Open systems –risks to foundations

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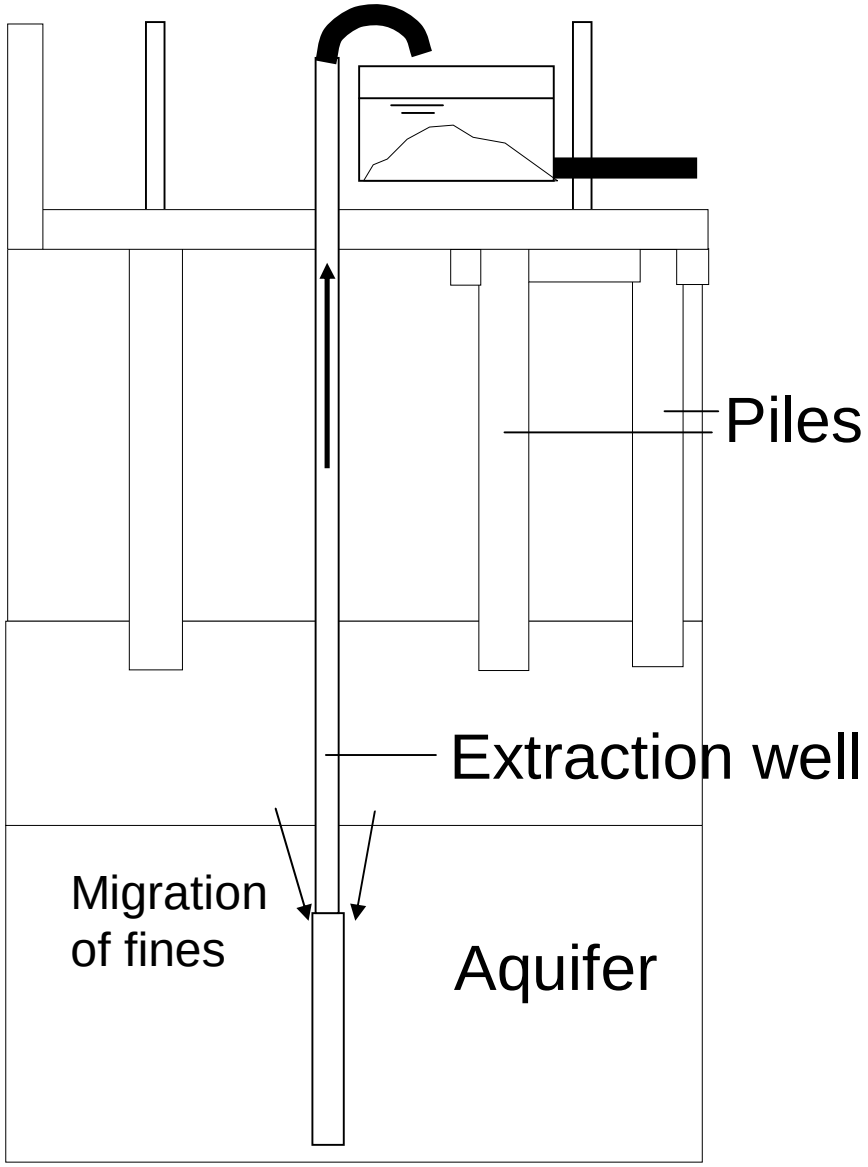
Contents

Introduction to issues

Issues to consider:

- How will the well be constructed?
- How will the volume of material extracted (fines) during the operation of the open system impair the bearing capacity of the building's foundations?



1. Well construction - Summary

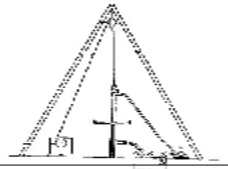
Rotary, direct circulation

Issues to consider:

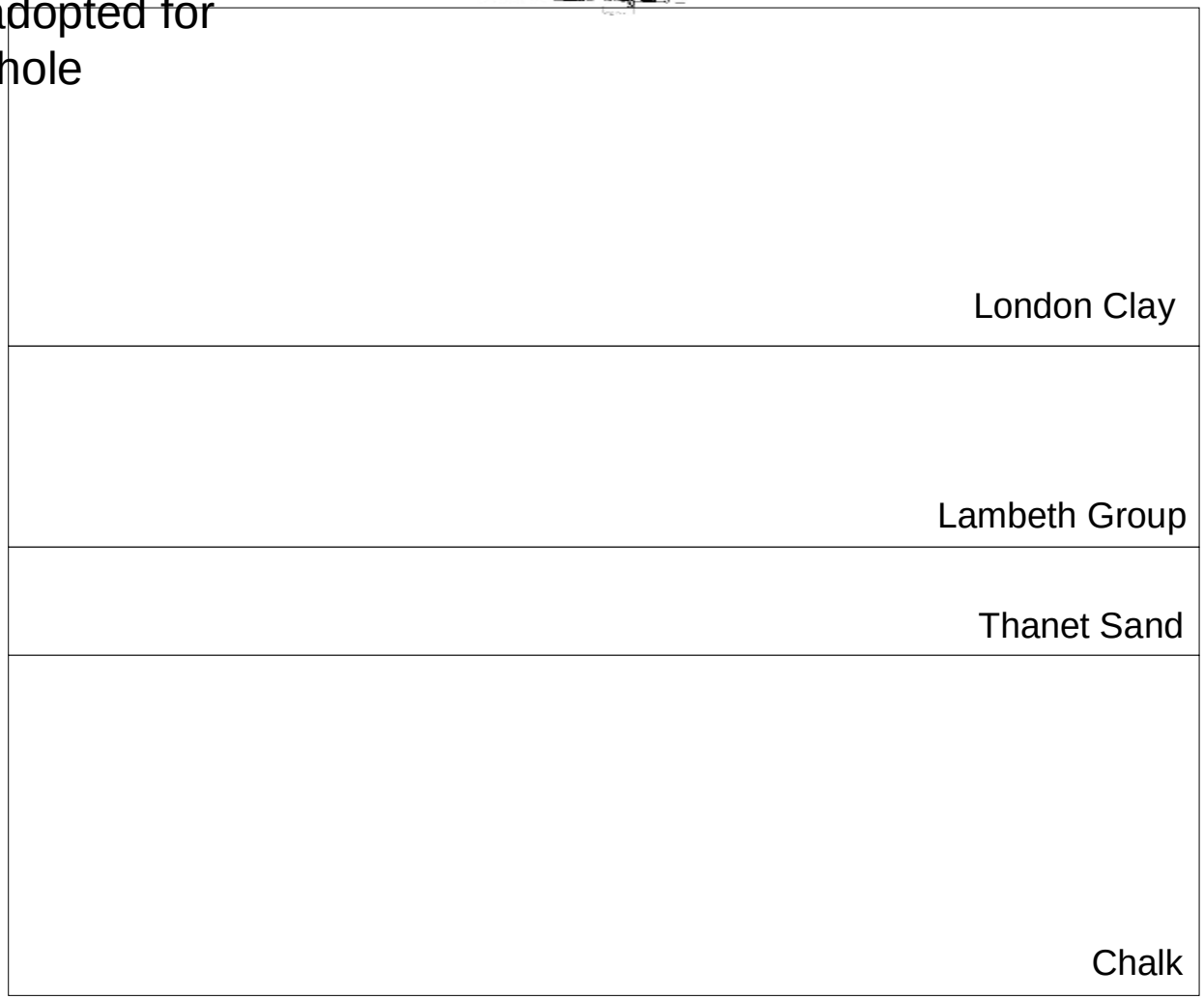
- Well construction method
- Position of wells relative to piles
- Grouting of casing

