What should I read to get a background of the geology and soils around the Rotorua area?

"The Taupo Volcanic Zone (TVZ) is without doubt the most exciting part of the North Island, geologically speaking, and marks the southern end of the Tonga -Kermadec -New Zealand active volcanic arc. This arc enters the North Island at White Island, the active volcano in the Bay of Plenty, passes through the Rotorua and Taupo volcanic districts, and ends at Mt Ruapehu in the centre of the island" (Ballance, 2009)

"An obvious question is: 'How can all these different tephras be recognised?' The answer is complex, but most tephras have distinctive colours, or a developed topsoil (subsequently buried and now called a 'paleosol). or a distinctive particle size or mineralogy. The tephras have built up like layers in a huge volcanic landscape cake, with interfingering of the tephras from the three volcanic centres - Tongariro, Taupo and Okataina." (Molloy, 1998)

"However, in North Island landscapes where tephras have been repeatedly deposited, many of the soils are formed by upbuilding pedogenesis. This is the ongoing formation of soil via topdown processes whilst tephras (or loess, alluvium, etc) are simultaneously added to the land surface ... The profiles become multi-layered soils that reflect this interplay of geological versus pedological processes... Where a thick tephra layer is deposited ... the antecedent soil is suddenly buried and isolated at depth (becoming a buried paleosol), and soil formation begins again on the fresh materials at the new land surface. This process is retardant upbuilding pedogenesis (because the original soil's development has been permanently 'retarded' by its sudden/rapid burial)" (Lowe & Tehnuka, 2023)

