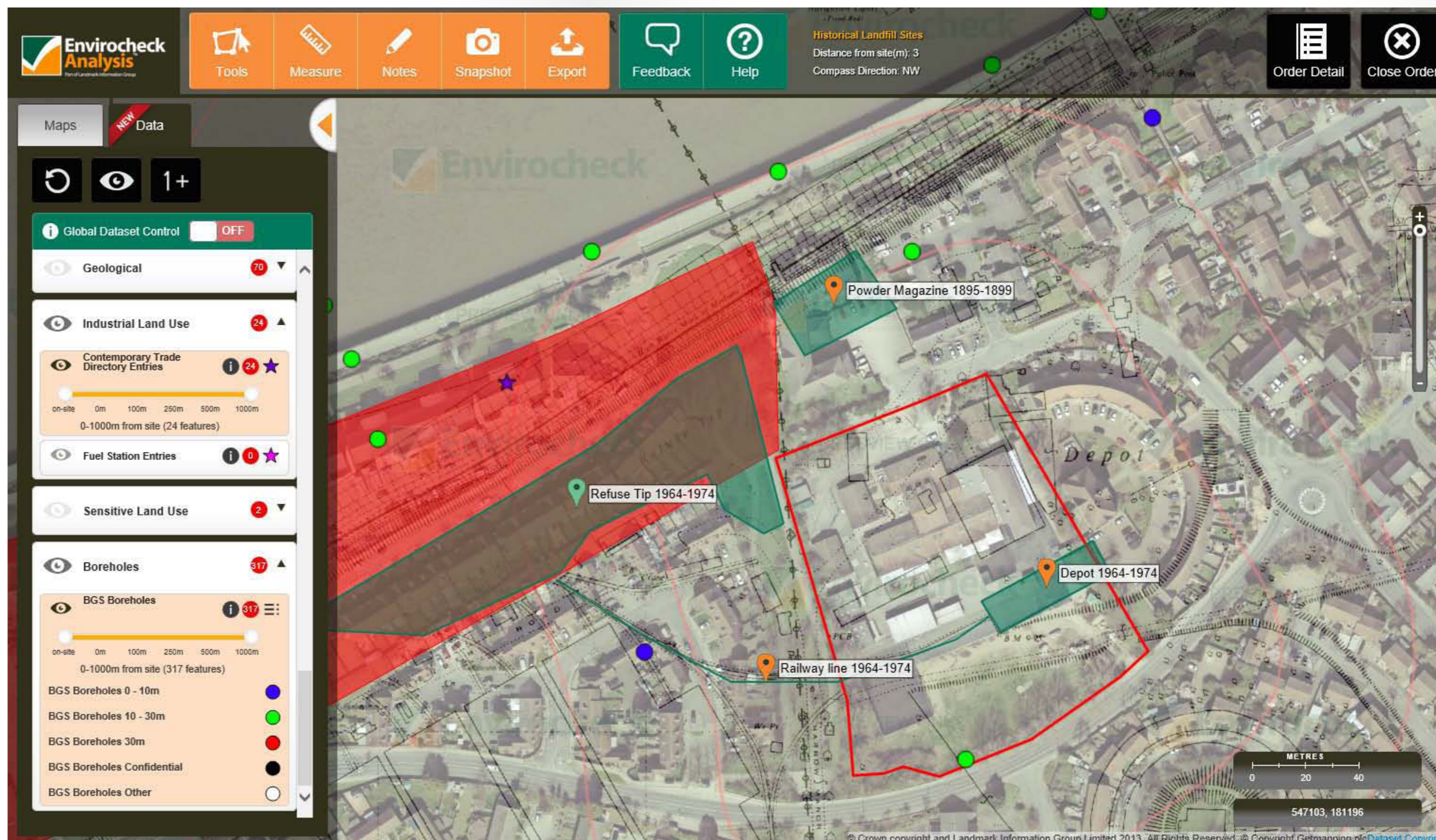
**Less Time, Greater Accuracy**  
Feedback from consultants already using the platform

suggest that in some cases Envirocheck Analysis is reducing the time it takes to analyse historical mapping and environmental data by up to half, meaning that consultancies are able to turn reports around faster for their clients, save money on additional recruitment and even take on more work.

Confirms Richard Puttock, Partner of Peter Brett Associates LLP said: “Envirocheck Analysis

**“In the past, we have ordered our environmental data and historical map reports through Envirocheck...”**

*is really changing the way that we conduct our Phase 1 Site Assessments. In the past, we have ordered our environmental data and historical map*



reports through Envirocheck and spent our time analysing PDF reports and even printing the documents out to have physical copies to work through. Since adopting Envirocheck Analysis, we are already saving significant amounts of time in analysing historical mapping, and the measuring and drawing tools provide a great level of accuracy, in much less time.

Continues Richard: "We have been involved in the entire user testing phase for the new Envirocheck Analysis, and we can't wait to start using it for all our Phase 1 desk studies. With all of Envirocheck's environmental data layers being added into the application, we no longer have to spend so long identifying symbols on maps and relating ID numbers back to separate

**"Now we can visualise everything alongside current and historical mapping, and make an assessment on the potential risk in much less time."**

*datasheet reports. Now we can visualise everything alongside current and historical mapping, and make an assessment on the potential risk in much less time. Ultimately, this allows us to complete the job more efficiently without comprising accuracy or quality, which helps us provide an even better service to our clients."*

In terms of sustainability, use of Envirocheck Analysis will deliver perceptible and tangible benefits to a business.



Firstly, its use will reduce the amount of paper consumed by a Phase 1 project. By enabling the entire review of information to be conducted within a digital environment, it will result in a reduction in paper usage; paper that could be put to better use elsewhere.

The Future is Bright: the Future is Mobile

Ultimately the ability to assess current or historical maps and aerial photography, in conjunction with environmental data, provides specialists with immediate access to a wealth of knowledge that can be relied on during the site investigation process - in less time and with more accuracy. It offers a non-intrusive approach to calculating site risk and enables professionals to accurately assess environmental factors related to a piece of land, without the need to overlay printed maps, manually draw boundaries, search through rafts of printed reports for potential sources, pathways or receptors of contamination as well as undertake physical groundwork explorations.