1. Well construction

Step 1: Set up drilling rig



Rotary direct circulation commonly adopted for drilling borehole

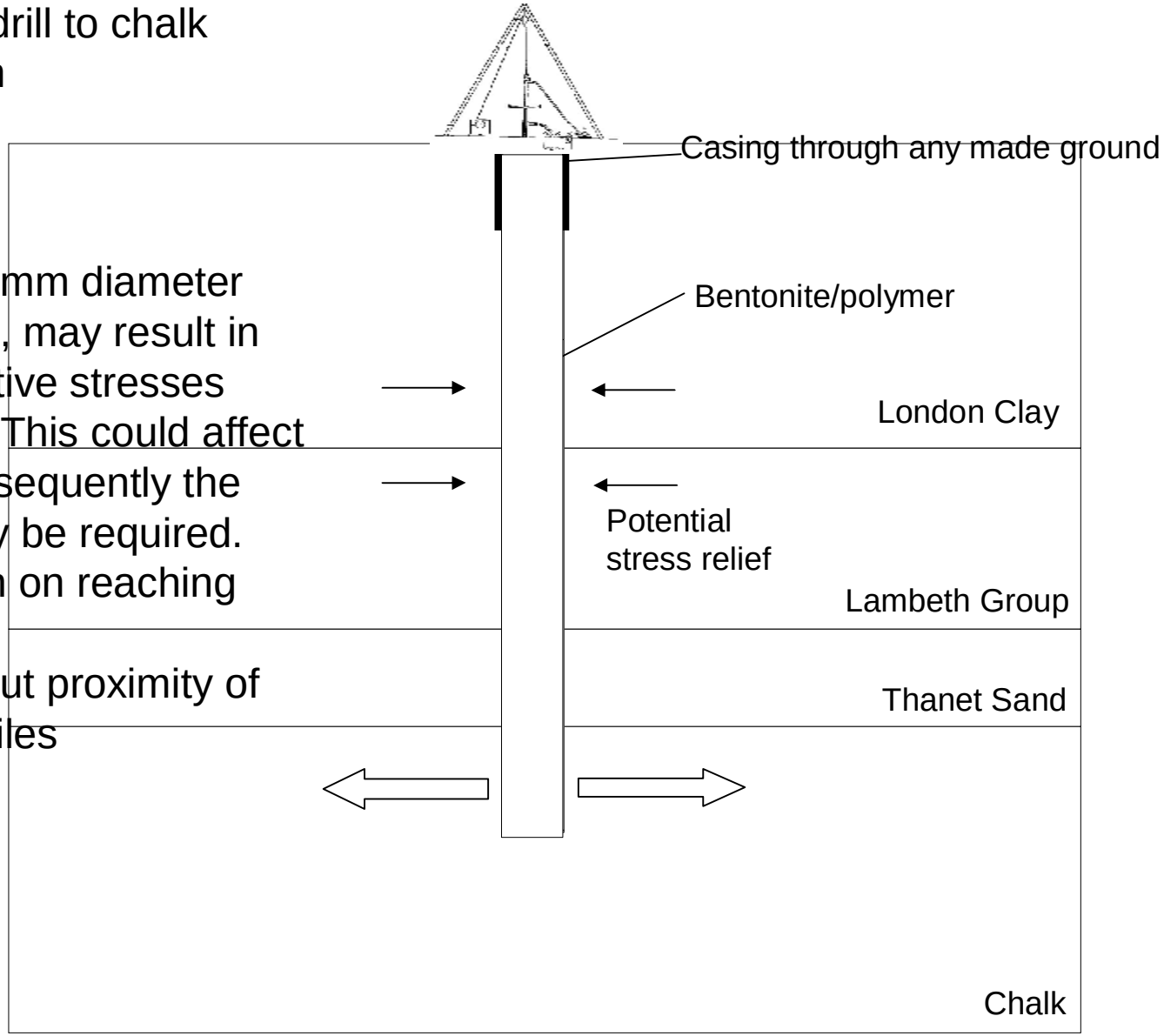


1. Well construction

Step 2: Open hole drill to chalk supporting hole with bentonite/polymer

Notes:

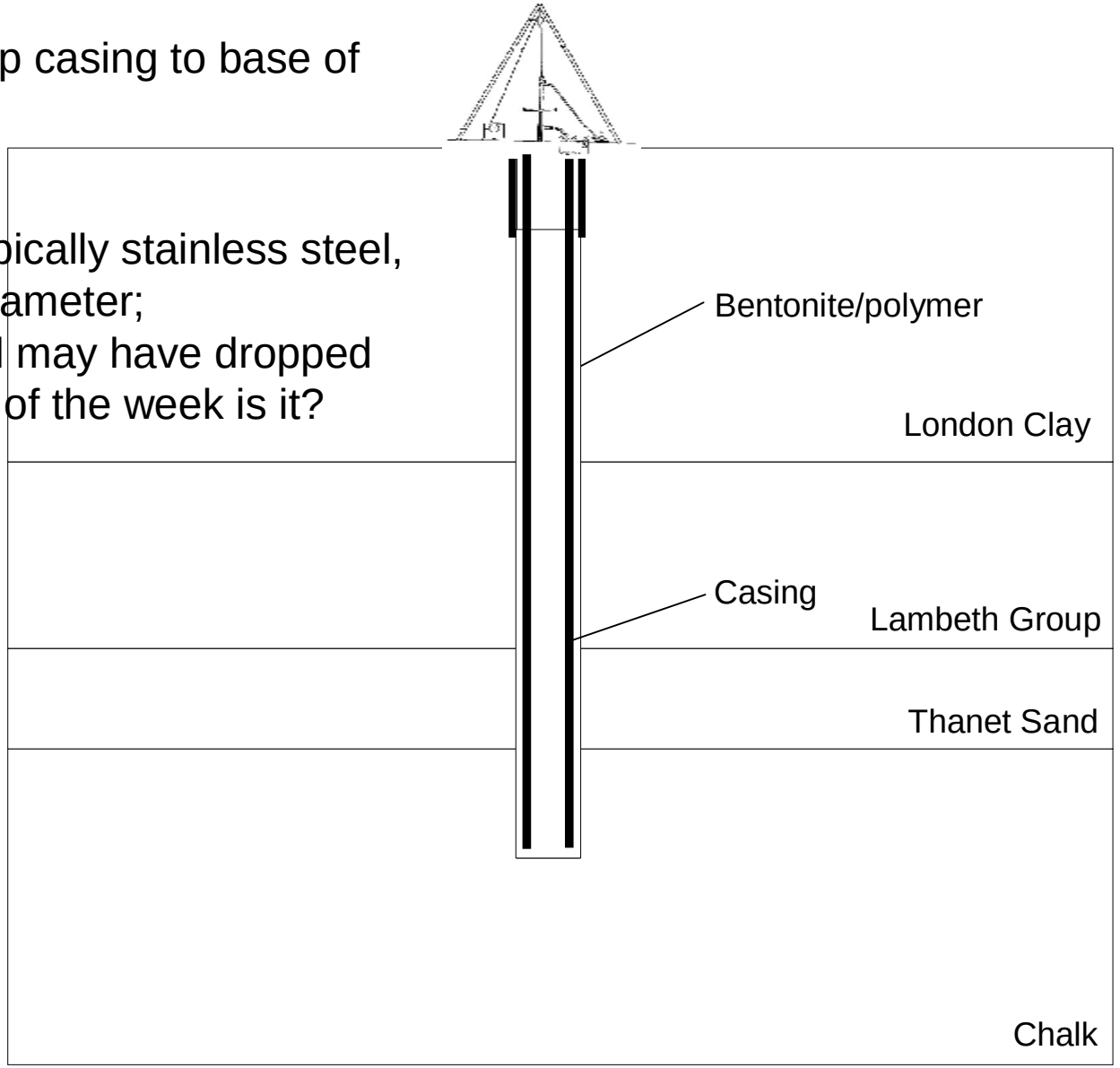
- Hole typically 400mm diameter
- If casing not used, may result in reduction of effective stresses close to the hole. This could affect pile capacity, consequently the use of casing may be required.
- Loss of circulation on reaching the Chalk
- Need to think about proximity of well to adjacent piles



1. Well construction

Step 3: Drop casing to base of hole

Notes:
- Casing typically stainless steel, 300mm diameter;
- Fluid level may have dropped
- What day of the week is it?

