The Institute of Cemetery and Crematorium Management

GROUND WATER SEMINAR 2017

Environment Agency

Cemetery Development Services

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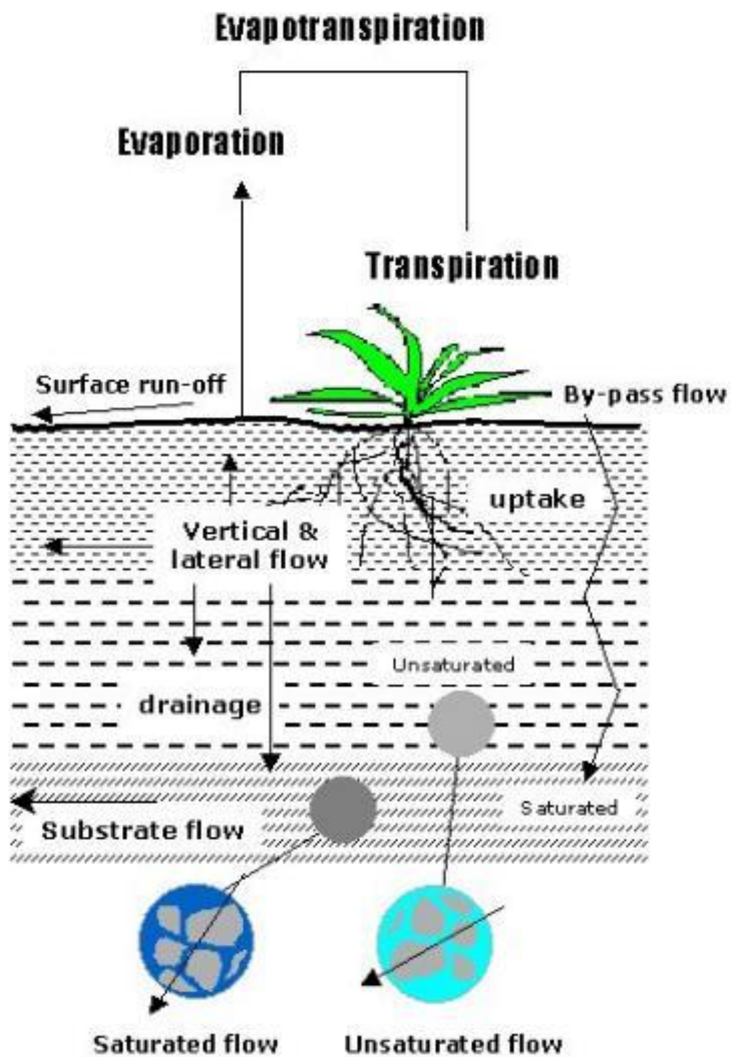
Managing water within cemeteries

Alex Vickers & Justin Smith

Soils, water and risks posed by cemeteries – a basic introduction to soils and water flow through them

Soil type and its effect on water movement


Evapotranspiration
Evaporation
Transpiration
Surface run-off
By-pass flow
uptake
Vertical &
lateral flow
Unsaturated
drainage
Saturated
Substrate flow
Saturated flow
Unsaturated flow

Texture & Structure

Texture

- Relates to the size of particles

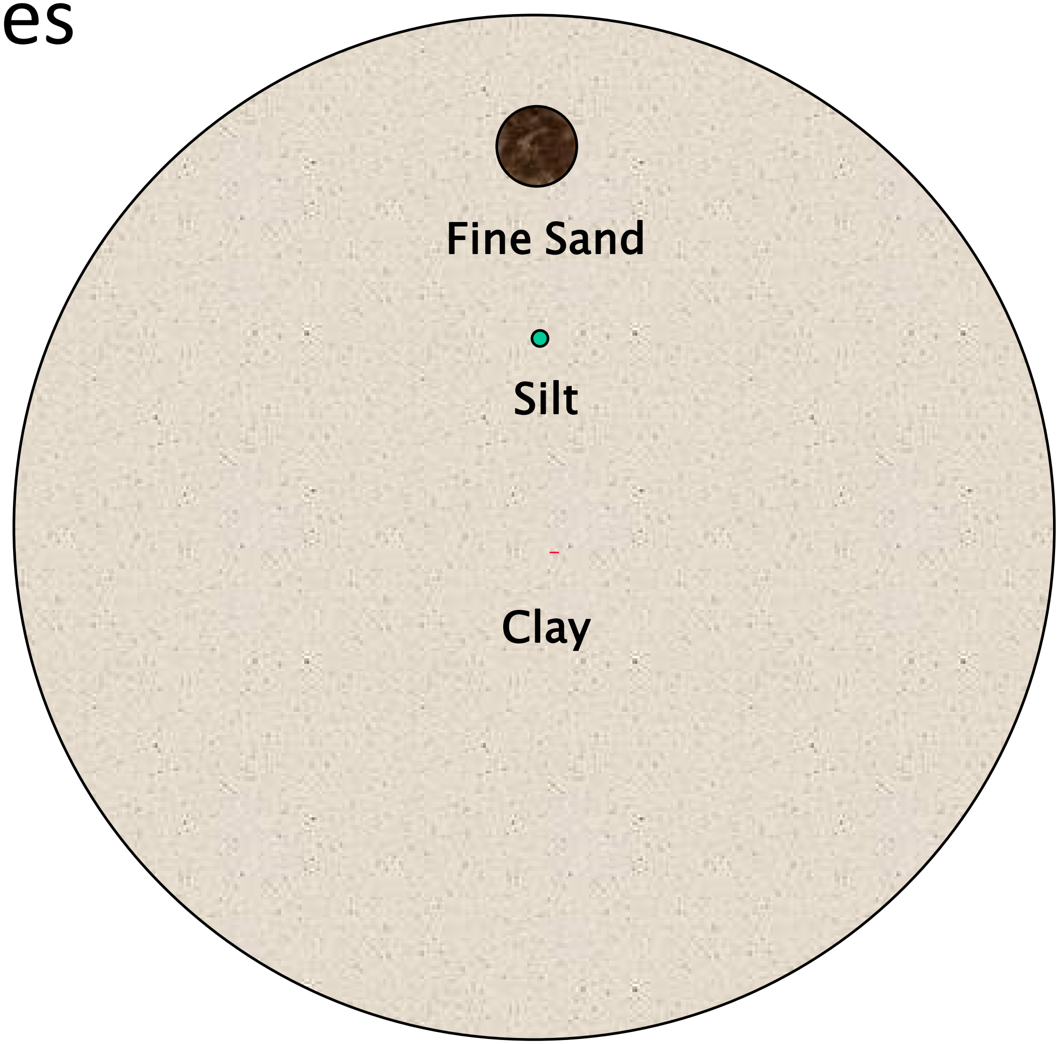
Structure

- Is the configuration of these particles

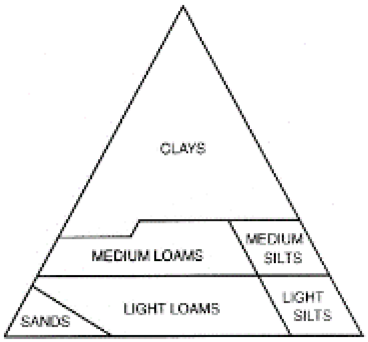
Soil mineral fractions

Fraction Name	Diameter (mm)		
Sand	2.00	to	0.05
Very Coarse	2.00	to	1.00
Coarse	1.00	to	0.5
Medium	0.5	to	0.25
Fine	0.25	to	0.10
Very Fine	0.10	to	0.05
Silt	0.05	to	0.002
Coarse	0.05	to	0.02
Medium	0.02	to	0.01
Fine	0.01	to	0.002
Clay	< 0.002		
Coarse	0.00	to	0.0002
Fine	< 0.0002		

Relative sizes

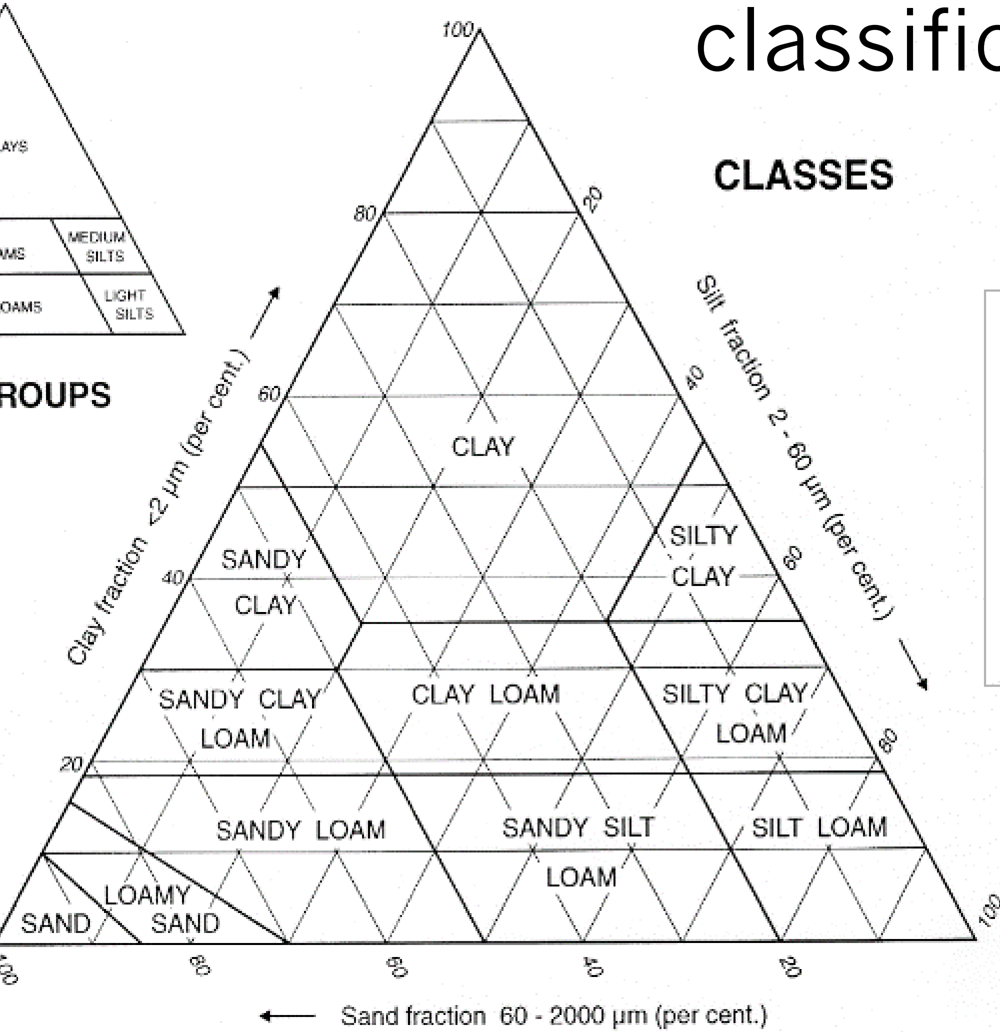


Soil texture classification



SUBGROUPS

CLASSES



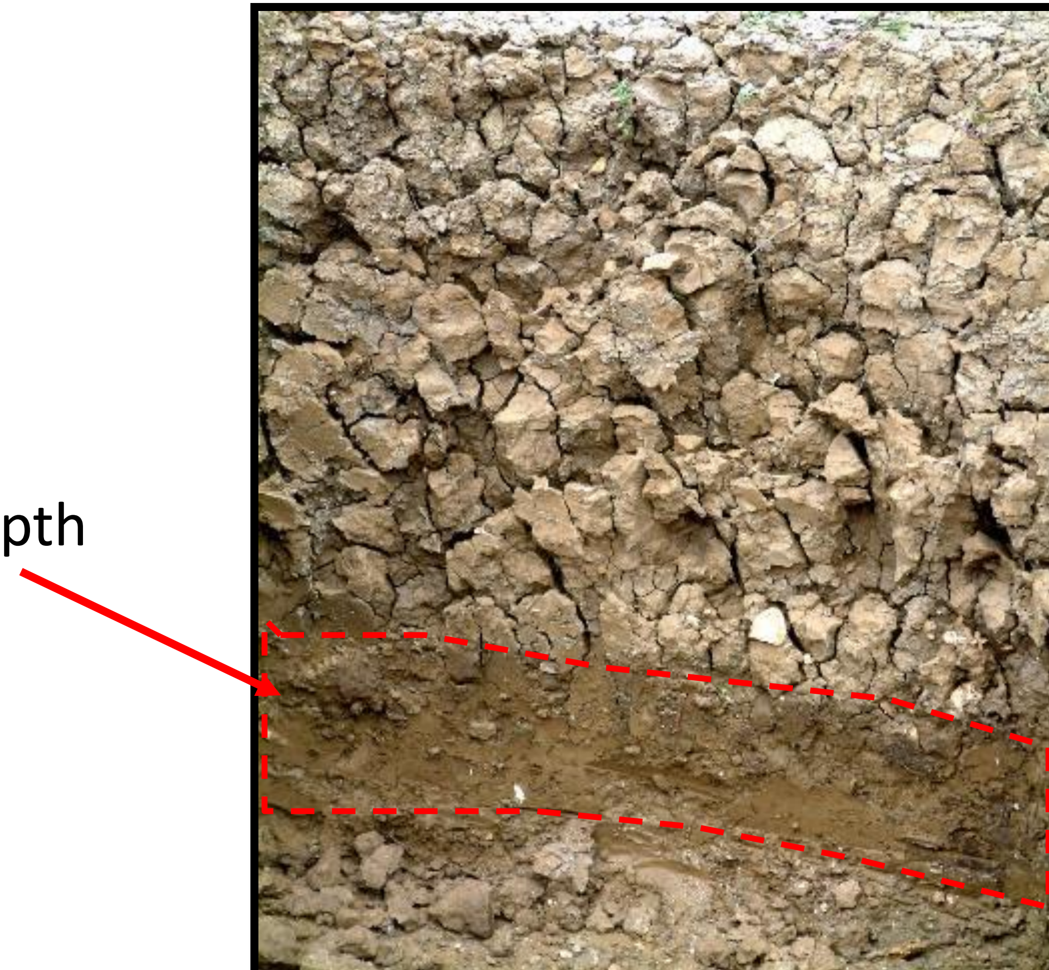
Texture abbreviations

C	clay	S	sand
CL	clay loam	LS	loamy sand
ZC	silty clay	SL	sandy loam
ZCL	silty clay loam	SCL	sandy clay loam
ZL	silt loam	SC	sandy clay
SZL	sandy silt loam		
f	fine grade	m	medium grade
c	coarse grade		