**"The evolution of online services today enables faster environmental assessments, with improved accuracy and delivers detailed reports to clients, faster."**

The evolution of online services today enables faster environmental assessments, with improved accuracy and delivers detailed and highly accurate reports to clients, faster. And, the progression of digital environmental reporting doesn't stop here: plans are already well underway to integrate Site Walkovers to take the whole Site Investigation process 'mobile'. The end of the light boxes, scale rules and physical paper print-outs of site-related information may not be too far away. ■



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- Reduce risk
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# THE RECESSION IS OVER: PREPARE FOR THE NEXT ONE

Following a long career in contracting Tim Fitch formed [Invennt](#) in 2011. Invennt is a business consultancy focussed on the construction sector. It seeks to create value for clients and the supply chain through; strategic review, collaboration, relationship marketing, leadership and coaching. In this month's issue of **theGeotechnica** Tim writes about the best plans we can make to prepare ourselves for the next recession.

In a speech at Mansion House on Thursday 12th June, Bank of England Governor Mark Carney gave the strongest hint yet that not only is the recession over but GDP is now accelerating beyond the previous high reached in 2008. As a consequence he indicated that interest rates will rise sooner than the market had previously expected.

In June the Office of National Statistics issued a revised estimate for construction growth in the first quarter of 2014.

So what does this mean for UK construction?

Gardiner and Theobald recently issued their tender price trends for Q2 2014 which shows strong inflationary pressures.

In a recent update Dr Noble Francis chief economist of the Construction Products Association forecast that construction output would grow by 4.7% in 2014 (<http://bit.ly/1qNtUBI>). Taken together these two pieces of evidence indicate clearly that construction is growing faster than the general economy in

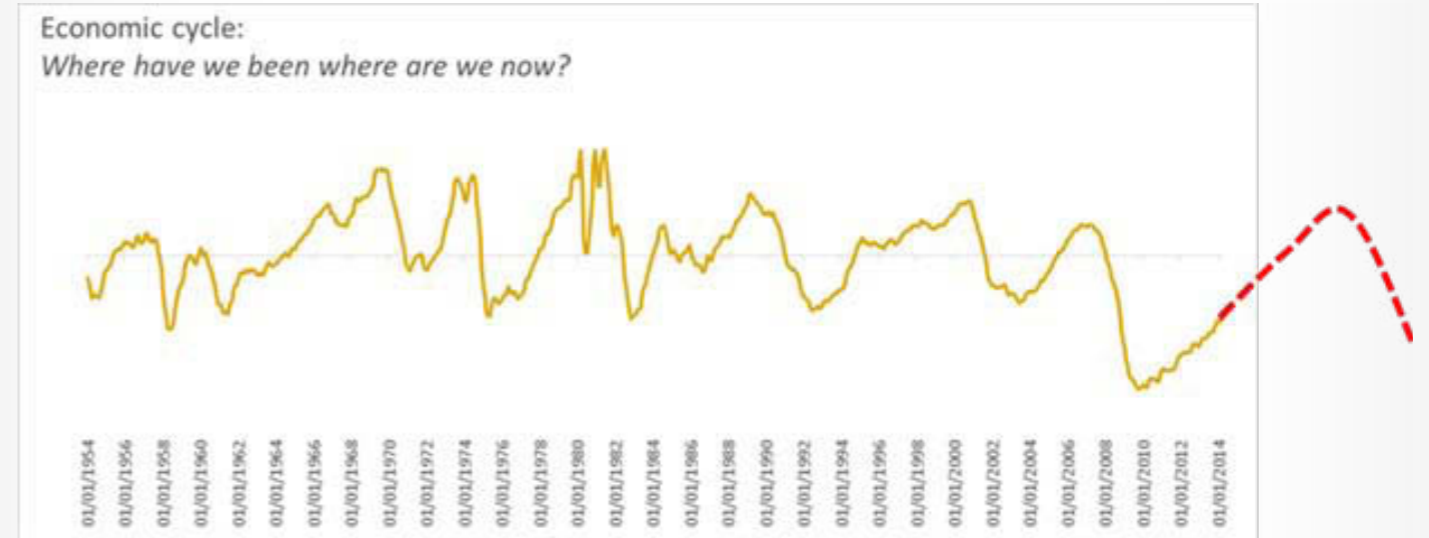


**“So with this good news why is this article talking about the next recession? Well we all know that construction is cyclical and follows the general economic cycle.”**

the UK.

Prepare for the next one? Am I a pessimist?

So with this good news why is this article talking about the next recession? Well we all know that construction is cyclical and follows the general economic cycle. My good friend Martyn Dorey kindly supplied me with the following data which shows how the economic cycle has fluctuated over the last 60 years or so. Looking at the most recent cycle which we all know started in 2007/8 with the financial crisis we can see the big dip which we all know was mirrored by construction activity. Martyn's



Data supplied by Martyn Dorey of [www.doreyltd.com](http://www.doreyltd.com)

**“In this time frame business managers can plan to mitigate the effects of this high probability scenario.”**

model is able to look forward as shown on the diagram and sure enough we can expect another down turn within the next 5-7 years following what will have been a substantial boom. In this time frame business managers can plan to mitigate the effects of this high probability scenario.

So armed with this knowledge what strategies can the industry and individual **“Key to being able to respond to this down turn is understanding and accepting that it will happen and therefore preparing and implementing a strategy to position your business to cope with this circumstance.”**

businesses adopted to prepare for and mitigate the effects of the next down turn? Key to being able to respond to this down turn is understanding and accepting that it will happen and therefore preparing and implementing a strategy to position your business to cope with this circumstance. We have observed from our own consulting work that there **“...there are notable construction businesses which have been able with the right strategy and leadership to come out of the last recession having grown substantially...”**

are notable construction businesses which have been able with the right strategy and leadership to come out of the last recession having grown substantially and well positioned to make bumper profits during the coming boom.

Once a business has decided to prepare not only for the boom but also the following down turn we advocate a three point strategy:

- Really understand your market and watch for early indicators of market changes

**“As an example infrastructure spending is set to grow strongly between 2014-20 based on stated government policy...”**

As an example infrastructure spending is set to grow strongly between 2014-20 based on stated government policy, committed major projects and enhanced spending on highways, rail and power, see the chart below. This clearly indicates massive growing potential for the geotechnical industry.