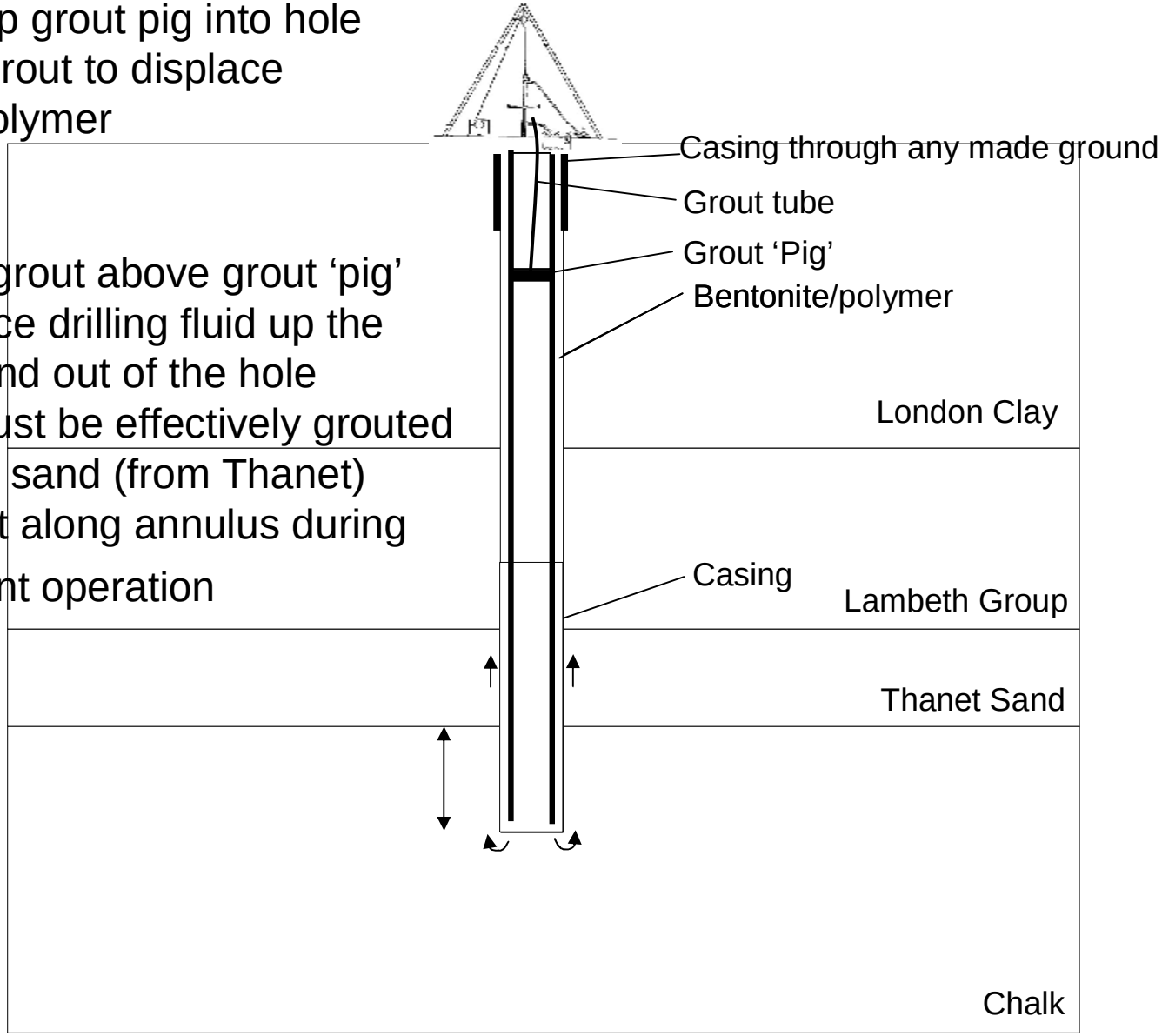


1. Well construction

Step 4: Drop grout pig into hole and pump grout to displace bentonite/polymer

Notes:

- Pumping grout above grout ‘pig’ will displace drilling fluid up the annulus and out of the hole
- Casing must be effectively grouted to prevent sand (from Thanet) movement along annulus during subsequent operation



