

**Activity 4c:
Enhanced ability to predict the likelihood of pipe
corrosion and its severity along the pipe**

Activity researchers : Tony Wells (UoN)

Objective of activity 4c

- **Develop a methodology for predicting soil properties between measured sites that are relevant to cast iron pipe corrosion**



- **Develop a corrosion model to predict present and future corrosion condition along the pipe**



Activity 4c. Predicting pipe corrosion along the pipe

Activities

- 1. Identify soil properties that impact on buried cast iron pipe corrosion**
- 2. Look at practicality of developing an advanced monitoring tool**
- 3. Develop methods for predicting along the pipe soil properties**
- 4. Develop a corrosion model to predict present and future corrosion condition along the pipe**

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Activity 4c. Predicting pipe corrosion along the pipe

Activities

1. Identify soil properties that impact on buried cast iron pipe corrosion

From Activity 3: Soil moisture

Some soil chemistry

- nitrates
- chlorides
- phosphates
- sulphates

Activity 4c. Predicting pipe corrosion along the pipe

Activities

1. Identify soil properties that impact on buried cast iron pipe corrosion
2. Practicality of developing an advanced monitoring tool
3. Develop methods for predicting along the pipe soil properties
4. Develop a corrosion model to predict present and future corrosion condition along the pipe



Activity 4c. Predicting pipe corrosion along the pipe

Activities

2. Practicality of developing an advanced monitoring tool

a) **Long term soil moisture** - Lab analysis of grab samples or long term logging

b) **Soil chemistry**

i. **Nitrates**

ii. **Chlorides**

iii. **Phosphates**



- analysis of grab samples

c) **LPR** - analysis of grab samples

Only SM amenable to on site analysis?

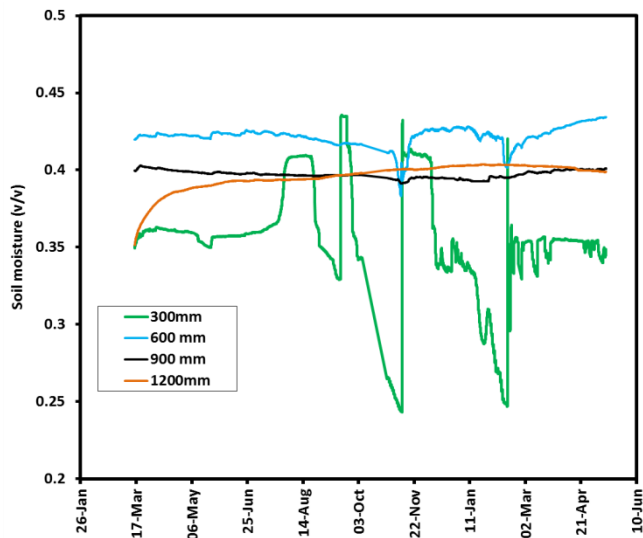
Activity 4c. Predicting pipe corrosion along the pipe

Activities

2. Practicality of developing an advanced monitoring tool

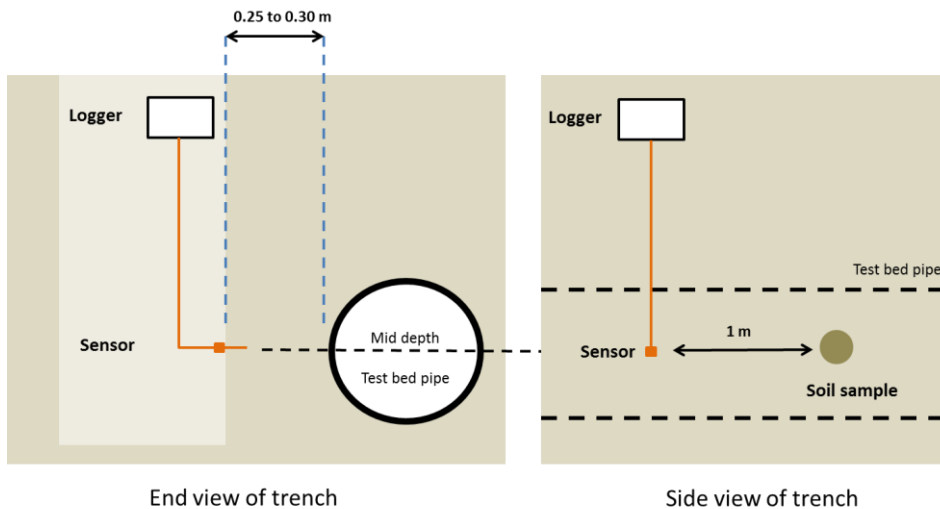
a) **Long term soil moisture** • Lab analysis of grab samples/long term logging?

- If soil moisture is stable at pipe depth then long term monitoring not needed



Jayantha Data – indicates stable

a) Long term soil moisture



- We are going to double check along the test bed.
- 10 SM loggers to be installed
- Soil grab samples also taken
- Installation mid July??

Activity 4c. Predicting pipe corrosion along the pipe

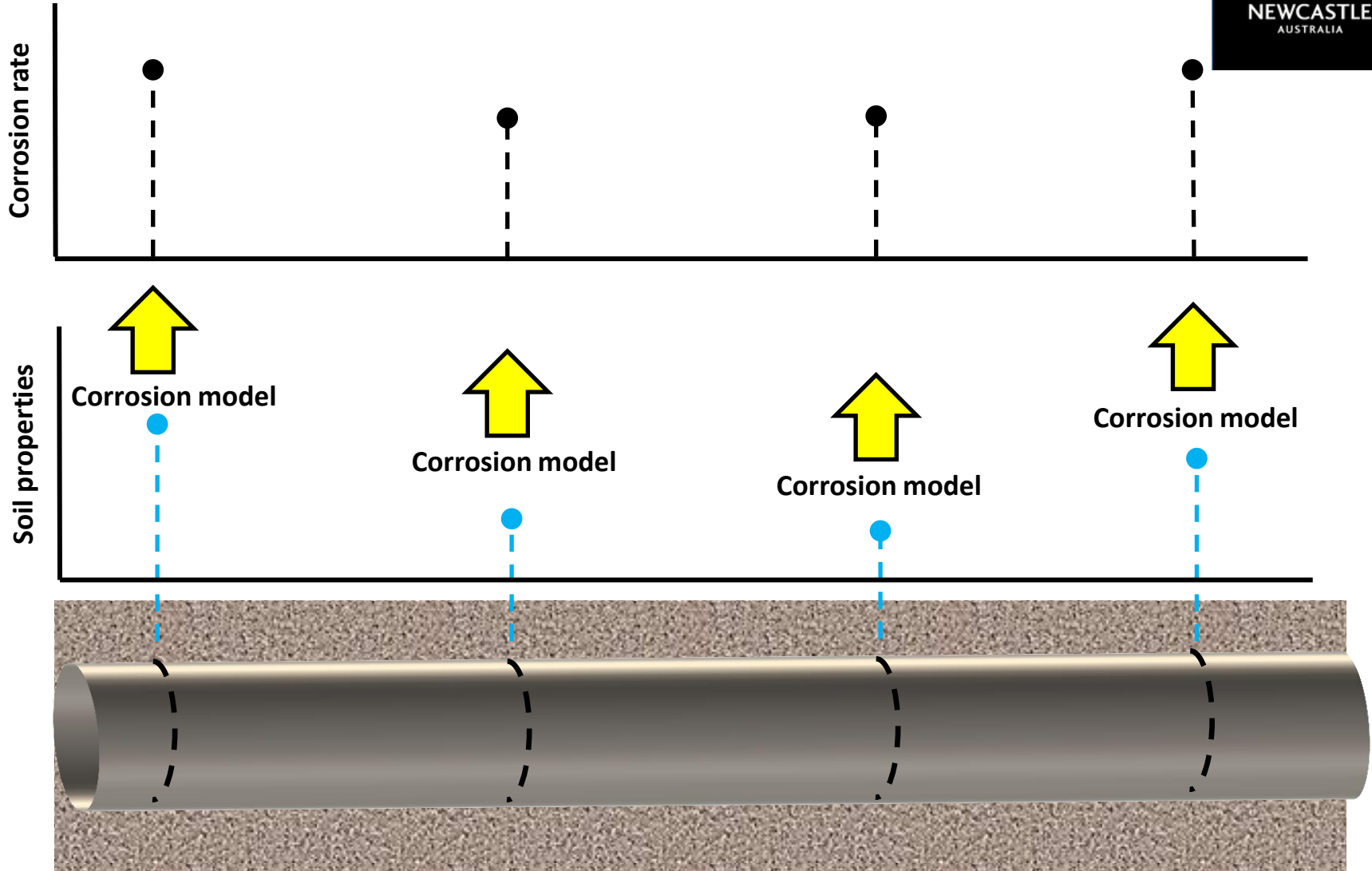
- **Activities**
 2. **Practicality of developing an advanced monitoring tool**
 - **If long term SM is stable at pipe depth then can obtain all information from analysis of a grab sample**
 - **i.e. no 'integrated' tool necessary**