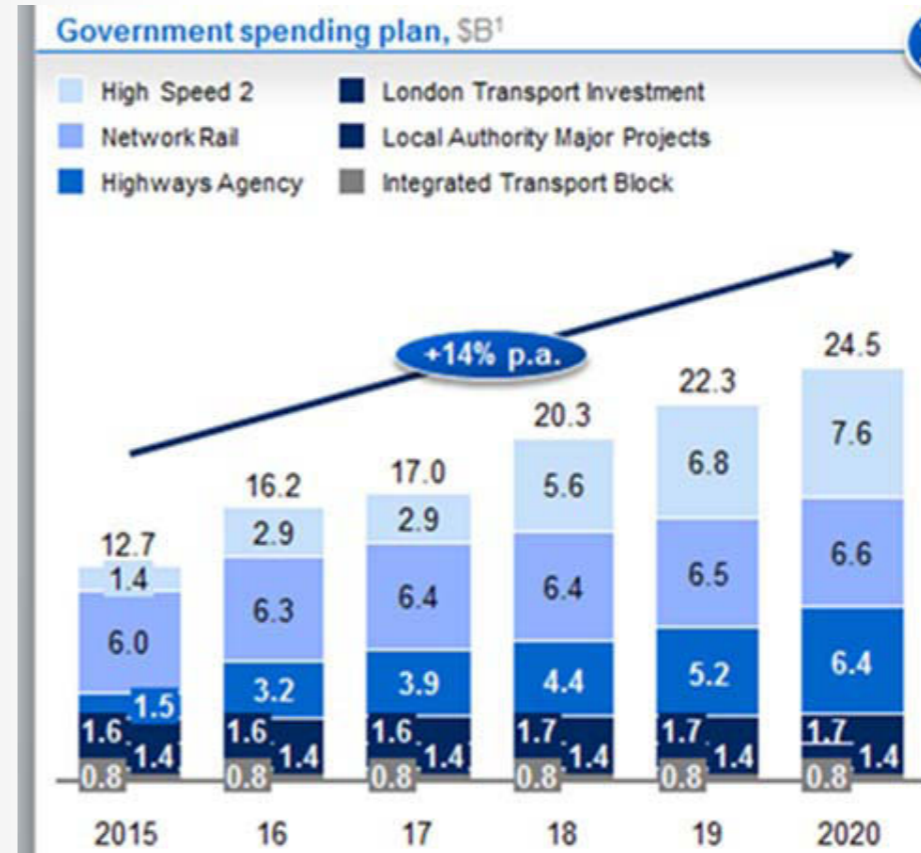
House building is enjoying a major boom (all be it suffered disproportionately in the recession) but is a ►►



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Graphic from McKinsey

“Although these two sub-sectors are both growing strongly it is likely from our research that housing will move into a recession whilst infrastructure will continue to grow beyond around 2019.”

much more volatile market because of the influence of interest rates on demand. Although these two sub-sectors are both growing strongly it is likely from our research that housing will move into a recession whilst infrastructure will continue to grow beyond around 2019.

- Build selective collaborative relationships whilst it is a sellers’ market

Since 2008 it has been a buyers’ market which has resulted in a move away from partnership thinking. This has resulted in a return to very transactional behaviour and short-term thinking from clients. Now there is an opportunity to work more closely with clients in an effort to create more value together as there is more incentive for clients to engage as supply resources becomes scarcer.

“If successfully implemented this strategy will lead to a much stronger business relationship.”

If successfully implemented this strategy will lead to a much stronger business relationship. This will pay dividends for when the next

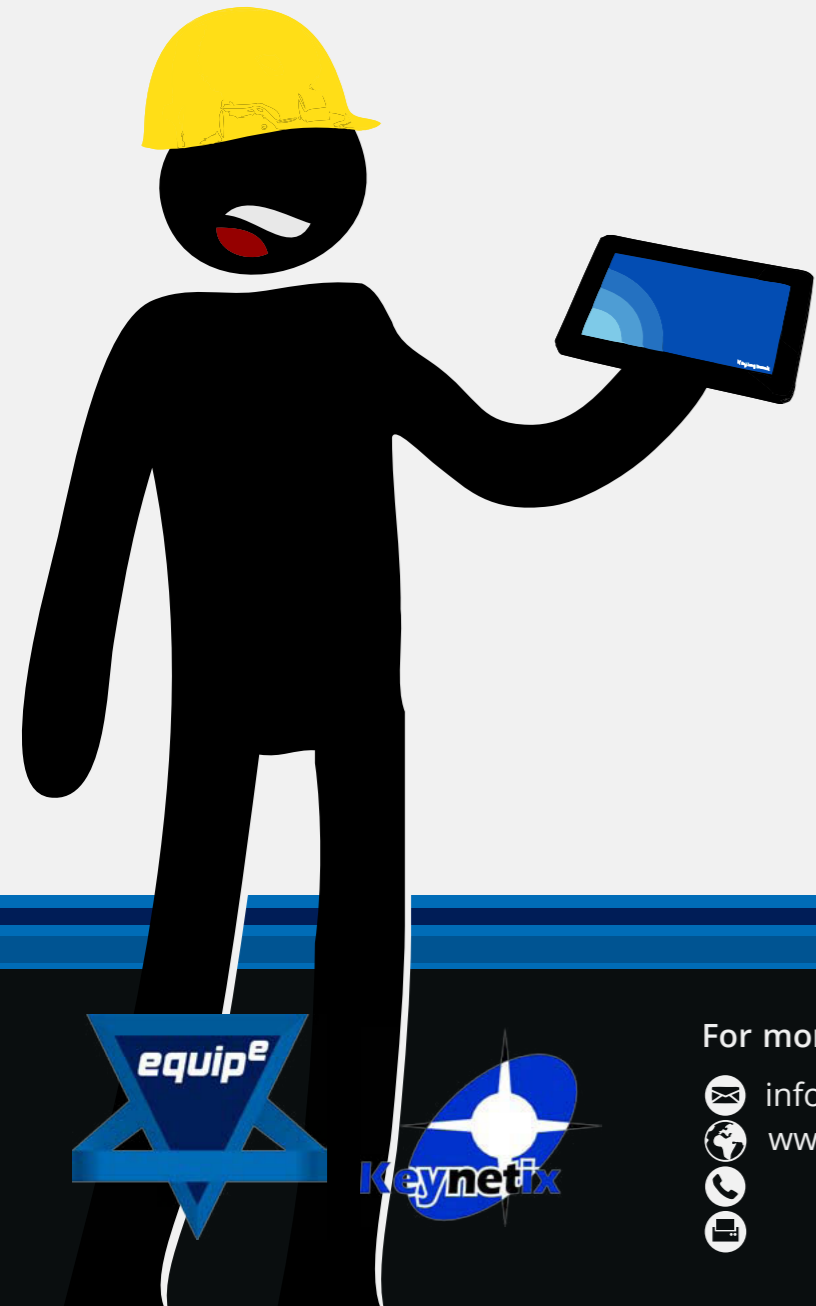
recession strikes.

