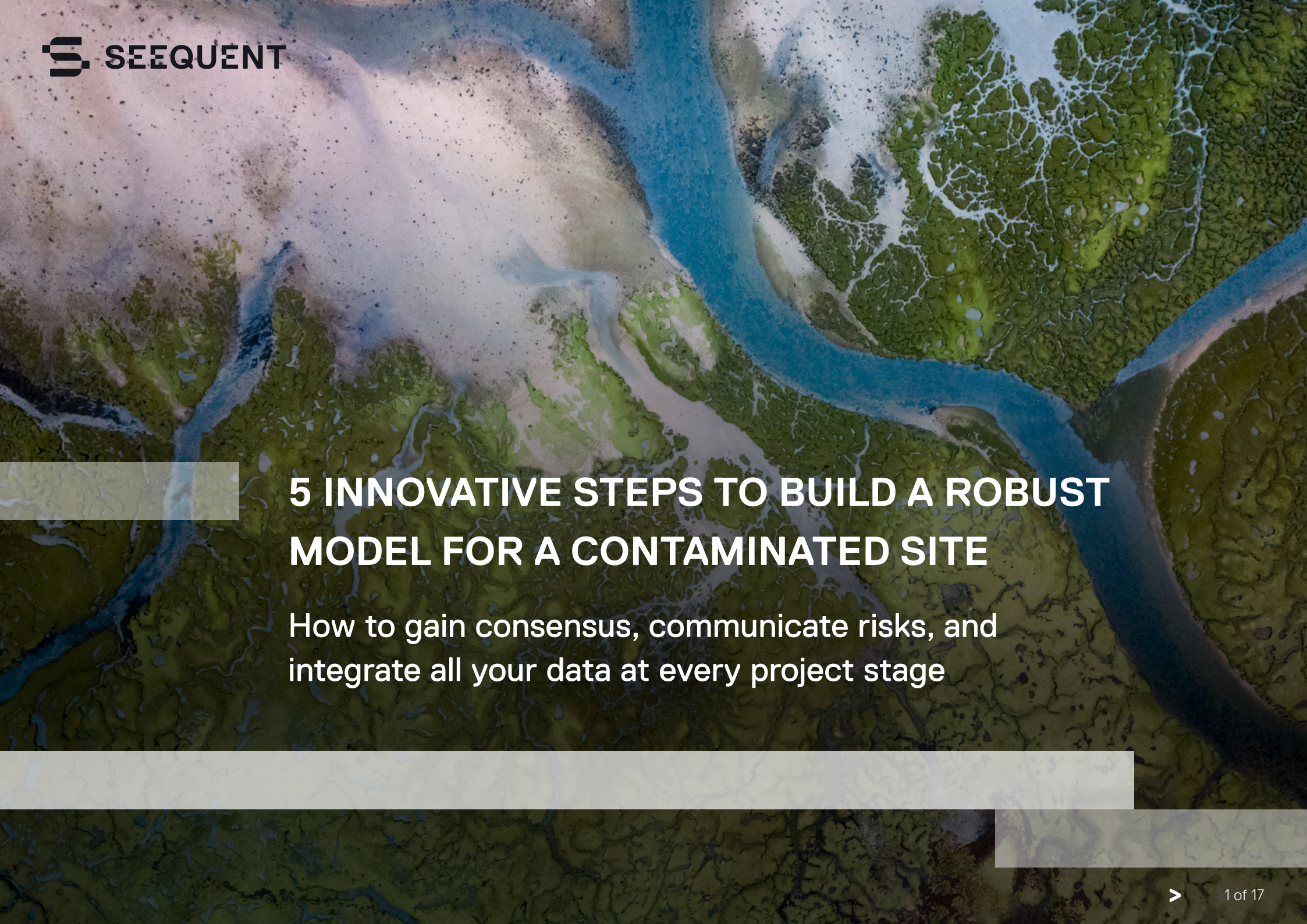

5 INNOVATIVE STEPS TO BUILD A ROBUST MODEL FOR A CONTAMINATED SITE

How to gain consensus, communicate risks, and integrate all your data at every project stage

Table of contents

Expert Insights	3
Introduction	4
Stage 1: Discover	5
Stage 2: Define	7
Stage 3: Design	10
Stage 4: Operate	12
Stage 5: Restore	14
Conclusion	16

Expert Insights

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Introduction

Contamination is the problem, consensus the solution

It's rarely good news when you arrive at a potentially contaminated site. Your client likely has a problem that's going to be costly. They're hoping you can help them understand it, satisfy stressful legal obligations, and minimise the potential costs and time so that they can move forward.