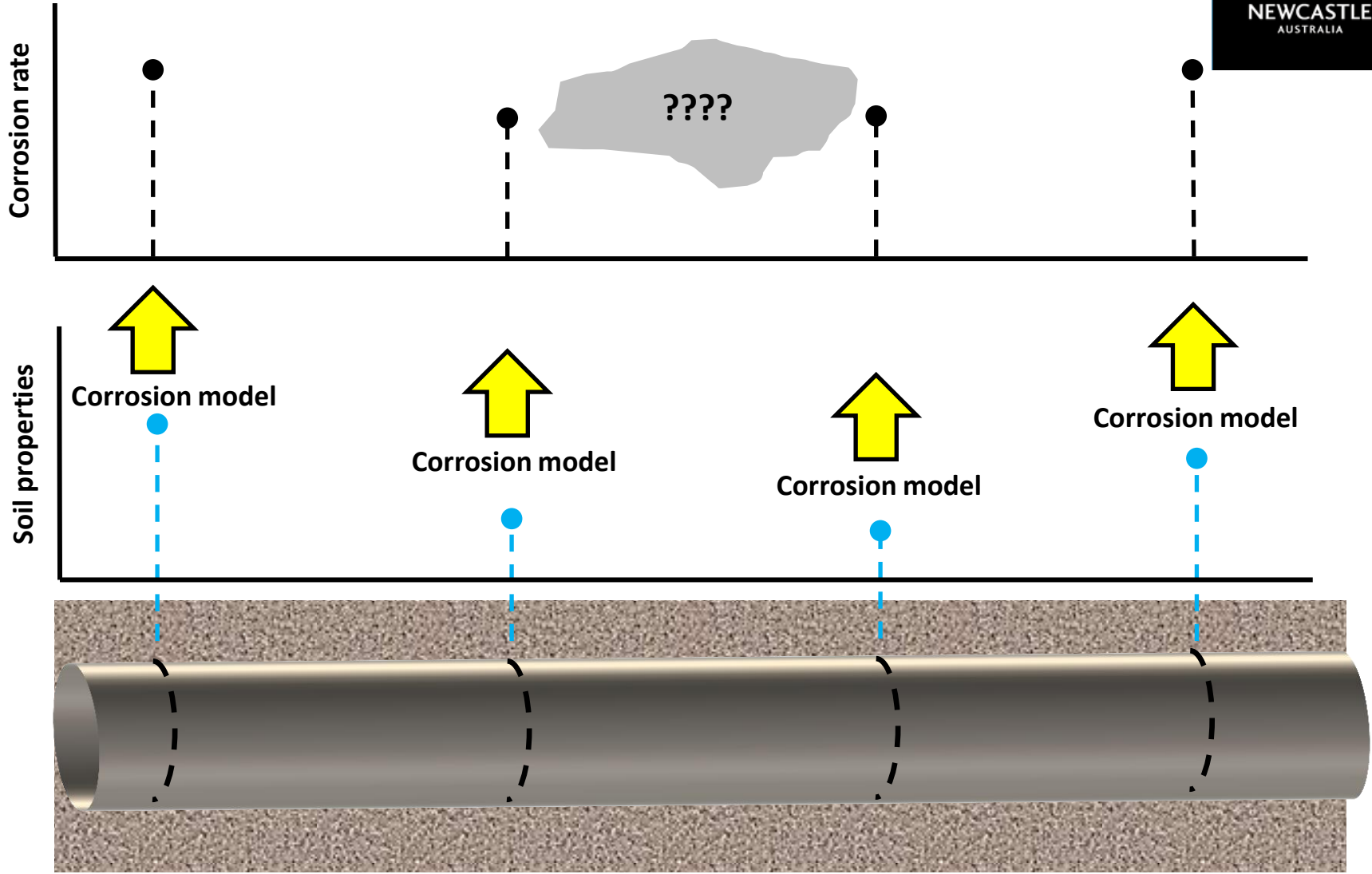


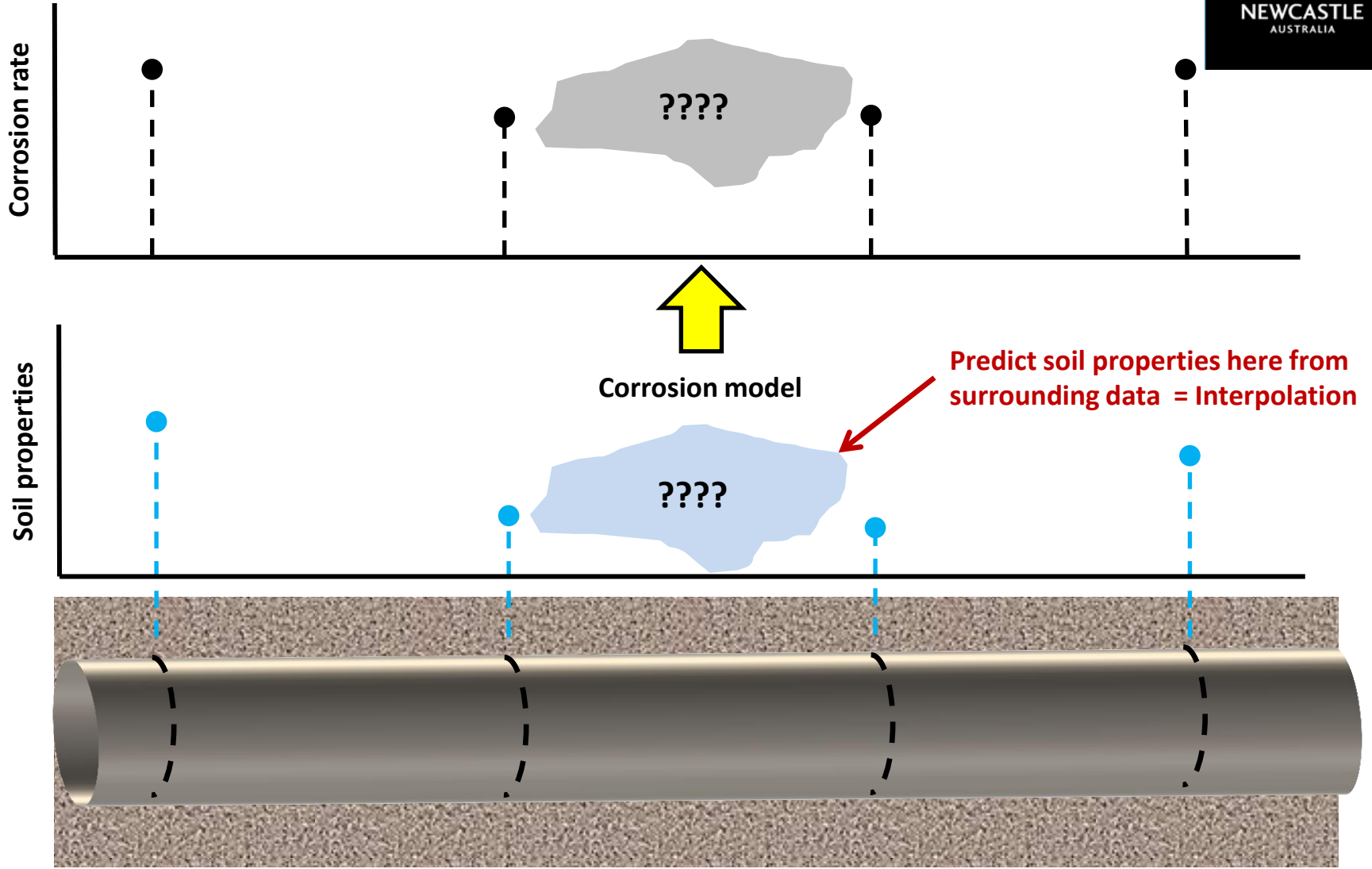
Activity 4c. Predicting pipe corrosion along the pipe

Activities

1. Identify soil properties that impact on buried cast iron pipe corrosion
2. Look at practicality of developing an advanced monitoring tool
3. Develop methods for predicting 'along the pipe' soil properties
4. Develop along the pipe corrosion model to predict present and future corrosion condition along the pipe

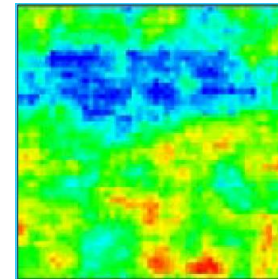






Predicting soil properties from a limited number of soil samples

- **Common problem in agriculture, environmental and geosciences**
 - as sampling costs are high -> more 'prediction' needed
- **More often done over a national or regional scale (1000-1,000,000 km²)**
 - Less often at catchment scale (1-100 km²)
 - Much less often at <paddock scale (1-100m² scale - our resolution)
- **Normally done over two dimensions (or sometimes 3)**
- **Our scale < 0 - 1000m (1D)**



Predicting soil properties from a limited number of soil samples

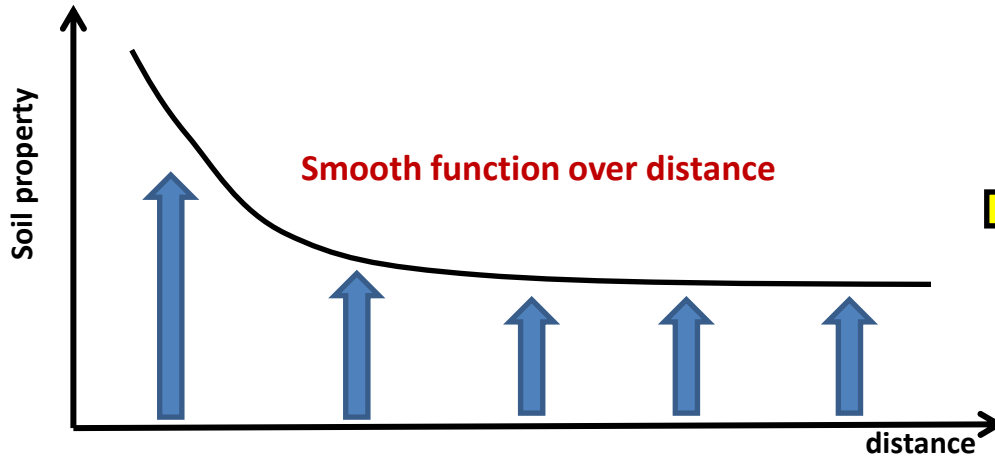
Issues:

- (a) At what spacing do we need to do our sampling?**
- (b) How much of surrounding data to use when predicting unknown?**
- (c) Best method of interpolation (simple average, join the dots, polynomial, IDW, Kriging..)**

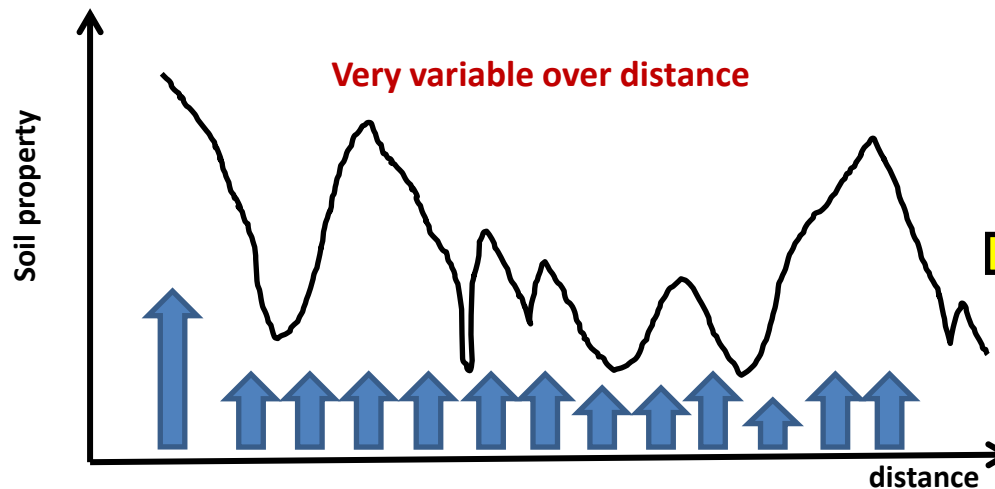
The answer to all 3 questions depends on:

- a) The nature of the data and how it varies over distance (the ‘spatial structure’ of the data)**
- b) The requirements of the corrosion model
(i.e. what is the acceptable uncertainty in final corrosion prediction)**

Why is spatial structure of data important?