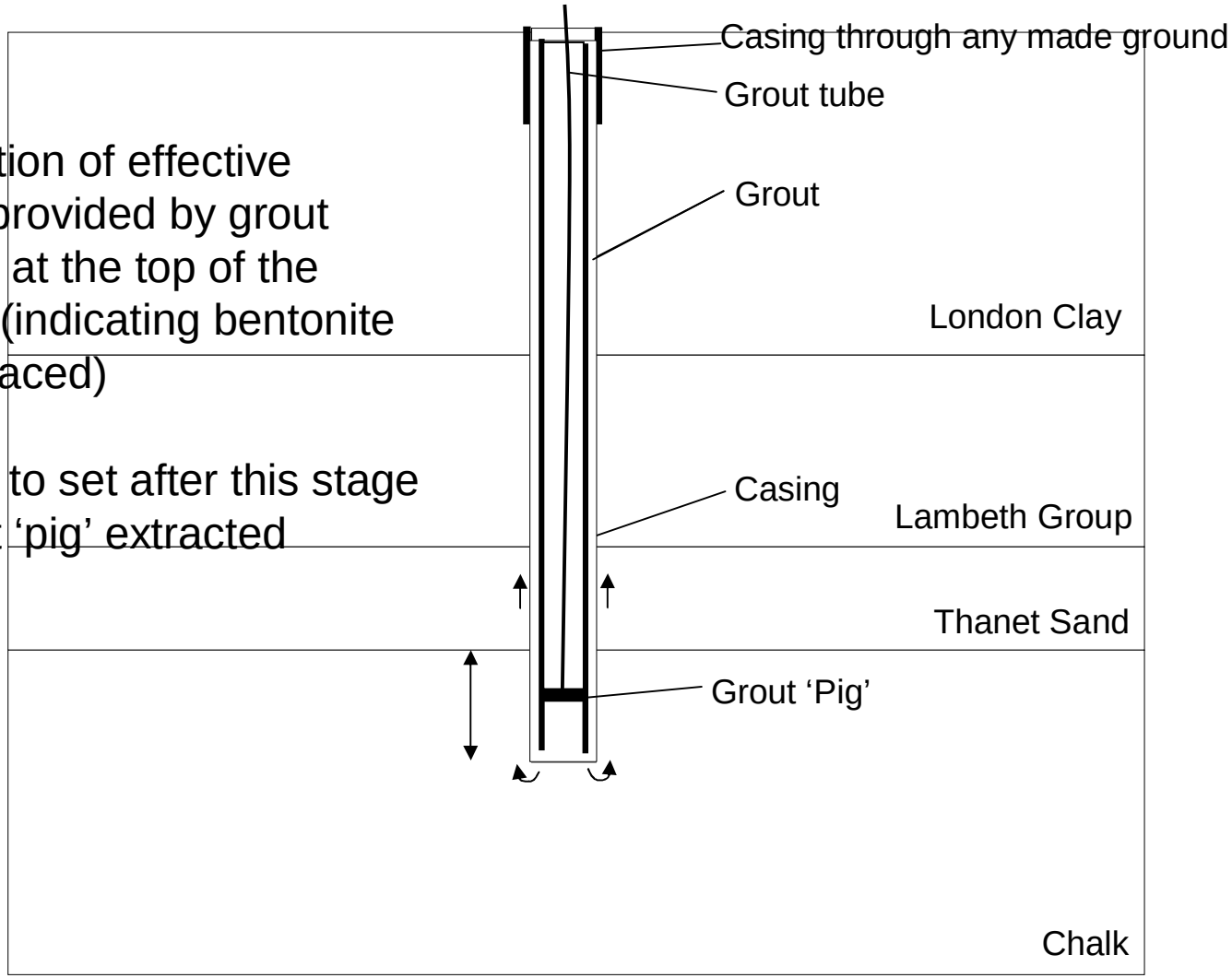
1. Well construction

Step 5: Drive grout “pig” down hole to displace grout

Notes:

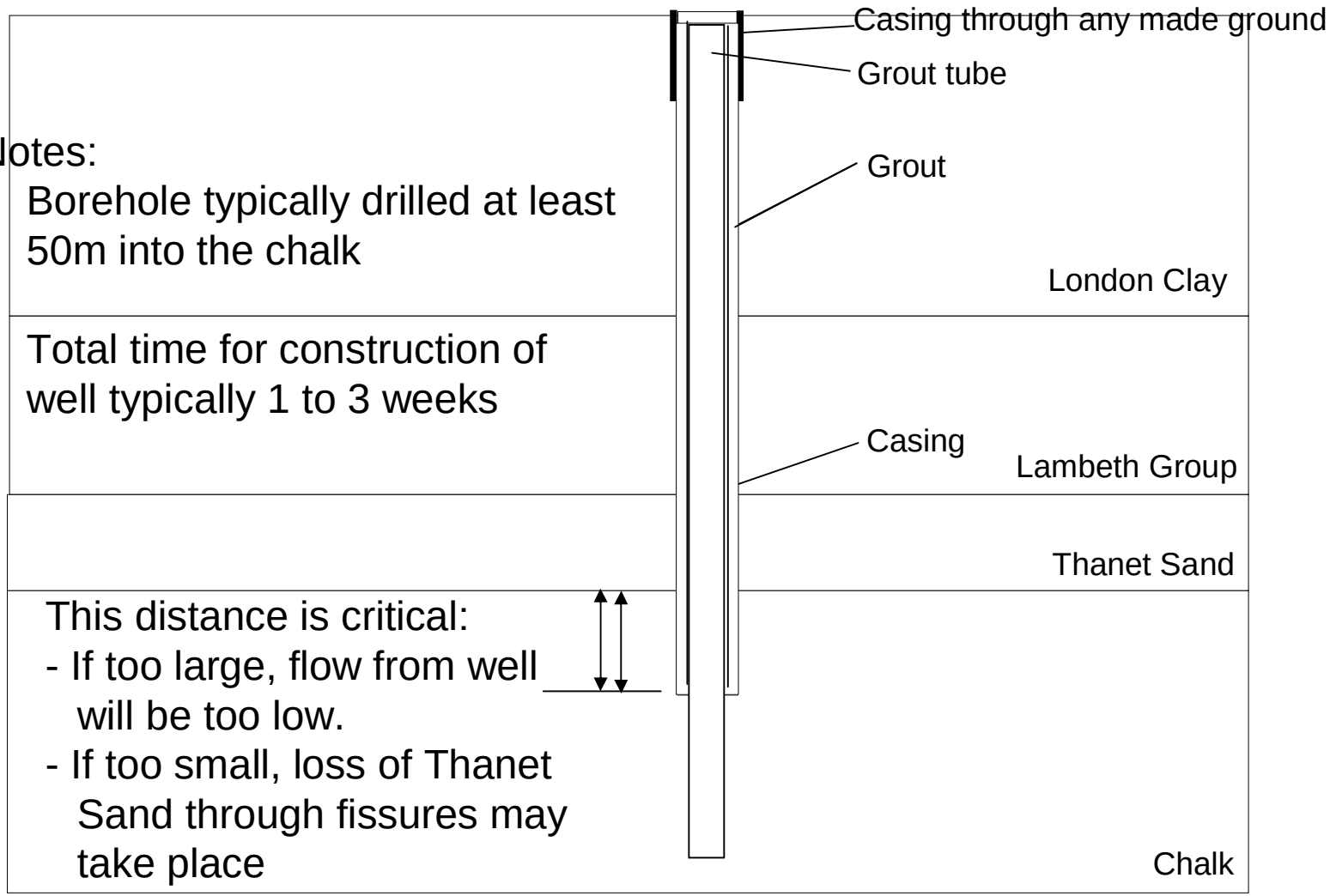
- Confirmation of effective grouting provided by grout emerging at the top of the borehole (indicating bentonite fully displaced)

- Grout left to set after this stage and grout ‘pig’ extracted



1. Well construction

Step 6: Drill remainder of well



Notes:

- Borehole typically drilled at least 50m into the chalk
- Total time for construction of well typically 1 to 3 weeks

This distance is critical:

- If too large, flow from well will be too low.
- If too small, loss of Thanet Sand through fissures may take place

2. Fines extraction

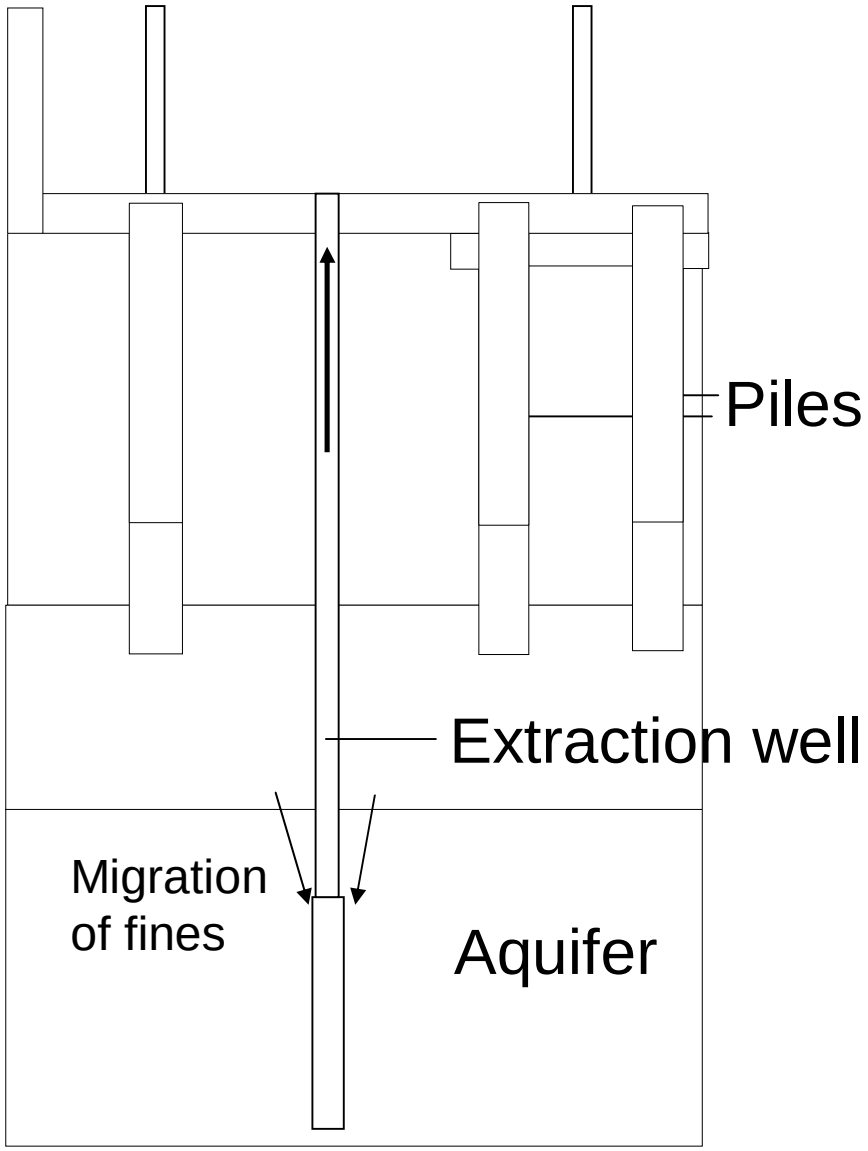
How will the volume of material extracted impair the bearing capacity of foundations?