Hydraulic conductivity and infiltration rate

Surface compaction

Compaction at tine depth



Porosity and water retention

BALLS!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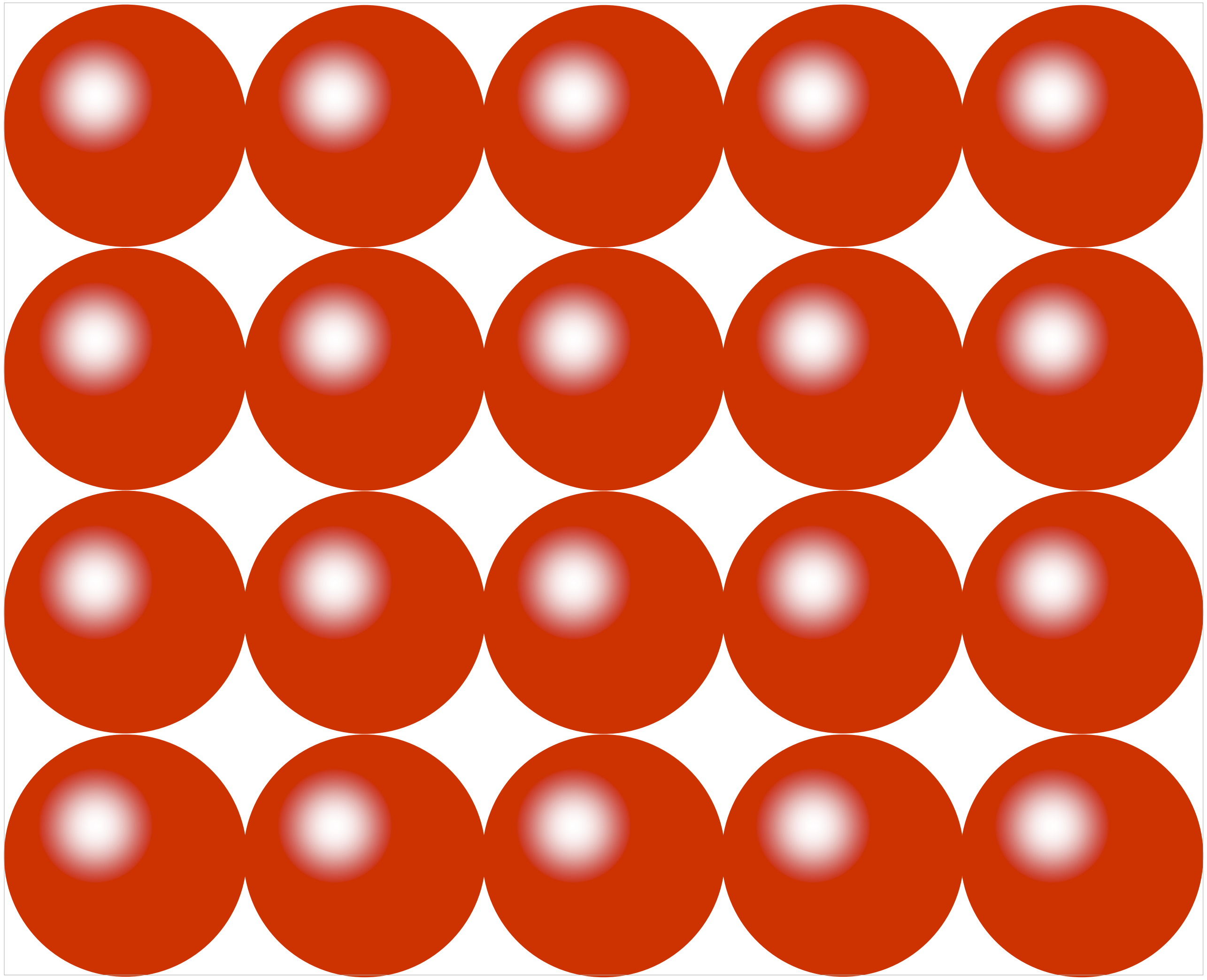
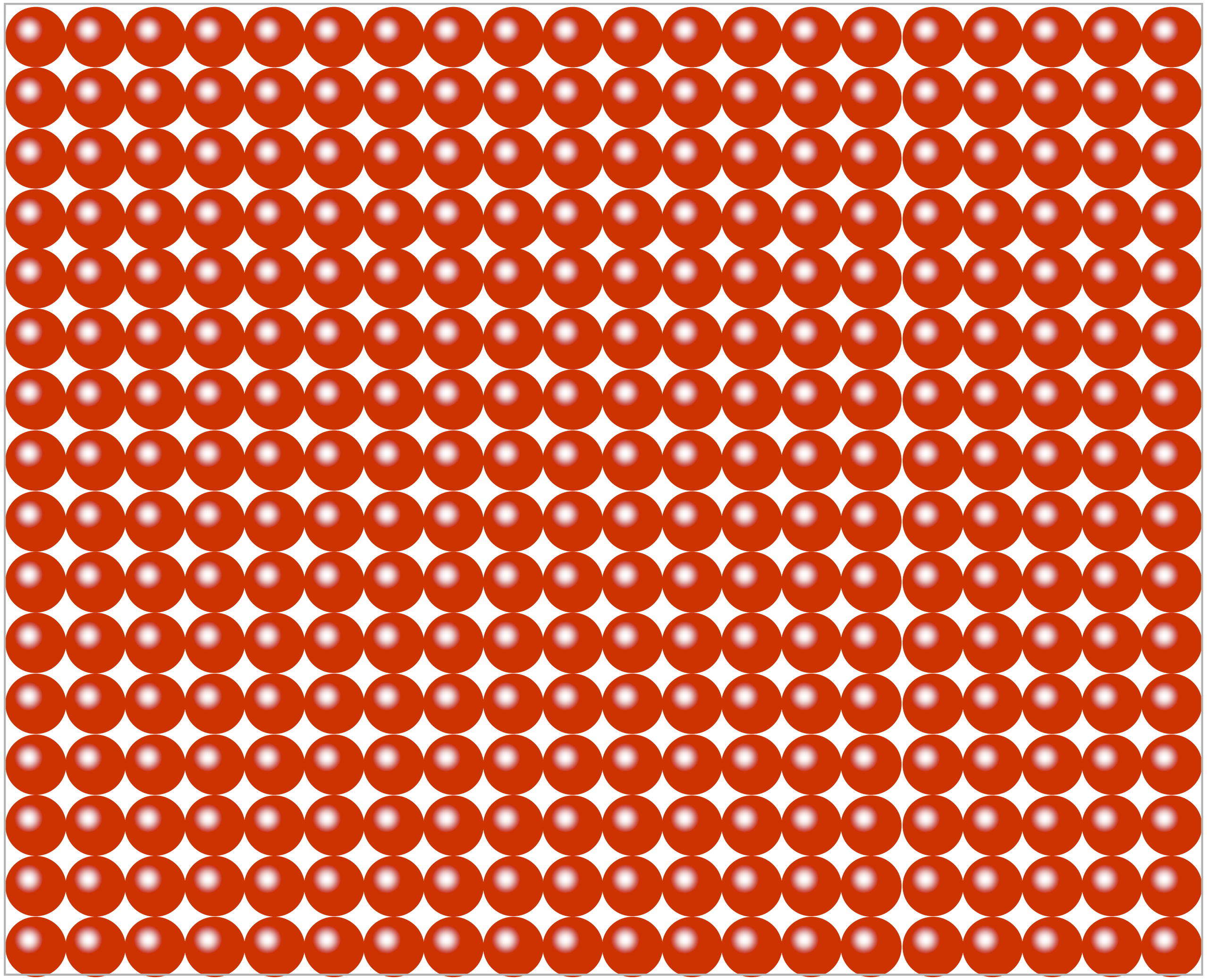
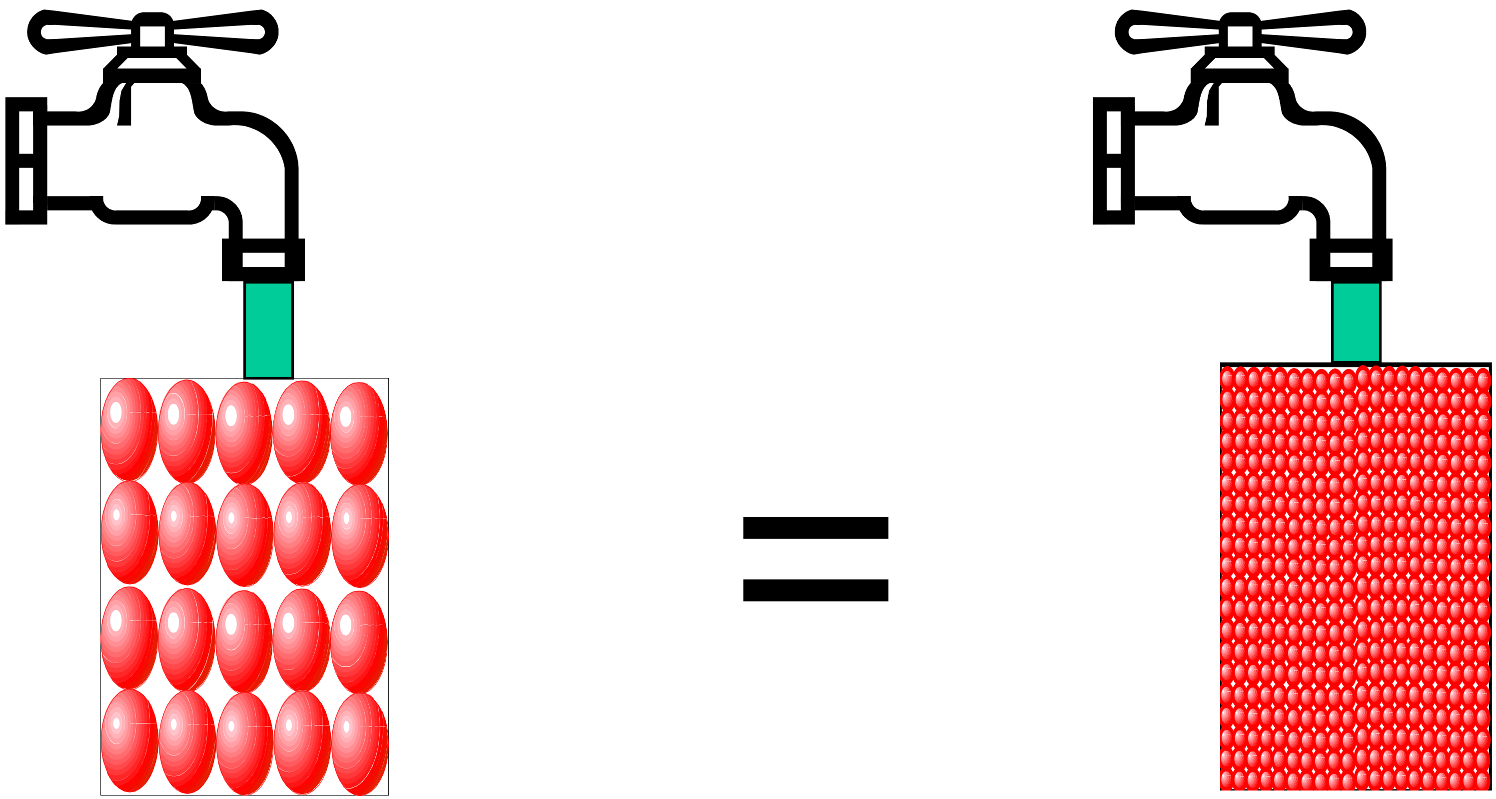


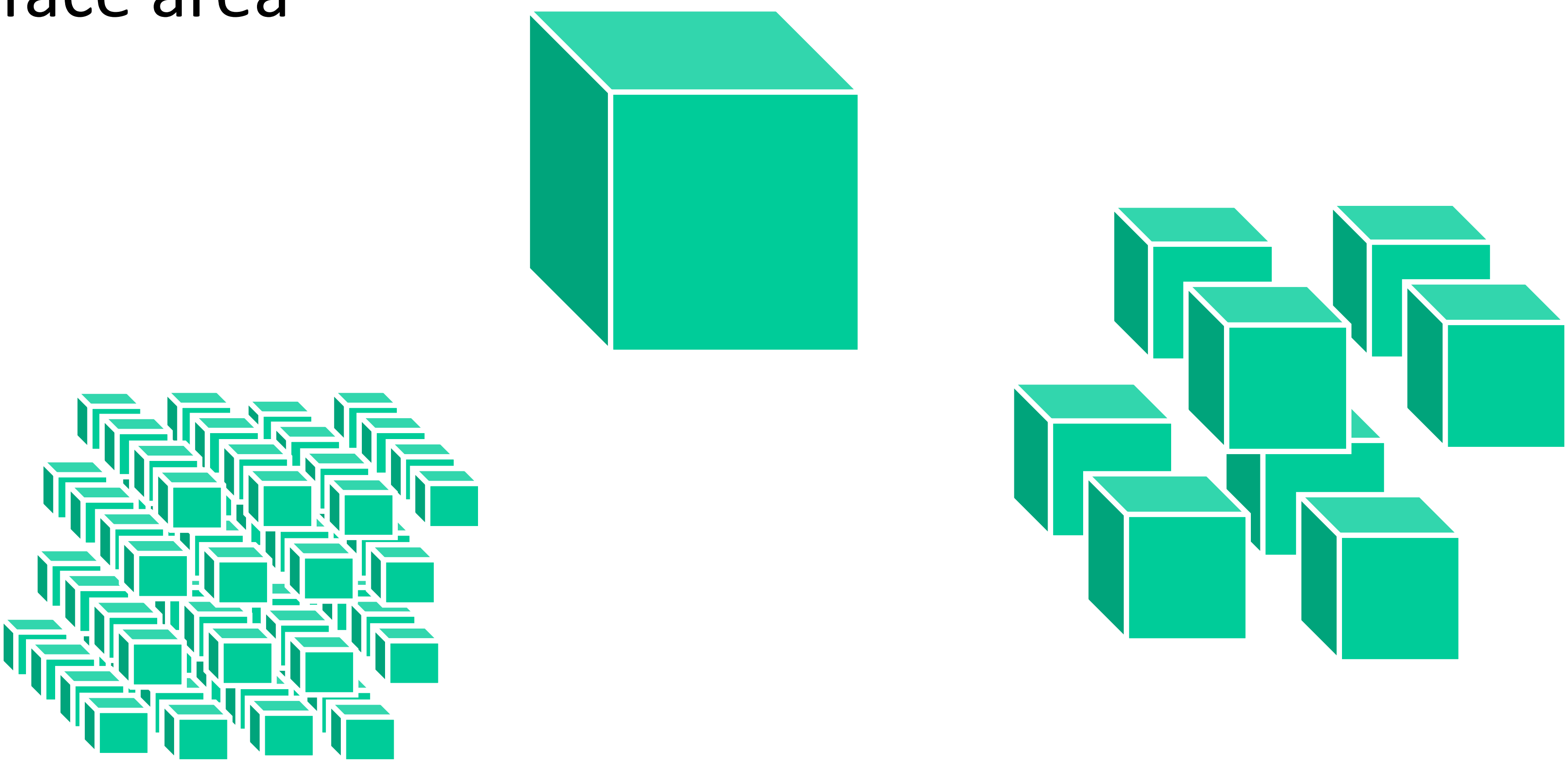

Cemetery
Development
Services



WHICH WILL TAKE THE MOST WATER?



