Random Field Modelling of Subsurface Stratigraphy and its Potential Applications in Site Investigations

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Introduction

Aims:

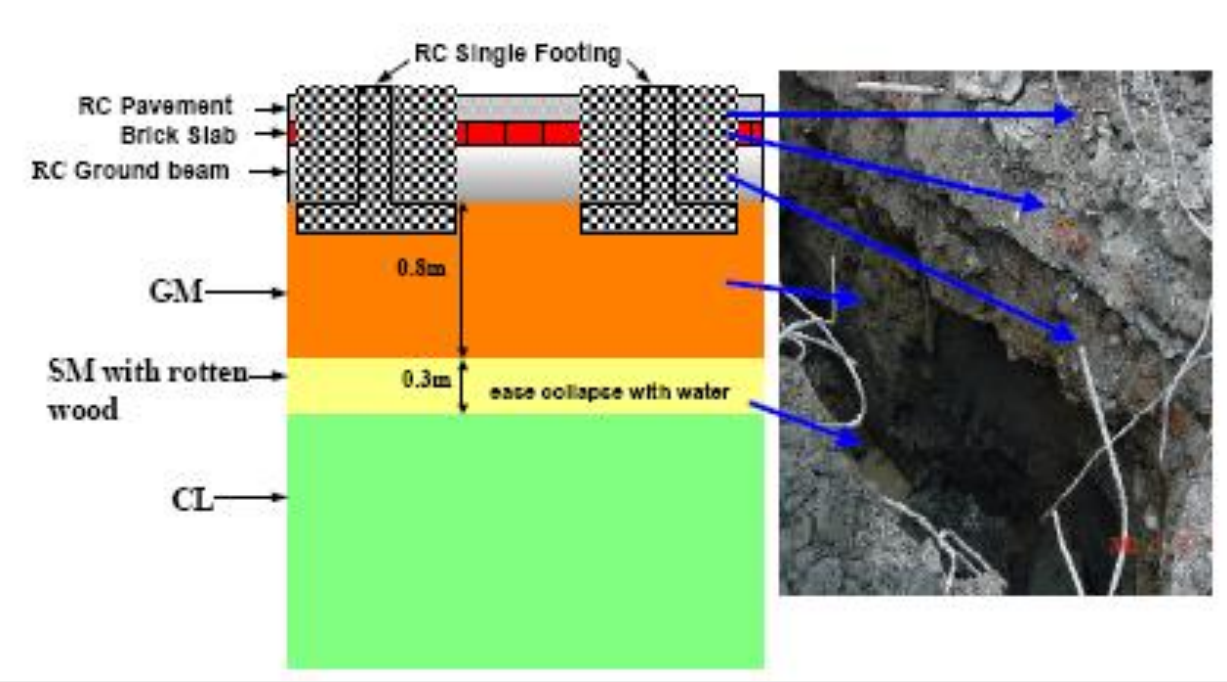
- Produce random field model
- Assess model parameters
- Consider potential applications

What is a site investigation?

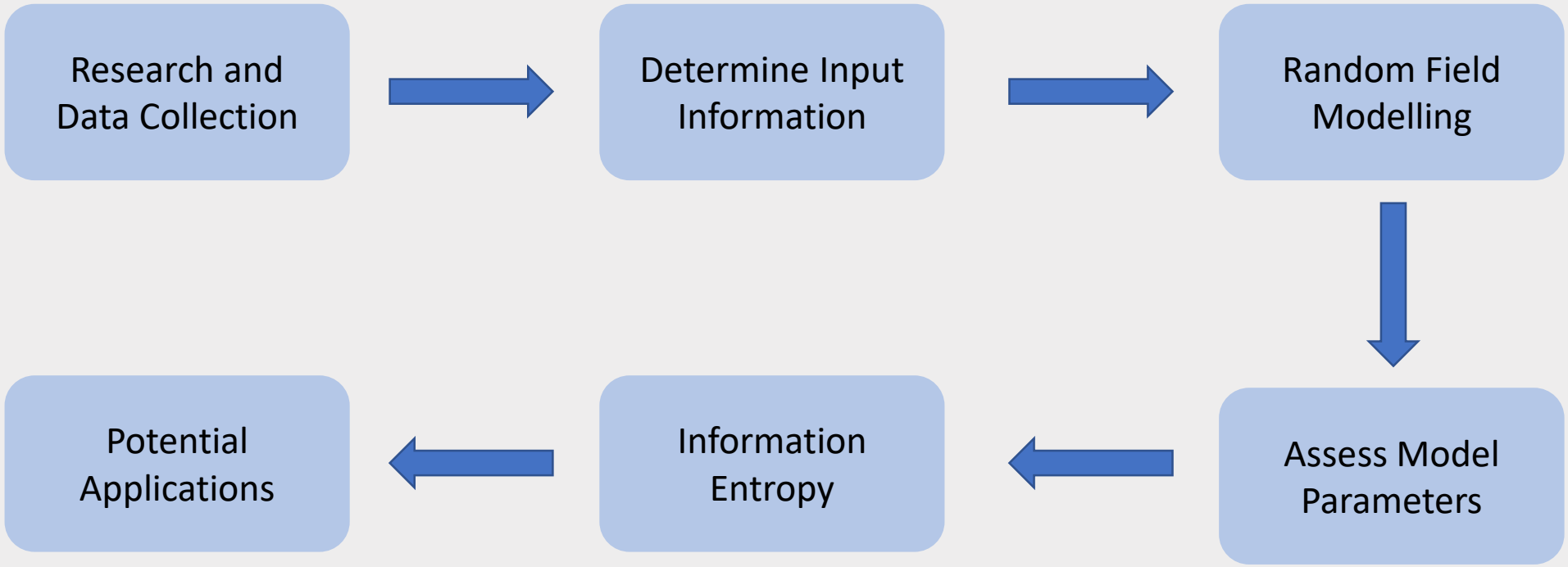
- Site investigations are required to determine the engineering (and environmental) properties of soil and rock and how they will interact with a planned development.
- The design and scope for each investigation will depend upon site-specific circumstances like the anticipated geology, previous use of the site and the construction proposals.