Many stakeholders with different levels of technical understanding are involved: community members, contractors, engineers, geologists, corporate representatives, legal authorities, and regulatory boards.

You need to understand risks for your client, communities, and the environment but more importantly – communicate them.

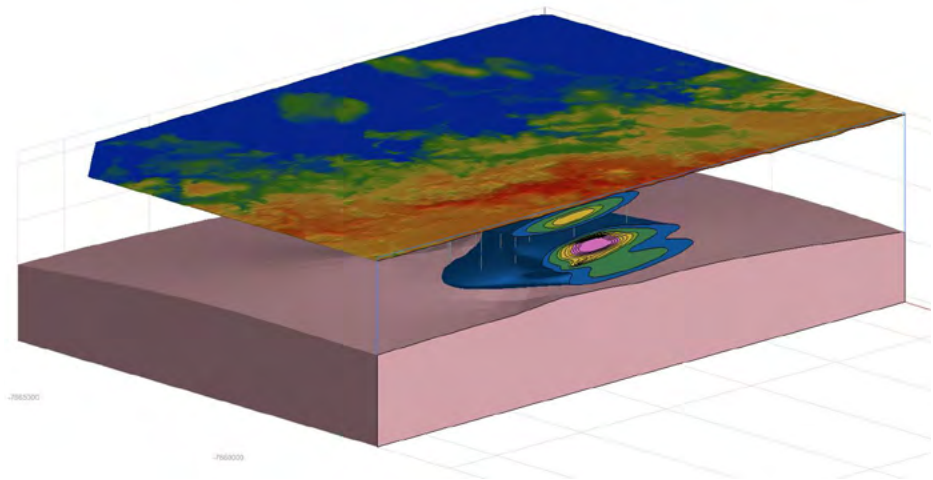
Your recommendations are based on the data and cost/benefit analysis. How can you make sure that clients feel confident in the plan you present – and make the best decisions?

Simply stating that contamination is "20 metres below a building," might not sound that deep to everyone until you can place it in perspective.

When people see that it's the equivalent of a six-storey building underground, they'll instantly understand why you didn't recommend digging.

> **"A picture says 1,000 words.**
> **An interactive, 3D image says 1,000,000."**

Which techniques are best to address the contamination? Teams need to bring together their diverse technical expertise and the data to build the full picture.



If you oxidise the contaminant will it cause subsidence? Would pumping benefit the cleanup, or will it cause other problems?

After you make your decisions, do you feel you can confidently defend them with data? Can you show why each choice was made?

Technology makes it easier to bring together all your geoscience data to tell a complete and clear story.

With everyone on the same page, you'll gain the shared understanding and consensus you need to minimise time, costs, and risks.

This guide will help you address key challenges at each project stage, from contaminant discovery to site restoration.

Regards,

The Seequent Environmental Team

Stage 1: Discover

Your clients need answers.
Is there contamination? Where is it?
What is the extent?

Whether contamination is in groundwater, soil, or you're removing unexploded ordnance (UXO), finding the problem and defining it is the foundation of your project.

Here's how technology can help you avoid risks before they cascade into each following project stage:

Don't guess, measure

Often, you're dealing with a big space and a small budget. Geophysical surveys allow you to sweep large areas faster, for a much lower cost than more invasive techniques.

Geophysics data can help you identify where an aquifer is, the shape of it, and the surrounding geology – even in locations where you can't drill.

You will likely need to use a variety of survey techniques to find what you're looking for. Oasis montaj helps bring disparate datasets together and extrapolate the areas between them. With the UAV extension, you can even plan your surveys (including adherence to Line of Sight drone regulations) and stitch the data together seamlessly.

Using automated and manual processes in Oasis montaj, you can rapidly QA/QC the data, process it, and build an accurate, initial understanding of the site. This can be brought into Leapfrog Works combined with lithology, hydrogeological, and contamination data to construct the initial site conceptual model.