Surface area



1 gram of 0.2 micron clay

has a surface area

= 20 - 80 square metres!

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Pollutants from Cemeteries
A Basic Introduction to Fate & Transport

Philip Lewis

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Land Contamination
Hydrogeology
Engineering Geology

Pollutant Fate & Transport.

What happens when a human body is buried?

- Exposed to environmental controls e.g. rainfall
- Body biodegrades and breaks down
- Effluent generation
- Effluent leaching

Pollutant Fate & Transport.

What Pollutants?

- P223. Large number of pollutants e.g. Cl, NH_4, NO_3^-, PO4, Fe, Na, K & Mg
- In terms of risk assessment we are principally concerned with Ammonium and Nitrate.

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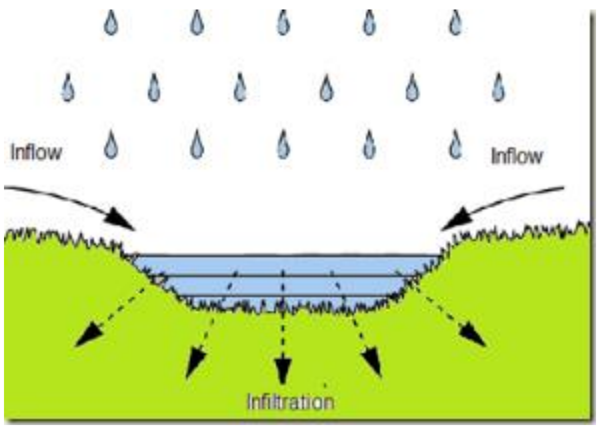
Unsaturated Zone

Soils

- **Dirt is dirt – right?**
- **What makes soil a high or low risk in terms of pollution transport?**

1. Infiltration rate



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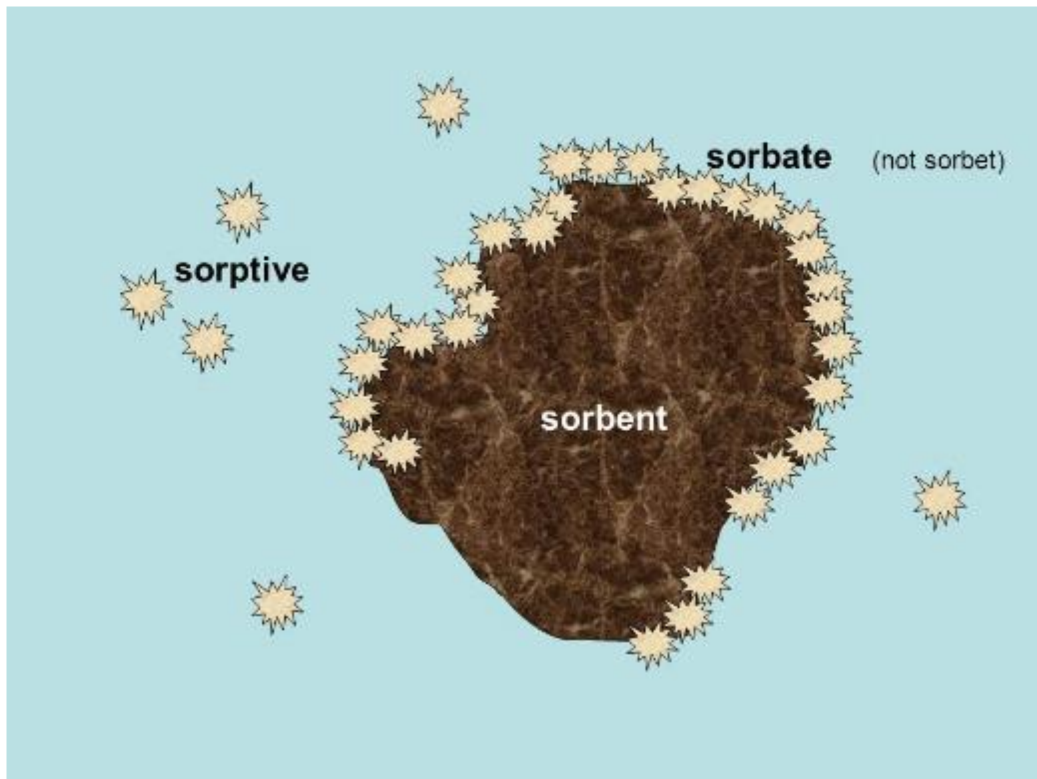
Unsaturated Zone

2. Sorption & CEC



Unsaturated Zone

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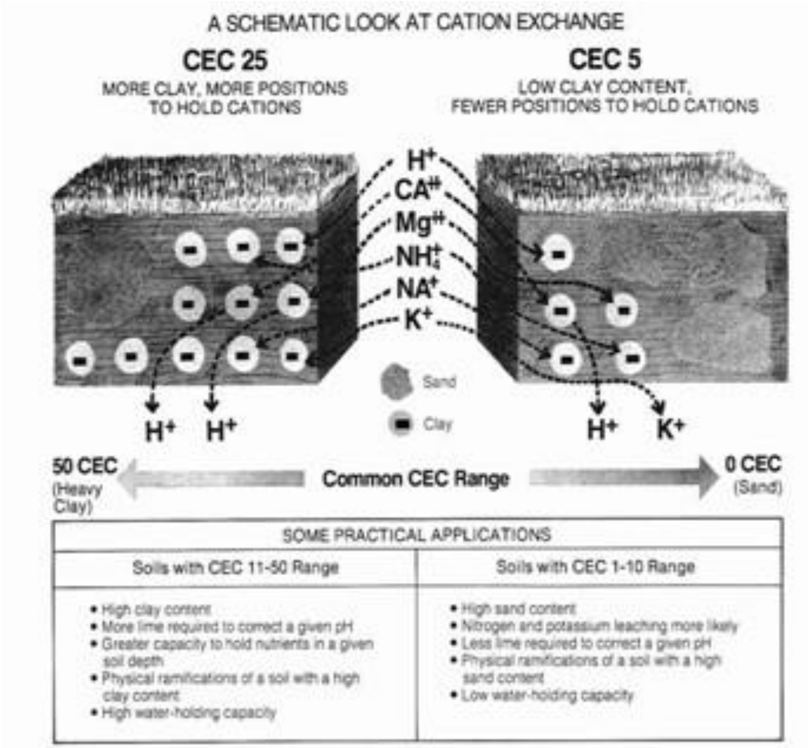
2. Sorption & CEC



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Unsaturated Zone

3. Degradation (nitrification). → 4. Transport through the UZ – retardation

- **All processes are important but probably biggest influence is infiltration (particularly with modelling).**

- **Can we influence this?**
- **Bentonite**
- **Zeolite**

- **So what is a good soil for us?**
- **Clay content?**
- **Thickness?**
- **Pore / fracture size?**

Unsaturated Zone

What happens next?

- **Pollutants enter Groundwater.**
- **Surface water?**

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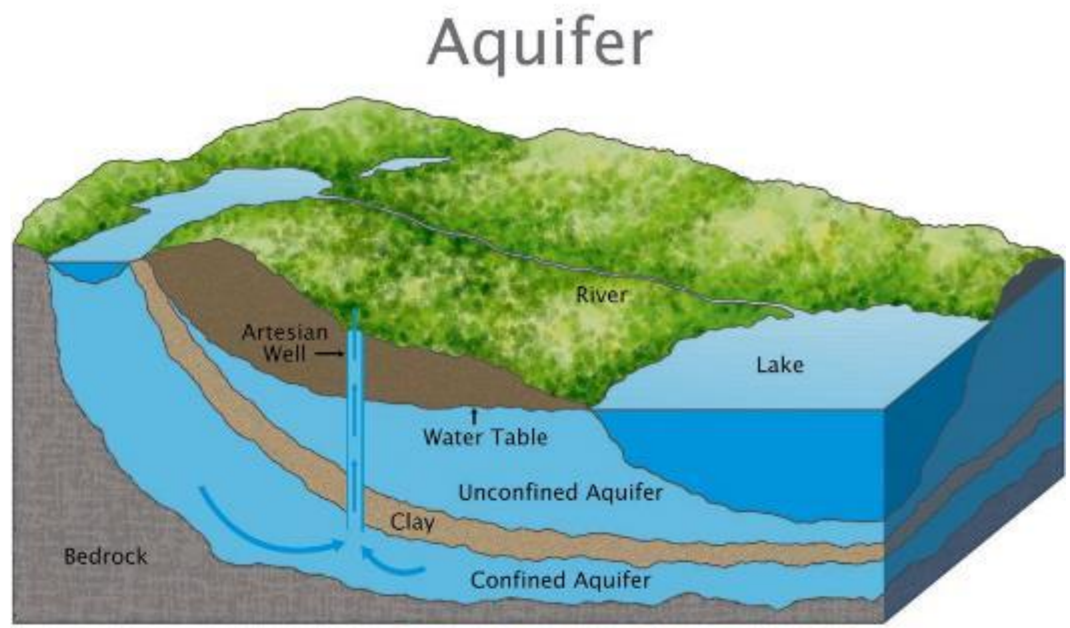
Groundwater

What is groundwater?

What we care about really are:

- **Aquifers**
- **Groundwater that creates a pathway to a receptor.**



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Groundwater

Do aquifers differ?

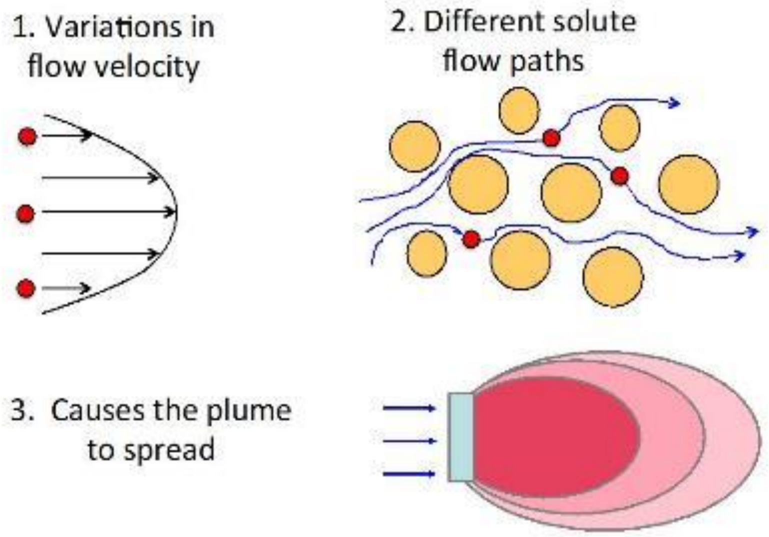
- Drift (mostly secondary)
- Bedrock (mostly principal)

Are processes in aquifers different to processes in UZ?

- Still get sorption & degradation.
- Also you get:
    - Advection
    - Dispersion
        - Mechanical dispersion; &
        - Diffusion.

Groundwater

Advection & Dispersion



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Groundwater

Where and what is the risk?

- **Sensitive receptors in water environment e.g.:**
  - **Groundwater abstractions; &**
  - **Surface water courses.**

Modelling the Risks

How do we model the risks?

- Firstly we try and get an idea of the local ground & groundwater conditions.
- We then try and conceptualise the conditions.
- We use basic deterministic models to simulate the pollutant fate & transport e.g. EA Infiltration Worksheet & Remedial Targets Worksheets.
- Parameters for the models are typically from a mixture of site specific and literature sources.
- Contaminants – Ammonium & Nitrate, different WQS but interlinked.
- Lots of conservatism in model e.g. max vs equilibrium concentrations and initial compliance point of 50m.
- Finally the key is using the outputs to aid professional judgement.

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Case Studies

Glacial Till over Coal Measures

- **Proposed 150 burial / annum on c. 6 hectare site**
- **Glacial till (primarily clay but with sand and gravel lenses) over Coal Measures (primarily mudstone with interbedded sandstones).**
- **High rainfall (not necessarily high infiltration but assumed to add conservatism).**
- **Groundwater in GT c. 4m (sand and gravel unit) and in Coal Measures c. 20m.**
- **Both GT and CM designated secondary aquifers.**
- **Minor surface water courses c. 100m from site.**
- **Considered unlikely that gw in CM at risk and gw in GT limited resource potential so priority given to local surface water courses.**
- **Conceptualised a thin and laterally persistent water bearing sand & gravel unit – hydraulic connection to surface water.**
- **Results suggested potential for some minor impact on surface water BUT when looking at equilibrium concentration and justifiably longer compliance point augmented with professional judgement conclusion was low risk.**

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Case Studies
Clay w/flints over Chalk

- **Proposed 100 burial / annum on c. 10 hectare site**
- **Clay with flint (primarily clay but with some sand & gravel) over Chalk (Lewes Nodular & Seaford Chalk Formations).**
- **Relatively low rainfall.**
- **No groundwater in Clay and in Chalk c. 50m i.e. significant unsaturated zone.**
- **Chalk is designated a Principal Aquifer.**
- **Public water supply abstraction c. 1km for site (total & outer catchment).**
- **Relatively simple conceptually – pollutants leach through UZ into Chalk Aquifer and migrate via groundwater.**
- **However, chalk is a bit more complicated because it's a dual porosity system – this has a knock on effect in terms of pollutant attenuation, particularly in the UZ**
- **Results suggested potential for impact on off-site groundwater and with professional judgement conclusion was high risk without applying mitigation measures – in this case application of zeolite.**

Thank You

Any Questions ?