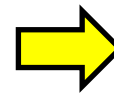
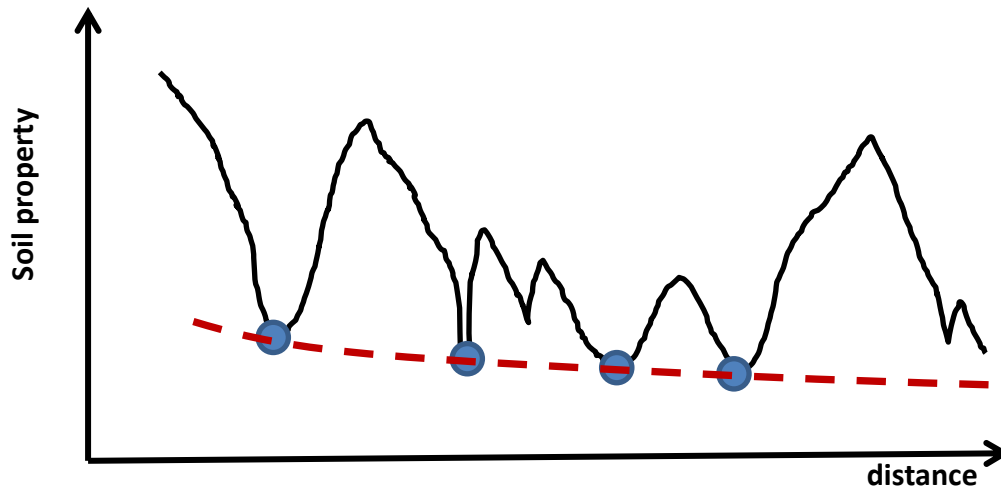
Less samples needed (greater spacing)



More samples needed (less spacing)
or
Greater uncertainty in prediction of values between samples

Why is spatial structure of data important?

Very variable over distance



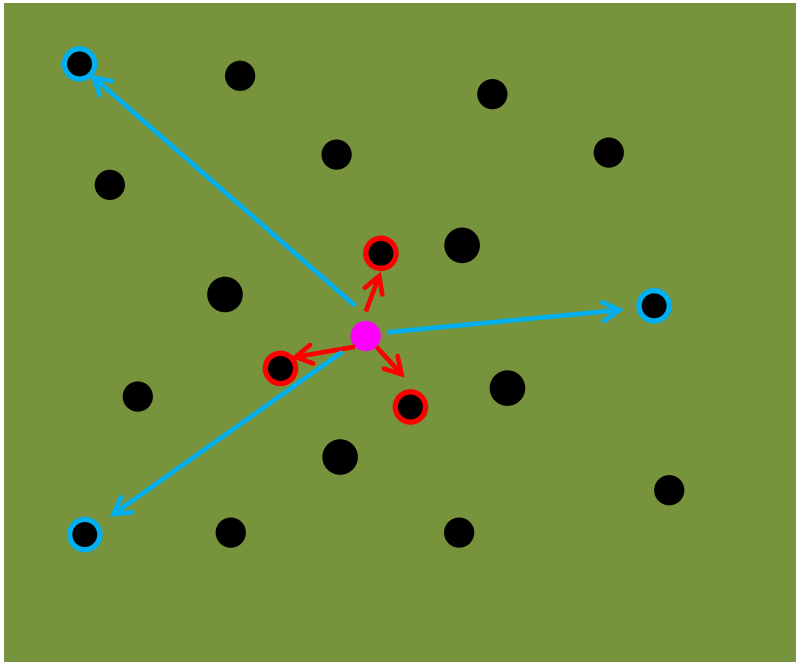
Low number of samples



Completely wrong picture of what is going on

How can we characterise spatial structure?

One method sometimes used in soil science is the variogram

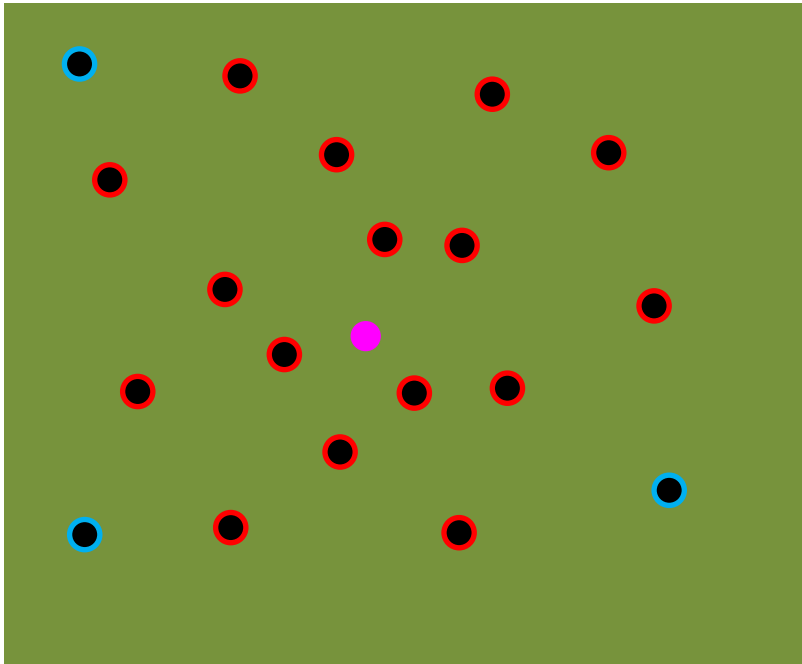


Pts nearby on average:

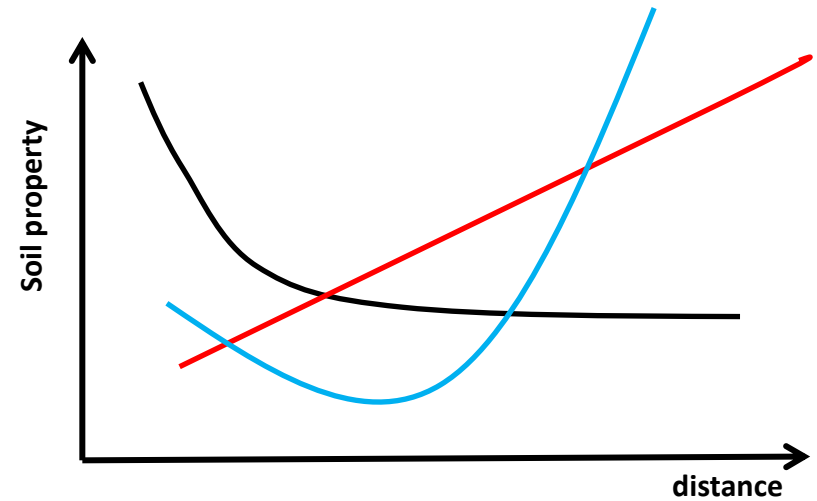
- tend to have similar values
- follow similar trends over time
- are said to be better correlated

Pts far away on average:

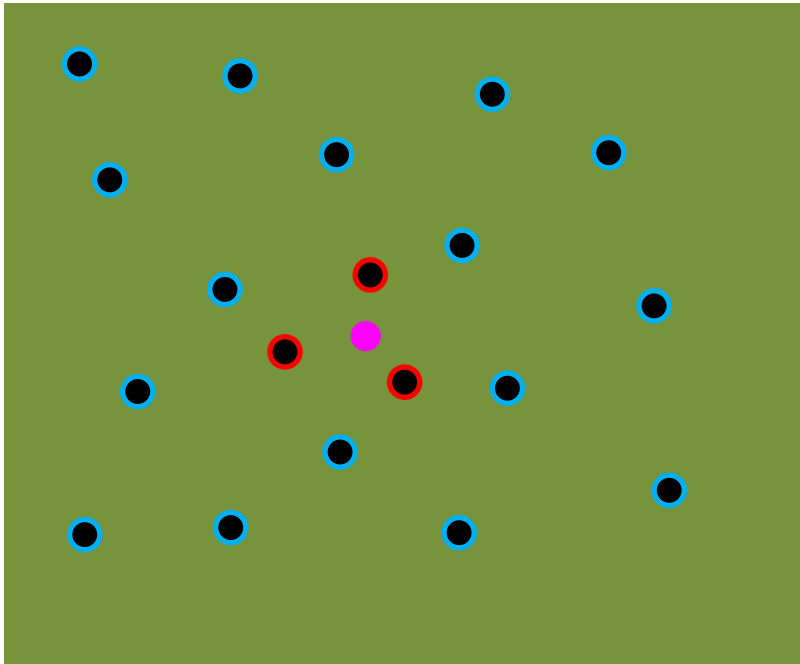
- tend to have less similar values
- less likely to follow similar trends over time
- are said to be more poorly correlated



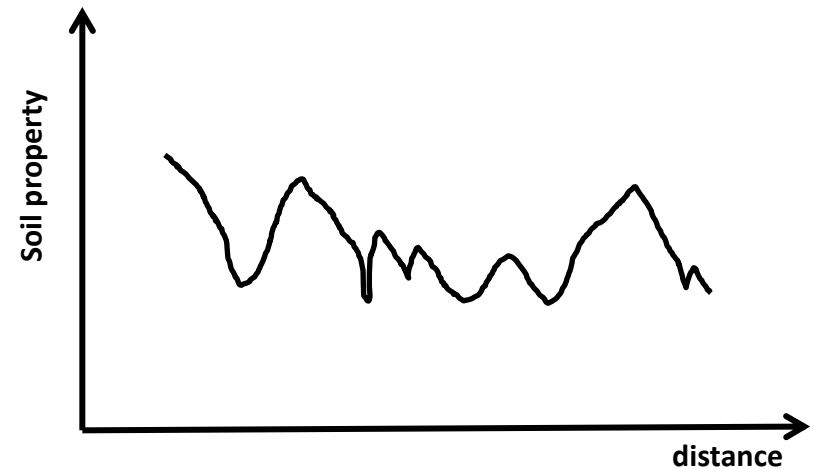
In some systems the distance over which points are correlated can extend a long way