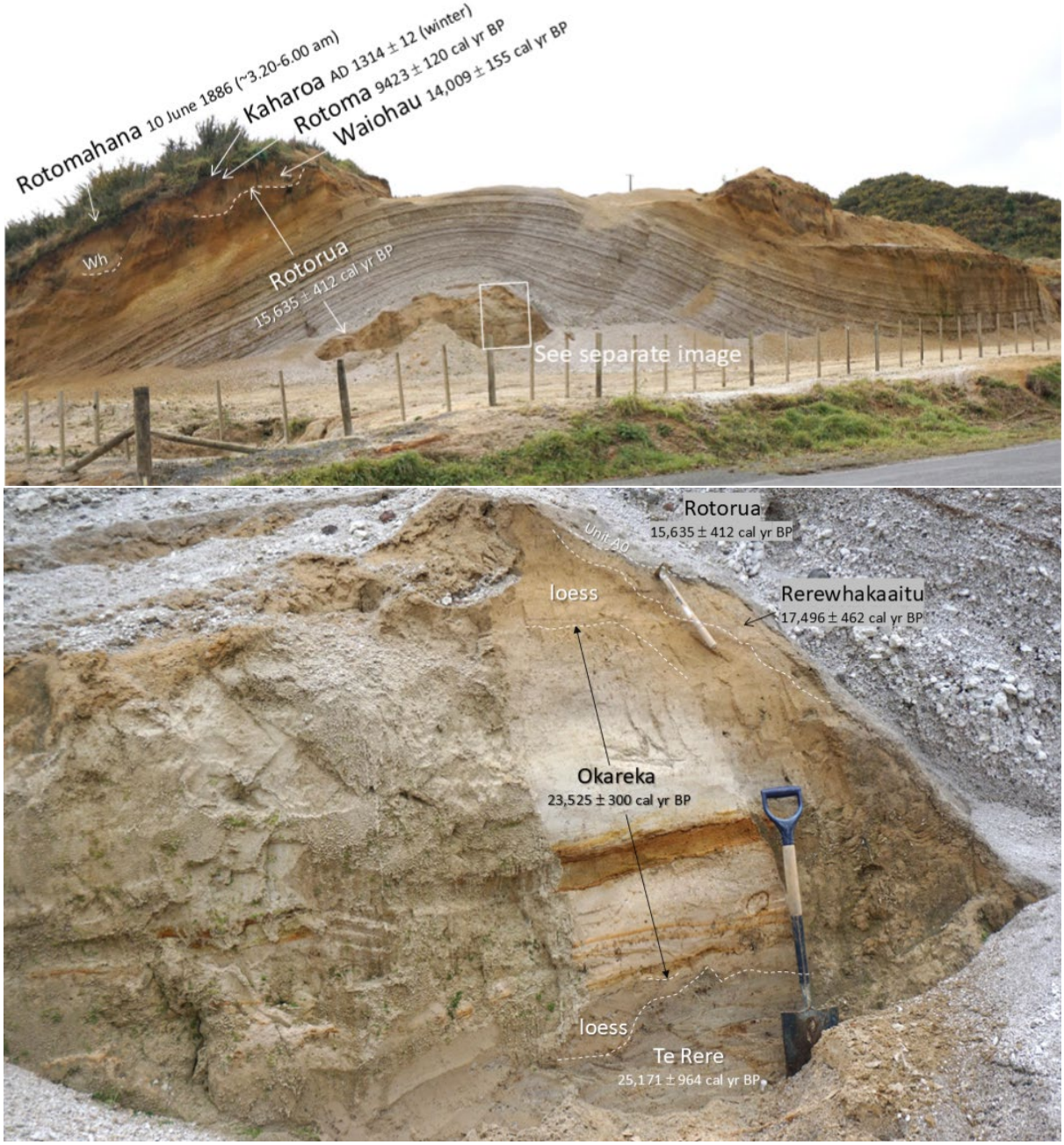

Figure 1 Section on Okareka Loop Road near Rotorua showing stratigraphy and ages of tephra deposits, (minor) loess, and soils/paleosols dating back to c. 25,200 years BP (from Lowe and Ilanko, 2023; partly after Nairn, 1992). The photo shows the distinctive lapilli- and block-dominated Rotorua tephra-fall deposits mantling an antecedent small hill. In lower image, note thin iron pans and redox segregations (Fe-Mn oxides), including blue-black pyrolusite, and redox depletions (low chroma colours, i.e. pale grey–white colours), as secondary reductimorphic/redoximorphic features (Hewitt et al., 2021). Photos: D.J. Lowe.

The geology and soils of the Rotorua area may be some of the most complex in New Zealand, and understanding the relationship between the deposition of different tephras and soil pedogenesis is very important for describing soils in the area, particularly for horizination. Below is a list of useful resources. You do not need to read these for the competition, but it will help significantly with your understanding and learnings from the competition!

- *New Zealand geology: an illustrated guide (Balance P. 2009)*
  Produced by the Geoscience society of New Zealand, this is a great resource for understanding the background geology of the Taupo Volcanic Zone (TVZ) (of which the Rotorua Lakes area makes up a significant part) Chapter 9 covers the TVZ, with plenty of helpful diagrams. It also covers the types of volcanoes and parent materials found in the area. A great starting point!
  https://www.geotrips.org.nz/downloads/Ballance_NZ_Geology-V2.pdf

- *Guidebook for Land and Lakes Field Trip (Lowe, D.J. 2006)*
  This guidebook is produced our geomorphology expert for the SJC, David Lowe, and contains several sections that are directly related to the material needed for the soil judging competition. *Introduction to North Island volcanoes and their products (pg. 8-16),* goes into the material covered in (Ballance, 2009), with more focus on tephras (very important for soil judging!). *Introduction to tephra-derived soils of the Rotorua region (pg. 17-21)*, covers how these tephra form different soil types based off chemical and climatic conditions.
  https://researchcommons.waikato.ac.nz/entities/publication/e2e735fd-d3db-4667-a93a-259ddf665c22
- *Pre-conference tephra data workshop – Hands-on session II: tephra excursion,Okareka Loop Road. (Lowe, D.J., Ilanko, T. 2023)*
  Covering similar material to the tephra section in the above guidebook, this publication (again co-authored by David Lowe) covers the tephra derived soils we will see in significantly more depth. Particularly of focus is the difference between retardant upbuilding pedogenesis vs developmental upbuilding pedogenesis, as well as many tables and figures covering the many historical tephras in the area, their properties and distribution.
  https://researchcommons.waikato.ac.nz/entities/publication/dbdc456f-4f35-4a54-85ea-c3bde42276b1

- *Supplementary notes, 2024 Moana Oceania soil judging competition (Lowe, D.J. 2024)*
  David has produced a document specifically for the soil judging competition that contains figures and tables taken from his other publications, that have been explained in depth. It also contains specific information about the formation of the Mamaku Plateau – an ignimbrite plateau adjacent to the Rotorua Lakes area. It also contains information about allophane and its importance and formation in the area.
  (Download linked on website)