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COFFEE BREAK

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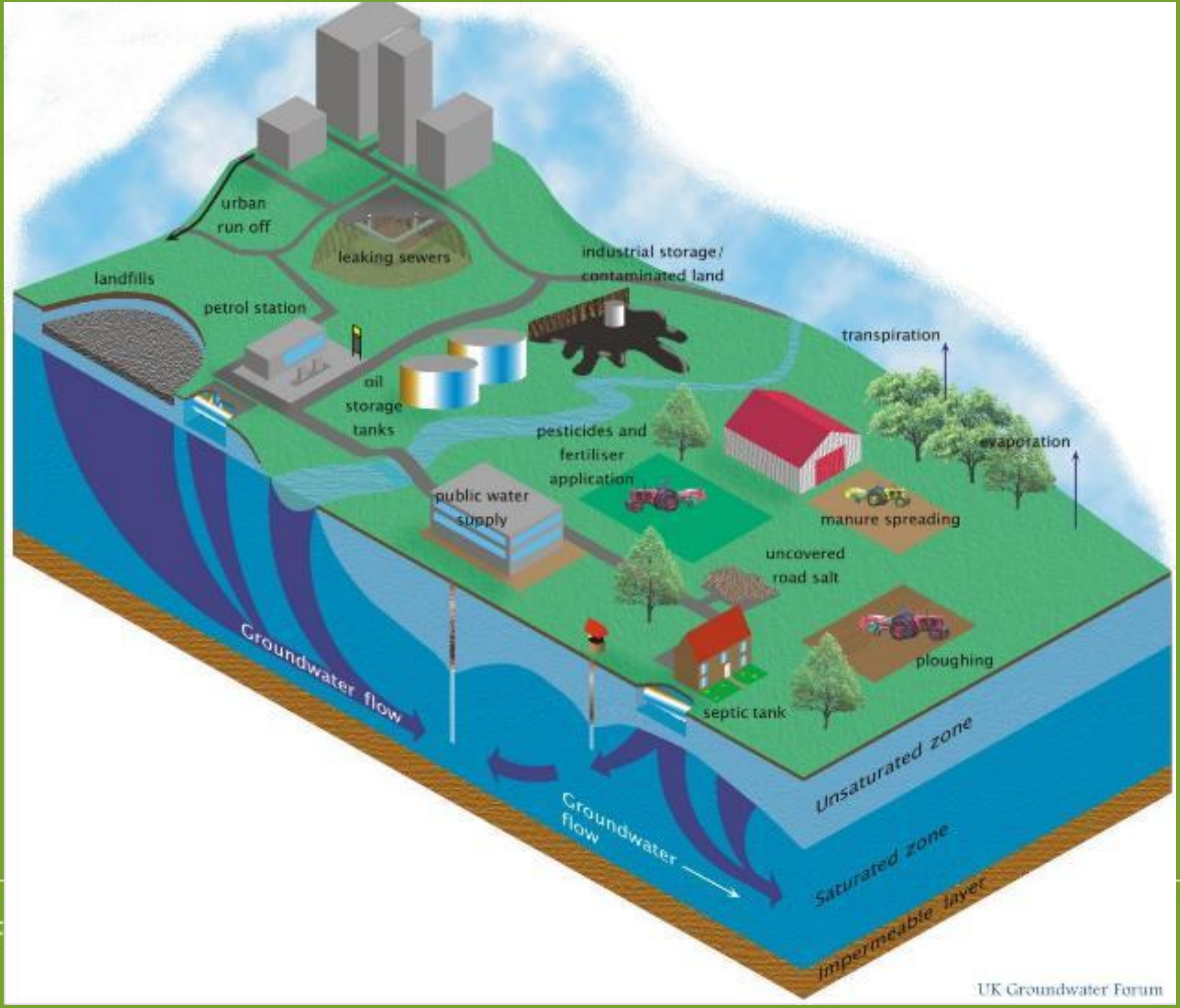
Groundwater & Cemeteries

Richard Brandsma
Technical Specialist
West Midlands Area

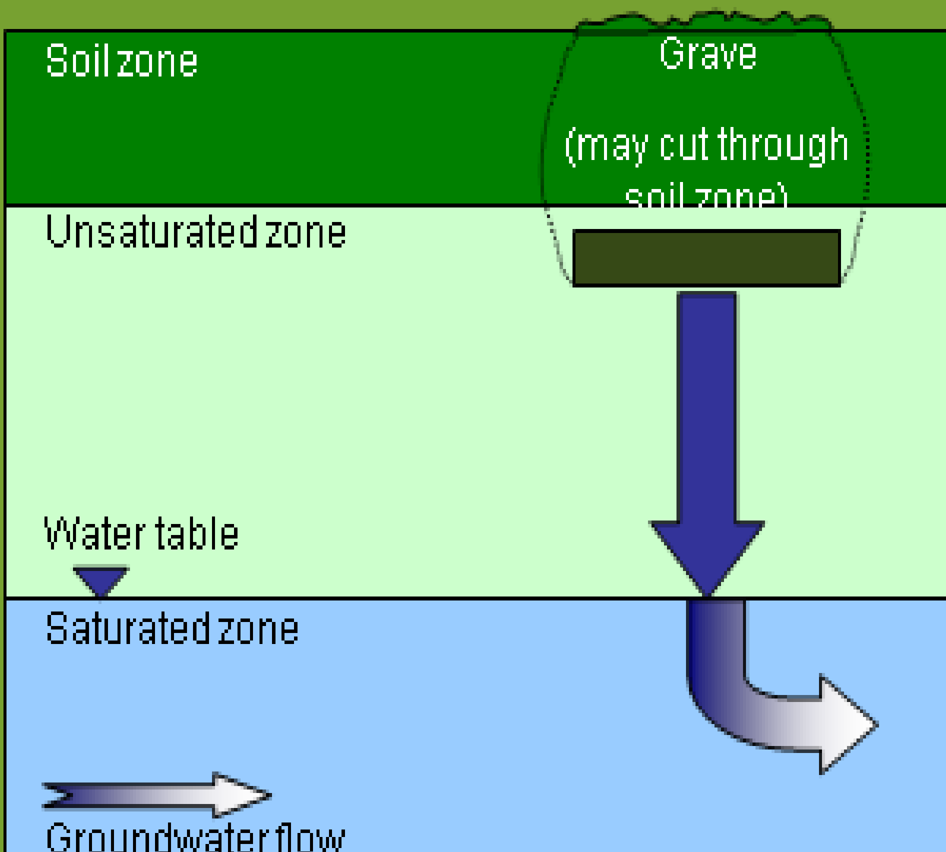
Groundwater – out of sight, out of mind



Cemetery risks to groundwater

- Groundwater can be at risk of pollution where the burial rates are significant and the ground protection is poor (e.g. shallow soil, porous rocks, high water table)
- These risks are site specific and need to be assessed upfront
- Typical cemetery pollutants include cadmium, mercury, copper, lead, ammoniacal nitrogen, sodium, sulphate, chloride, pathogens etc.

Attenuation of contaminants



Soil zone	Sorption. Intense chemical and biochemical degradation.
Unsaturated zone	Continued sorption. Reduced chemical and biochemical degradation.
Saturated zone	Dilution and dispersion dominate. Extent of filtration dependent on nature of aquifer. Chemical reactions dependent on groundwater chemistry.

Town and Country Planning Act 1990

- Local Authorities control most developments and land use proposals in their boroughs via the planning regime

- Planning approval (if granted) comes with conditions

- Potential groundwater pollution is a material planning consideration and Environment Agency is statutory consultee for cemetery applications / extensions

- Typical cemetery development proposals require site investigation, risk assessment and possibly monitoring

Environmental Permitting Regulations 2010

- Implements Water Framework Directive (2000) and Groundwater Daughter Directive (2003)
- System of permits, conditions and notices
- Enables control of polluting activities - e.g. large burials or discharges of site drainage to ground, groundwater or surface water
- Offers Notice powers –

  Groundwater Prohibition Notice (Para 9 Sch. 22)

  Permit non-compliance (Reg. 36)

Water Resources Act 1991

- Section 85 states that it is an offence to pollute Controlled Waters (either causing or knowingly permitting)

- Section 161 give us the powers to serve Anti-Pollution Works Notices to prevent or seek remedial action for any such pollution

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Groundwater Protection Tools

- Aquifer Classifications, Vulnerability Maps and Source Protection Zones are used to identify site specific risks to groundwater

- Groundwater Protection Position Statements set out the Environment Agency's approach to managing and protecting groundwater from a range of human activities

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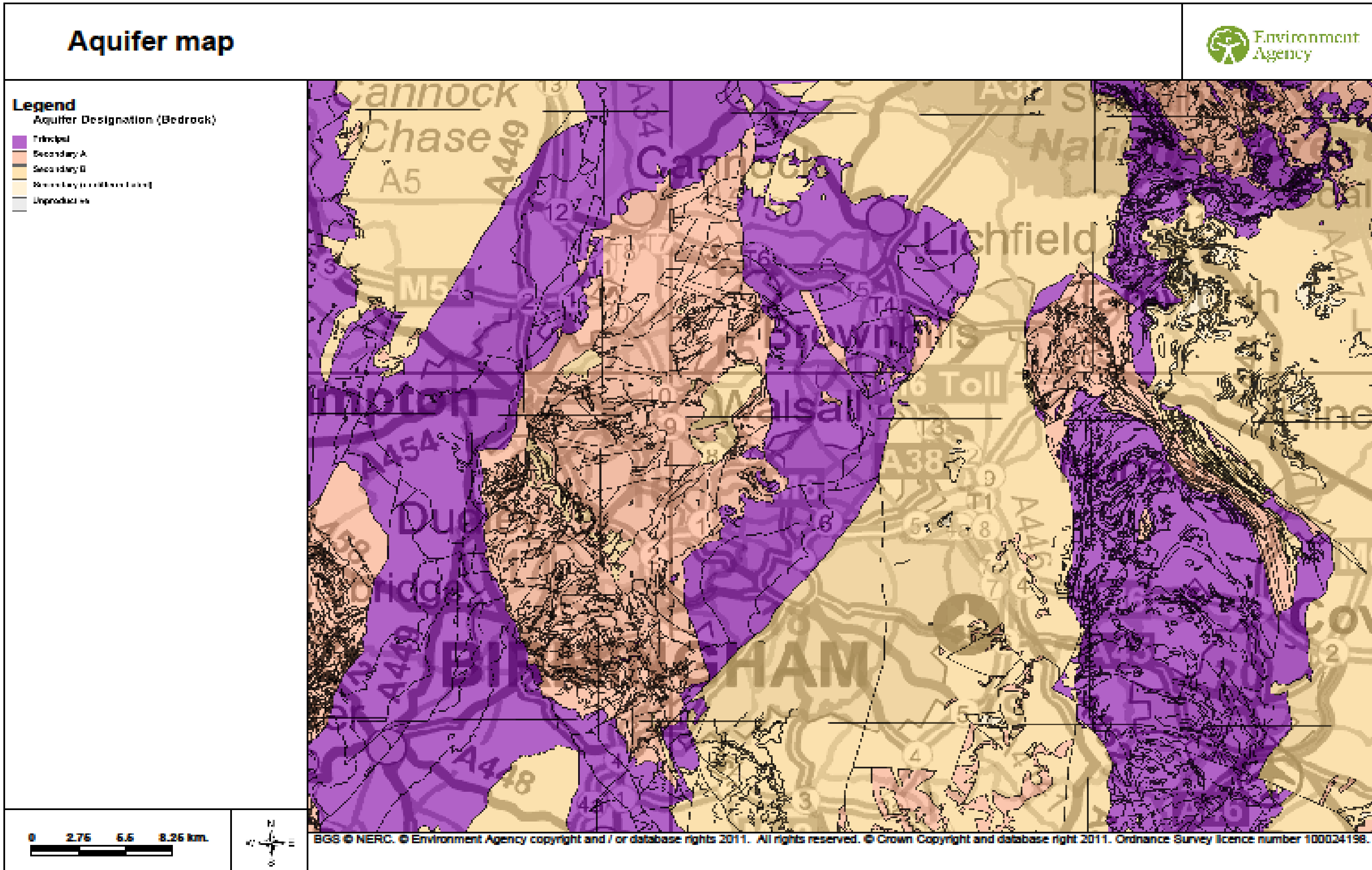
Aquifer Classification

- **Principal**: Strategic / regional scale importance e.g. Permo -Triassic Sherwood Sandstone.
- **Secondary A**: Locally important e.g. Carboniferous Coal Measures, Millstone Grit, Sand & Gravels or Alluvium.
- **Secondary B**: May support very minor abstractions e.g. Triassic Mercia Mudstone.
- **Unproductive Strata**: Negligible significance e.g. Glacial Till.