These structures lend themselves well to prediction of values between measured points

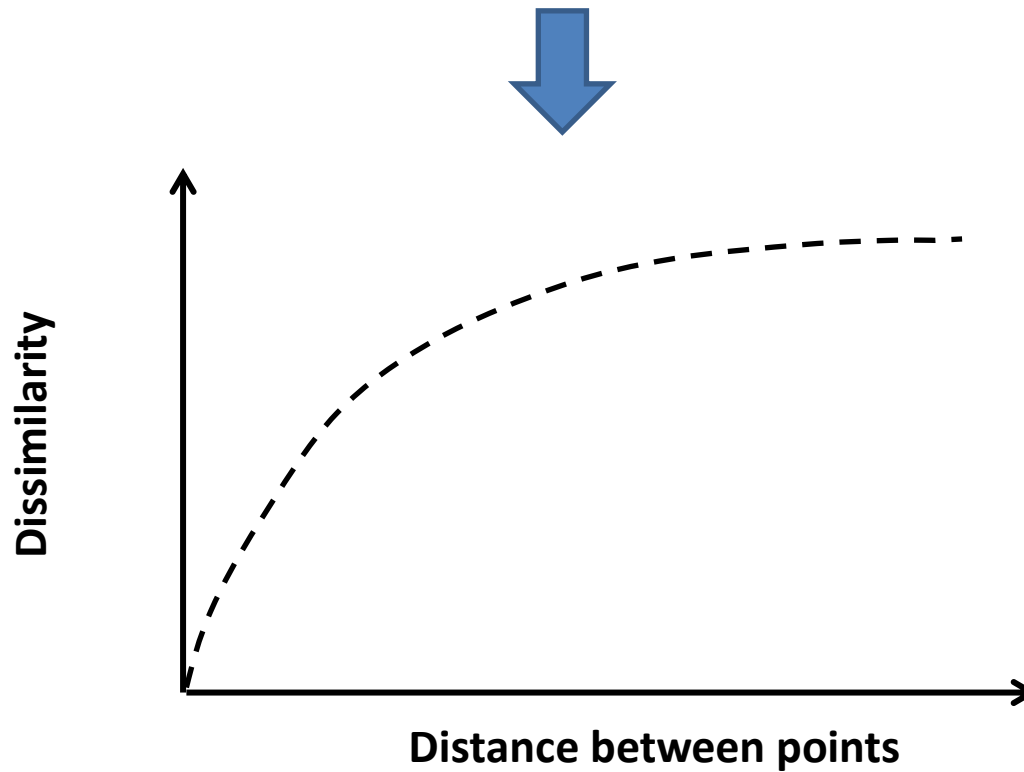


In some systems the distance over which points are correlated is only very short



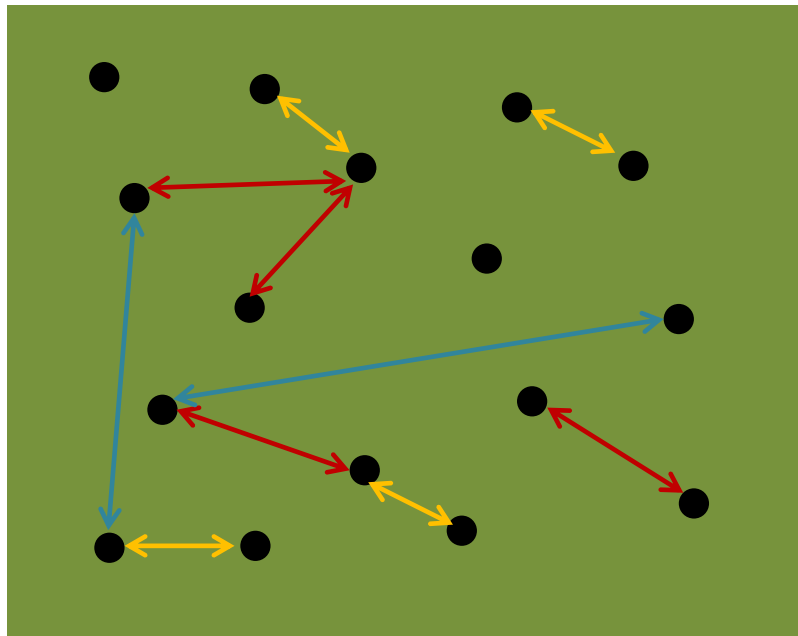
These structures do not lend themselves well to accurate prediction of values between measured points




- For any system we would expect the following general trend:



In soils analysis such plots are often used to characterise correlation or organisation of soils data over distance

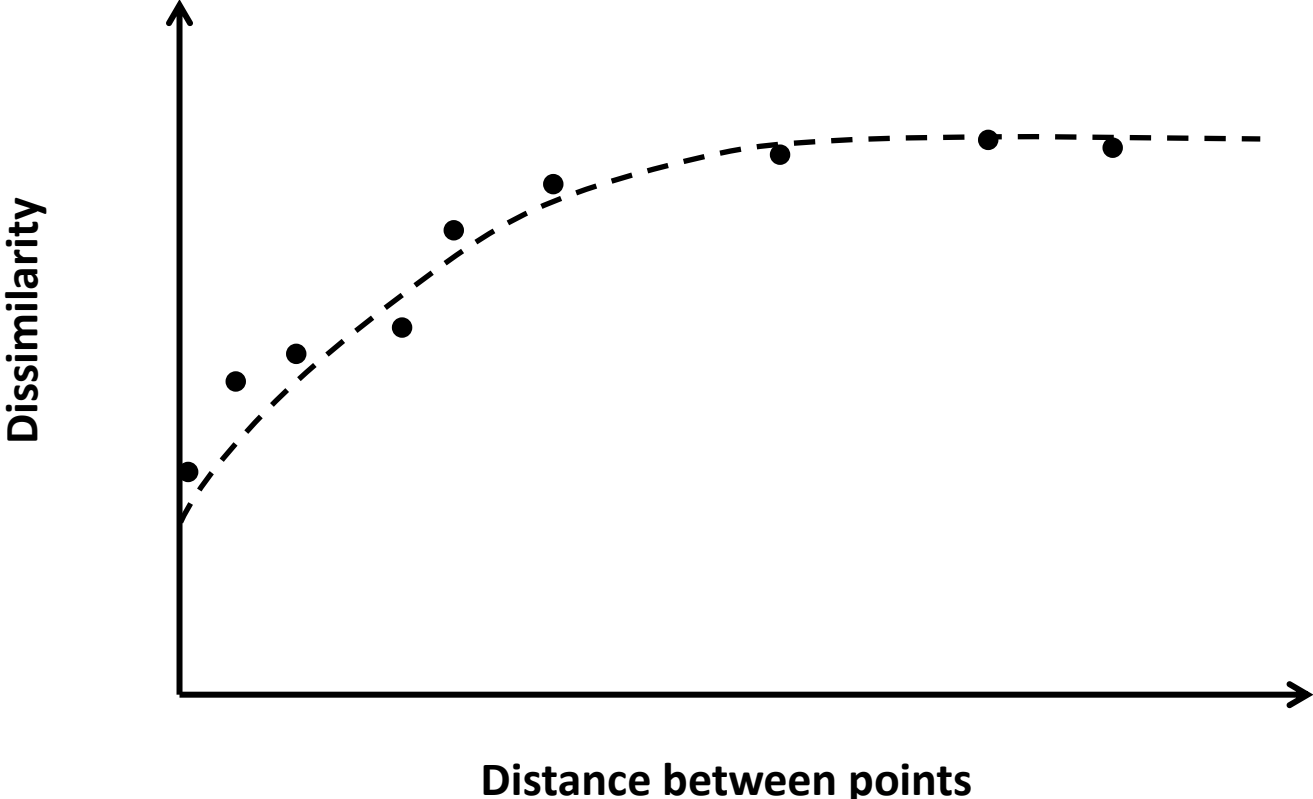
All pairs of points looked at and differences in values plotted against distance between points



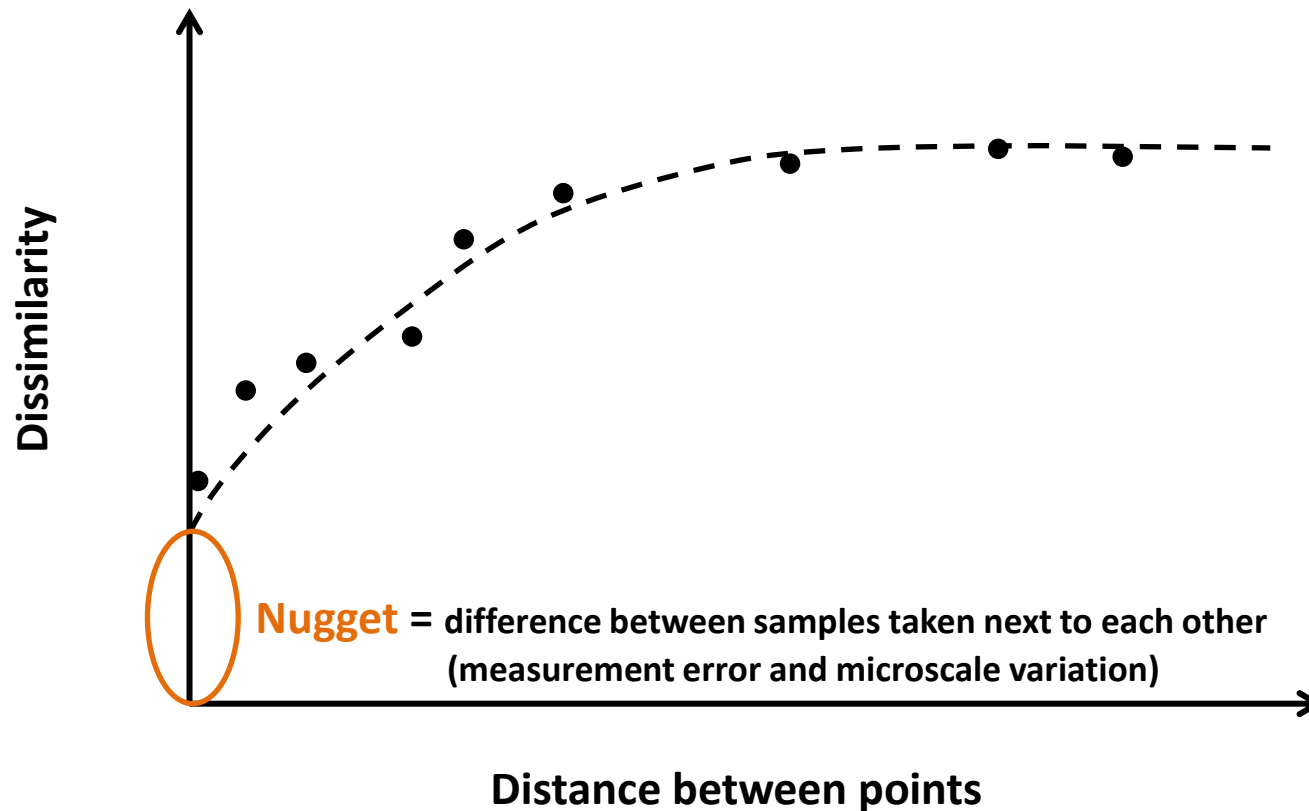
	separation	Av Δ
	10m	5.2
	20m	10.3
	50m	12.6