Develop ways of maintaining your collaborative business relationships. Collaborative business arrangements require more management effort than traditional transactional arrangements. In particular once established and the partnership begin to transact then leaders needs to be focussed on maintaining the appropriate behaviours and ensuring that the collaboration continues to

“With an eye on the future and changing circumstance it is important that both sides have a plan to disengage when mutual value can no longer be maintained.”

create value. With an eye on the future and changing circumstance it is important that both sides have a plan to disengage when mutual value can no longer be maintained. This three element strategy fits quite neatly into the BS11000 framework standard. Although imperfect this standard if well implemented will lead to a more collaborative business with a more certain future.

In past booms the industry has adopted a ‘make hay whilst the sun shines approach’ This time around will we have learned from the mistakes of the past or are we doomed to repeat them? ■



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## CPD Approved Courses for Geotechnical Academy Alumni

### Specifying Site Investigations

This one day course will look at the various methods available to carry out intrusive and non intrusive investigation. Whilst the course will concentrate on geotechnical methods some geo-environmental methods will be briefly discussed. The course will look at the aims of SI and categorise the various stages in an investigation.

### Soil Description Workshop

From 2007 new European Standards have started replacing the British Standards (Codes) under which investigations in the UK have been carried out. UK working practice will have to change to meet these new requirements but few practitioners are aware of the changes or the timetable. The workshop will comprise a series of lectures on the changes, and lectures on soil description followed by practical sessions describing soil samples.

### Rock Description Workshop

From 2007 new European Standards have started replacing the British Standards (Codes) under which investigations in the UK have been carried out. UK working practice will have to change to meet these new requirements but few practitioners are aware of the changes or the timetable. The workshop will comprise a series of lectures on the changes, and lectures on rock description followed by practical sessions describing rock and compiling mechanical logs of rock core.

### In Situ Testing

The course will cover both the theory and the practice of various In Situ Testing techniques used on typical geotechnical projects. In addition the courses will consider the effect that Eurocodes will have on the UK's current practice. This course provides an overview of in situ tests used in common practice and some of the more specialist tests together with their advantages and limitations.

### Instrumentation and Monitoring

The course comprises a comprehensive one day appreciation of the complete process involved in Instrumentation and Monitoring in the geotechnical environment. The course provides an overview of the current guidance documents and their requirements. The course will consider the design of both individual installations and the installation of suites of instruments in the wider site context.

### Basic Foundation Awareness

This one day course will provide a general overview of foundation design. It will include an assessment of the use and choice of shallow foundations and piles. It will cover the derivation of bearing capacity formula and their use. Exercises will be carried out to calculate the working loads and settlement of simple foundations. The methods used to calculate these will be in accordance with those described in Eurocode.

### IOSH Working Safely on Geotechnical Sites

This one day course is developed by industry specialists within RPA Safety Services and Equipe Training as a foundation to site safety. Its aim is to impart the core safety skills required of those working on geotechnical sites by building on their existing specialist technical skills. After attending the course, candidates should be able to identify hazards on site, understand basic safety legislation, participate fully and confidently in site safety consultation and manage priority risks to a sufficient standard.

### IOSH Avoiding Danger from Underground Services

Partnering with RPA Safety Services once again, Equipe provide another IOSH certified health and safety course. This one day course is aimed at anybody involved in specifying, instructing, managing, supervising or actually breaking ground and really addresses the problems and risks related to underground services, which may be encountered during both planning and execution of geotechnical projects.

### IOSH Safe Supervision of Geotechnical Sites

Equipe has partnered with RPA Safety Services, an independent occupational health and safety specialist, to provide a unique IOSH certified course for the Drilling and Geotechnics industry. The three day course is certified by IOSH, is specifically focussed on the geotechnical industry and provides a totally unique and relevant Health and Safety course for managers and supervisors.

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# HOW TO AVOID THAT SINKING FEELING!

Writing for *theGeotechnica* this month is Tim Archer, Technical Director of [Arrow Geophysics Limited](#), a geophysical consultancy established in 2004 that provides advice on geophysical risk reduction for UK construction projects. In this, the second of a series of articles, Tim explains the usefulness of geophysical techniques for locating and investigating subsidence and void development.

Catastrophic ground failure has recently been very much in the news. Stories that hit the headlines following the torrential rain earlier this year spoke of cars disappearing down holes, buildings tilting and cracking, and motorways being shut down for extended periods following the sudden appearance of cavities in the road surface or adjacent verges.

**“Apart from the obvious disruption caused by these incidents, several involved a genuine risk to human health and safety...”**

Apart from the obvious disruption caused by these incidents, several involved a genuine risk to human health and safety, and it was

a blessing that more did not have fatal consequences.

**“Ground failure, or more gradual subsidence, may occur due to unknown infrastructure...”**

Ground failure, or more gradual subsidence, may occur due to unknown infrastructure – such as soakaways, tunnels, denoholes and burial vaults. It may also result from progressive ground deterioration over time – perhaps caused by leaking pipes, reactivated chalk solution features or poorly-compacted made ground.

Based on the overview that we provided last month, it is important to understand what role non-intrusive geophysical investigation can play in the investigation of subsidence



A 3m void opened up in a car park outside a pub. Image courtesy of Arrow Geophysics Ltd.

and void development, both before and after failure has taken place.

Let us consider three scenarios in turn. Each of these scenarios is based on a real project that has come across our desk since we started providing geophysical consultancy to the UK construction sector

more than ten years ago.

## Scenario One: The Big Hole

In this scenario, the client was a pub landlord, who took regular delivery of beer barrels on heavy trucks. One morning, the delivery truck sank up to its axle into a void in the pub car park that

turned out to measure 3m in diameter!

## Scenario Two: The Wobbly Car Park

In this scenario, we were commissioned to carry out a geophysical survey at a prestigious secondary school in East Sussex.

**“The lead contractor was concerned by the level of subsidence in kerbs and across areas of hard standing...”**

The lead contractor ►►



One thousand cubic metres of ground went down the side of this reservoir in a single afternoon! Geophysical investigation was used to locate other areas of potential ground failure. Image courtesy of Arrow Geophysics Ltd.

was concerned by the level of subsidence in kerbs and across areas of hard standing that had occurred within a relatively short period following the completion of a major rebuild. The school had only just been put up, and now it was starting to fall down!

### Scenario Three: The (Almost) Flooded Motorway

Without apology, we have re-used the compelling image from last month's article, which shows one of our surveyors on site at an 18 million litre water reservoir situated adjacent to a motorway and in close proximity to a major railway line in south-east England. Here, one thousand cubic metres of ground

**"Here, one thousand cubic metres of ground disappeared in a single afternoon."**

disappeared in a single afternoon, and the client was understandably concerned that the reservoir might disintegrate completely!