Aquifer maps

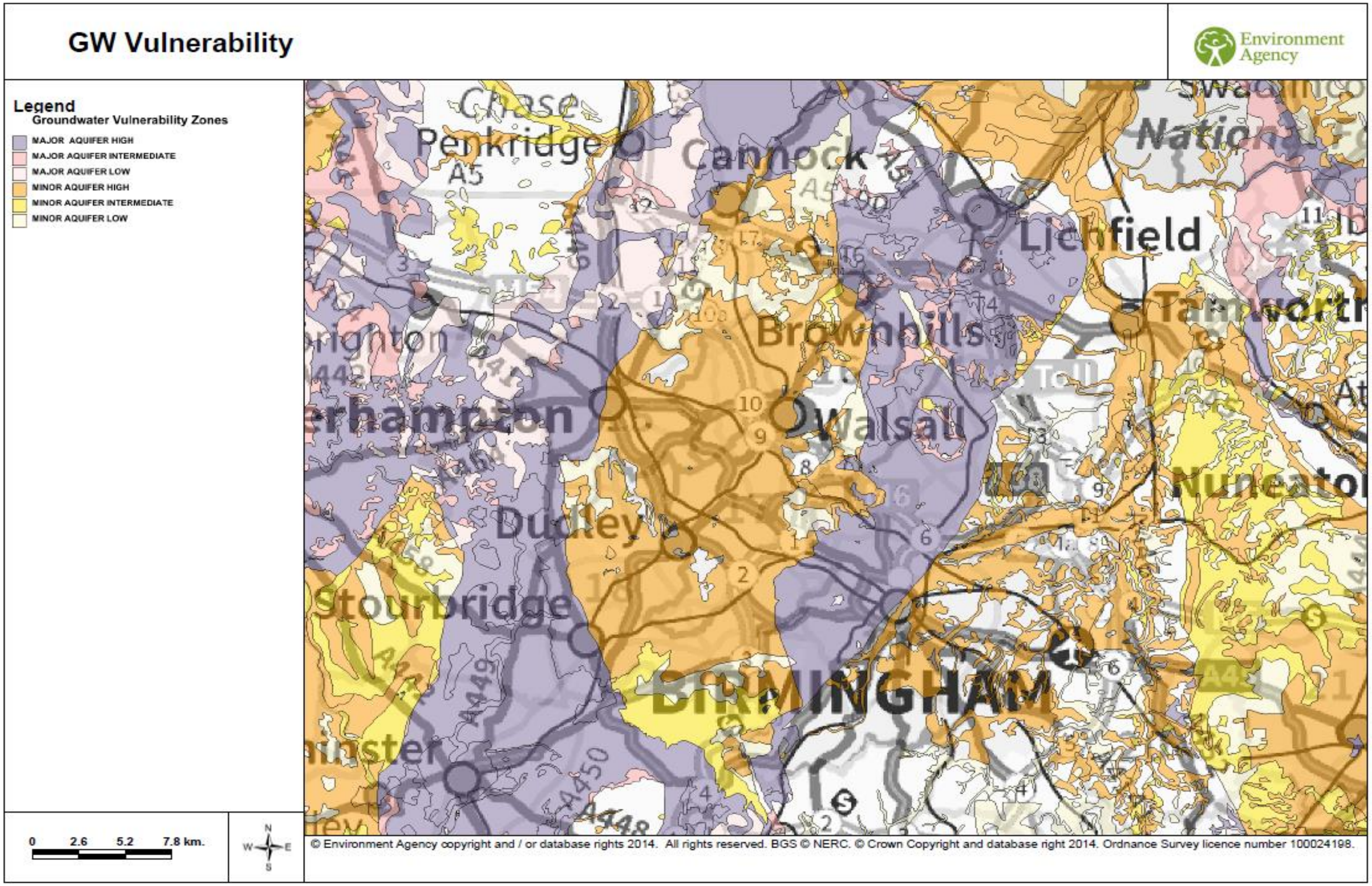


Groundwater vulnerability maps

The risk of groundwater pollution from a given activity will vary from place to place depending on -

- physical, chemical and biological properties of the underlying soil and rocks
- depth and quality of soil
- presence of superficial or drift deposits
- depth of the unsaturated zone

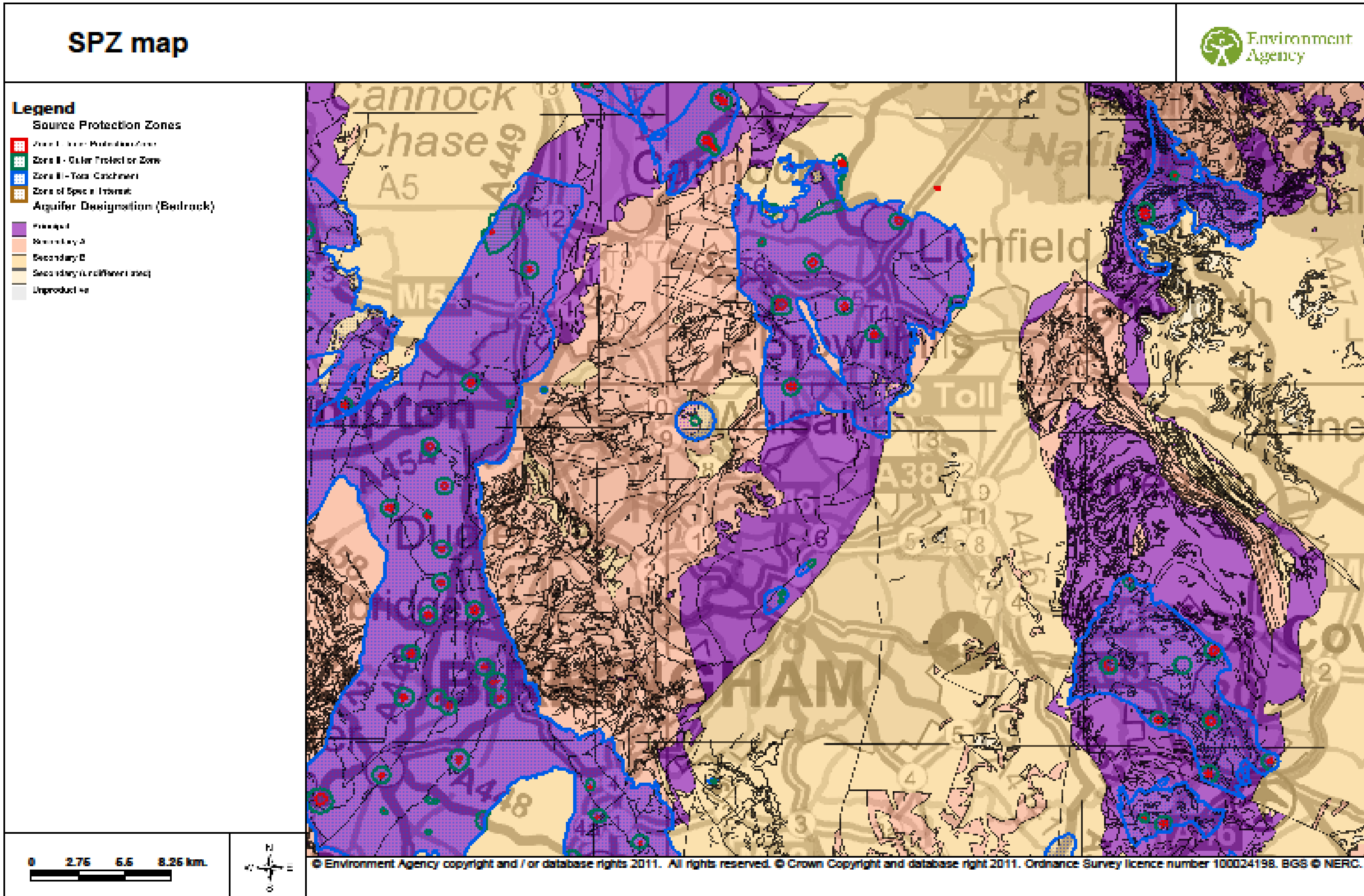
Groundwater vulnerability maps



Source Protection Zones

- SPZs defined around Public Water Supplies and food industry abstractions:
  - Zone I – 50 day travel time to source
  - Zone II – 400 day travel time to source
  - Zone III – total catchment
- The closer a polluting activity is to a potable groundwater abstraction the greater the risk
- Maps available on line (WIYBY)
- Zones are periodically updated

Source Protection Zones



Groundwater Protection Position Statements


Environment Agency

The Environment Agency's approach to groundwater protection

March 2017 Version 1.0

- Sets out our latest framework to make decisions on activities that could impact on groundwater
- Aims to remove uncertainty and potential inconsistency
- Overall objective is the prevention of pollution of groundwater and the protection of it as a resource

L. Cemetery developments

This section contains the position statements on the development of new cemeteries or the extension or redevelopment of existing cemeteries.

For further information see the guidance for cemeteries and burials.

For burial of animal carcasses see section M - burial of animal carcasses.

Burials are covered by the requirements of EPR as they can discharge hazardous substances and non-hazardous pollutants to groundwater.

For individual burials that are spaced out over time, the risks to groundwater are likely to be low and the de minimis exclusion in EPR applies.

Large numbers of burials in a short time, or the cumulative effects of many individual burials, may cause or have the potential to cause groundwater pollution. In general, the shorter the time over which burials occur and the higher the number of burials, the greater the risk of groundwater pollution. In these cases the Environment Agency will, where appropriate, use its powers under EPR to control or prohibit the burials.

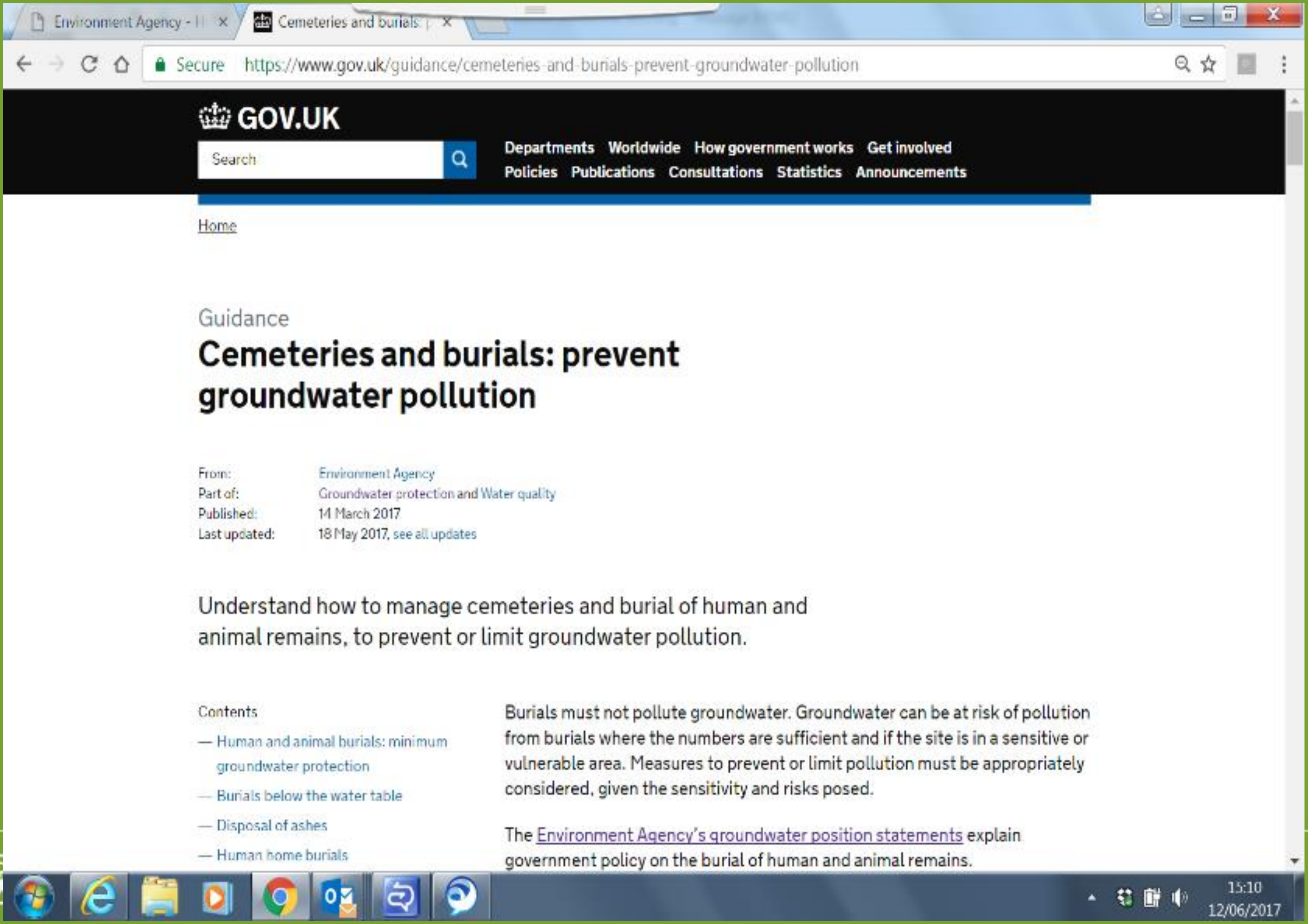
The European Commission has indicated that, for ethical reasons, human corpses cannot be defined as waste. As a consequence, the Waste Framework Directive 2008/98/EC which defines waste, and basic waste management principles, does not apply, and burials are not controlled by waste legislation in England. The Environment Agency can therefore only control groundwater pollution from burials as a consultee on planning applications, or through environmental permitting and water resources legislation where risks of pollution are greatest.

L1 - Locating cemeteries close to a water supply used for human consumption
The Environment Agency will normally object to the locating of any new cemetery or the extension of any existing cemetery, within SPZ1, or 250 metres from a well, borehole or spring used to supply water that is used for human consumption, whichever is the greater distance.

L2 - Mass casualty emergencies
The Environment Agency will normally object to or may refuse to permit new or existing cemeteries planned for use in mass casualty emergencies if they are in SPZ1 or within 250 metres of an abstraction point, whichever is the greater distance. Where there is a risk of disease transmission into groundwater the Environment Agency will extend its objection to SPZ2.

L3 - Cemeteries: protecting groundwater in highly sensitive locations
The Environment Agency will apply a risk-based approach to assessing the suitability of sites for cemeteries outside of the zones noted in position statements L1 and L2. A high priority is placed on protecting groundwater within principal aquifers and groundwater catchments used for drinking water supply, and new larger cemetery developments in such areas might not be appropriate. Proposals for new cemetery developments for greater than 100 burials per year are considered to be high risk even in a lower sensitivity groundwater scenario. Such proposals will only be agreed by the Environment Agency where a developer can demonstrate through detailed risk assessment that, given the site specific setting and the engineering methods proposed, groundwater pollution will be avoided. Note that all cemetery developments and burials must maintain an unsaturated zone below the level of the base of the grave(s). The Environment Agency will work with the local authorities to identify alternative site and burial options where necessary.