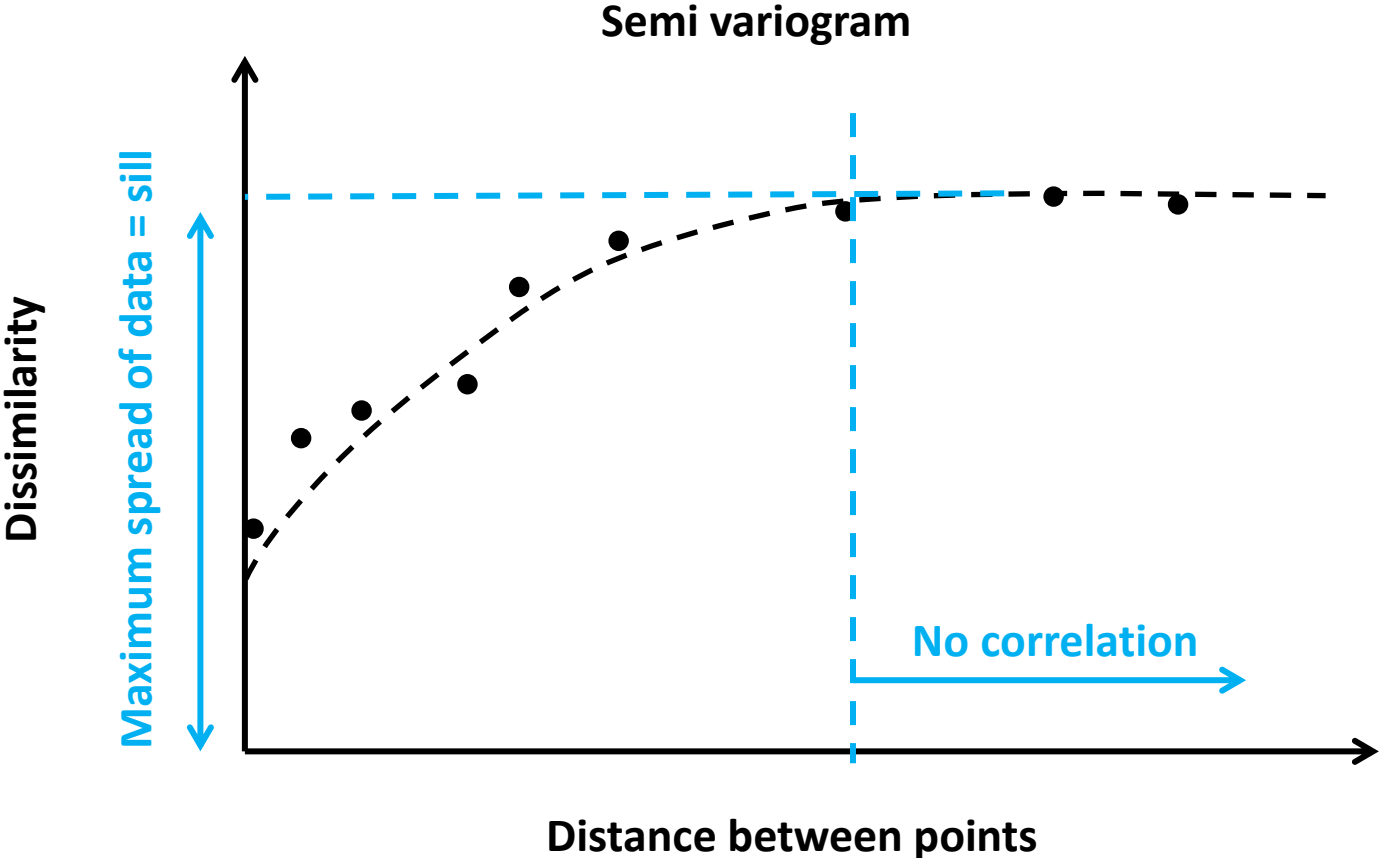


Semi-variogram



Semi variogram



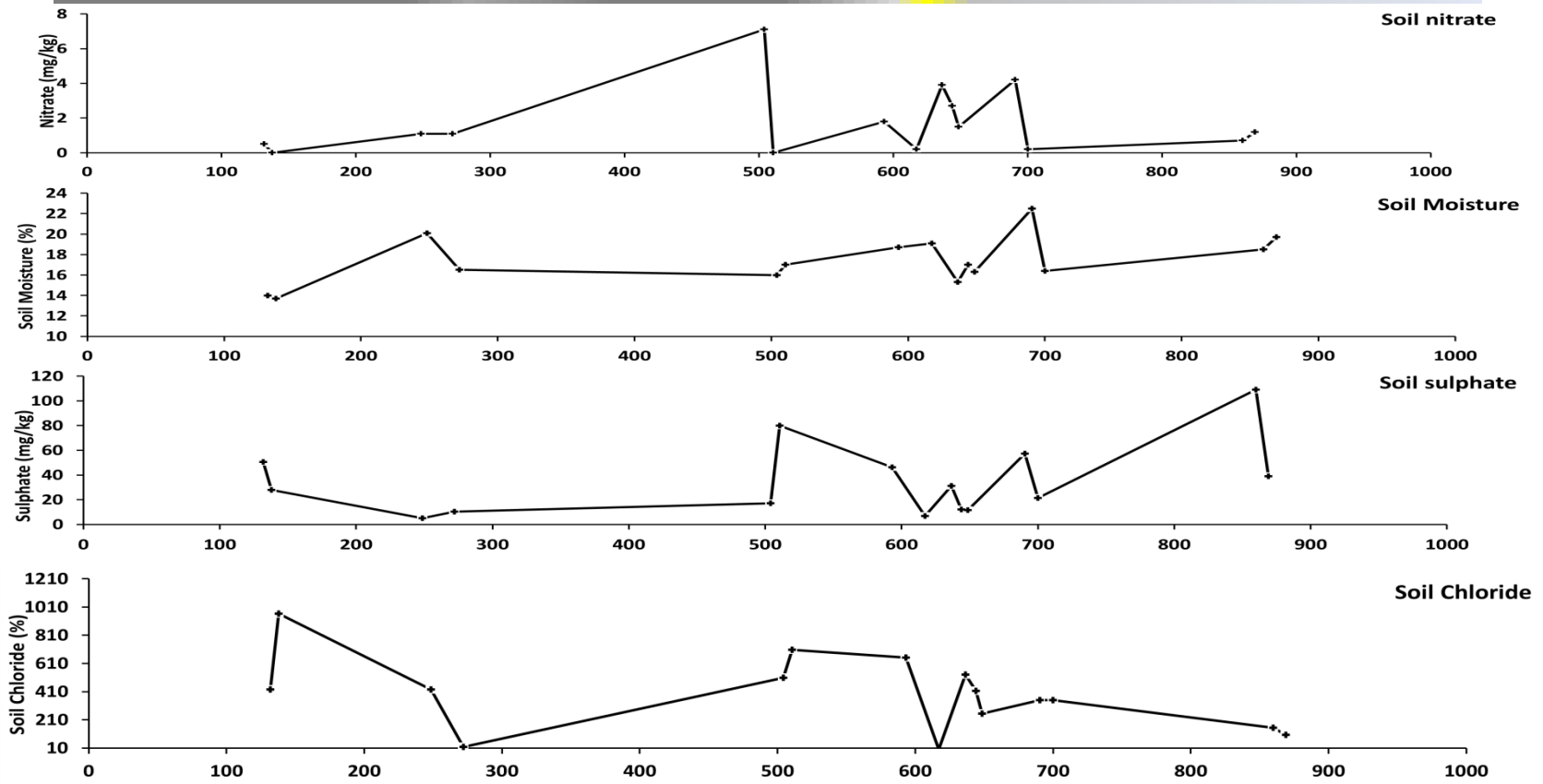




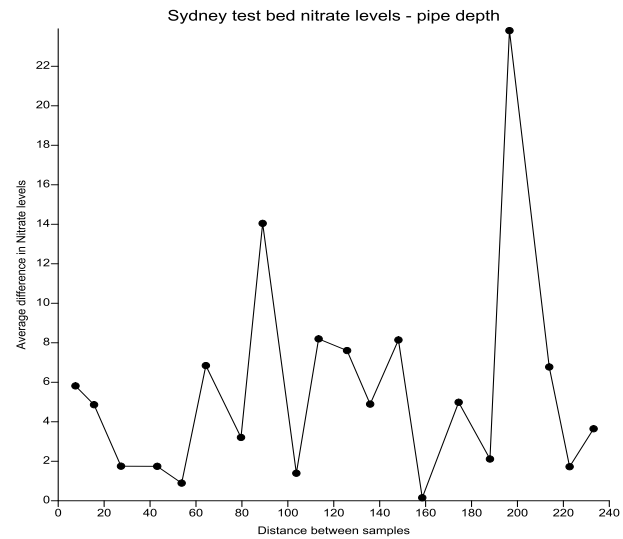
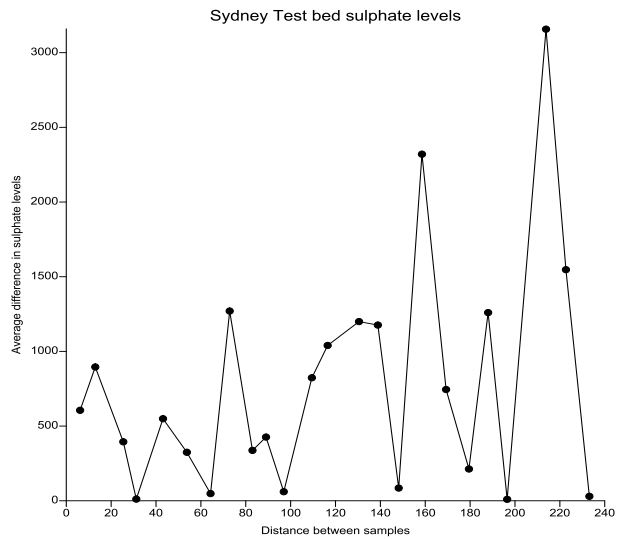
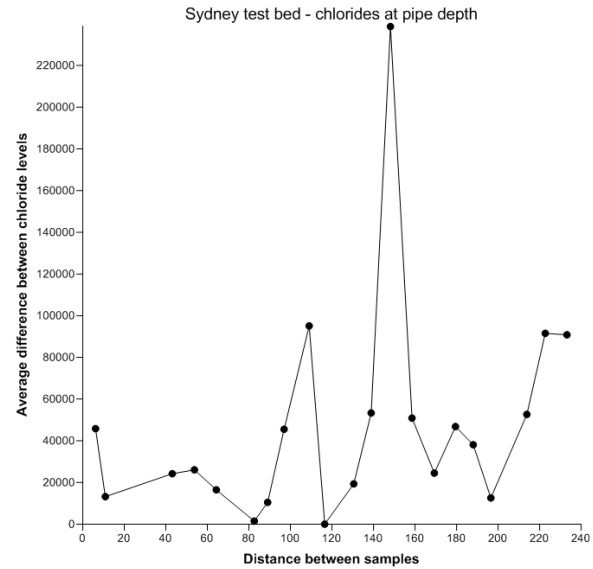
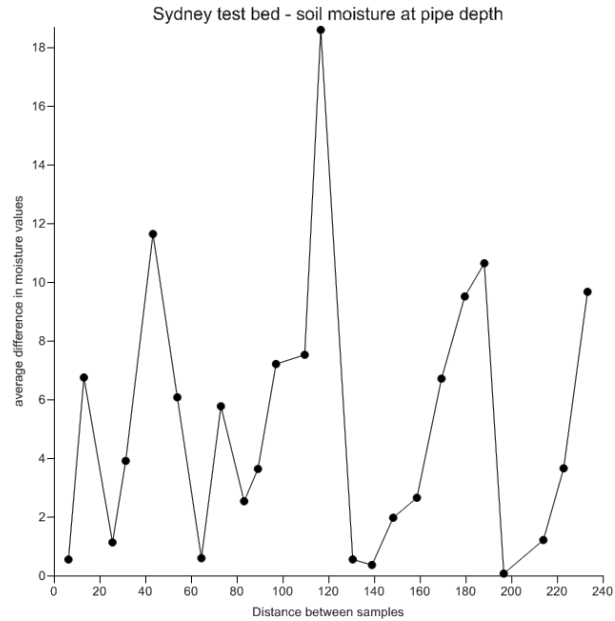
Spatial structure of our soil data

Lets look at some relevant soil properties along the Verona St test bed in Sydney

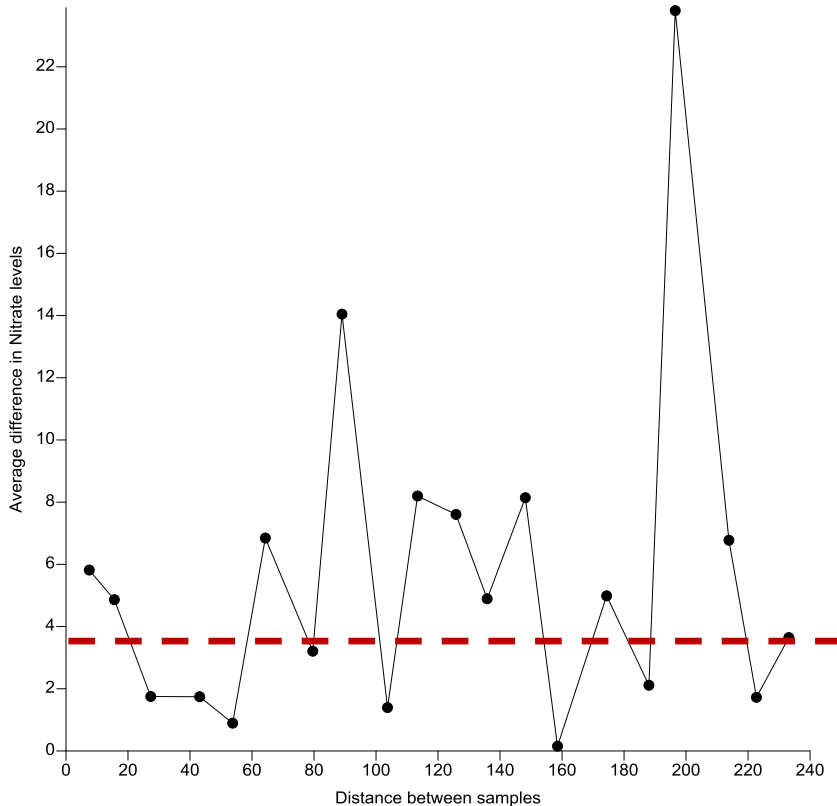
- **Soil moisture**
- **Soil nitrate**
- **Soil chloride**
- **Soil sulphate**



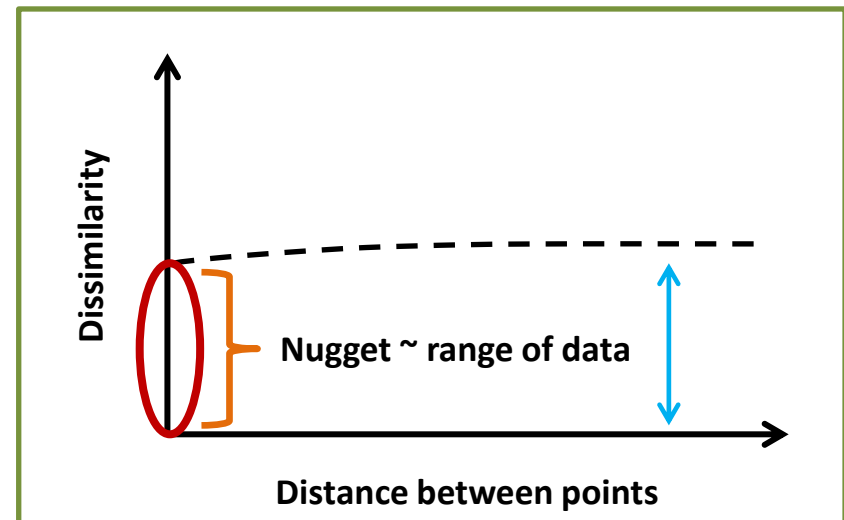
Average sampling distance = 56m (min=4.6, max=232)



Sydney test bed nitrate levels - pipe depth



- Data a bit 'lumpy' (few points)
- but no obvious increase in difference with increase in separation distance
- Data = some average + noise (microscale variation + measurement error)
- Nugget \sim same as overall range of values



- Data suggests that at the resolution the test bed was sampled (min 4m; av 55m):