Define targets and methods

Now that you have an overview of the site, you can determine where you need more data and invest there. Your goal is to provide an accurate cost-effective scope and timeline to your client.

Digging is expensive and you likely want to minimise the amount you do. You also don't want to make the situation worse. Imagine if you dig and unexpectedly hit water: It becomes much more costly. You need to react quickly when new information comes in to avoid the risks.

As you add new data, Leapfrog Works models update automatically – instantly providing understanding that can drive decisions on where to target and which investigation method will work best based on geology and geophysics. This helps you adjust your project in near real time and avoid unexpected costs.

Ensure your data is defensible from day one

Data drives all of your decisions. As a project continues, you'll add more and more from different teams. You need to ensure the right files are accessible to the right people anytime, anywhere.

Cloud-based Seequent Central acts as a single source of truth for project data and analyses. You can share data, models, and updates with your client to build trust and transparency; iterate and collaborate on models with different teams; and maintain an audit trail for everything.

Never again will you be in doubt which file version is the latest, saving time and reducing the risk of mistakes. Team members can quickly build and test their own hypotheses off of a master model without impacting others. Any change that becomes incorporated into the master model notifies all team members automatically. Everyone can contribute their insights while staying up-to-date.

If you need to defend your decisions to clients or regulators later, you can go back through an interactive timeline of changes to your data, models, and file versions in Seequent Central. The data behind each decision is always right at your fingertips.

> "Geophysical survey methods make it possible to significantly reduce the cost of exploring the subsurface soils over large areas... This is possible because of the relatively short duration of geophysical field work, significantly fewer required borings and piezometers for confirmation of the geophysical data, and no required trenching."

Mustafa Saribudak, Ph.D.
Principal Geophysicist-Geologist, Environmental Geophysics Associates.

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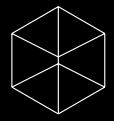


Contamination Toolbox

- √ **Leapfrog Works:**
- √ **Contaminants extension**
  Hydrogeology extension
  Leapfrog Viewer
- √ **Seequent Central**
- √ **Oasis montaj:**
- √ **UAV extension**
- √ **UXO extensions**
- √ **Geosoft Viewer**

GeoStudio Vadose Edition:
SEEP/W
TEMP/W
CTRAN/W

Try out Leapfrog Works and the Contaminants extension for 30 days, free of charge

Stage 2: Define

What's the project scope? Who will you collaborate with? What's the cost?

To accurately delimit plumes in this crucial preliminary modelling stage, decision making must be ongoing, transparent, and defensible.