Latest guidance



March 2017 Guidelines

- Update and clarification only, nothing ‘new’
- Still based on 2004 R&D Technical Report 223 and usual groundwater protection framework
- Adopts GOV.UK style of writing (non-tech)
- Live document, so open to ongoing updates
- Happy to take away queries or suggestions

Locational requirements

A burial site must be -

- outside an Inner Source Protection Zone (SPZ1)
- at least 250 metres from any potable well, borehole or spring
- at least 30 metres from any non-potable spring or watercourse
- at least 10 metres from a field drain or ditch

Grave requirements

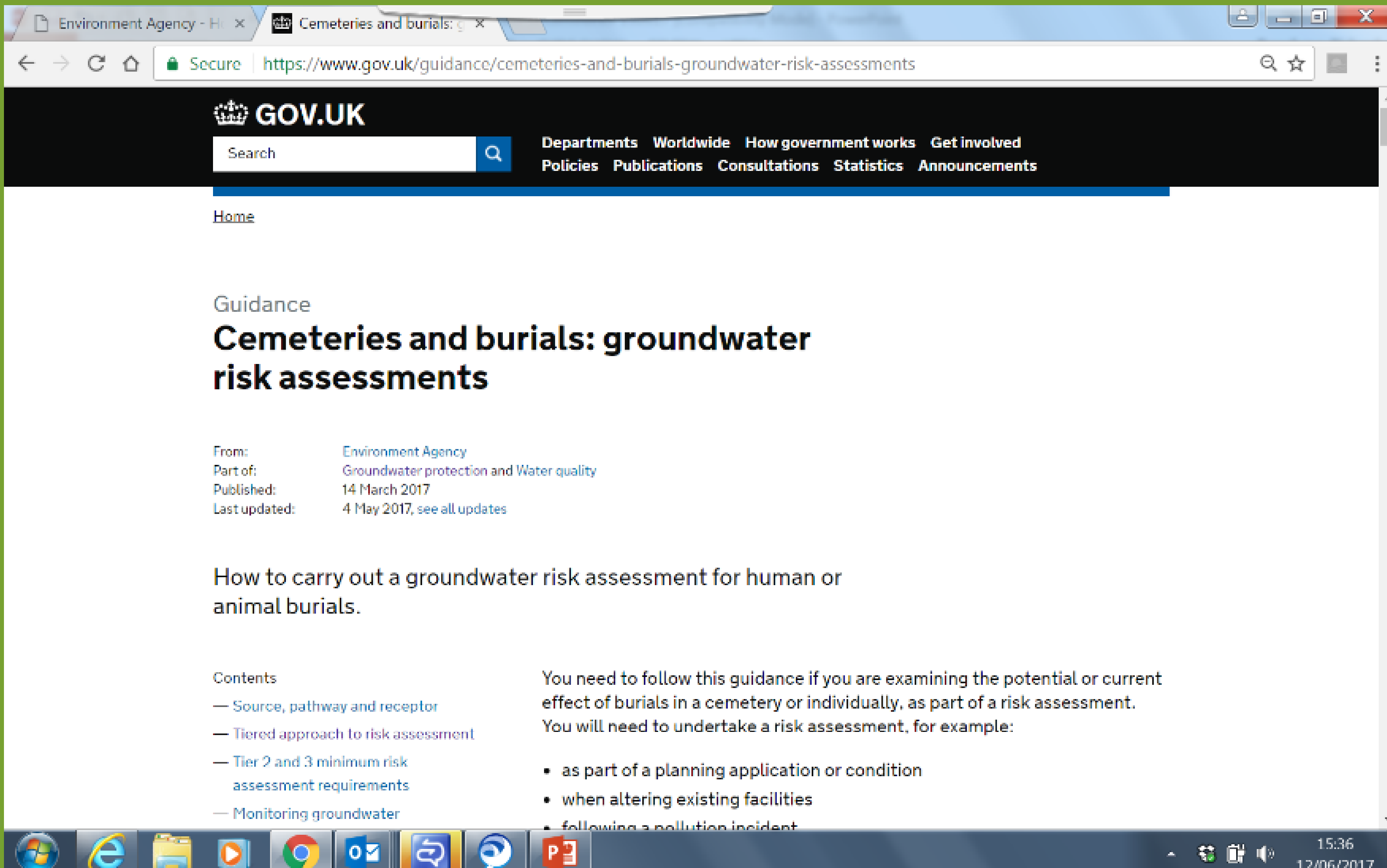
Graves must –

- have at least 1 metre clearance between their base and the top of the maximum water table
- not be dug in areas prone to groundwater flooding
- be deep enough so at least 1 metre of soil will cover the top of the coffin

General requirements

- There must be no direct input of *hazardous substances* to groundwater and no pollution from *non-hazardous pollutants* (EPR 2010)
- A site specific risk assessment is required for all proposals, with a Tier 1 as a minimum
- A site may need some form of intervention to control groundwater levels, e.g., via land raise, drainage or abstraction
- A site may need groundwater monitoring

Hydrogeological risk assessments



Environment Agency - H ×   Cemeteries and burials: ×

Secure | https://www.gov.uk/guidance/cemeteries-and-burials-groundwater-risk-assessments

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Guidance

Cemeteries and burials: groundwater risk assessments

From: Environment Agency
Part of: Groundwater protection and Water quality
Published: 14 March 2017
Last updated: 4 May 2017, see all updates

How to carry out a groundwater risk assessment for human or animal burials.

Contents

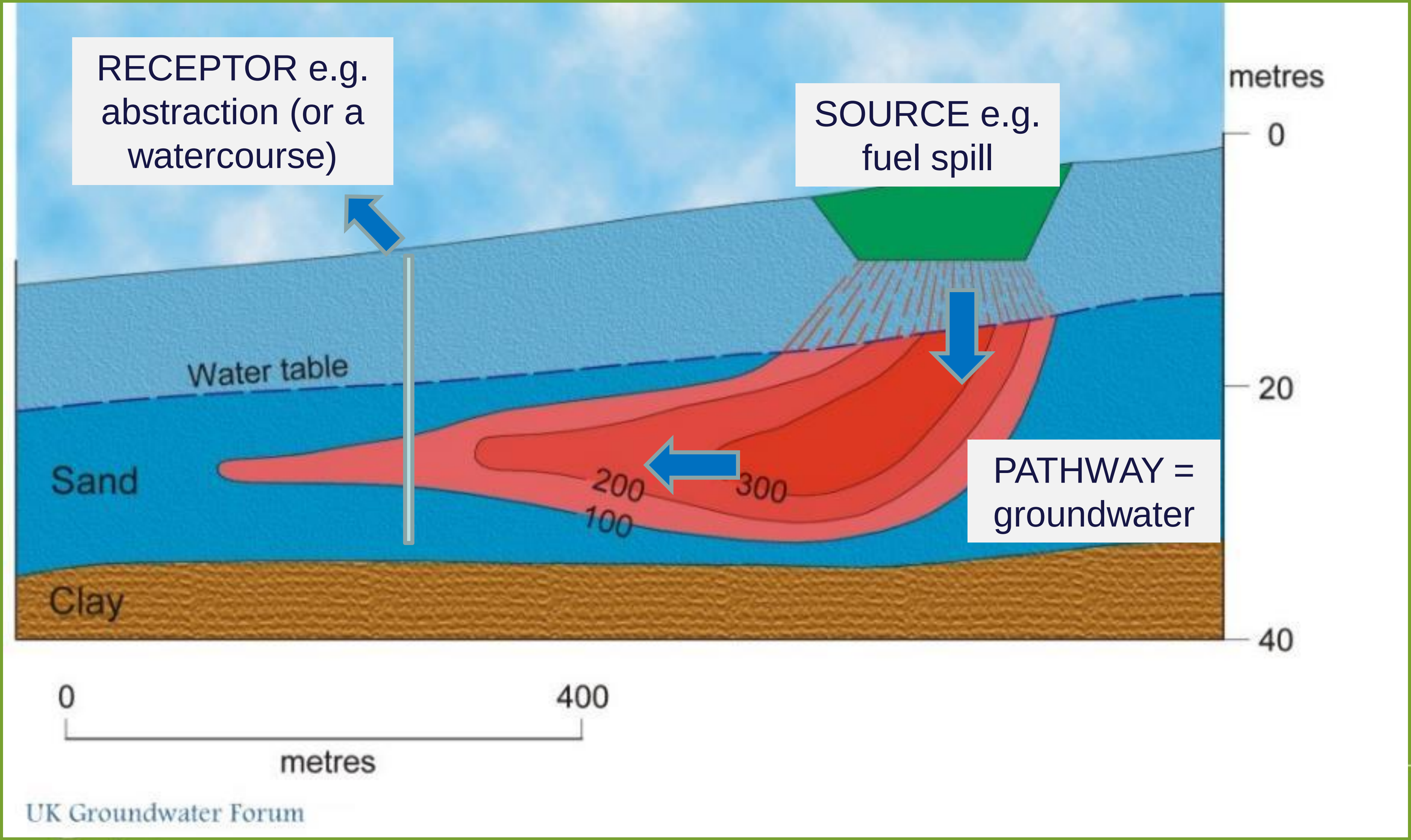
— Source, pathway and receptor
— Tiered approach to risk assessment
— Tier 2 and 3 minimum risk assessment requirements
— Monitoring groundwater

You need to follow this guidance if you are examining the potential or current effect of burials in a cemetery or individually, as part of a risk assessment. You will need to undertake a risk assessment, for example:

- as part of a planning application or condition
- when altering existing facilities
- following a pollution incident

15:36
12/06/2017

Site conceptual model



Tiered risk assessments

- Tier 1 – Desk top study and qualitative assessment only (low, medium, high)
- Tier 2 – Generic quantitative assessment using local / literature data (e.g. soil survey maps, nearby groundwater levels, average rainfall)
- Tier 3 – Detailed quantitative assessment using largely site specific measurements and bespoke risks modelling

Groundwater monitoring

Frequency and extent will depend on –

- cemetery size and rates of use
- results of the risk assessment
- hydrogeological characteristics
- ongoing results of the monitoring

Typical monitoring requirements

- One up-gradient, two down-gradient boreholes
- At least a few metres below the minimum groundwater level
- 12 months prior, 3 – 5 years post development
- At Quarterly intervals
- Possible up- and downstream surface water monitoring too
- Testing to include pollutants, water conditions, degradation parameters, groundwater level etc

Green burials

These usually have more rapid decay rates, as –

- relatively shallow depth of burial
- Typically single depth burials
- biodegradable nature of the coffins / shrouds
- lack of embalming fluids

So pollution risks / planning conditions are much less likely

Existing cemeteries

- They need to be managed to limit any environmental impacts
- They can be controlled using our Notice powers if they cause significant and/or ongoing pollution
- They should have an appropriate risk assessment undertaken…

Many thanks for listening

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LUNCH

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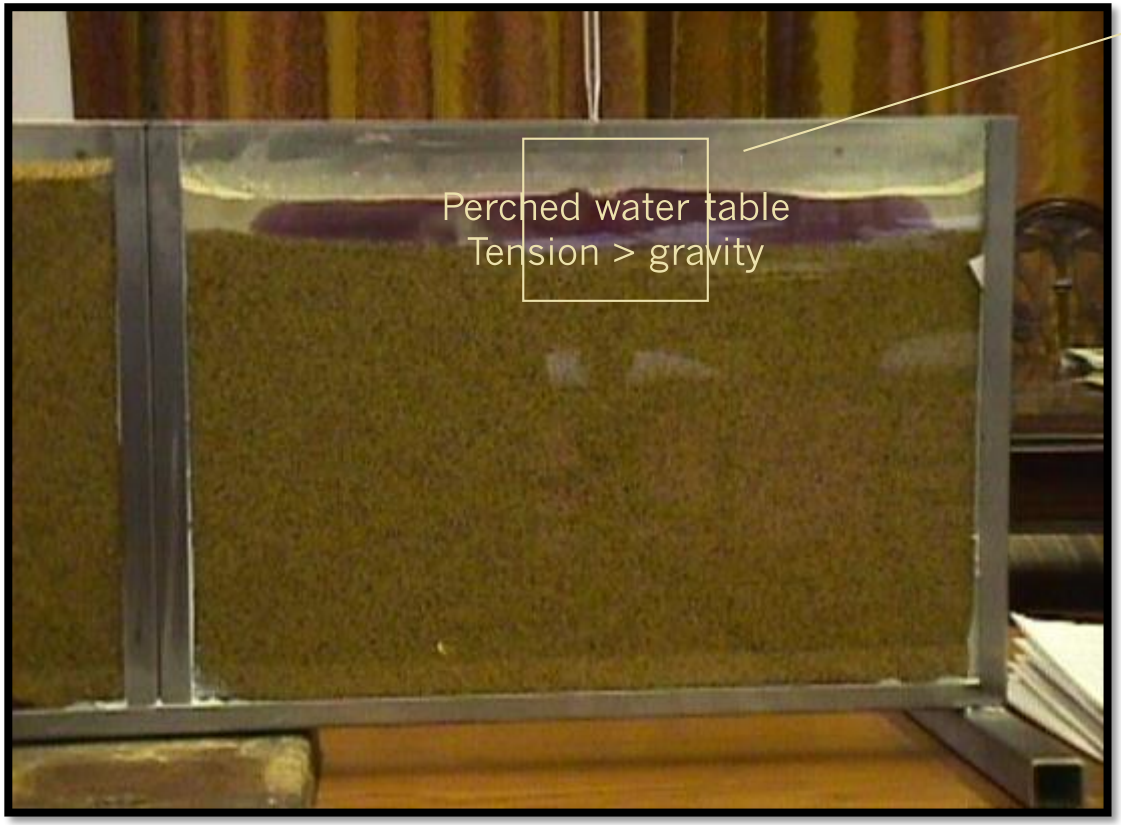
Soils, water and risks posed by cemeteries – managing water in cemeteries