Why is it important and what are the applications?

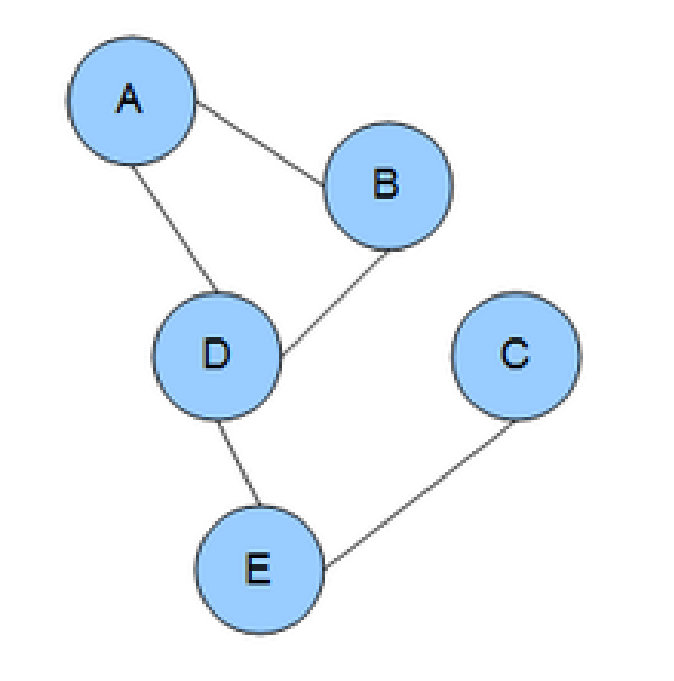
- It is estimated that around 80% of problems discovered on construction projects are attributable to unexpected ground conditions. (For example, Taipei Underground Extension in 1990s).
- Random field models could nd therefore ground investigati
- Although there has been pr t hasn't been widely applied i
- Little appetite for innovatio ver the past 20 years+



Methodology



Markov Random Fields



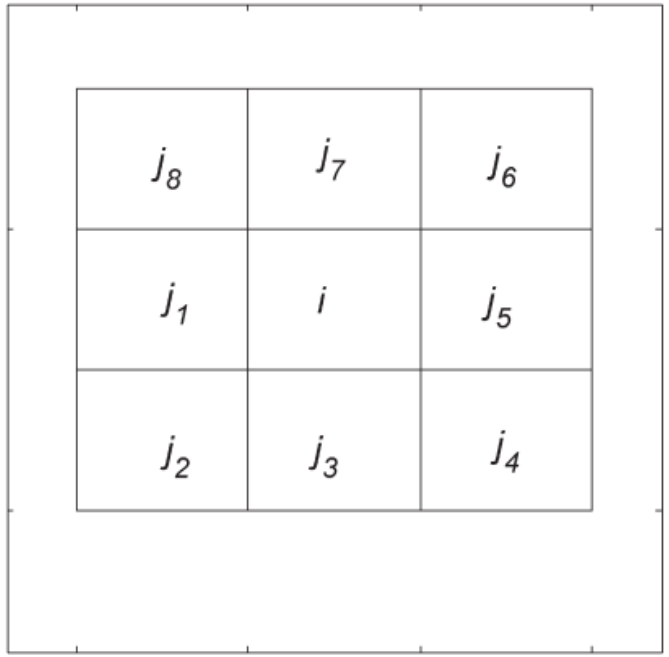
Undirected graphical model is a graph

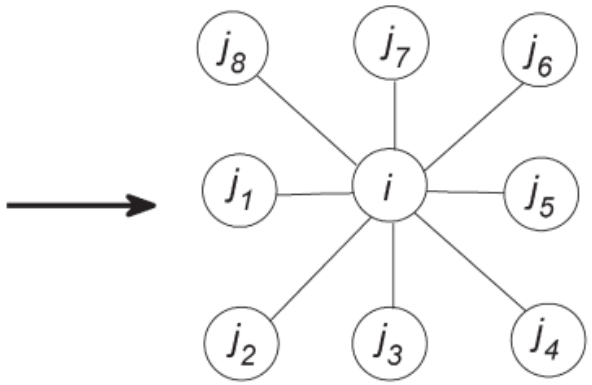
G(V, Ɛ), where:

- v is a set of nodes
- ε is a set of undirected edges

Nodes represent variables. Edges represent potential functions between variables

Neighbourhood system





- Geological model is constructed by discretizing the geological body of interest into small square elements.
- Neighbours are spatially related.
- Spatial correlation divided into 2 parameters

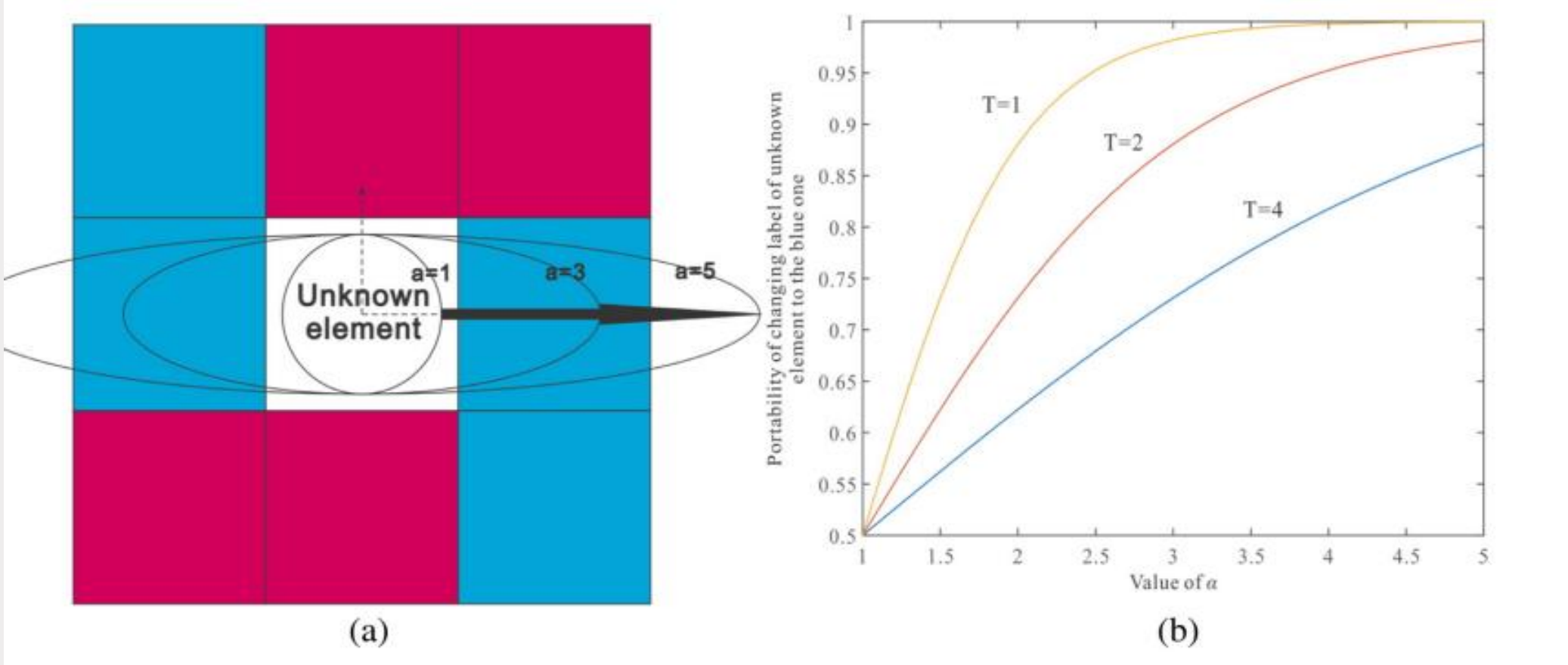
Model Parameters

The spatial correlation in the local neighbourhood system is divided into two components:

- ψ – orientation information of geological formations
- a –strength of correlation in the tangential direction

(so far in this study the value of ψ is set to 0)