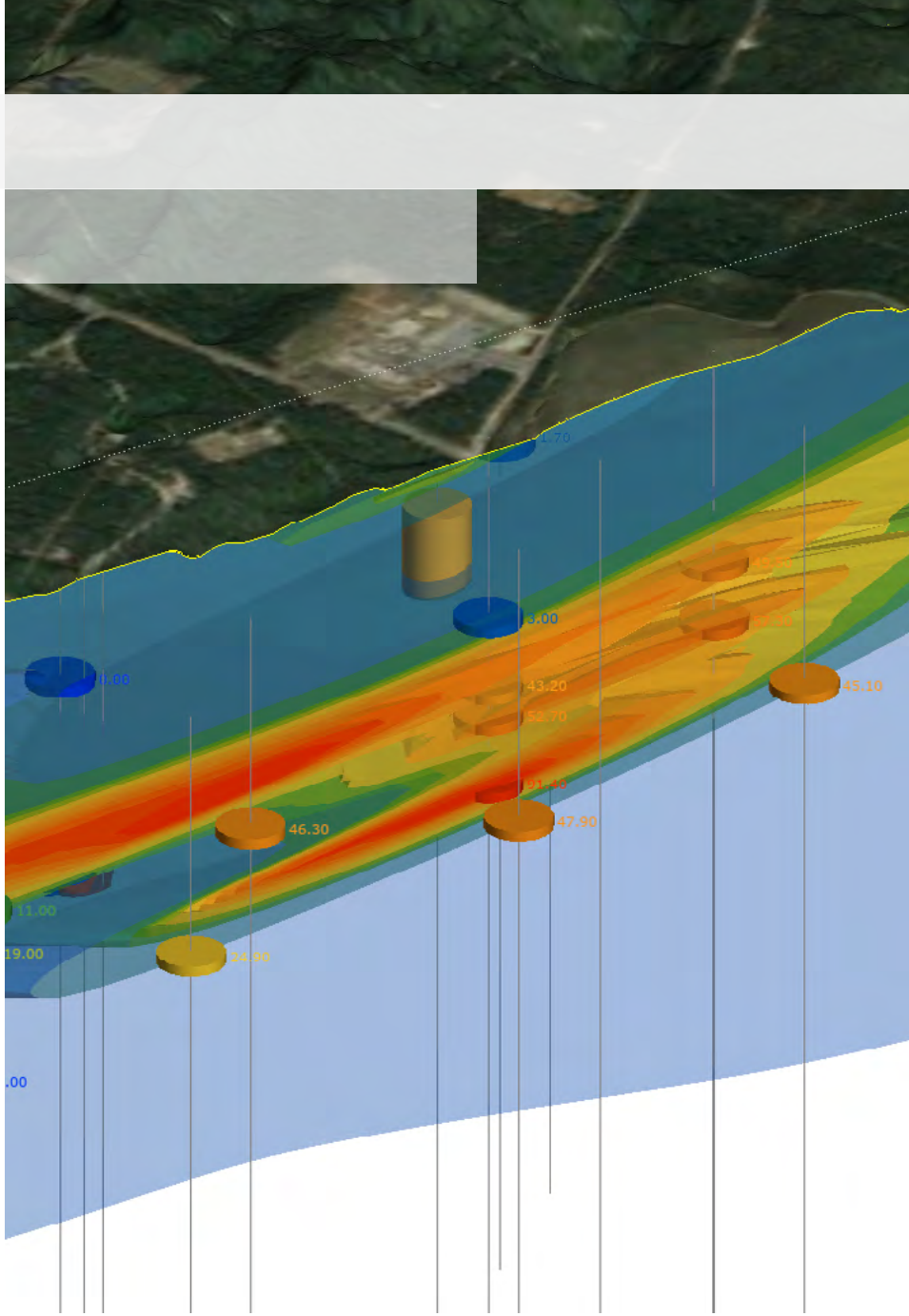
Bring data together to bridge geostatistics with geology

To rapidly build a solid conceptual model, you want to focus on data analysis – not software manipulation.

First, you need to see a simple construction of a geological model that enhances your understanding of the aquifer or vadose zone. In Leapfrog Works, you can easily import a variety of data into a 3D scene. Then, share your cross sections, model sections, or surfaces with teammates for collaboration and buy-in, or export files for use in geotechnical and numerical modelling packages, like GeoStudio.

> **“Our software helps environmental scientists, environmental geologists, hydrogeologists, and environmental engineers to do their work properly without having to spend years learning software or carrying out cumbersome scripting.”**

Ignacio Torresi
Solutions Director, Geostatistics at Seequent



Maintain a clear, data-driven plume interpretation

You're under time pressure to develop your plume interpretation and explain it.

You want a transparent and auditable data-driven interpretation that will stand up to cross examination. The Contaminants extension allows you to characterise land and groundwater contaminant plumes right inside your Leapfrog Works model. You gain full control over your input data, spatial model, and sample search variables all in one place.

Interactive, visual tools within the extension make geostatistics accessible for all geoscientists and ensure all teams can work with the data.

Create robust standard estimations using **Simple and Ordinary Kriging, Inverse Distance, Nearest Neighbour, and Radial Basis Functions (RBF)**. These methods are supported with dynamically linked **Spatial Models** that incorporate useful tools, like Variable Orientation which allows you to locally re-orientate your search and variogram, and visually validate them with the search ellipse. During cross examination, you can easily **Interrogate Estimations** to avoid disputes by clearly demonstrating the link between your sampled data points and the plume model.

Update models with new data

At this iterative stage, you're working to determine how closely your model reflects reality.

To gain a direct understanding of the bottom line for remediation or monitoring strategies, you need to compare differences between interpretations. Built-in report tables and cross section evaluations in the Contaminants extension are dynamically linked to your plume model, and update automatically as new data is entered. This ensures your calculations of contaminant mass in saturated and unsaturated zones are always derived directly from the latest data.