- Location of foundations relative to abstraction wells
- Where are abstraction wells?
- Where will the piles be?
- Acidisation
- Units of acceptable fines extraction?

Acidising well to increase flow rate

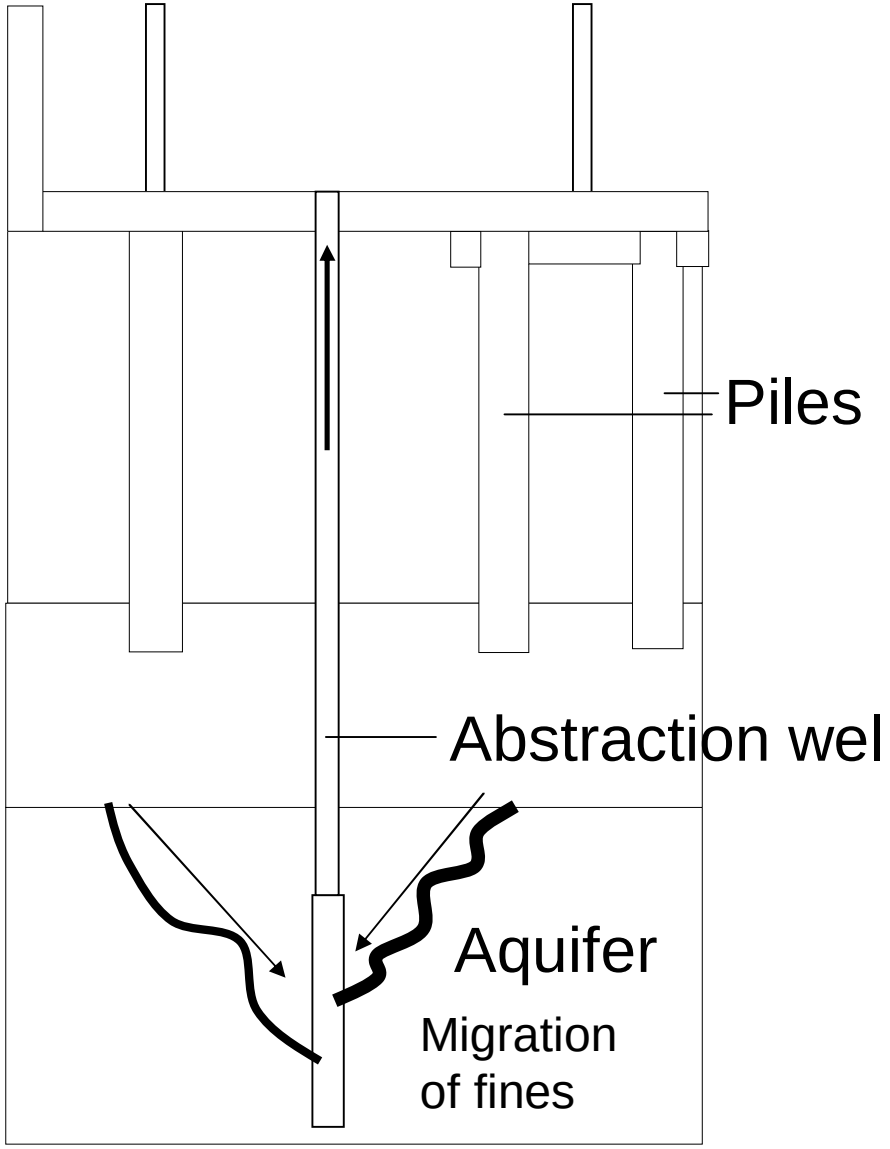
2. Fines extraction

Where are the foundations relative to the point of fines extraction?



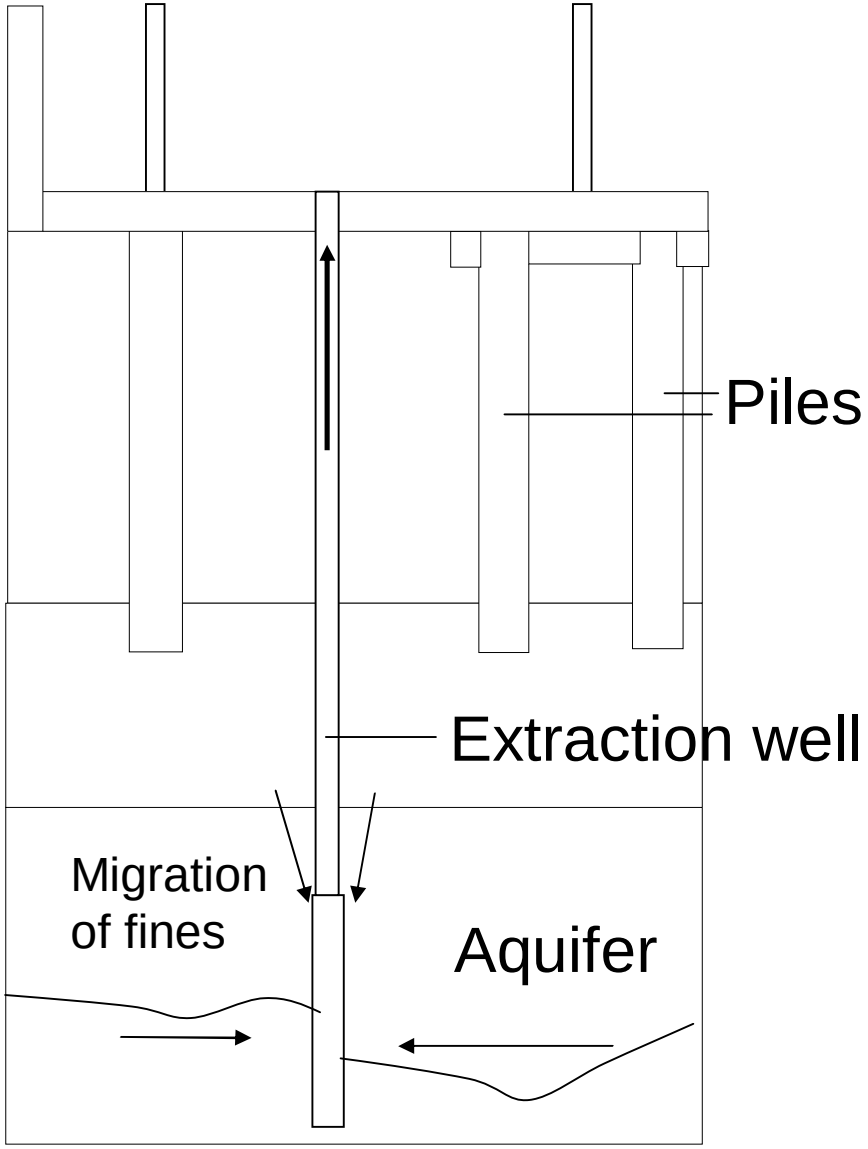
1. Risk to foundations – fines extraction