Although different in detail, all three of these scenarios pose a common challenge: something catastrophic has happened, and no-one knows the extent of the problem.

As we discussed last month, geophysics comes into its own when there is a requirement for rapid evaluation of a problem's extent, so that a

sensible containment and remediation strategy can be developed as quickly and cost-effectively as possible.

There are several geophysical methods available for the investigation of subsidence and void development, including:

*Ground penetrating radar:* a useful workhorse for a range of shallow investigation requirements, GPR is usually effective on UK sites to a depth of 1.5 to 2.0 metres below surface. Conductive soils (including clay and saline ground) and waterlogged conditions can reduce this penetration depth considerably. GPR energy reflects off hard features (masonry, pipes and cables,

storage tanks) but can also image more subtle changes (change of fill, stratigraphic boundaries etc). Preserved voids show up well on GPR; collapsed voids can be more difficult to interpret.

*Electromagnetic survey:* modern EM instruments measure the electrical conductivity of the shallow, medium and deep subsurface to a maximum depth of approximately six metres. EM surveys are particularly useful for locating solution features, which are often filled with more conductive material

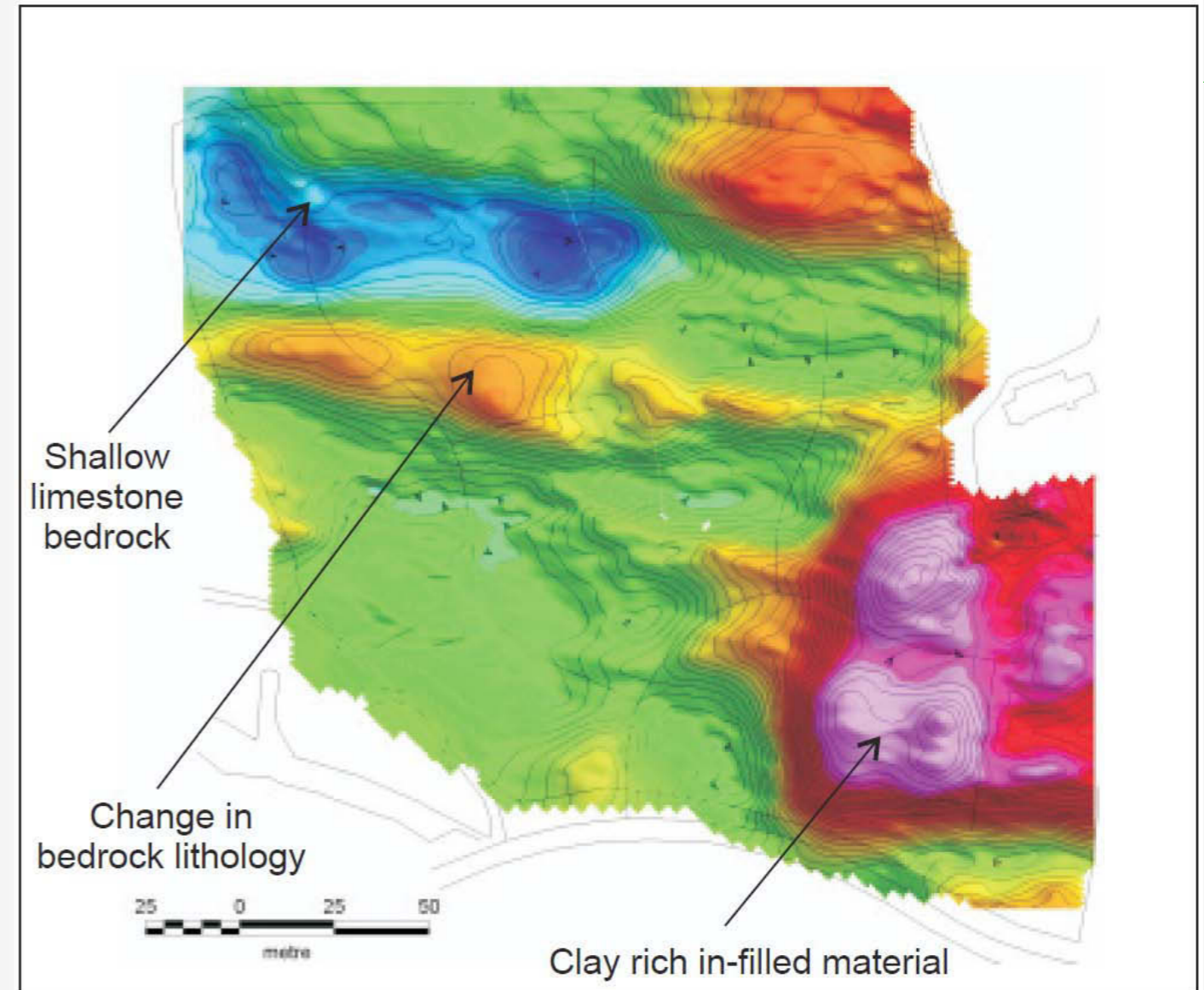
**"EM surveys are particularly useful for locating solution features, which are often filled with more conductive material than the underlying geology."**

than the underlying geology.