> "We were able to perform a mass calculation using the solids from the 3D model, which enabled us to significantly reduce the expected disposal costs."

Tobias Querfurth, M.Sc.
Geological Engineer, Lieberman Engineering

READ CASE STUDY

Communicate the extent of contamination

Failing to communicate clearly leads to project delays or can quickly escalate to disputes. With so many stakeholders of all different technical levels and specialities, everyone needs to be on the same page.

Model management solution Seequent Central allows technical experts to dig into the data, and confer and agree as the project progresses.

For other stakeholders, it's easier for them to understand something if they can see it. Throughout your project, visualisation tools Seequent's Web Visualisation (enabled through Central), Leapfrog Viewer, and Geosoft Viewer allow you to easily share your model in a way that a variety of audiences can understand.

> “Taking into account the spatial distribution of the data combined with experimental variography, the Contaminants extension allows you to predict what contaminant concentration will be at any location in the model. Because it is coupled with the geological model it provides a better, more productive modelling experience and toolset.”

Pat McLarin
Segment Director, Civil at Seequent

Stage 3: Design

Do you monitor and hope the problem diminishes? Do you take action: dig it, pump it, heat-treat it, or transform it?

Now you've defined the contamination you need to decide how to mitigate it. Your model must inform engineering decisions and provide reports to stakeholders.

Check if the model matches reality

You need to examine the model to make sure it matches reality by bringing in expertise, including thermal or chemical engineers, hydrogeologists, and other scientists. Everyone needs to understand each other's insights and effectively communicate to reach consensus.

Seequent Central allows multiple disciplines to collaborate from a single source of truth. Stakeholders are able to look at the same project in real time, comment, and refine a model. Modelling becomes a smooth continuous process with less back and forth. Everyone is clear on what the information means, improving decision making, simplifying the workflow, and allowing you to transition much more smoothly through project phases.

The Leapfrog Works Hydrogeology extension makes it easy to interoperate with MODFLOW and FEFLOW and use lithology models as the basis for flow models, further reducing risk and boosting efficiency between teams.

Provide reports to regulators, clients, and for litigation

Throughout your project you need to provide formal reporting for your clients and to meet regulatory and legal requirements. Reports need to be robust, professional, and readily communicate your findings.

The Contaminants extension has intuitive workflows that link data and domains to interpretation and report deliverables. Block model evaluations and calculations let you easily report on contaminant mass. Tools for technical cross examinations, data statistics, variograms, and cross sections further advance understanding and can be included in reports.

Seequent Central also allows you to easily step through a timeline of your models' evolution, readily identify different model versions, and return to them as required. Regulators or reviewers can also be given permissions to access Seequent Central for complete transparency.

Ensure slope stability and groundwater protection

Any excavations must be designed with regard to safety, reliability, economic, and remedial measures. You need to identify potential failure mechanisms and determine slope sensitivity to triggering mechanisms.

GeoStudio's comprehensive tools address issues from pre-construction and construction stages, as well as long term performance analysis. Both steady state and transient processes can be considered, as can the coupling of heat, gas, and water fluxes to climate conditions.

Seepage models can be linked with contaminant transport models or with slope stability models as required for a robust solution.

> "Once you know where the plume is, GeoStudio can help you explore where it will go. Particle tracking and advection/dispersion analysis in GeoStudio's CTRAN/W module allow you to explore the contaminant migration over time in a variety of scenarios. This enables you to design effective containment solutions that enable protection of the surrounding environment."

Paul Grunau
President, GEOSLOPE

VIEW EXAMPLE

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	√ **TEMP/W**
	√ **CTRAN/W**
	√ **SLOPE/W**

Try out Leapfrog Works and the Contaminants extension for 30 days, free of charge

Stage 4: Operate

Is the plume growing or shrinking? If remediation has taken place: What is the effect? Did the clean-up work?

To effectively manage contamination, you need to monitor, resample, and remodel.

Revisit your models

You're at a stage where you'll be evaluating decisions made in earlier phases and making course corrections.