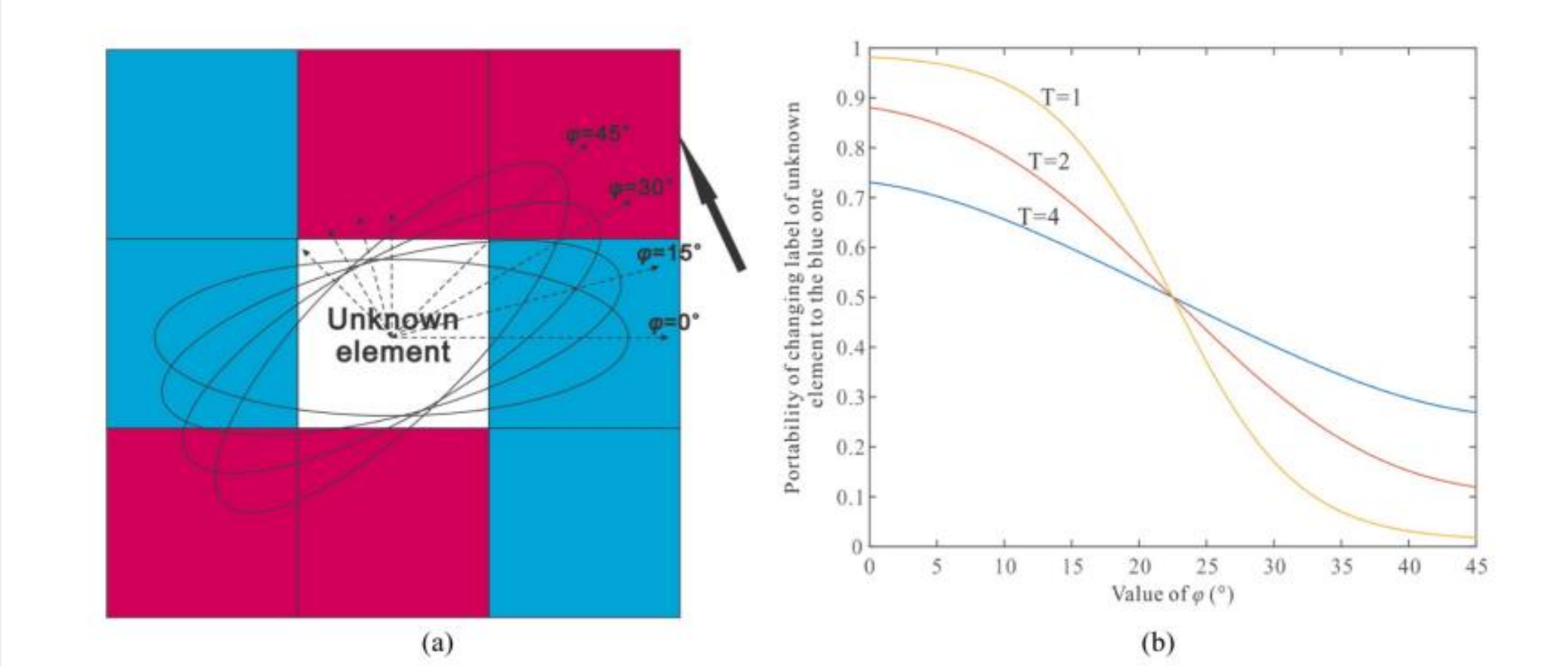
Parameter a



(After Li, et al. 2015)

T = temperature in system, which indicates the chaotic situation of a graphic distribution. High temperature presents more random graphic distribution.

Parameter Ψ



(After Li, et al. 2015)

4 step process

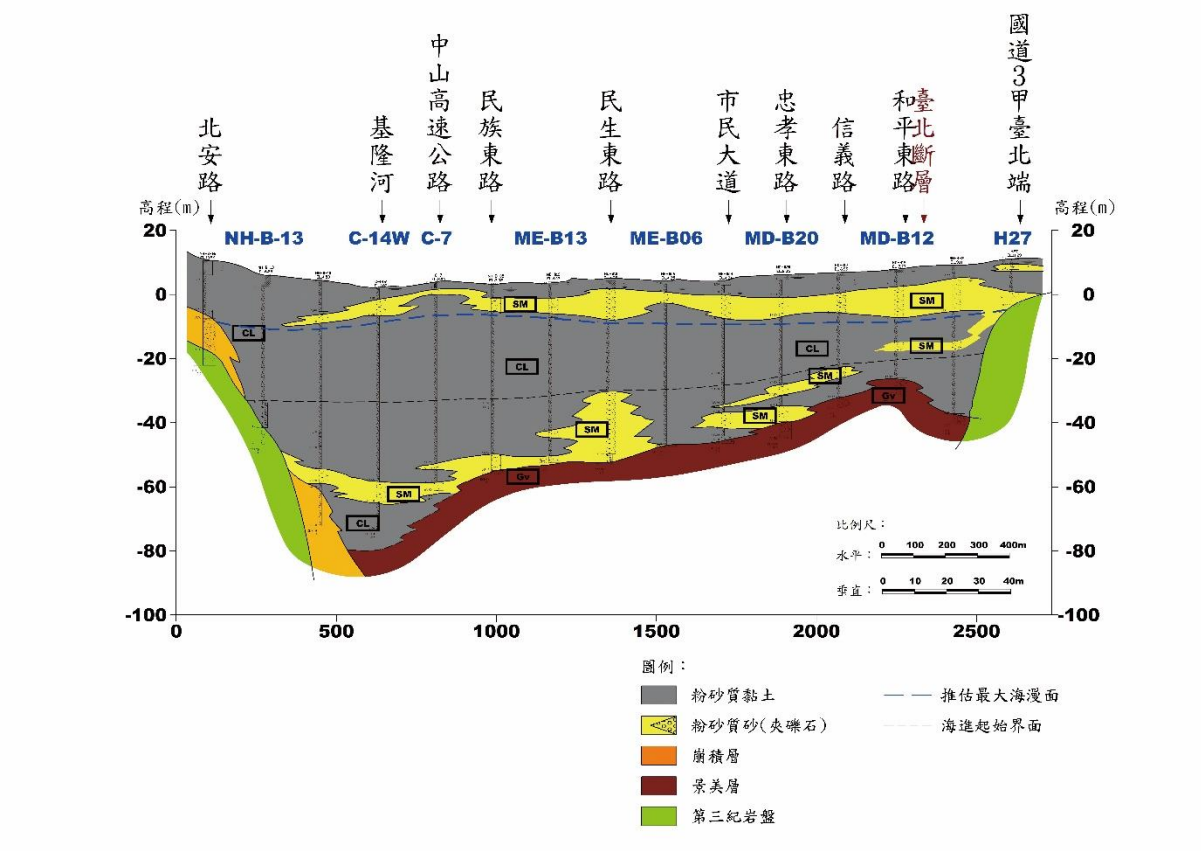
1. Determine input data
2. Run random field model simulation
3. Information entropy assessment
4. Likelihood assessment