 1. soil properties show little correlation (i.e. are independent)
 2. micro-variation in soil property + measurement error is large compared to range of values present

These are preliminary findings only.....

We can verify the level of microscale variation and/or reproducibility by:

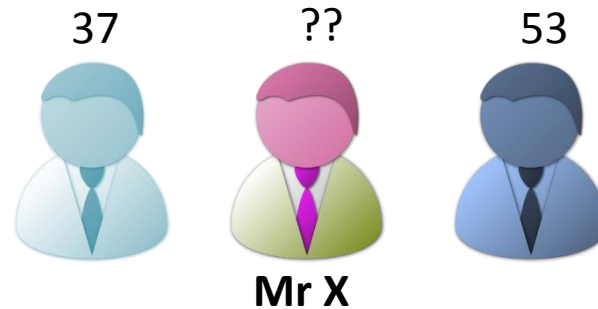
1. Analysis of very fine resolution sampling (microscale variation)
2. Analysis of replicate samples (measurement uncertainty)

Plan to do this from samples taken from trenches dug for SM monitoring of test bed

Also plan to look at results from Perth soil sampling to see if similar trends emerge (sandy soils may show different spatial trends)

What are the implications for the prediction of 'in-between' soil properties if conclusions remain the same?

When neighbouring samples are uncorrelated (independent) the situation is like trying to predict age of someone from ages of people sitting next to him/her at the same table.