Abstraction points – pathways for fines to travel



1. Risk to foundations – fines extraction

Assessment of flow rate – related to mass permeability or occurrence of fissures in aquifer

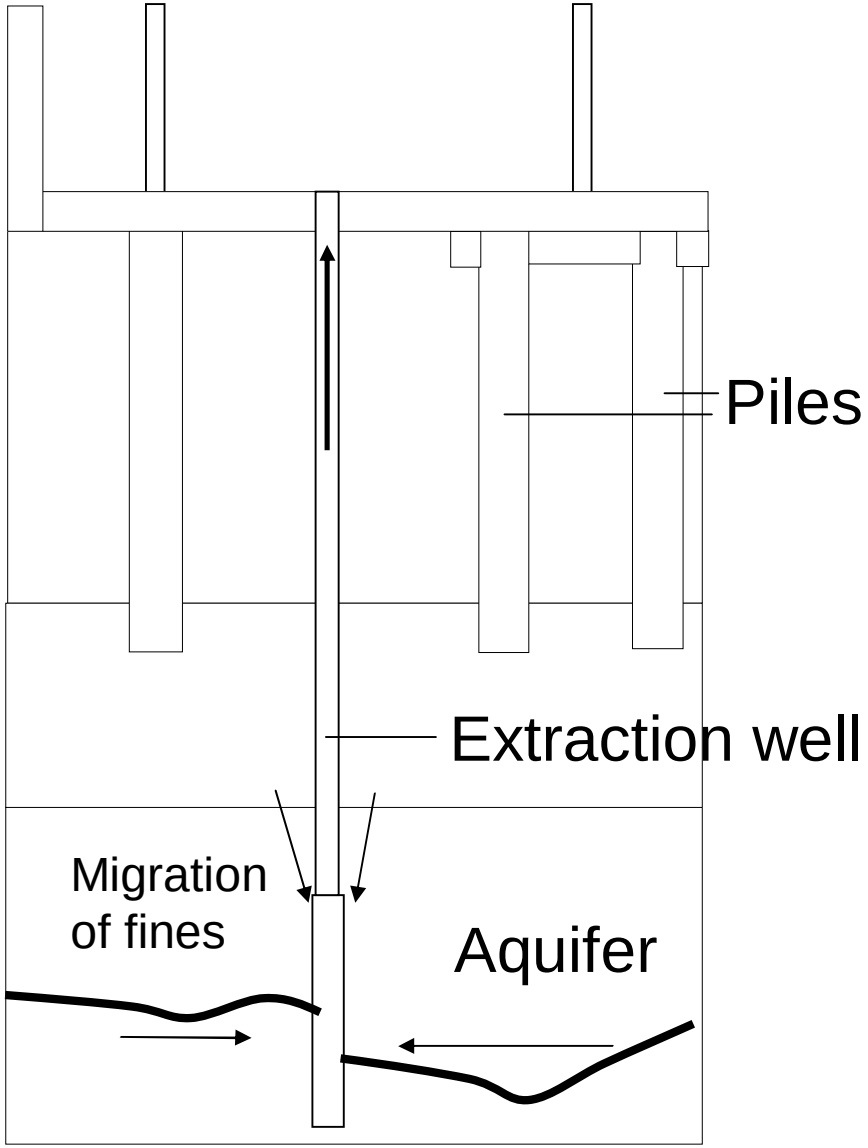


1. Risk to foundations – fines extraction

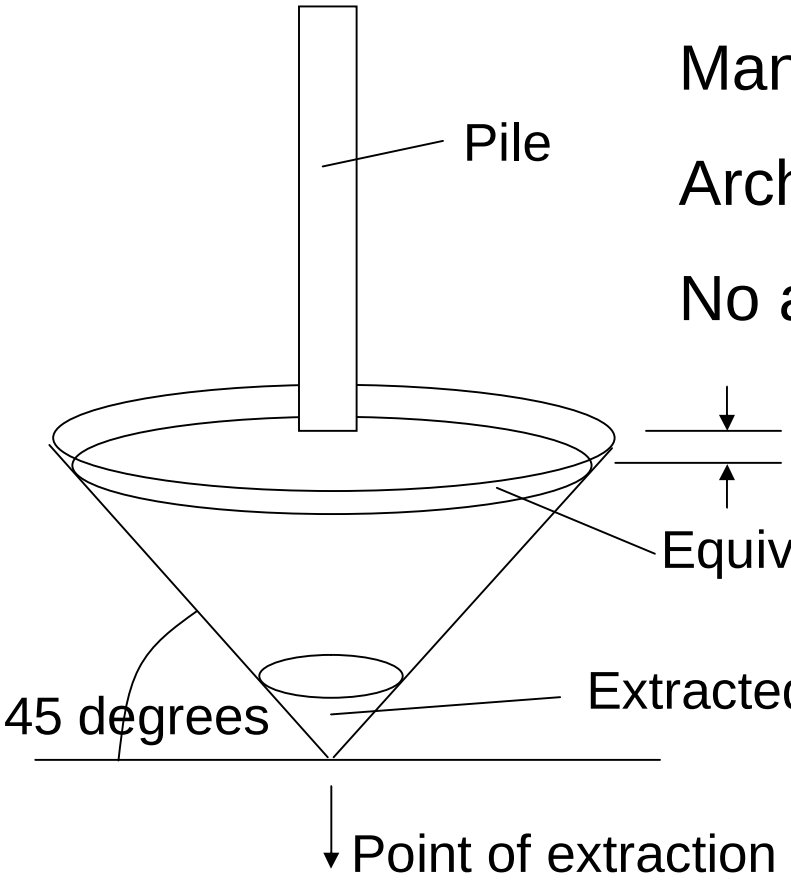
Acidisation – enlarges fissures causing increased flow rate, but also increased risk of fines

Units for acceptable sand extraction:

- Should limit on a total acceptable volume of sand over design life of building be ppm..mg/l…m^3…by volume…by weight…mg/sec…m^3…tonnes?
- What if you extracted much more water than expected?