Input Data

Borehole data in the Taipei Basin

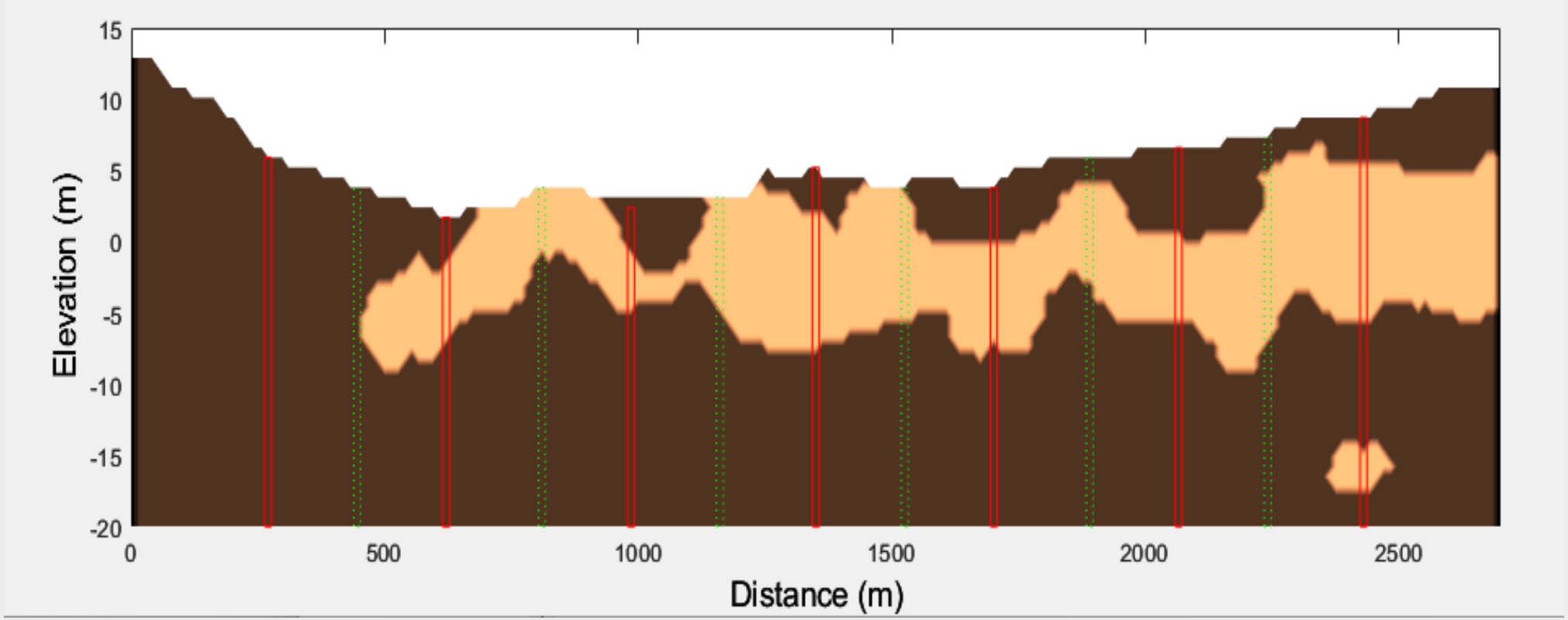
Data used:

1. Surface data – elevation and distance
2. Lithology types
3. Layer boundaries
4. Location of boreholes



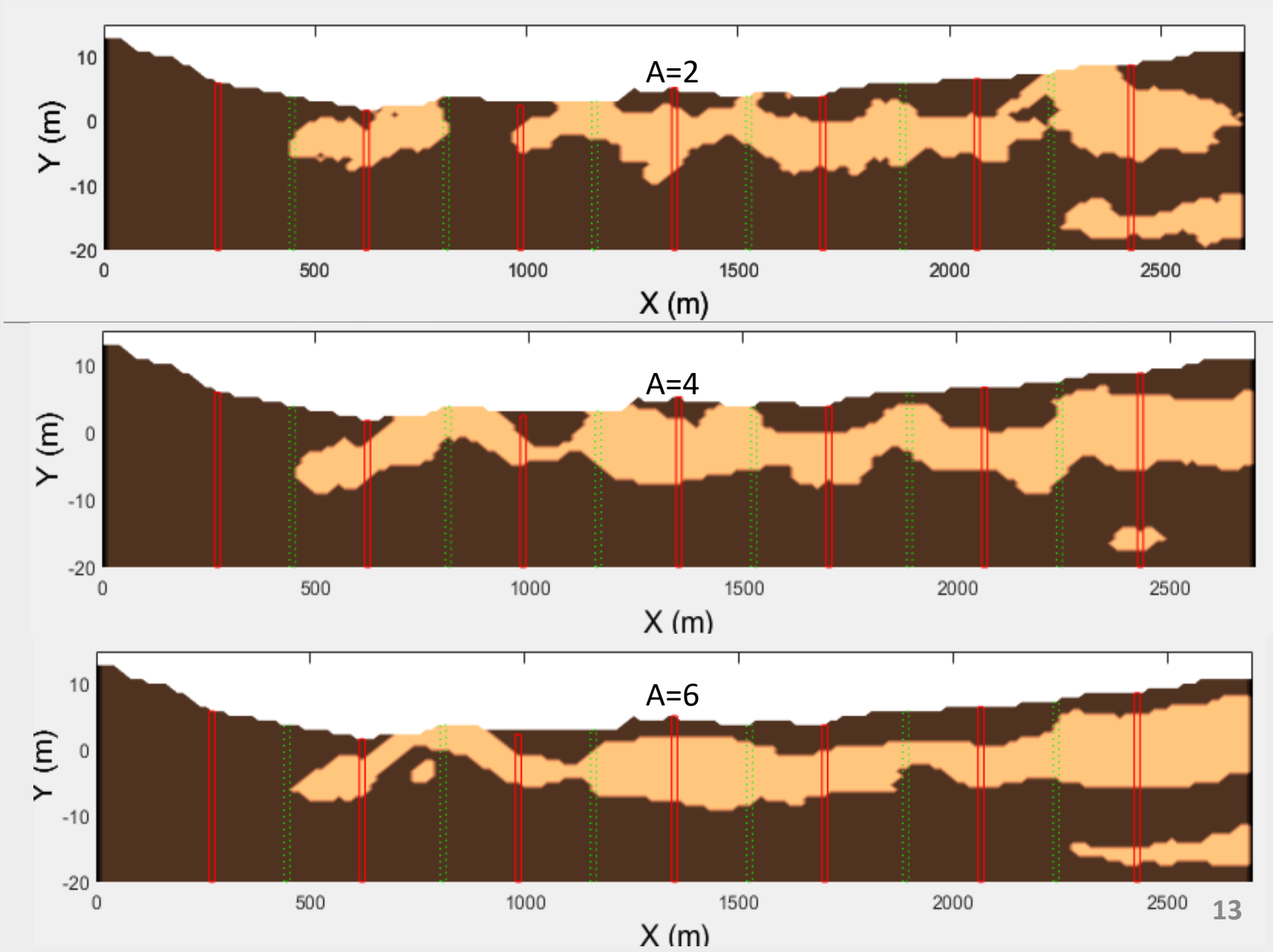
Observational and Conditional boreholes

Red lines – conditional boreholes, used to make the model
Green lines – observational boreholes, used for comparison (not simulated)