- *Soils in the New Zealand landscape, the living mantle (Molloy L. 1998)*
  This book, particularly chapter two, *Pumice Lands*, covers soil development in the area and has many examples of soils found in the area. Chapter 2 can be individually downloaded from:
  https://www.soilscience.org.nz/books/soils-in-the-new-zealand-landscape-the-living-mantle

- *The Soils of Aotearoa New Zealand (Hewitt A.E., Balks M.R., Lowe D.J.)*
  Part of the World Soils book series, this book is great for dialling down into specific soil orders that can be found in the Rotorua area, as well as the relationship between different soil orders. Particular focus orders for the area include (but not limited to) Allophanic, Pumice, Podzol, Recent.
  https://link.springer.com/book/10.1007/978-3-030-64763-6 (Access via institution may be required)

- *S-Map*
  S-Map is the digital soil map portal for New Zealand, with a free login maps and factsheets are available for 41.2% of New Zealand's area (Almost full coverage is available at 1:50,000 scale for the Rotorua area).
  https://smap.landcareresearch.co.nz/

Glossary of useful terms for the Rotorua area.

- Tephra - The name of the group of all unconsolidated pyroclastic volcanic material that during a volcanic eruption is transported through the air from the source. Tephra can be divided up into the following size classes:
    - Fine ash – Less then 0.06mm
    - Medium ash – 0.06 - 0.5mm
    - Coarse ash – 0.5mm - 2.0mm
    - Lapilli – 2 – 64mm
    - Blocks – Larger then 64mm & sharp and angular in shape.
    - Bombs - Larger then 64mm & smooth or partly rounded in shape.

    **Size descriptors may vary between publications - for this SJC we will be using the size classes set down in* (Lowe, Guidebook for Land and Lakes Field Trip, 2006).

- Allophane – A non-crystalline hydrous aluminium silicate clay mineral often found in volcanic ash soils.
- Caldera – A large basin-shaped volcanic depression, more or less circular in form.
- Cation exchange capacity - The sum total of exchangeable cations that a soil can adsorb.
- Colluvium - Rock fragments or soil materials that have accumulated at the base of steep slopes due to gravity.
- Loess – Windblown soil materials of approximately silt sized particles.
- Paleosol - soil that formed on a landscape in the past and that has distinctive morphological characteristics resulting from a soil-forming environment that no longer exists at the site. The former soil-forming process was either altered due to environmental change or interrupted by burial.
- Pumice – Light vesicular form of volcanic glass with a high silica content. It is usually light in colour and filled pores.
- Pedogenesis – soil development
- Pan - A compact, dense layer in a soil that restricts the movement of water and penetration by plant roots.
- Ped A naturally-occurring soil aggregate, as opposed to a clod, which is formed artificially (e.g. through cultivation).
- Phosphate, or P retention - Expressed as a percentage, this is a measure of the degree of phosphate retention or immobilisation by soil minerals.
- Vesicular – Containing many small cavities or holes (such as pumice).

Classification

The NZSC has a hierarchical structure with five levels. For the purposes of the Moana Oceania soil judging competition, we will be classifying to subgroup level using the New Zealand Soil Classification *3rd Edition* by A.E Hewit (NZSC).

1. Order: The 15 soil orders are the highest, most generalised level of the classification and provide the national overview of New Zealand soils.
2. Group: The orders are divided into 74 soil groups based on variation in factors such as drainage status, parent material, chemical and physical properties.
3. Subgroup: The soil groups are divided into 299 subgroups that provide more detail about the range of soils included in each soil group.
4. Family: The soil subgroups are subdivided into family criteria that provide more detail about the soil parent materials, rock class, texture, and permeability.
5. Sibling: The soil family are subdivided into sibling criteria that provide more detail about soil depth, stone content, upper and lower textures, and drainage. The family also contains functional horizon attributes detailing horizon stone content, texture, structure size, and consistence.