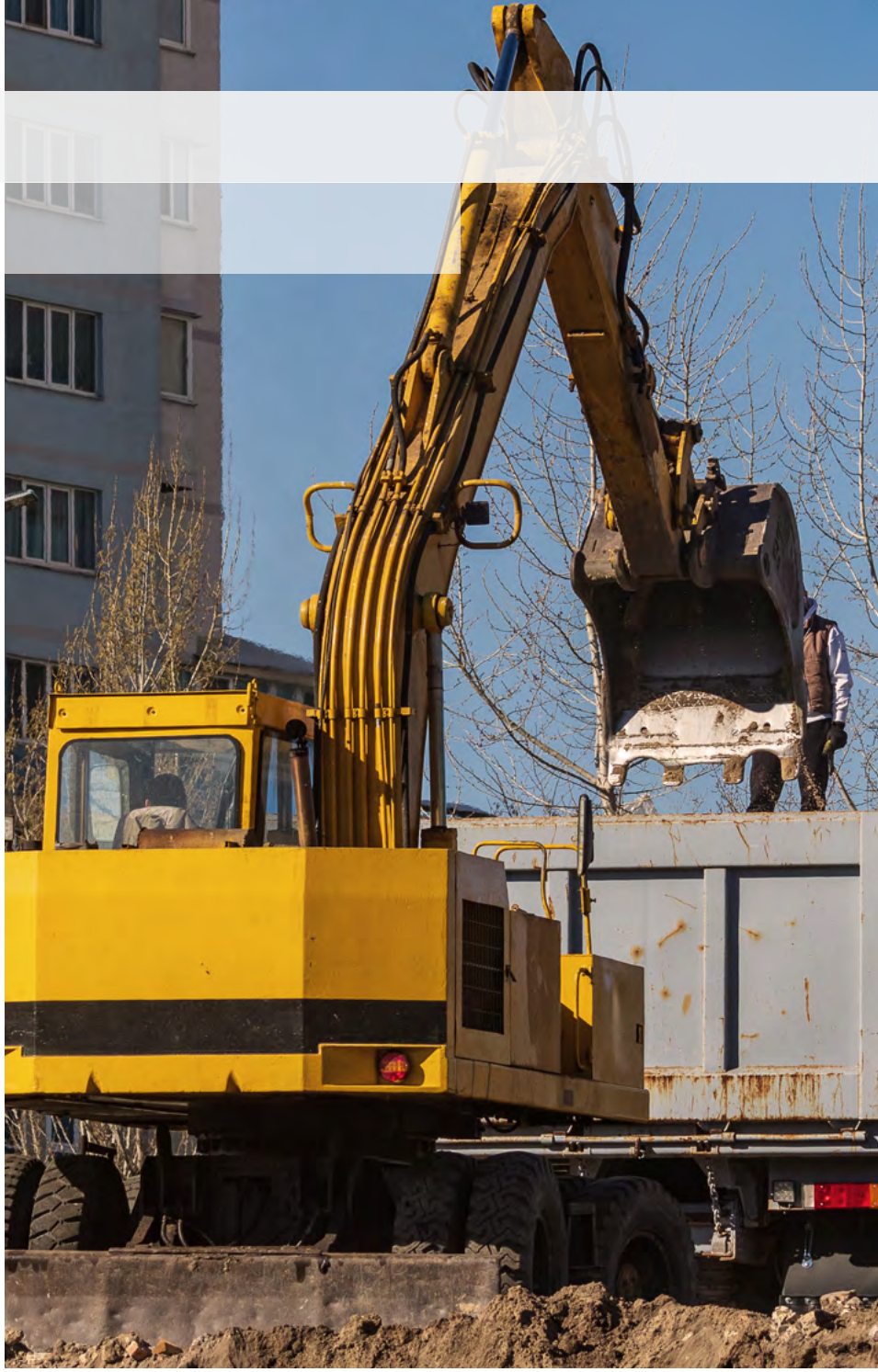
You may learn at this point that you have not modelled the underlying control mechanisms in your site adequately and you need to revisit the underlying model. For instance, you may need to run additional geophysics surveys to gain more insight into your previous data.

If you have a well-developed model, which is highly maintainable and accessible to all, your team can run through a timeline of changes, add new data, and test new ideas rapidly. Seequent Central empowers real time collaboration and integration within your geophysics, geological, and geotechnical models so teams can react quickly and adjust course effectively.

Hand off information

You'll need to hand information off to other teams while keeping control over the data and providing an audit trail.