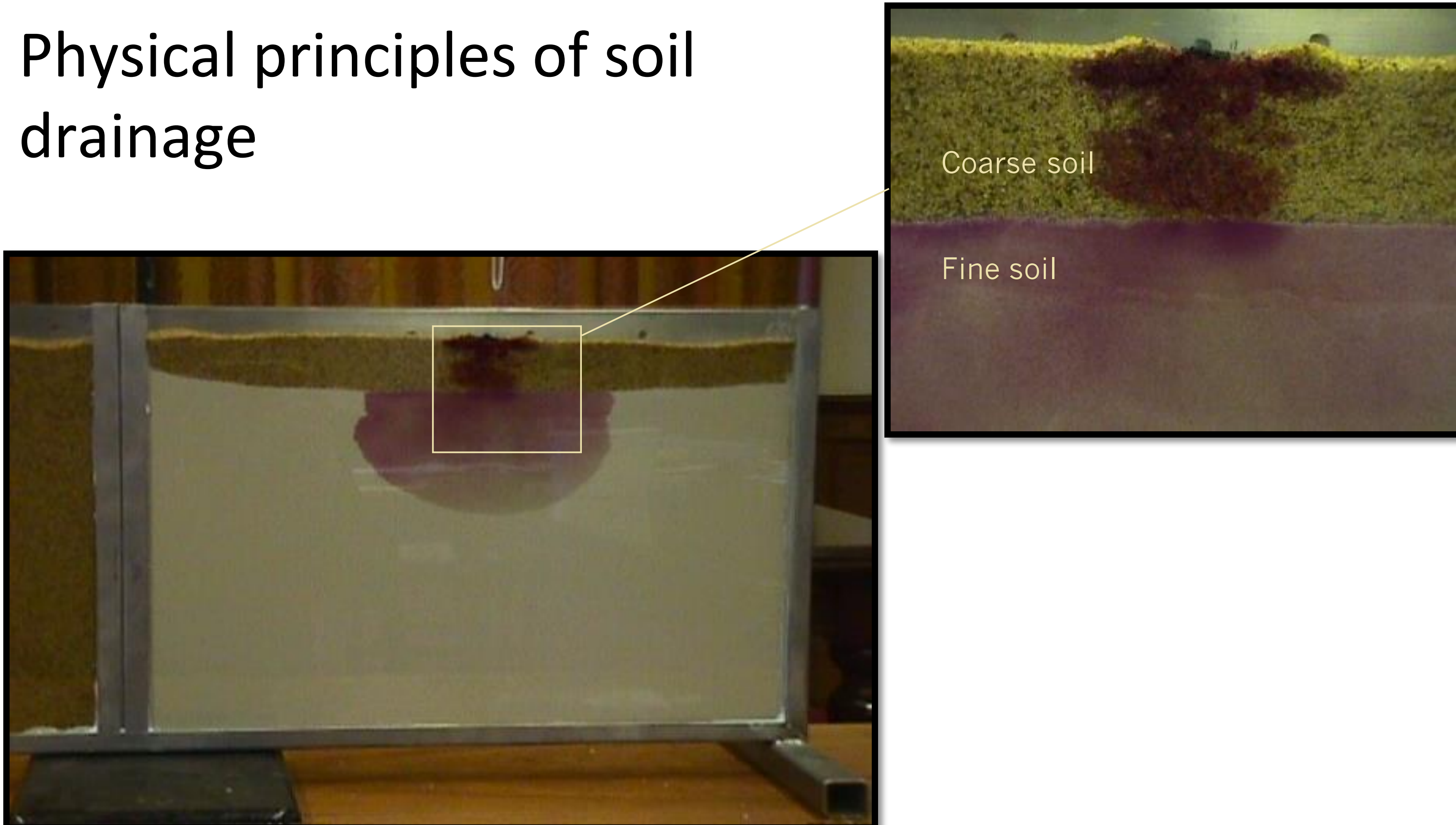

Alex Vickers & Justin Smith

Physical principles of soil drainage

Physical principles of soil drainage



Physical principles of soil drainage



What is the cause of poor drainage?