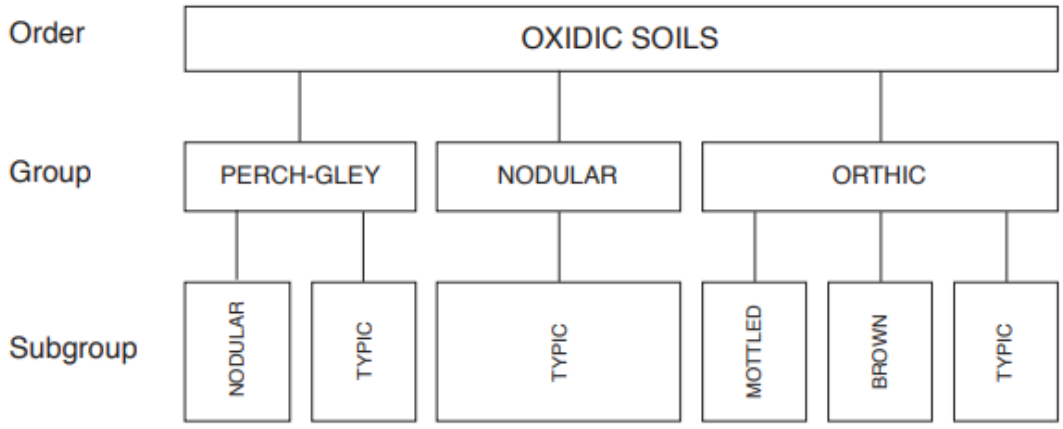

Figure 1. *The hierarchy of the Oxidic Soils as an example of the hierarchical relationships between orders, groups and subgroups. As the diagram suggests, the range of soil properties for each class is related to hierarchical position.*

The NZSC operates in a key system starting on page 35 with Organic soils, when a soil meets the specified properties at Order level then it classified as such, and then the classification moves to the appropriate group level, again working through the groups until an appropriate group meets all the necessary requirements, then moving to subgroup level.

While experienced soil scientists may shortcut part of the NZSC, for the purposes of soil judging following the key is vital. Similarly, reading all parts of the requirements for a particular order/group/subgroup is vital. Multiple requirements often must be met simultaneously, or only one from a list. Identifying linking words such as *EITHER, OR, ALL, AND, BOTH,* is vital for successful use of the classification. While the classification works as a key system, a simplified version of the relationships between order is found below. For further information on soil relationships *The Soils of Aoteroa New Zealand* is a good starting point.

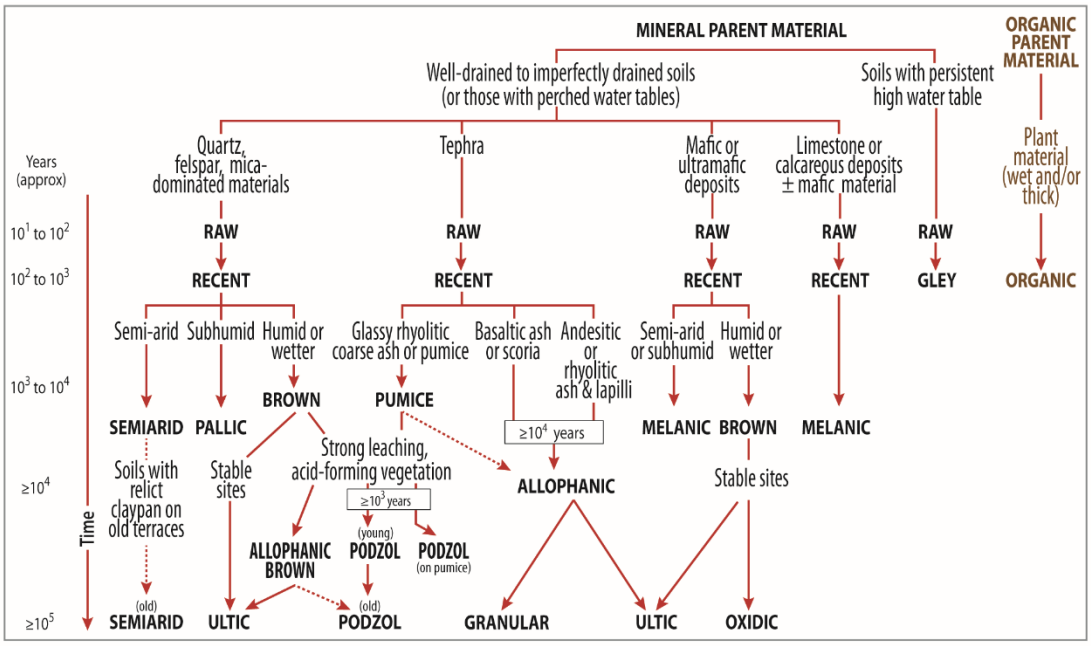

Figure 2 - Simplified relationship between soil orders.