Seequent Central allows for new team members or collaborators to see how decisions were reached and for experts to see how their interpretation was used. This provides a more holistic project view for everyone involved. Insight and accountability in decision making is improved, which further de-risks and ensures your model reflects the most informed consensus.



Share insights with both technical and non-technical stakeholders

To ensure both technical and non-technical stakeholders fully understand your interpretations you need easily digestible visualisations.

The Contaminants extension's 3D Plume is a fantastic way to communicate, speeding up understanding and improving engagement to keep your project on track. Share your complete 3D models in Seequent Central to collaborate with all stakeholders on a project. Share your model in the web through Seequent's Web Visualisation (enabled through Central) and stakeholders can interrogate, comment and @mention colleagues, who will receive a notification in real-time.

> "We use Leapfrog to construct interpolant models of soil concentrations, groundwater contaminants, and other geologic attributes. These are then combined with our lithology-based geologic models to parameterise our MODFLOW models. In our experience, Leapfrog has the most comprehensive and user-friendly tools for developing groundwater flow models."

Staffan Shor
Hydrogeologist, Montgomery & Associates

VIEW VIDEO

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  - TEMP/W
  - CTRAN/W

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Stage 5: Restore

Was remediation successful?
Have you returned the land to some beneficial use?

At the end of a project, some sites may remain problematic. You have to propose a strategy or conclusion, whether that's ongoing monitoring or a consensus that there's currently little more that can be done.

Monitor long term – has it been contained?

If you're monitoring, you need to demonstrate change and effectively explain it.

Leapfrog Works' dynamic modelling means that you never need to start again when you want to update your modelling, simply introduce new data and your model updates. Data or revised interpretations can be added at any stage in the workflow and changes will automatically flow downstream. This includes updating your plume model, as all models are linked to the underlying geology.

Compelling 3D visualisations allow you to effectively demonstrate new changes to your interpretation. Seequent Central takes this one step further and allows you to easily review models over time and interrogate these changes, giving you even more insight. This is invaluable when dealing with regulators or cross-examiners who you can give permissions to access Seequent Central to view the data-driven evidence for themselves.

Build trust and showcase your work

When people are fully engaged and there's a high level of transparency, they are more likely to feel that the project is being well managed, building trust and helping avoid costly disputes.

Seequent Web Visualisation (enabled through Seequent Central) offers a number of ways to achieve communication goals. Share your model in the web and stakeholders can interrogate, comment and @mention colleagues, who will receive a notification in real-time. Much more engaging than a static model, Web Visualisation enables stakeholders to fully interact with the data by rotating, zooming or slicing, and communicate in context.

Be strategic and meet standards

Knowing when to stop a clean-up or change your monitoring plan can save time and costs to a client. For instance, you might discover that you have to continue monitoring but can monitor less frequently or at fewer locations.

Seequent Central's auditability features help you keep projects on track and continuing to meet the expected standards at every stage. You can clearly present the methodology and the data it is based on so that every decision is robust and defendable. In addition, because you're able to monitor data during key project stages, you can avoid potential problems before they happen and make fast decisions about next steps.

Being able to show this level of transparency in your decision-making is key so that you can demonstrate the ecosystem is restored to acceptable levels.

> "Leapfrog Works allows for a quick and user-friendly way for the geologist to directly develop a 3D model which can be examined and reviewed very quickly. It also allows for fast and elegant communication of the model to other team members and clients via cross section layouts and slicing the model to display it in real-time."

Andrew Little
Geotechnical Engineer, HDR

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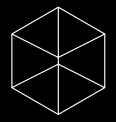

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Conclusion

At every stage of the lifecycle of a contaminated site there is a need to have a comprehensive understanding of geophysical, geological, and geostatistical data – and communicate it effectively to gain consensus.

Compelling 3D visualisations make data tell a story that brings clarity and confidence to your client, regulators, and the local community. With everyone on the same page and able to easily visualise, understand, and collaborate on a project, you can collectively make the most informed decisions to address a contaminated site.