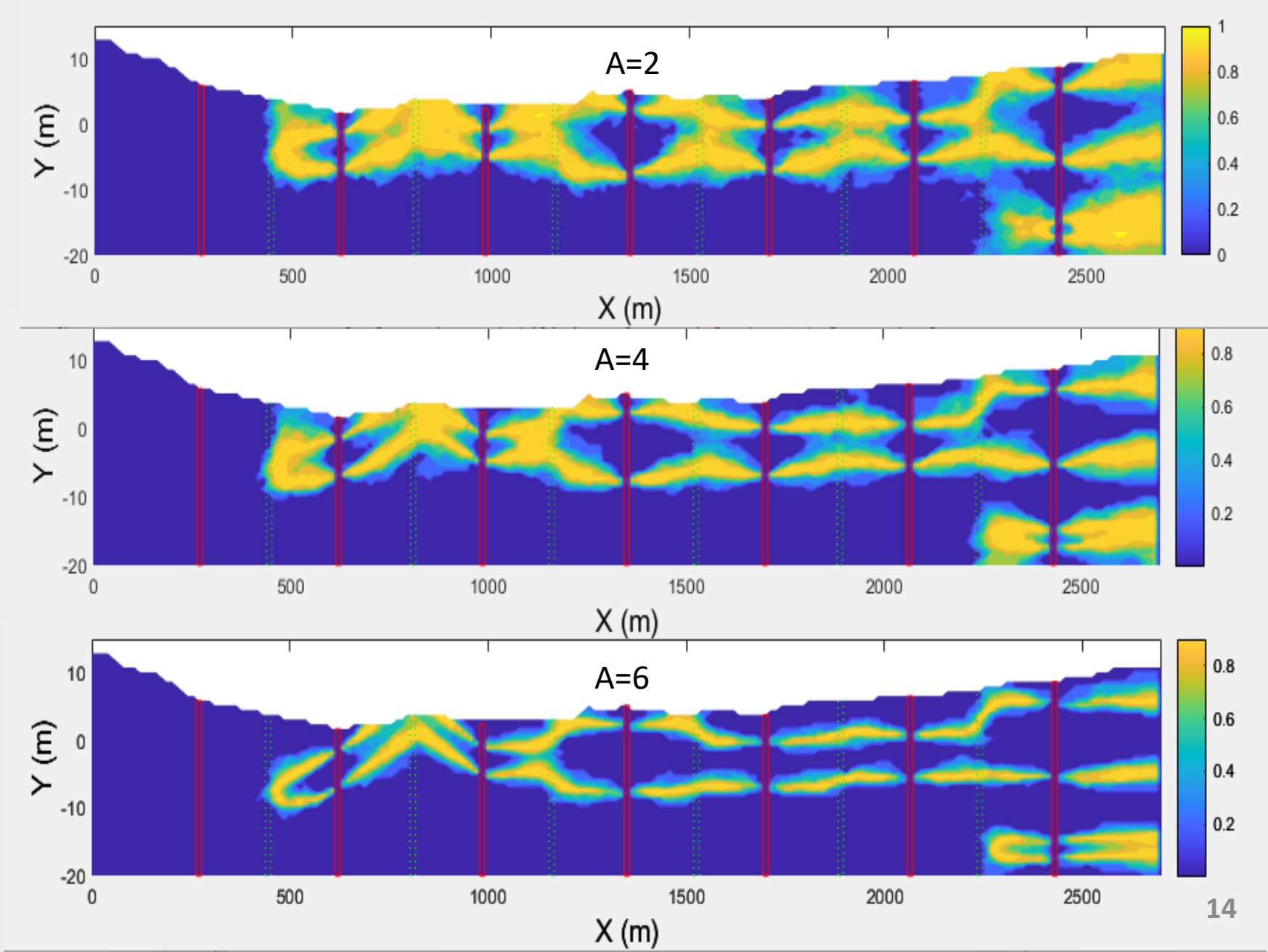
Model Simulation

- Realisations = number of simulations
- At least 500 realisations needed
- Higher number of realisations could improve the model but takes more time to process
- Different values of a produces some differences in the model



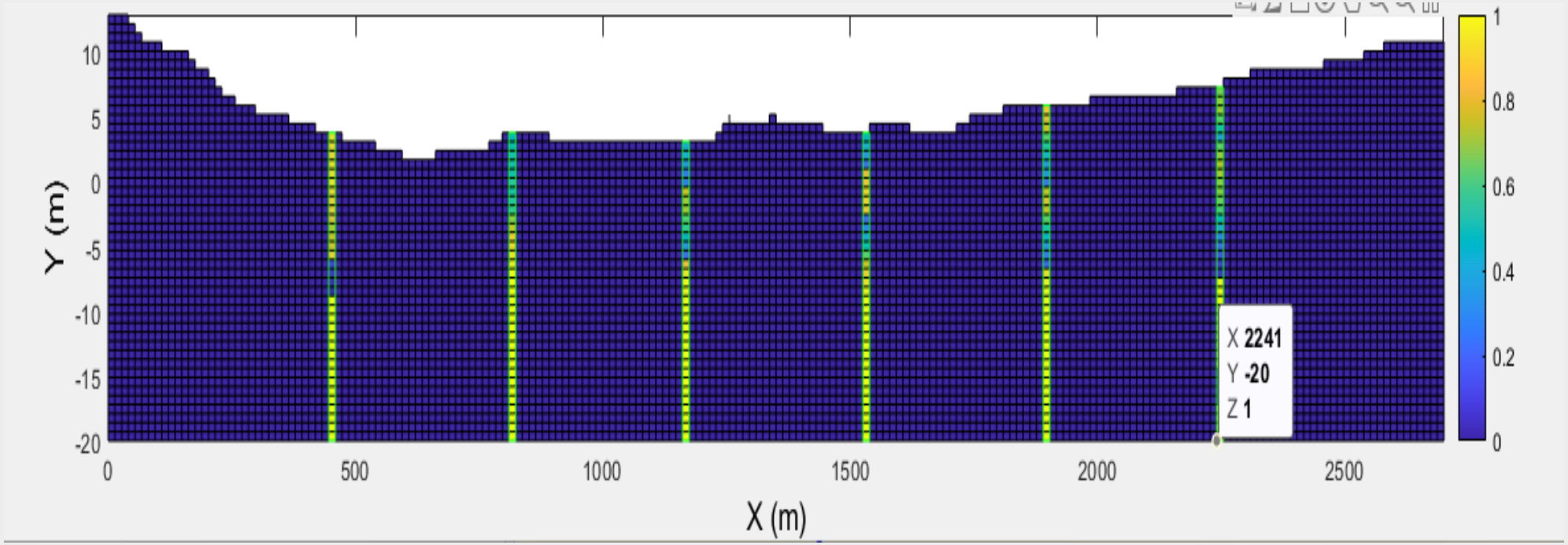
Information Entropy

- Uncertainty of the predicted lithological profile is assessed by the information entropy
- The entropy is 0 when no uncertainty exists (E.g. only 1 possible lithological unit)
- Entropy is highest when all lithological units are equally probable