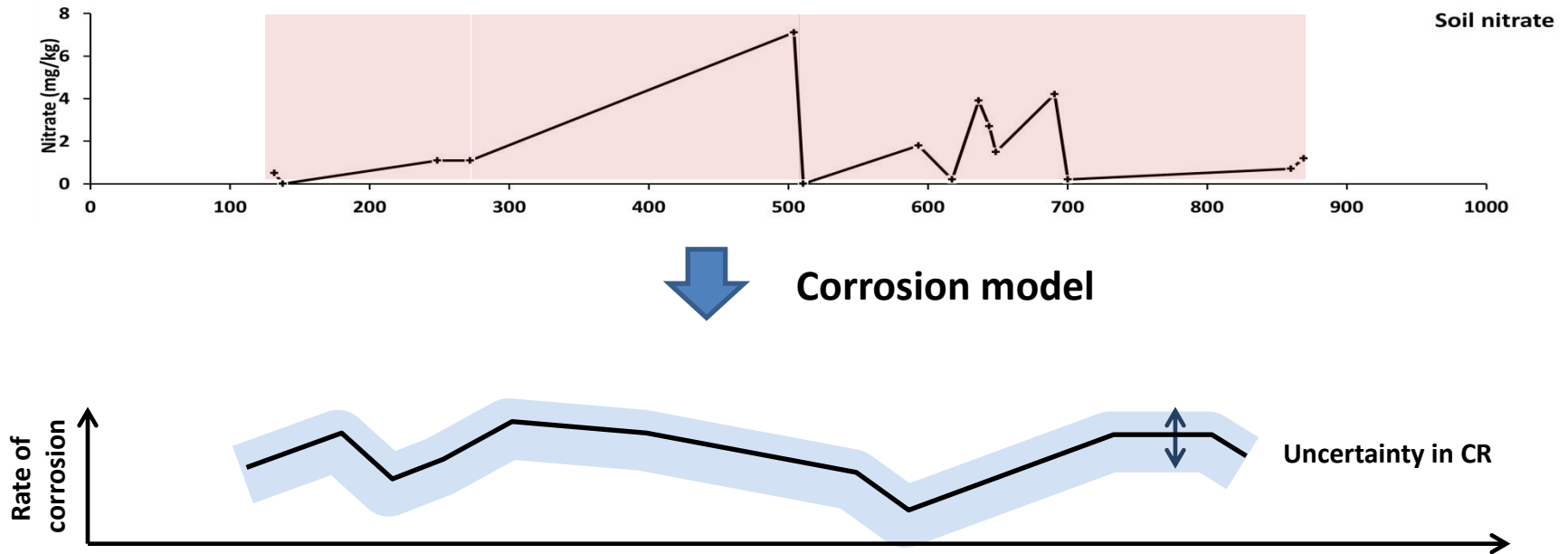


Can't directly predict that Mr X's age by interpolation of surrounding ages.

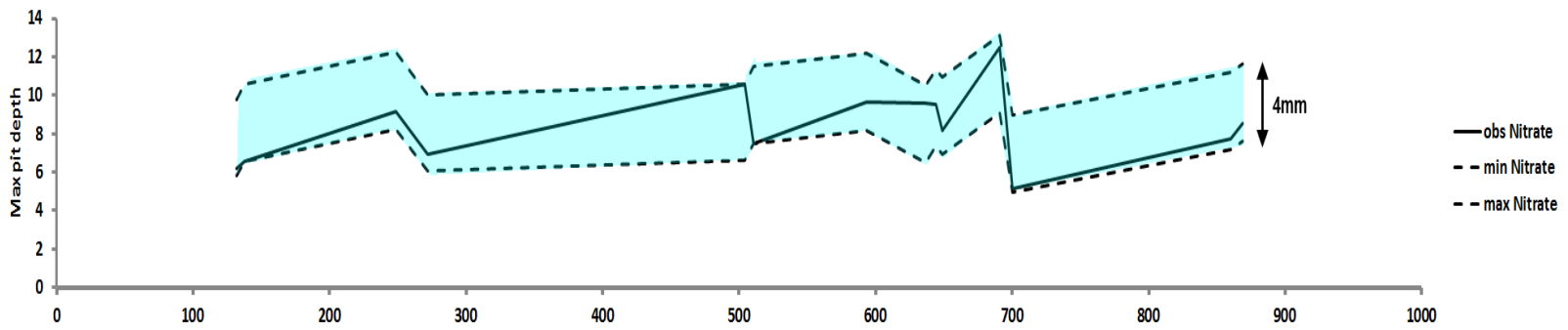
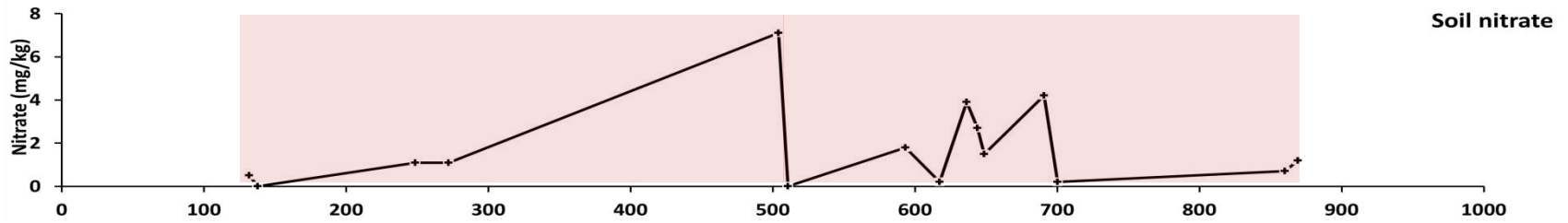
But can estimate age range of Mr X by looking at all the ages of the people in the room

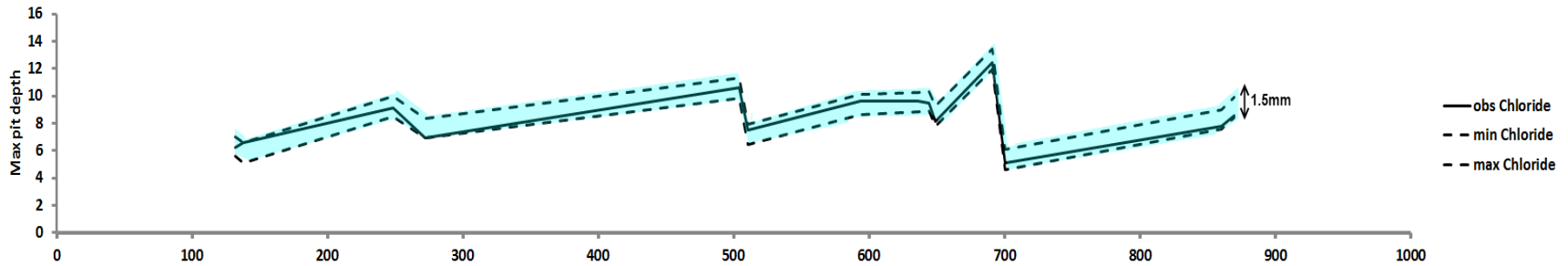
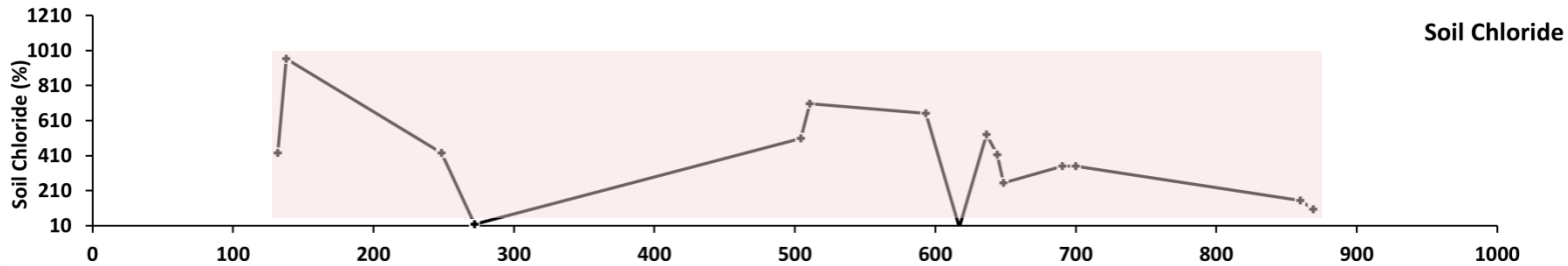
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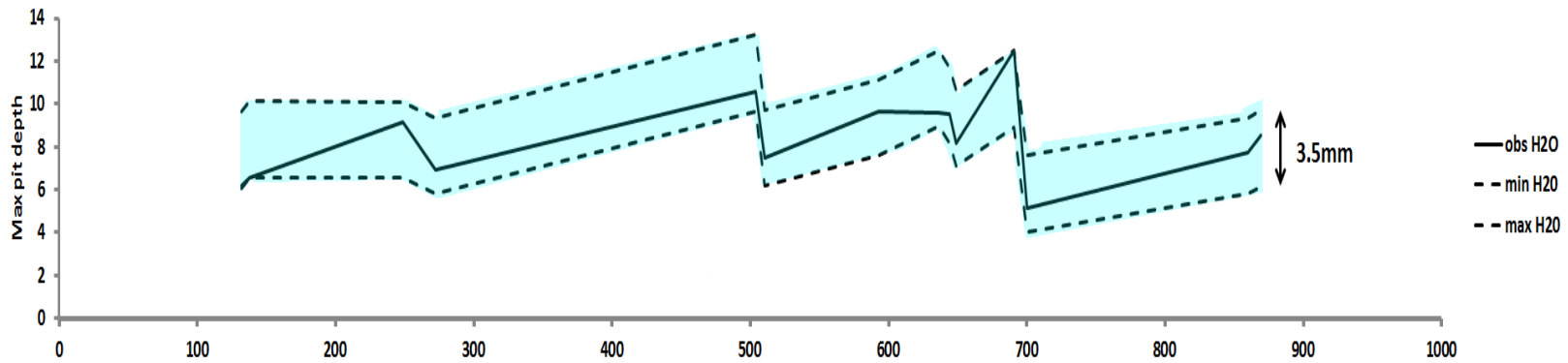
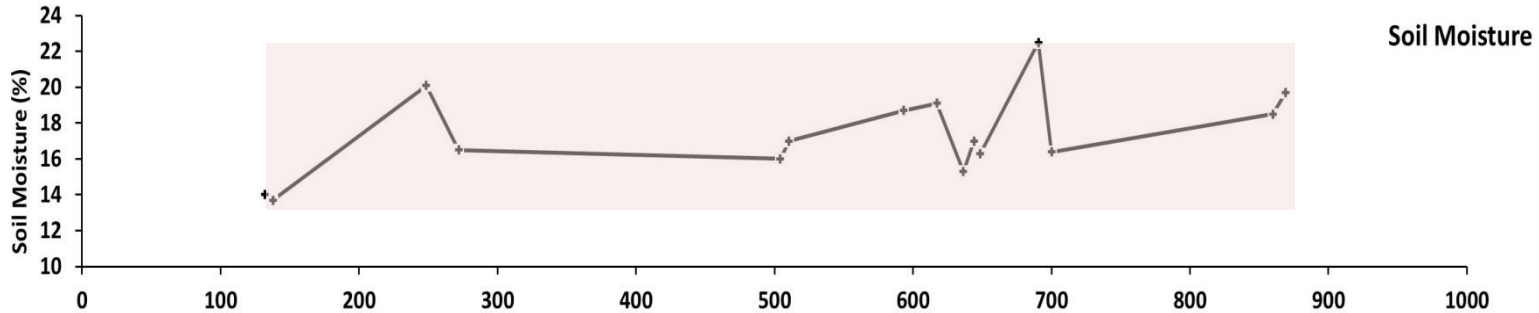
We can do a similar exercise here for soil properties (again using nitrate as an example)