Soil judging specific tips

Soil judging is different from standard soil descriptions – while most of the skills are identical, the emphasis and time management changes significantly. Several of our most experienced soil judging competitors have come up with a list of tips and tricks to help your experience during both the practice and competition days.

General tips and tricks

- Soil judging is primarily a learning experience. Be courteous to your fellow competitors, particularly on the practice day. Everyone is learning, and sharing knowledge and making friends is a big part of this!
- Ask lots of questions! There will be several expert judges, expert guests, pit master's and many more floating around who can help with your questions. No question is a dumb question!
- Rotate through all the tasks on the practice days, competitors may come into soil judging with strengths and weaknesses, but we are all here to learn and improve! Learning all the tasks will also be important for the individual competition!
- When it comes to the competition day, play to your teams' strengths!
- During the practice day pit master's will be present to oversee you. They will provide timing and advice at each practice pit – however for the first few pits it may be beneficial to focus on learning all the skills as a team rather than worrying about timing (explained below). However, for at least the last practice pit it is recommended to try and follow the timing to get some experience before competition day.

Gear

Some gear you may have not thought about:

- Soil storage devices – getting samples out of the pit (in an ordered fashion) is very important. Teams have used various methods in the past like muffin trays, disposable paper bowls (great until it rains!), petri dishes, click-clack containers. Make sure you label your containers so you don't mix up horizons!
- Calculator – There are some basic available water holding capacity calculations for each pit.
- Baby wipes/towel – Some way to clean your hands between samples is very important otherwise you risk contamination between samples! A set of cheap tea towels or hand towels works best without creating lots of rubbish.
- Pencils/erasers - As you describe the soil, you may find you want to change your answer. Writing in pen can make this very difficult! Copying all the answers onto a new scoresheet can be time consuming.
- Clipboards – Having something solid to write against that secures the scoresheet makes life a whole lot easier. A second clip/rubber band to hold the bottom of the scoresheet down is handy on a windy day
- Prying/picking tools - There are many tools that suit this purpose. Common ones include a Niwashi & Digi-Digi, but a paint scraper or dull knife can do the same job for a fraction of the cost!

- Books - Both the New Zealand Soil Classification & Soil Description handbook are available from the Manaaki Whenua – Landcare website as PDF's make sure you have downloaded copies on your phone for use on the practice day (Phones are prohibited while competing on the competition day)
- Storage - A bag to keep all your gear in makes organisation much easier – Tool bags make great cheap ways of storing gear, and often have small pockets to keep track of small items like pencils
- Small ruler/tape measure – Large pit tapes will be installed on the no-pick face to standardise depth measurements. However, a small ruler or tape (dressmakers tapes are very cheap and portable!) is handy for measuring the size of structural units or rocks.

Some spare gear will be available for use during the competition, particularly during the individual pit. If you have some spare gear available for the competition, please get in touch!

Where possible gear will be permanently installed at sites for use by all competitors – e.g. inclinometers will be tied to slope stakes.

Figure 3 - Standard Lincoln University soil description kit

Pit & site information

Each site will be set up with the following –

- Within the pit part of the pit face will be delineated with measuring tapes and flagging tape. This is the no-pick zone. Competitors are NOT allowed to touch this section of the soil pit. Depth measurements are taken from this area, as well as visual assessments of things like mottles, structure, stone content. The areas either side of the no-pick zone is for competitors to take samples. Please only take the amount of material you require and be courteous to your fellow competitors.
  A marker pin will also be placed somewhere in the third horizon (unless specified otherwise) to assist competitors with identifying soil horizons.

- Each pit will have one or more information cards – this will give competitors the pit ID to record on the scoresheet *e.g. Team pit 2, Left,* the depth of soil to be considered as well as the number of horizons to describe in that depth, pertinent chemical data as well as any other relevant information.

- Two slope stakes will be placed somewhere within view of the soil pit. These are to assist with measurement of the slope. It is the competitors responsibility to check the height of these slope stakes is equal. A section may also be marked out using tape or paint to assist with identifying features such as erosion/deposition.