Likelihood

- The spatial correlation of strata is estimated with maximum likelihood principle
- Lower likelihood = more uncertainty



Potential Applications

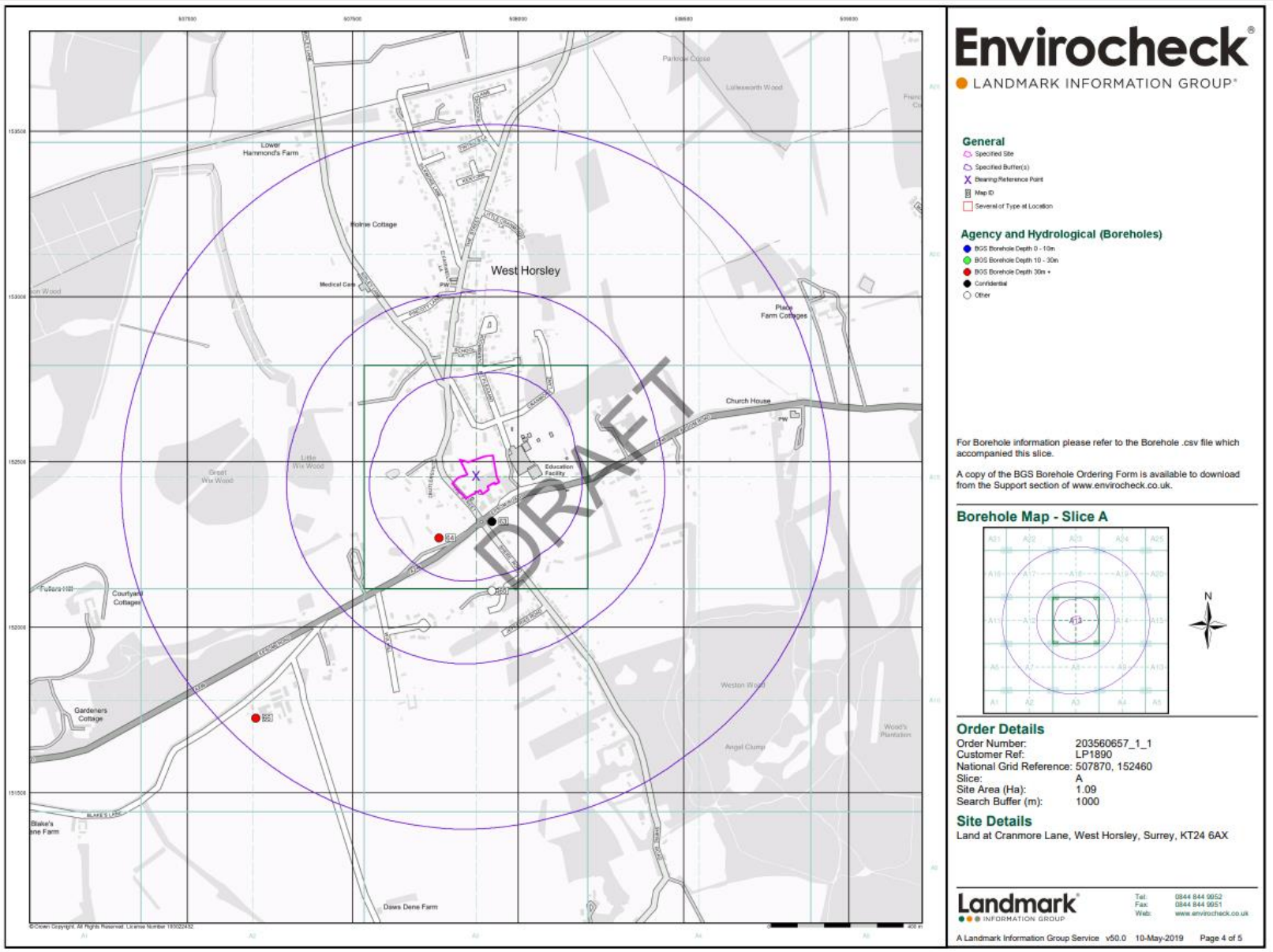
- MRF modelling can be used to help develop a conceptual site model for a range of engineering geology/geotechnical projects.
- A better understanding of the ground conditions could reduce the risk factor and save money.
- Could be useful during any phase of a site investigation.

Site Investigation Phases:

1. desk study and preliminary assessment
2. physical investigation at the site
3. designing a strategy/remediation for the site

Phase

- Some
- Better



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Phase 3 Site Investigation

- Useful tool to assess the ground conditions.
- Could help geotechnical engineers with design.

Conclusion

- Random field modelling can help reduce uncertainty in sub-surface stratigraphy.
- ‘A’ value depends on the continuation of the lithology.
- An improved geological model of sites can reduce the risk in engineering geology.
- Only a tool!

Future Work

- Orientation data
- 3D Modelling
- Apply to real-world case

Thanks for listening!