Note – more samples are still a help as they allow for us to be more certain of the range



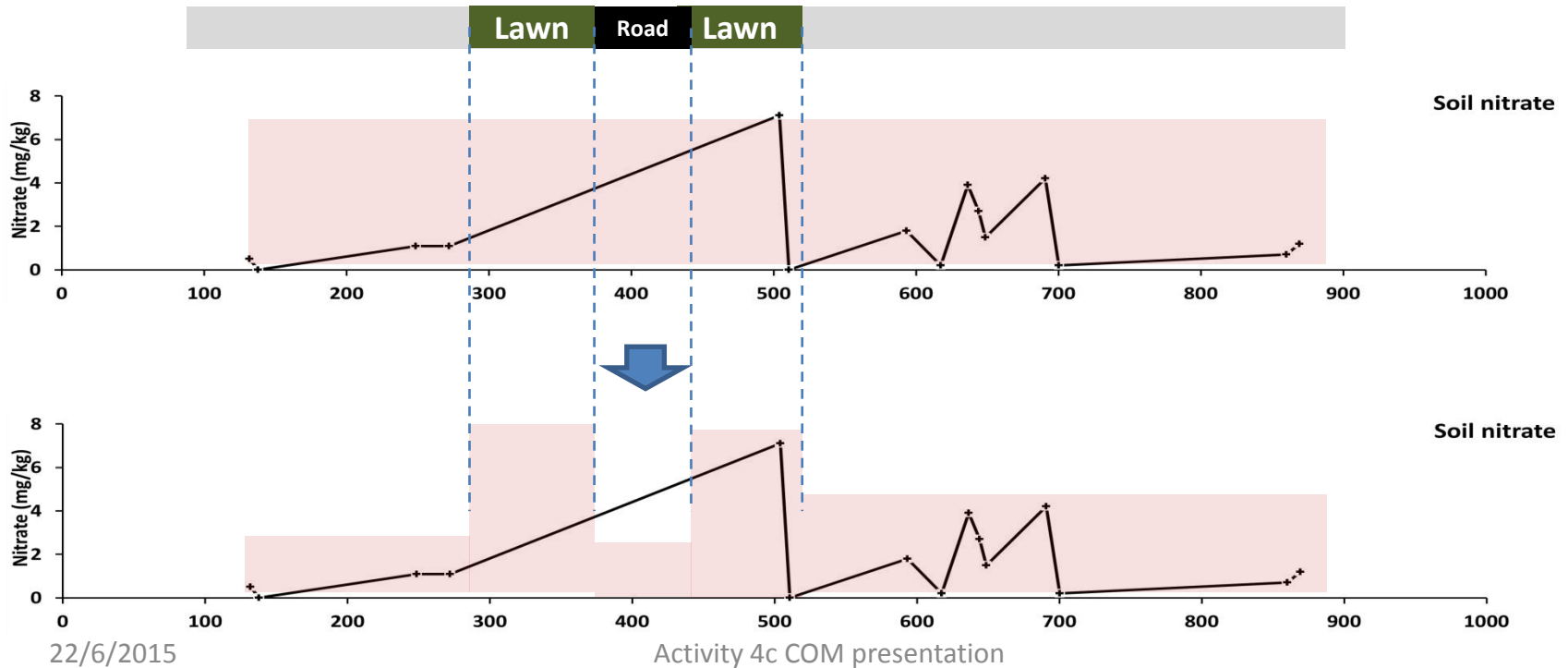




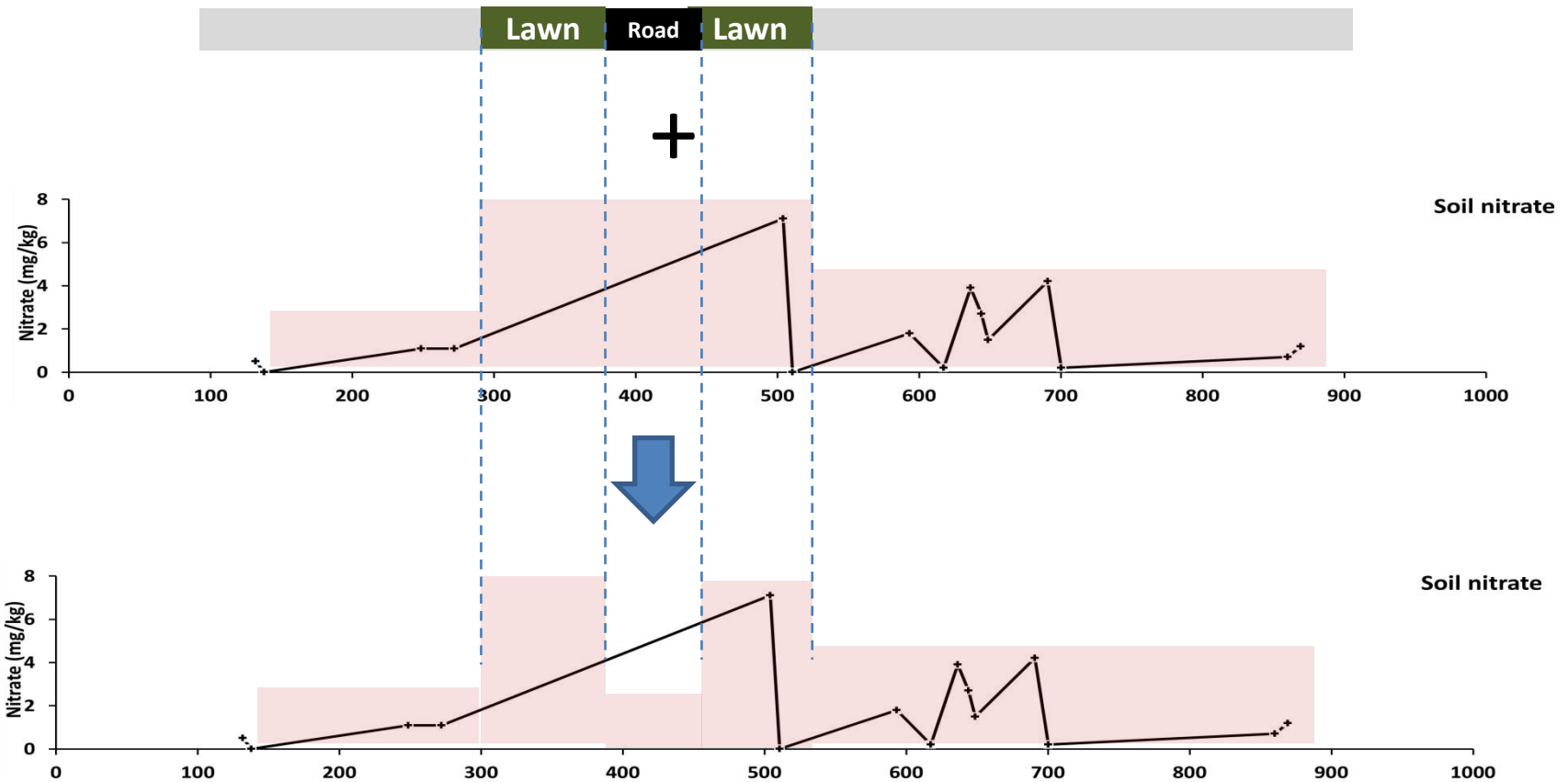
What are the implications for the prediction of 'in-between' soil properties if conclusions remain the same?

This approach is crudest (and most conservative) as it with the highest uncertainties especially when uncertainties from all factors are added together.

Will see if we can overlay additional information to help narrow our estimation



2. See if we can overlay additional information to help narrow our estimation



Future Plans

More fine resolution sampling of Verona St test bed to verify the level of microscale variation and/or reproducibility by:

- 1. Analysis of very fine resolution sampling (microscale variation)**
- 2. Analysis of replicate samples (measurement uncertainty)**

Look at Perth soil sampling results to see if similar trends emerge (sandy soils may show different spatial trends)

Go over precision ag literature to see if there is any data that can shed light on

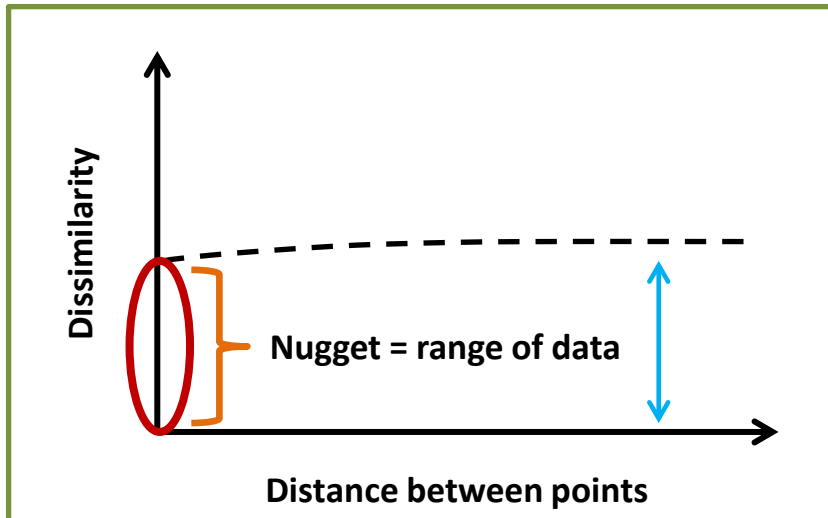
- (a) Spatial structure of soil chem at v. high resolution**
- (b) Factors we can introduce to narrow down our estimations of soil properties**

Also should start seeing results from soil moisture sensors in test bed



The End

Precision agriculture studies of N distribution:



Depth	Nugget%	ref
0.05m	30-100%	1
0-0.15m	85% (correlation range <5m)	2
0.3-0.6m	100%	3

- **Conclusion nitrate likely to vary significantly over very short spatial ranges**
- **How short a distance?? From data probably <5-10m (but this needs to be verified)**

1- (corn cropping + claypan - Ghidey, J. Enviro quality, 1999)

2- (maize cropping, Cahn, SSSAJ 1994)

3- (apple orchard –Aggelopoulo, Precision agriculture 2011)