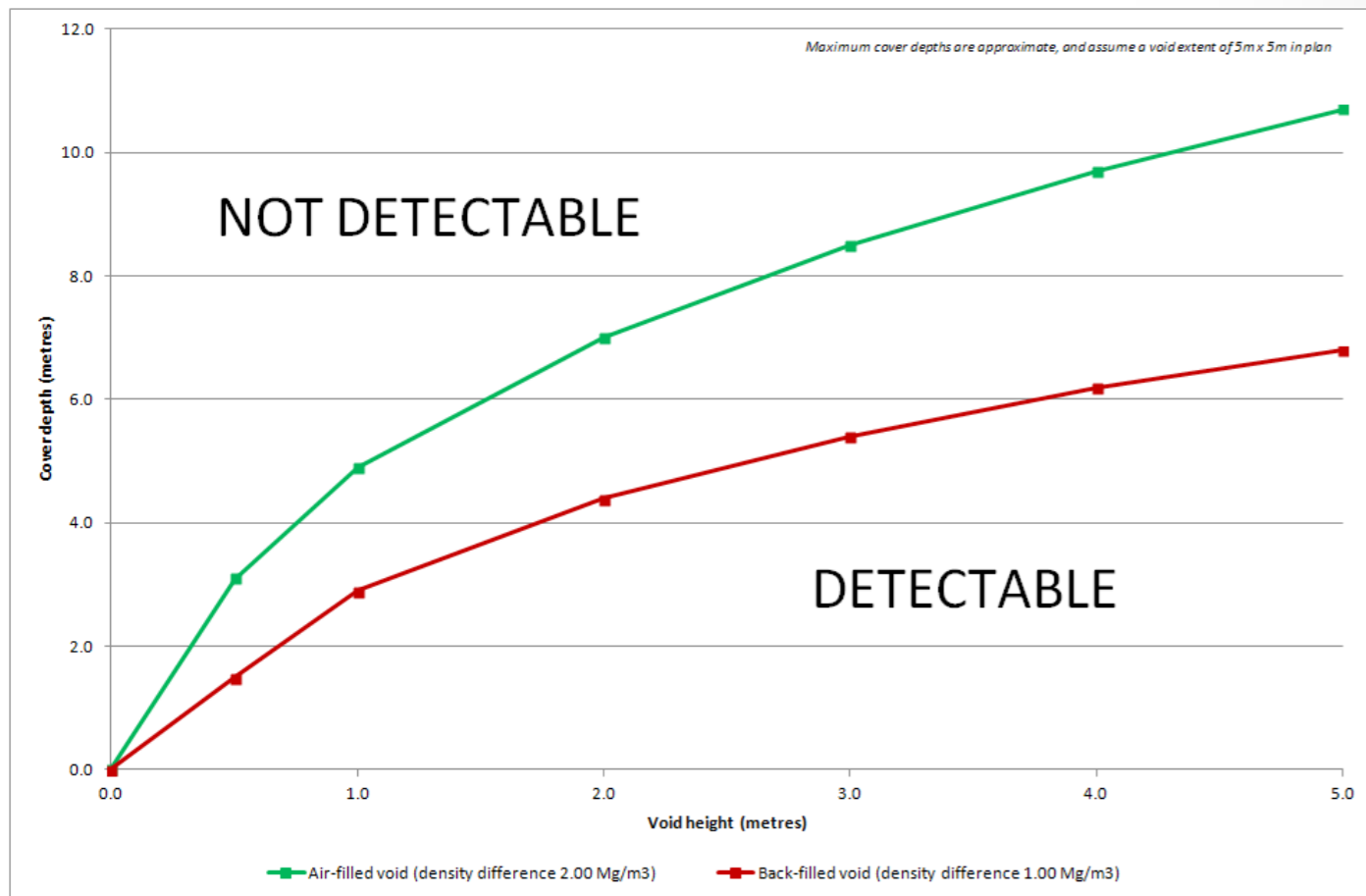
*Electrical resistivity tomography:* ERT measures variations in the electrical conductivity of the subsurface, and is particularly suited to imaging

low conductivity features (such as voids). Data are collected along profiles that allow vertical electrical sections of the subsurface to be viewed and interpreted.

*Microgravity:* this technique measures density variations directly, so is ideal for void location, although slower than GPR or EM survey. Variations in ground compaction can be mapped, as well as preserved or collapsed voids. Microgravity is able to operate through steel reinforcement, so can locate voids beneath concrete slabs. As



An electromagnetic survey to locate solution features enabled the client to optimise a borehole exploration programme. Image courtesy of TerraDat UK Ltd.



Maximum cover depths for void heights that can be detected using microgravity. Image courtesy of Arrow Geophysics Ltd.

illustrated in the following graph, the depth at which a void can be detected depends on its density contrast as well as on its physical dimensions.

Each of the geophysical methods listed above can be useful in investigating areas (or more accurately volumes) of ground that may pose a danger to built structures, site workers or the general

**“Large areas of ground can be rapidly investigated to determine the extent of the problem...”**

public. Large areas of ground can be rapidly investigated to determine the extent of the problem and what remedial action may be required.

Which geophysical method is most suitable for a particular project depends upon a range of factors that include the target’s depth of burial, its physical composition and the nature of the surrounding geology.

So let’s see what geophysical investigation was carried out in each of the three scenarios described earlier in this article.

#### Scenario One: The Big Hole

At this site, the aim was to determine whether any other voids were present beneath the rest of the pub car park. Following a single day of field work, microgravity was able to establish that no features of concern existed in the shallow subsurface, and the car park could be re-opened for public

access.

#### Scenario Two: The Wobbly Car Park

This site posed a more difficult technical challenge. The aim here was to determine where poor ground condition at depth would (over time) result in surface subsidence similar to what had already been noted at several locations.

**“Again microgravity was used, but this time to locate areas of relatively low subsurface density...”**

Again microgravity was used, but this time to locate areas of relatively low subsurface density rather than voids per

se across a total survey area of approximately 8,000 sqm. From an inspection of the geophysical survey results, several zones of relatively low subsurface density were interpreted, enabling the lead contractor to carry out subsequent intrusive investigation at far less cost, time and disruption than would have been possible without the non-intrusive geophysical work.

#### Scenario Three: The (Almost) Flooded Motorway

Perhaps unsurprisingly, the client decided to commission a range of geophysical techniques at this site, in order to rapidly understand what had caused the ground collapse and identify other areas of potential failure. Ground

penetrating radar, electrical resistivity tomography and microgravity were all deployed at a reconnaissance level. Unfortunately the client decided to spend the rest of their investigation budget on dynamic probing across a relatively small area of ground that left large parts of the site untested, so areas of concern identified from the geophysical reconnaissance survey could not be investigated in detail.

As an additional irony, we were informed that a geophysical survey had been planned at this site months previously but had never been commissioned. It is interesting to speculate how many tens of thousands of pounds could have been saved by the client if this work

had been allowed to go ahead before the ground collapse occurred.

As we stated last month, geophysical survey is not a replacement for intrusive geotechnical investigation, but can be used to rapidly characterise large areas and provide a clear indication of where more expensive and time-consuming work may be required.

Subsidence and void development can both be effectively investigated using a range of non-intrusive geophysical techniques, which save time and money and help to overcome the hazards posed by catastrophic and incremental ground failure. ■

## Are you aware of the benefits of subsurface investigation using Geophysical Techniques?

**Tried and tested geophysical techniques are minimally invasive or completely non-invasive. They can stand alone or assist in the planning of more expensive intrusive work.**

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# CLIFF INSTABILITY ON THE SOUTH COAST

Writing for *theGeotechnica* this month is of one Equipe's geotechnical consultants and part-time lecturer at [Brunel University](#) Pete Reading. This month Pete provides details of the recent survey works carried out on the English South Coast focussing on cliff instability. Pete worked as a consultant on the project on behalf of Brunel University who are assisting with the research of the landslide. This article particularly focuses on the work of [Quarry Design](#) and their Octocopter in carrying out an aerial survey of the affected area.

This winter has seen unprecedented rates of cliff regression along the south coast. One area which has seen an acceleration in the rate of cliff erosion has been the cliffs at Barton on Sea.