3. Assessing fines extraction – Hand calcs



Very simplistic:

Many assumptions

Arching of soil is likely to occur

No account for pile in calcs

3. Assessing fines extraction – TUNSET

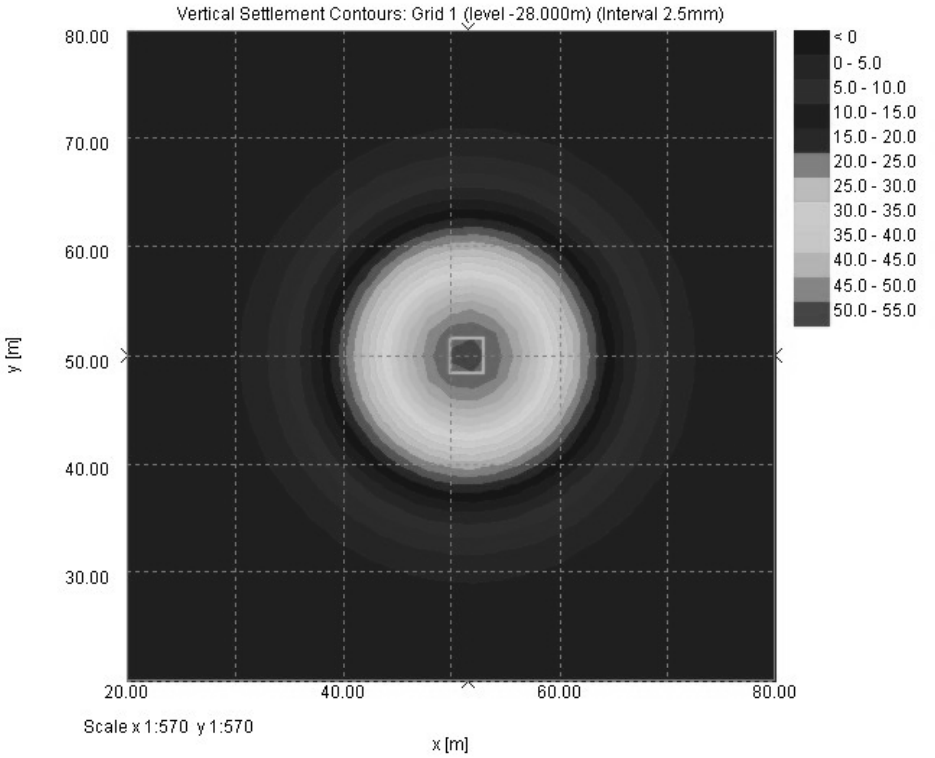
Used to carry out ground movement assessment for tunnels

Calculate ‘volume of sand loss’ over life cycle of building

TUNSET will indicate the distribution of movement (appropriate for tunnel construction) at a given position