Timing

Time management is everything in soil judging. For the competition pits you will have 75 minutes to make a full description of the pit, the site characteristics, and classify the soil. How you divide this time will depend on whether you start in or out of the soil pit. Below is an example pit rotation for a competition pit.

Time (minutes)	Team 1	Team 2
0-5	In*	Out
5-10	Out	In
10-15	In	Out
15-20	Out	In
20-30	In	Out
30-40	Out	In
40-50	In	Out
50-60	Out	In
60-75	----------Free** ----------	

*In and out refer to competitors allowed in the pit or outside of the pit, respectively.

**During free time, all teams/competitors may have access to the pit.

Team 1 in the first 5 minutes inside the pit will want to focus on establishing rough depths for the horizons and collecting samples. This will allow them to start on properties like texture, colour etc when they are out of the pit from 5 minutes onwards.

Team 2, in the first five minutes, will be outside the pit. They will want to spend the first 4 minutes on site characteristics – particularly the landscape and landform. Team 2 needs to make sure when the 5-minute changeover occurs they are ready to go – the first set of 5 minutes will go extremely quickly! Team 2 will then get rough depths for horizons as well as samples during the first 5 minutes in the pit.

After the first set of 5 minutes (5min x 2), both teams should have a rough idea of the depths of the horizons in the pit and samples to work on over the next few rotations.

Teams will then want to divide the workload based off skills. During your time allocated to be in the pit – you do not need to have to be in the pit during this time. After the first two sets of

rotations (5min x 4), most teams will only be going back into the pit to do things like structure, mottles etc so most of the time is actually spent outside of the soil pit!

Make sure you reserve time at the end for classification, this is normally the last thing teams will do but is also worth a larger share of points vs other tasks. Getting the classification right can make or break your chances of doing well in each pit! Often miniscule details can make a big difference in classification, and care needs to be taken when reading through the New Zealand Soil Classification book.

Scribing & scoresheet

The scribe is normally the team manager – they oversee making sure that everything gets recorded, and that tasks are being allocated. Make sure that communication with the scribe is clear, *e.g. sandy loam (SL) vs loamy sand (LS)!*

Just because the scribe is busy writing doesn't mean that they don't get their hands dirty – the scribe can also be busy doing other simple tasks such as colour, calculating water holding capacity etc.

Correctly entering answers into the scoresheet is very important – unlike normal soil descriptions there is a set way of writing all the answers for soil judging. Almost all answers are coded in the handbook to make marking quicker and easier for the judges. *E.g. a silt loam is written as ZL*. Failure to write the correct code can lead to loss of points! Make sure everything you write is clear – *ZL vs SL can be hard to decipher if not written clearly.*

Null entries are very important – every box on the scoresheet is worth points, and depending on what is being recorded there are specific ways of recording this. The handbook contains the correct way of recording null entries for each section. *E.g. if no secondary colour is described a dash must be recorded in each box for hue, value, and chroma. For each horizon this could loose 5 points by not including the dash. If no mottles are present in a horizon a N must be recorded, for both type and abundance, while an X must be recorded for the contrast. Putting a dash in for mottles will not give points.*

2.1 Horizon designation				2.2 Lower boundary			2.3 Particle size			2.4 Structure and consistence					2.5 Matrix colour(s)			2.6 Redoximorphic ft.			2.7
Master prefix	Master letter(s)	Letter suffix(es)	Numeric suffix	Depth	Distinct-ness	Topo-graphy	Class	Coarse fragments		Degree	Type	Size	Strength	Failure Mode	Hue	Value	Chroma	Type	Abund.	Contrast	Coating Type
								Abund.	Size												
1 each	2 each	2 each	1 each	2 each	2 each	2 each	3 each	1 each	1 each	2 each	2 each	1 each	1 each	1 each	1 each	2 each	2 each	2 each	2 each	2 each	2 each
-	A	p	-	12	DS	W	ZL	2	FG	S	PH	3	2	F	10YR	4	3	N	N	X	X
															-	-	-				
-	AB	-	-	25	ID	WO	ZL	2	FG	S	PH	4	2/3	F	10YR	5	4	N	N	X	X
															10YR	6	6				

Figure 4 Example scoresheet showing appropriate usage of null entries

The scribe needs to make sure they enter the correct site code for the pit – Teams may be assigned to a left or right face of a pit. This must be recorded as per the site information card otherwise they may be marked against the wrong model answers!