These cliffs have been the focus of studies for decades, with a number of schemes having been undertaken in

an attempt to either slow or halt the rate of erosion, some of which have been more successful than others. The success of the stabilisation measures is a combination of the existing geology and storm severity together with the cost and complexity of the solutions applied. Several investigations have already been undertaken to provide

**“Working on the landslide is difficult and often dangerous...”**

further information on the geology and hydrogeology along with surveys. Working on the landslide is difficult and often dangerous; recently a full survey was undertaken using an unmanned aerial vehicle (UAV) a six bladed copter operated by Quarry Design.

Erosion of this section of the coast has been estimated to have been taking place for no more than 6000 years -

**“Sea level has risen and what was once a river valley is now a coastal environment.”**

or in geological terms 'recent times'. Sea level has risen and what was once a river valley is now a coastal environment. Recent sea level rises and the general sinking of the south of England from isostatic response to ice loading has seen this relatively new coast and the associated cliffs coming into contact with severe storms which develop deep in the Atlantic Ocean; the result is relatively rapid regression of the coast.



**Land slip: Erosion at Barton on Sea**



**Flying machine: Quarry Design's Octocopter**



**Cause for concern: Properties close to the slip**

For the most part the section under consideration runs eastward from the Hampshire Dorset border at Chewton Bunny, to some 3km to the Barton Golf course. The cliff is topped by open grassed areas however there is some public concern at the rate of erosion which is encroaching on a Mobile Home Park at the western end and some

business premises in the central part of this section. There are properties set back from the cliff edge along the whole section and whilst currently there is 50m or more between these properties and the current cliff edge there is real concern at the increased rate of erosion. This, coupled with the prospect of more severe weather predicted by global warming could



**In flight: Quarry Design's Octocopter**



**Exposed: Damage caused by the slip**

lead to the accelerating of the regression of the cliffs.

Following severe storms and significant movement on the landslide towards the end of 2013 and continuing into 2014 the council took the step to close the entire length of coast to the public. This followed several instances " . . . e m e r g e n c y services were mobilised to free people who had strayed on to the landslip and become stuck in the liquefied clay silt and sand."

when the emergency services were mobilised to free people who had strayed on to the landslip and become stuck in the liquefied clay silt and sand. Because of this risk

surveys on the landslide are particularly hazardous and in addition, for much of the time surveys are carried out the sea laps the toe of the slip making works extremely hazardous.

This is where Quarry Design's Octocopter comes into its own. Using the Octocopter flights can be made over any inaccessible area to take high resolution photographs, when these are tied into survey points the result is a high resolution point cloud which can be used to define features which would otherwise be hidden.

The Barton Survey was undertaken on the 15th August 2014, this coincided with a particularly low tide around mid-morning. This enabled survey stations to be set up on the thin strip of beach exposed by the low tide. Although not essential

**"The aim was to provide a continuous picture showing the cliff top and slip toe."**

this provided survey stations along the toes of the slide and along the crest. The area of interest was divided into four roughly equal sections with overlaps to each section. The aim was to provide a continuous picture showing the cliff top and slip toe. The copter flight path and height was predetermined and set onto the controlling computer by Adrian Charters - Director at Quarry Design.

Set up is simple with the copter contained in a large Peli Case which readily fits into the boot of an estate car or van. The copter is powered by four batteries which are changed at the end of each flight section, this just being a precaution to ensure that power is not lost during flight. Adrian explained that prior to each flight he must register the proposed flight with air traffic control. There are also strict protocols which need to be followed regarding privacy and flying in public places. Adrian is also a trained pilot - a requirement for anyone who flies unmanned vehicles in the UK.

**"When arranging flights weather can be an influencing factor..."**

When arranging flights weather can be an



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influencing factor, although the copter can cope with relatively high winds it was decided that light winds would be preferable when flying at Barton due to the risk of turbulent flows upward and over the cliff, together with the obvious risk to the copter if it were to come down over water. The weather on the day was even better than expected with a clear blue sky and little coastal haze.

The four flights were undertaken with each flight taking about an hour, the actual flight time in each section was less than 15 minutes the rest of the time was spent walking to each lift off point and setting out and surveying the control points.

Photographs are taken under computer control along the flight path using a high definition camera fixed in a cradle to the underside of the copter. The flight path is tracked along a Google image of the cliffs via the wifi connection. Manual control can be instigated at any time if required. At the end of each flight oblique photos were also obtained of the sections. The whole exercise took about 4 hours to complete including several pauses to talk to interested passers-by. As with many data collection exercises the real work is done at the office processing the data. This took 36 hours of computer time to produce a full image of the entire 3km section. This will form the base data for ongoing research into the behaviour of

**“It is proposed to make further flights at regular intervals to provide valuable information on the regression of these cliffs...”**

the landslide and will enable a better understanding of the complex slide system.

It is proposed to make further flights at regular intervals to provide valuable information on the regression of these cliffs, thus enabling prediction of the risk to properties in the proximity.