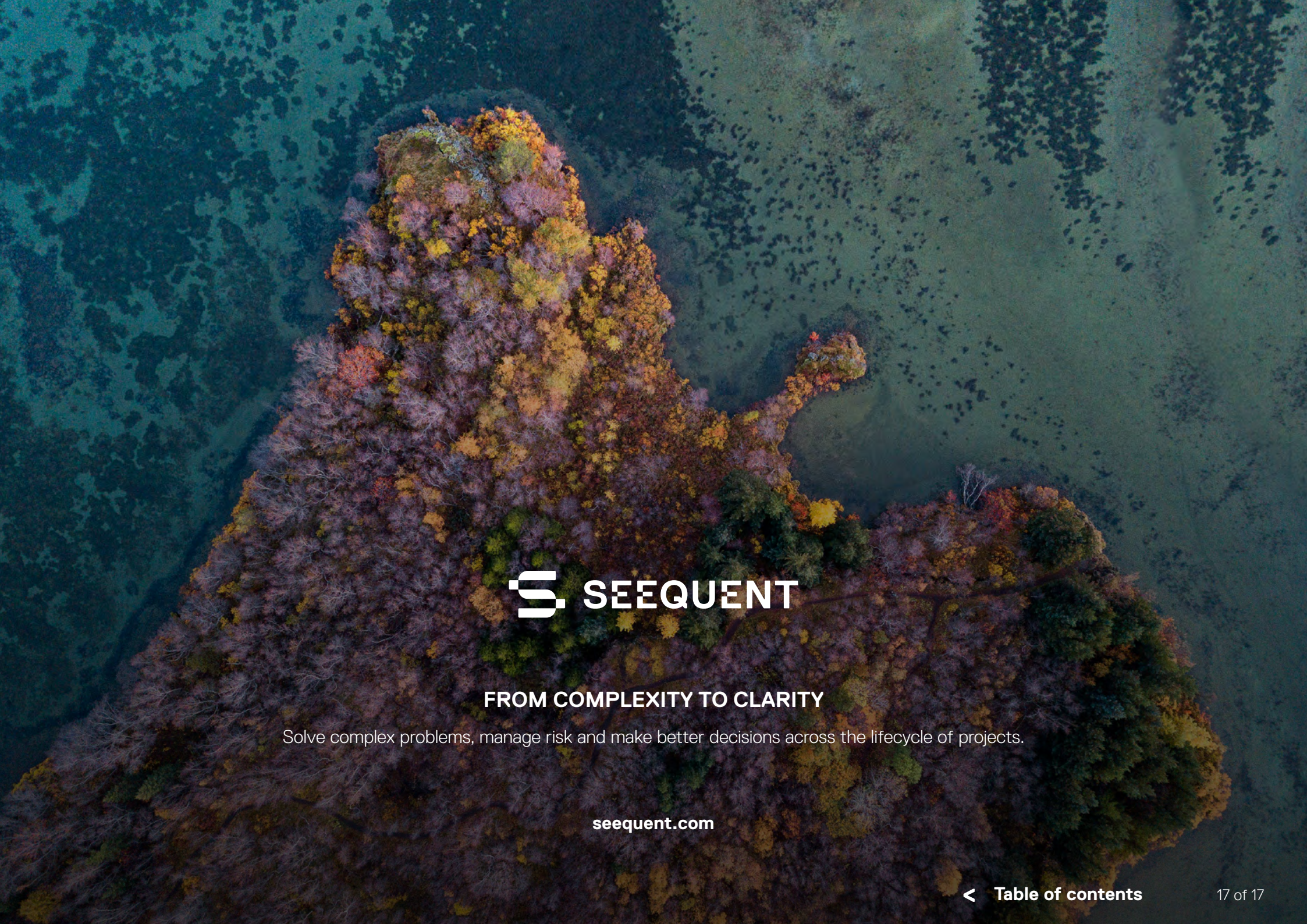
Seequent solutions empower you to efficiently produce a robust analysis that is auditable, defensible, and addresses the needs of all of your stakeholders.

> **“Customers have said to me that a 3D visualisation of the site with all the data and infrastructure is worth a million words... Being able to visualize and interact with the data is critical for explaining the problem and getting consensus.**
>
> **If you get consensus right from the start, effective site management is much easier.”**

Thomas D Krom Ph. D.
Segment Director, Environment at Seequent

Discover how Seequent and the Contaminants extension for Leapfrog Works can help with your project needs.

LEARN MORE



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