Cannot model pile

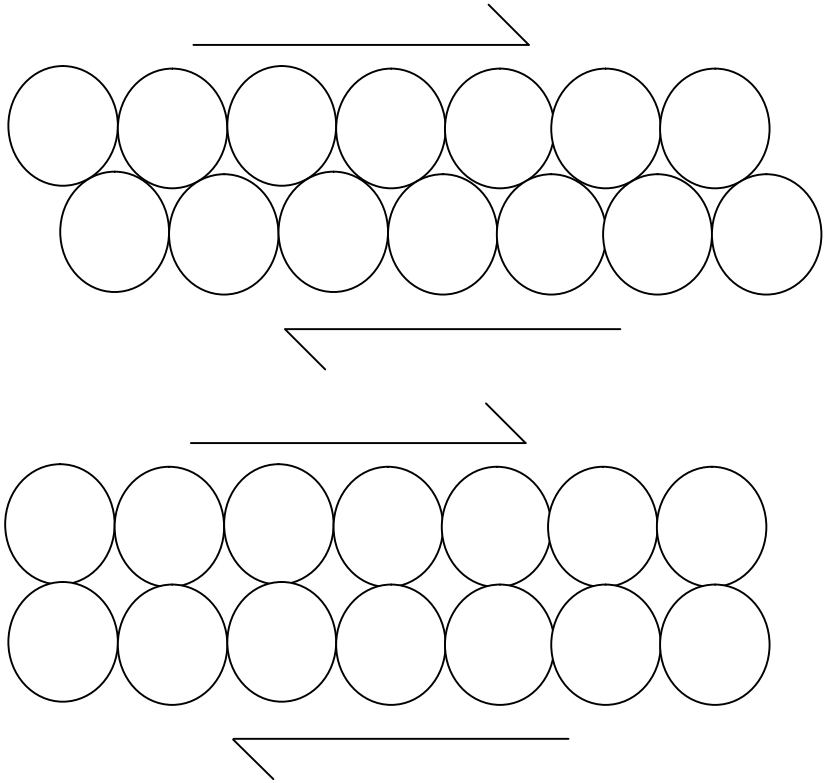
Simple models don’t consider dilation



3. Assessing fines extraction

Angle of dilation – not accounted for in simplistic models

Think about shearing of ball bearings

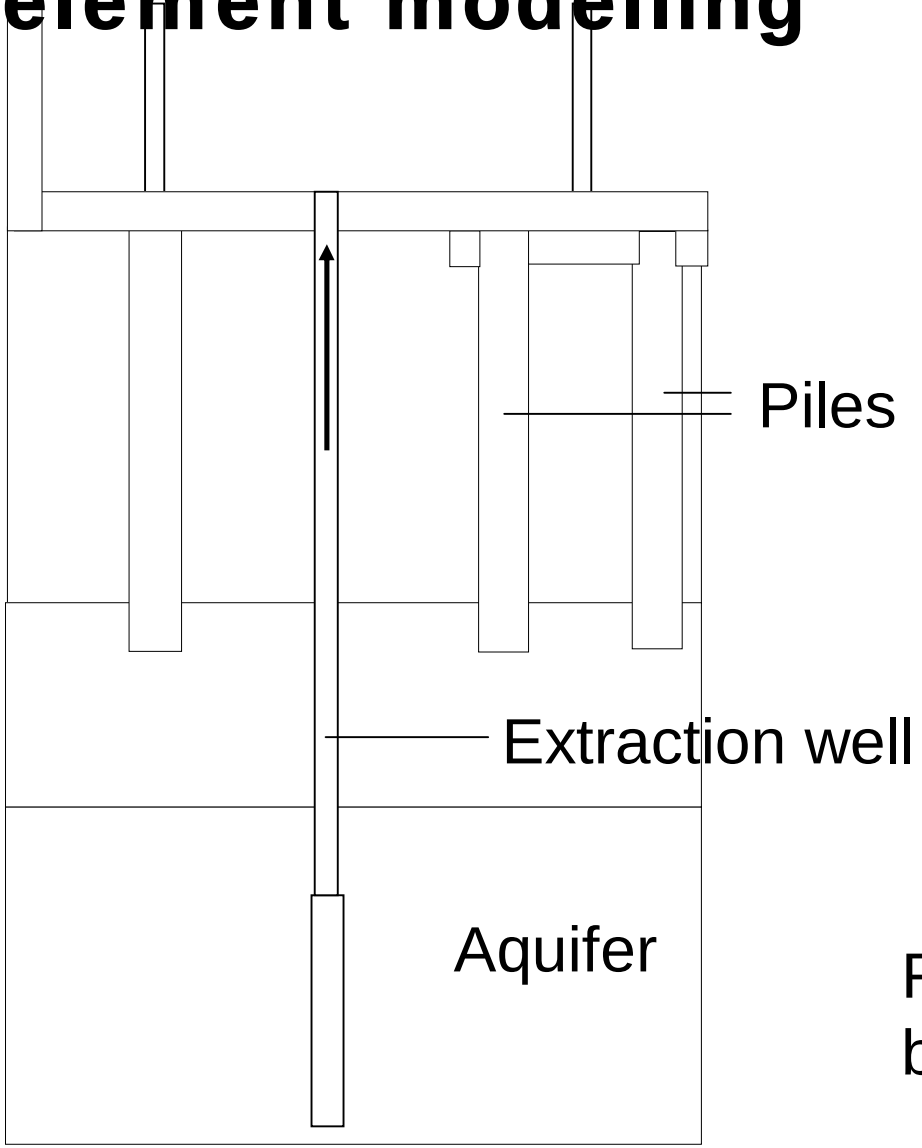


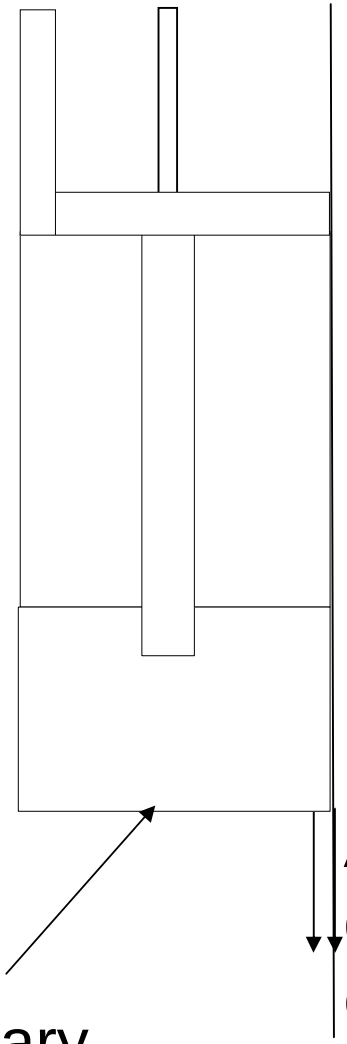
Volume increase

Hand calculations and TUNSET have to make assumptions to account for this

Can use FE to make assumptions. Question then is how much dilation occurs?

3. Assessing fines extraction – finite element modelling





Axi – symmetry assumed

Rigid boundary

Applied displacement or stress

3. Assessing fines extraction – finite element modelling

Issues:

- Boundary conditions

- Clay swell

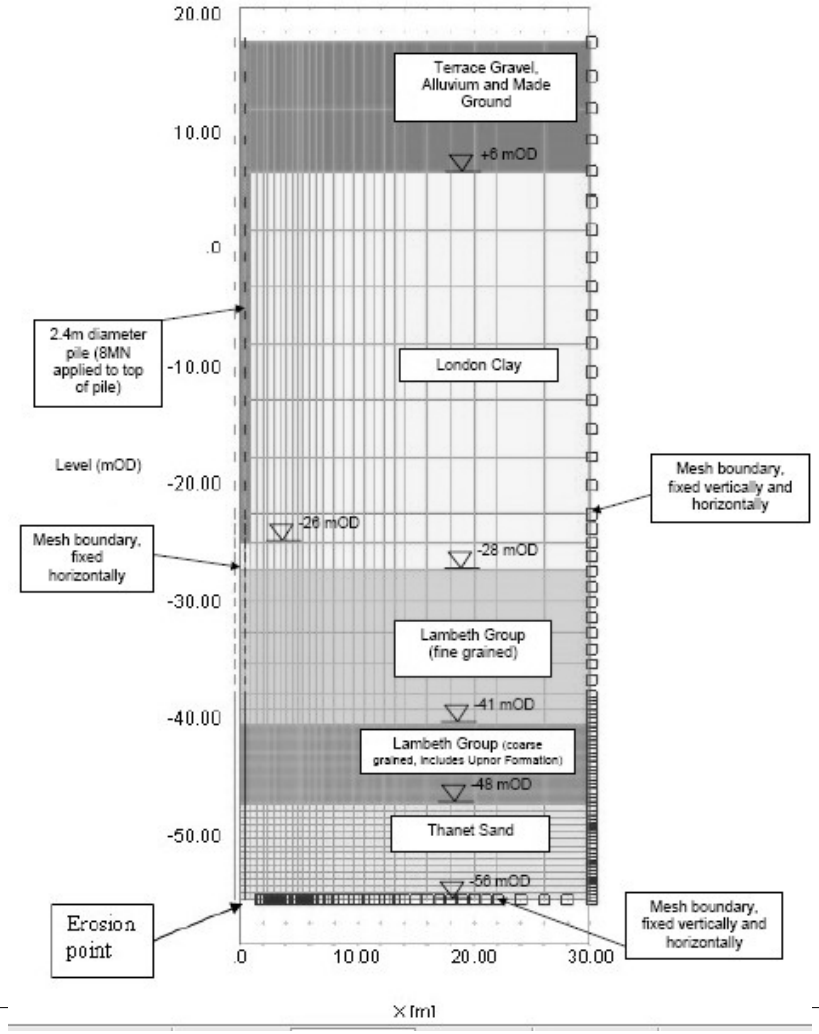
- Convergence (application of stress or strain).

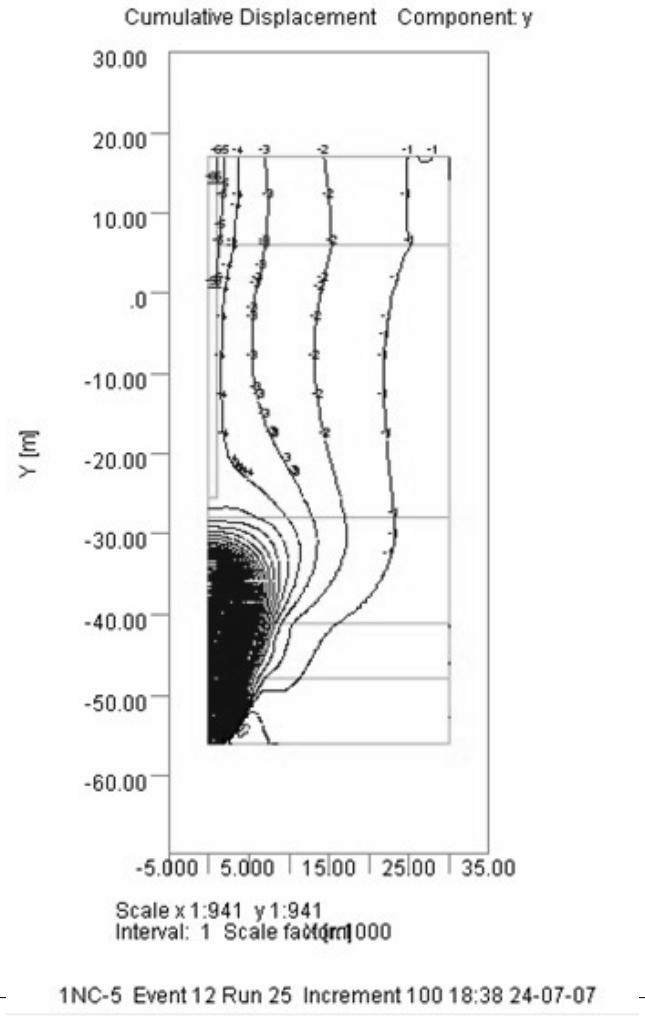
Modelling therefore not straightforward to carry out

Input parameter uncertainty, E, Ko, radius that sand extracted

- Angle of dilation (limit on percentage expansion)

3. Assessing fines extraction – finite element modelling





3. Detection & monitoring

- How will the quantity of material be monitored throughout the life of the structure?
- Need to consider the effect on M&E systems
- ‘continuous’ rather than ‘discrete’ monitoring preferable

Discrete interval monitoring

- Rossum sand monitor

Imhoff cone

3. Detection & monitoring

Continuous monitoring

- **Recent efforts to measure using X-Ray diffraction**

  Not a great deal of success!

- **Could propose settling tanks to be set on electronic scales. Fines left in tanks would increase mass over time.**

4. Conclusions

- **Specification and construction of wells are important and must be carried out carefully**
- **Risk to your development is dependent upon the geology and where your piles are founded.**
- **Site specific assessment provide assistance in appreciating the level of risk**