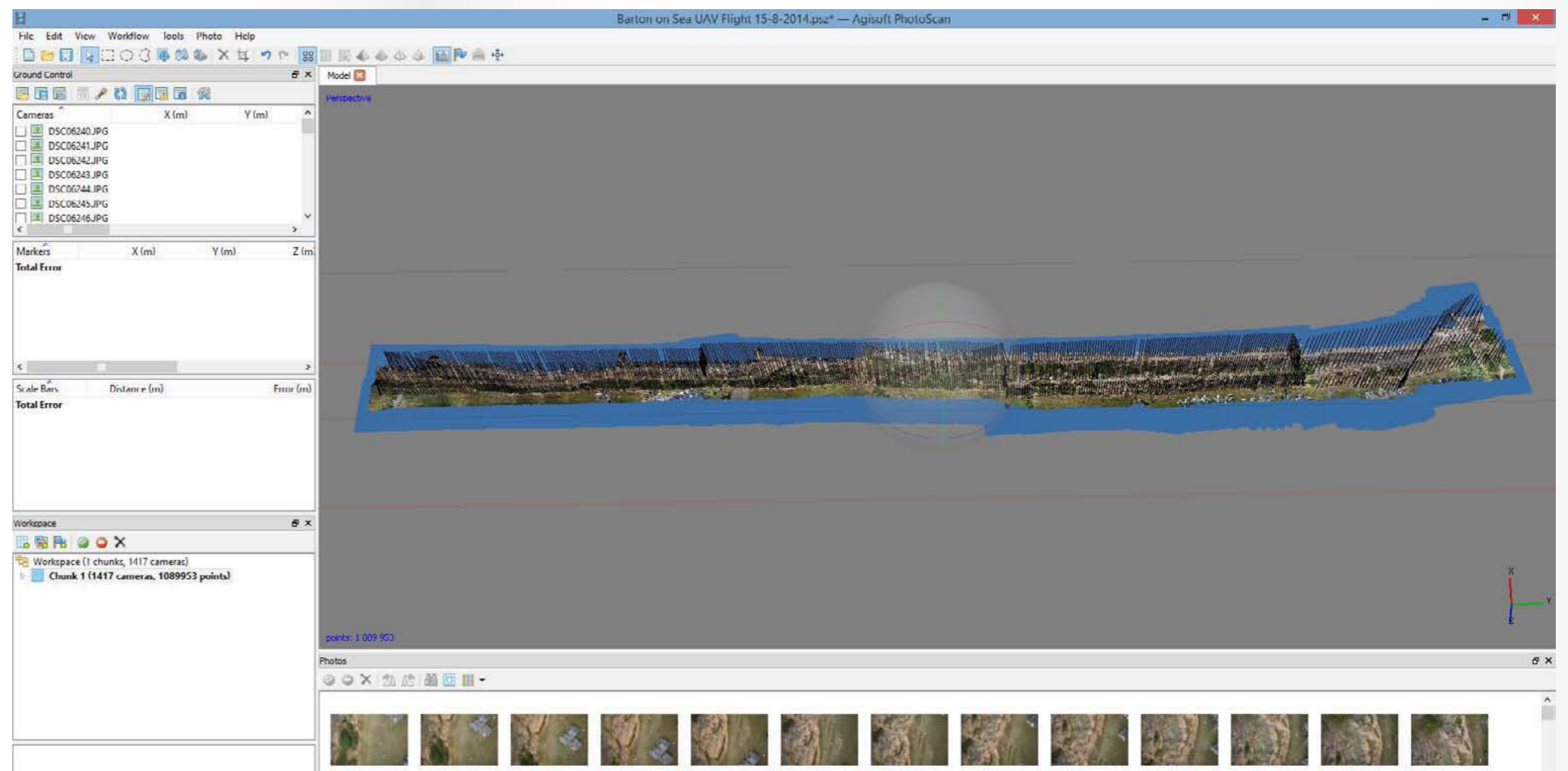
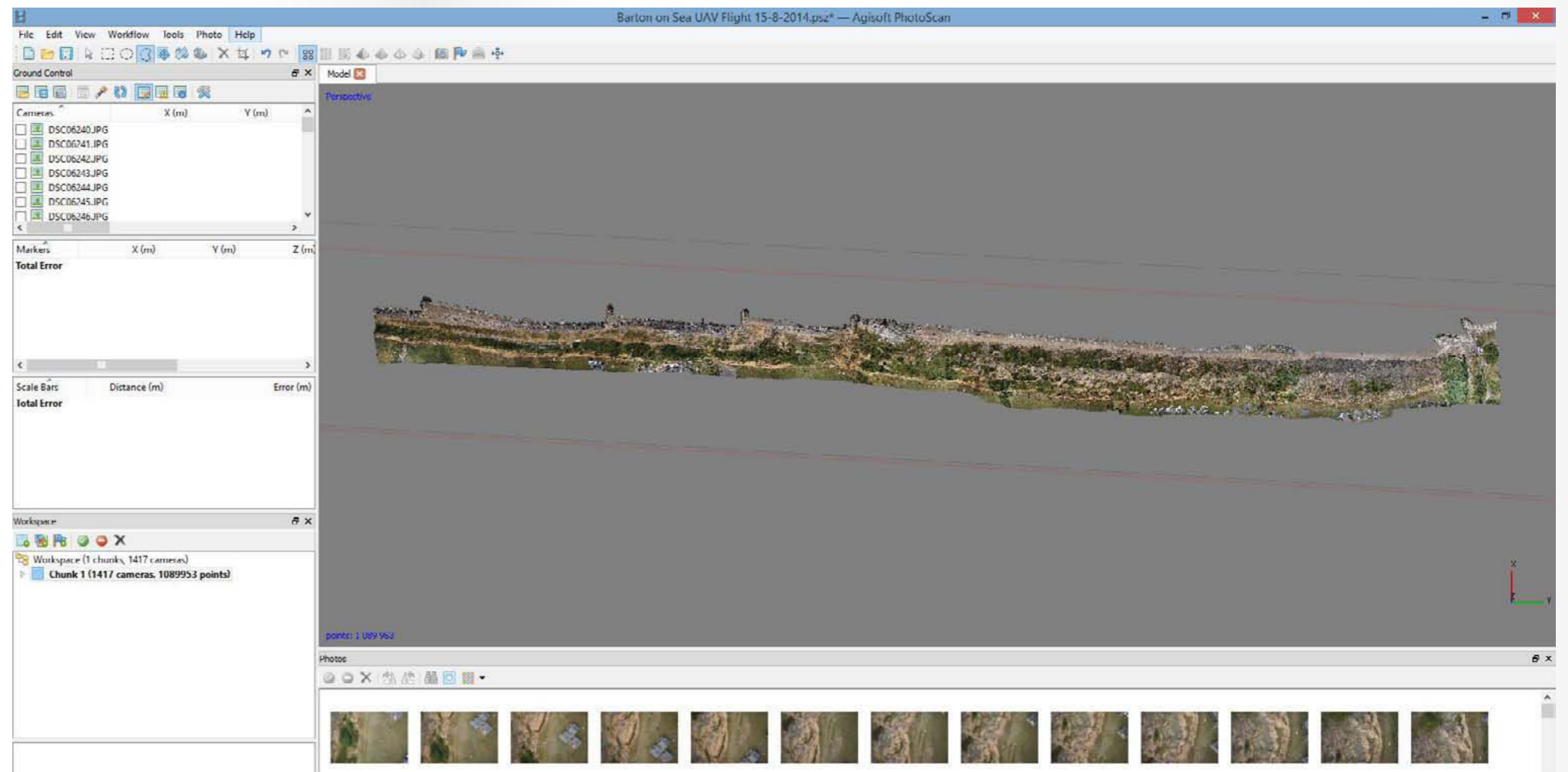
It is evident from this exercise that UAV technology is an important new advancement which can be used in difficult and unsafe environments to provide information which would either be unobtainable or take a very long time to gather using conventional methods. Using the computing power now at our fingertips it is possible to provide this information in a few days rather than weeks. ■

For further information on the projects undertaken by Quarry Design see detail below:

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**Computer image: The entire 3km section. (Right)**



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