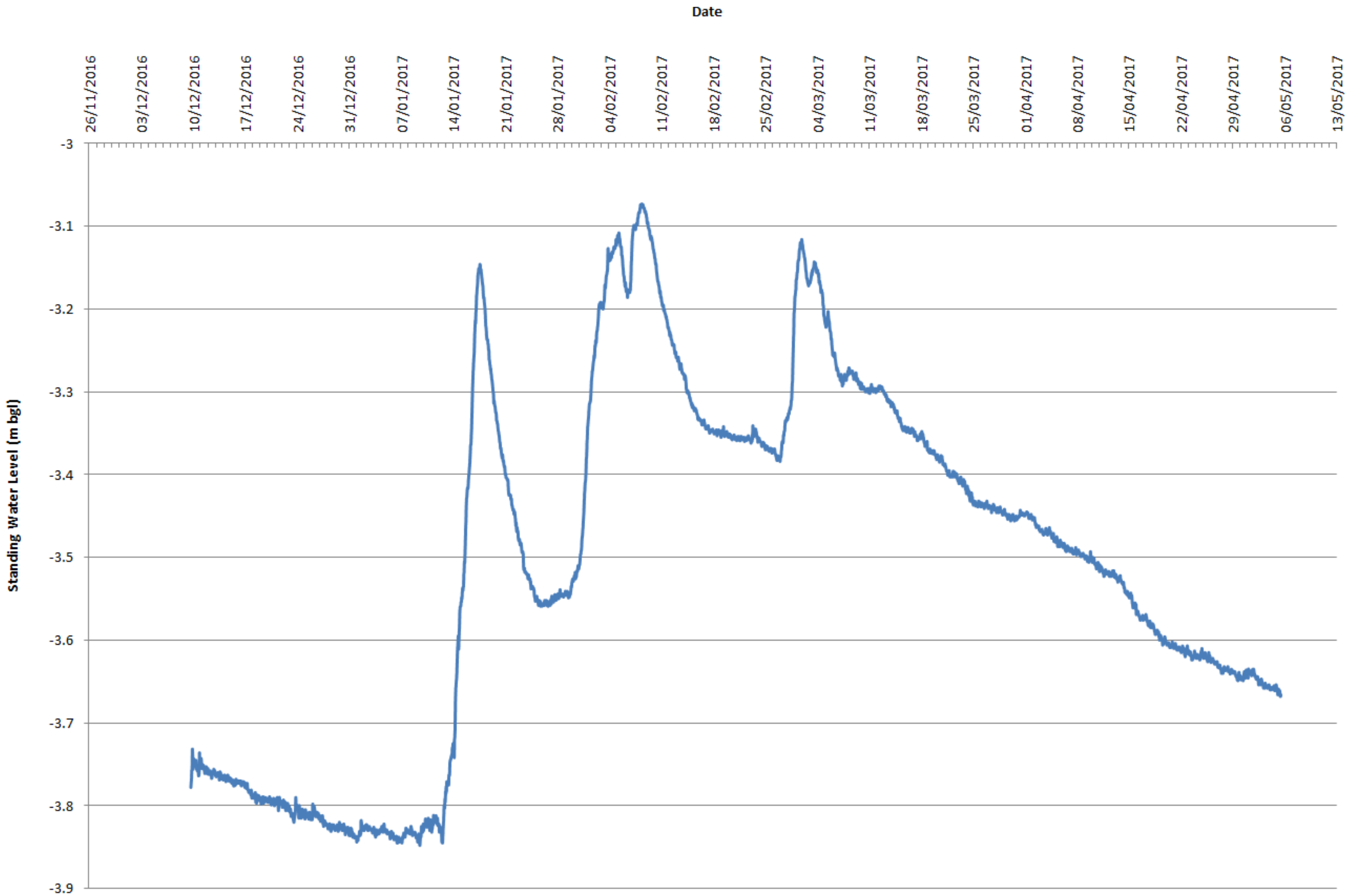
Temporary water tables

High / rising water tables

High water tables

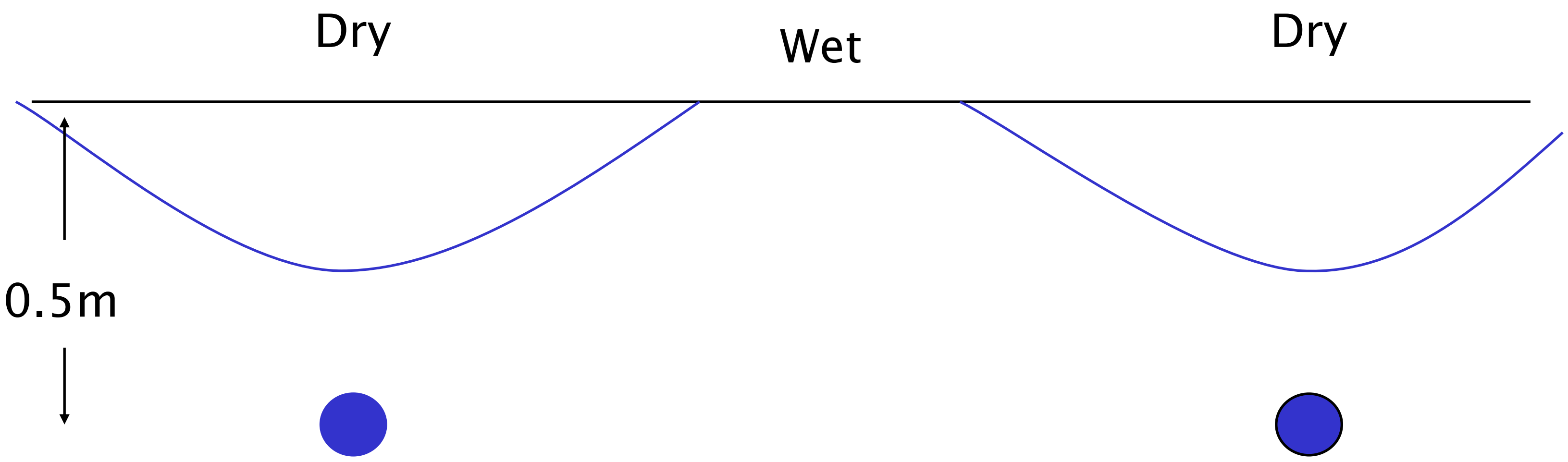
Bore Hole 2 Results Borough Cemetery

Fig.2

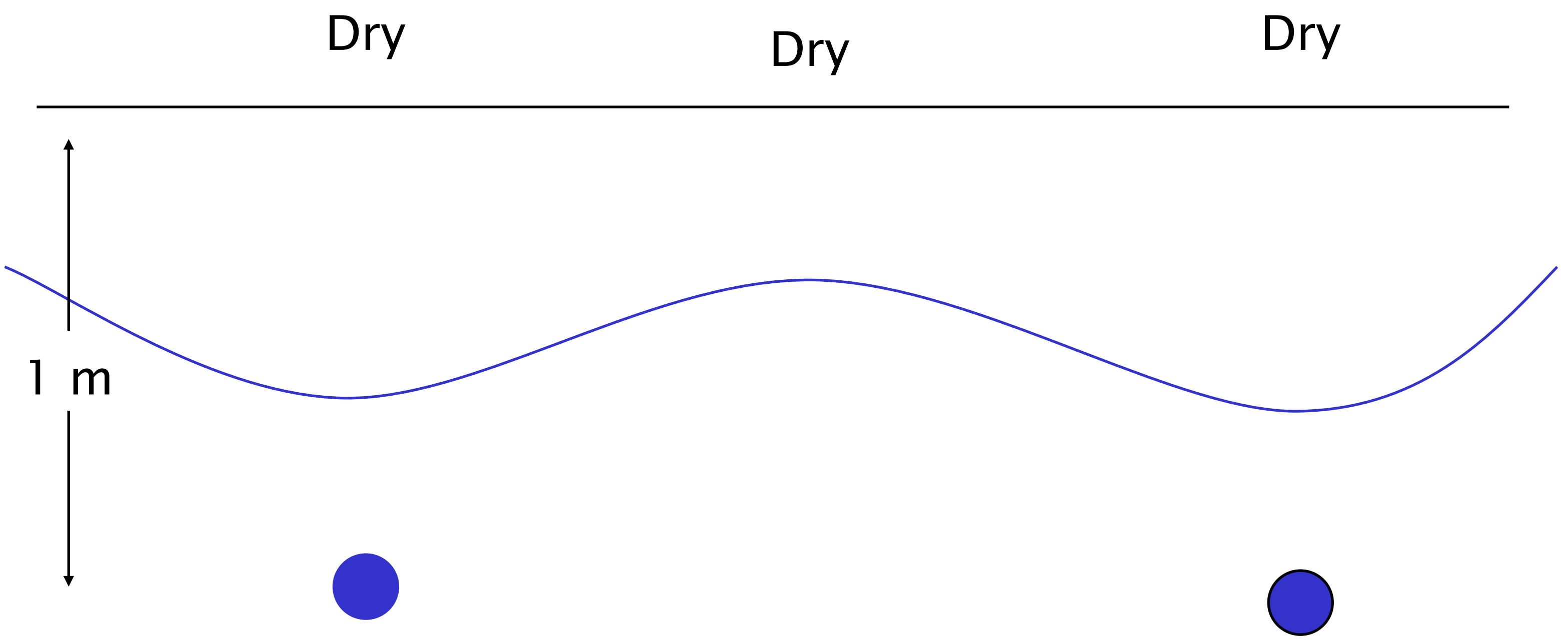


Confined aquifer

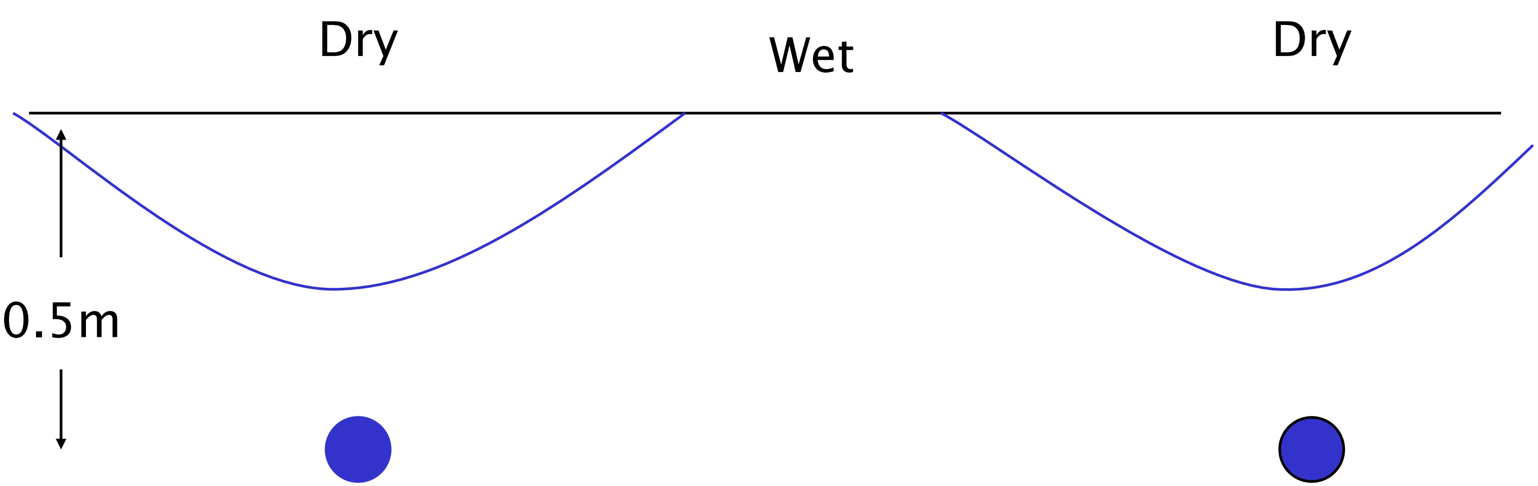
Effect of depth on drain spacing



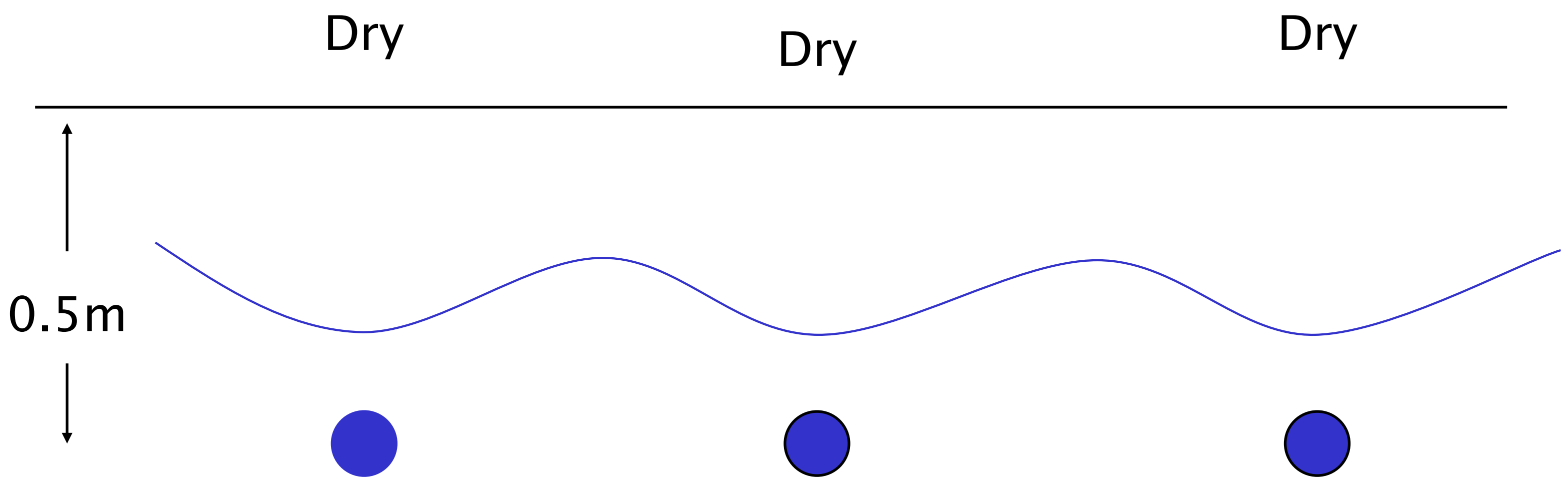
Effect of depth on drain spacing



Effect of depth on drain spacing

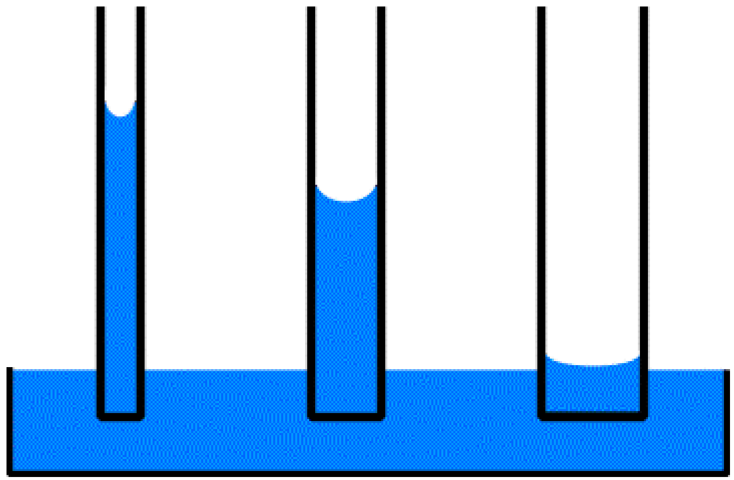


Effect of depth on drain spacing



Capillary rise

Capillary rise



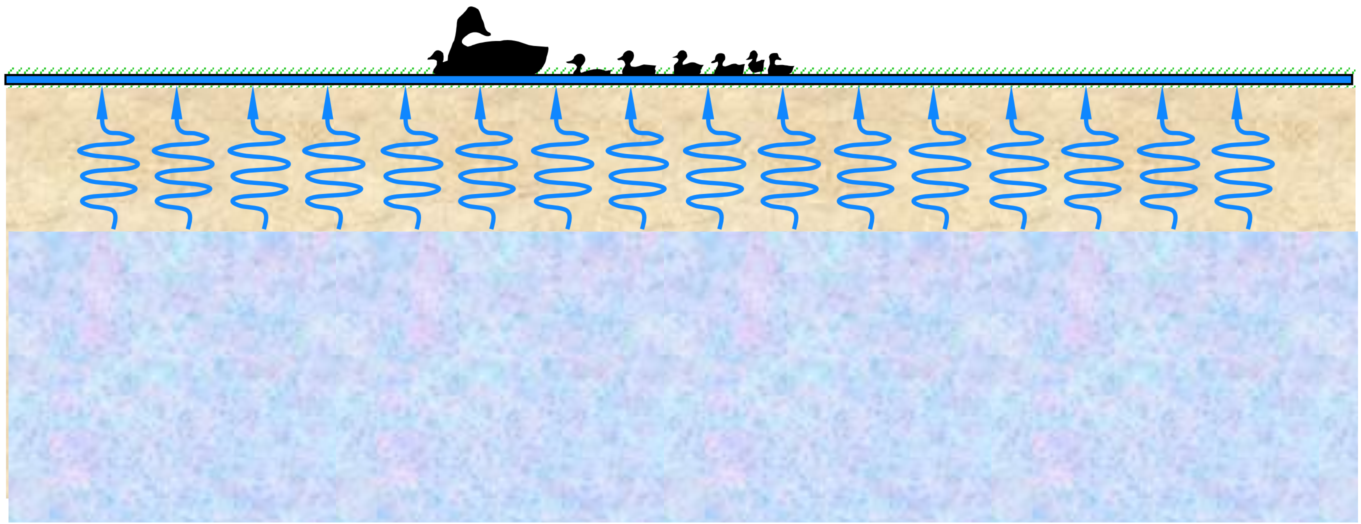
Two forces cause capillarity

ADHESION

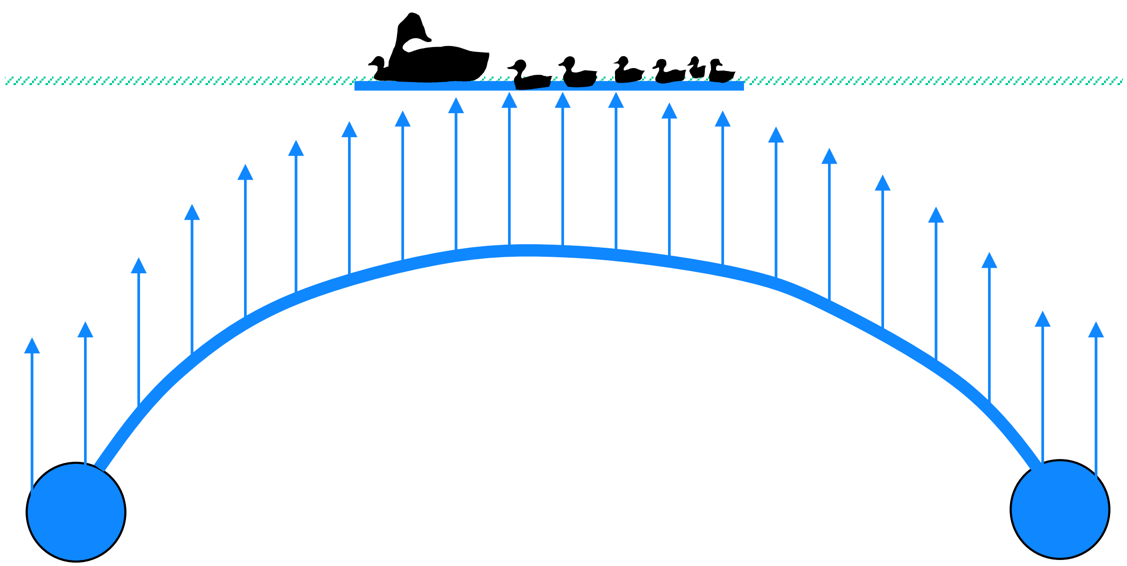
COHESION

Drainage design consideration (laboratory tests)

Capillary rise



Drain spacing and capillary rise

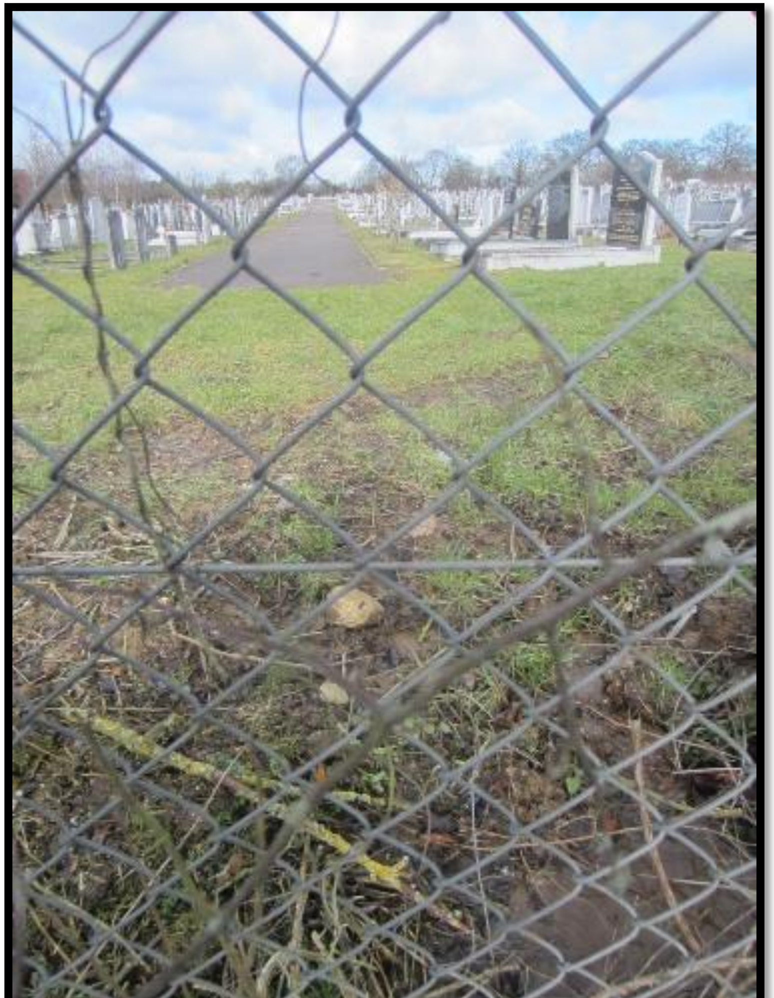


Ochre

Iron ochre

Migration of water from adjacent land

Elevated land



Outfall

Inadequate outfall

Inadequate outfall

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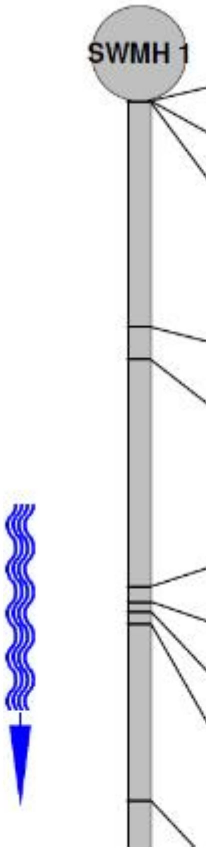
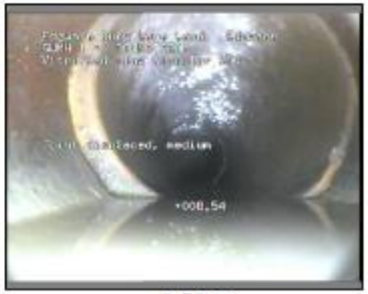
Drain survey



1:162	Position	Observation	Grade
	0.00	Start node type, manhole, reference number : SWMH 1	(Constr) 0
	0.00	Water level, 5% of the vertical dimension	(Serv) 0
	0.01	General remark Remarks: DUE TO UNABLE TO ACCESS SWMH 1 IN GARDENS SURVEY IS BEING RESUMED FROM CP 3, SURVEY WILL BE CARRIED OUT WITH PUSHROD AND NOT PAN & ROTATE CRAWLER DUE TO ACCESS	(Misc) 0
	3.85	Joint displaced, medium	(Struct) 1
	4.41	Joint displaced, medium	(Struct) 1
	8.28	Joint displaced, large	(Struct) 1
	8.53	Joint displaced, medium	(Struct) 1
	8.70	Line deviates down	(Serv) 0
	8.91	Line deviates down	(Serv) 0

4.41 m

8.28 m



8.53 m

Achieving outfall

Achieving outfall

Runoff and drain flow attenuation

Detention basins

Swales

Attenuation ponds

Soakaways

Hydro-cells

Water harvesting

Poor drainage design

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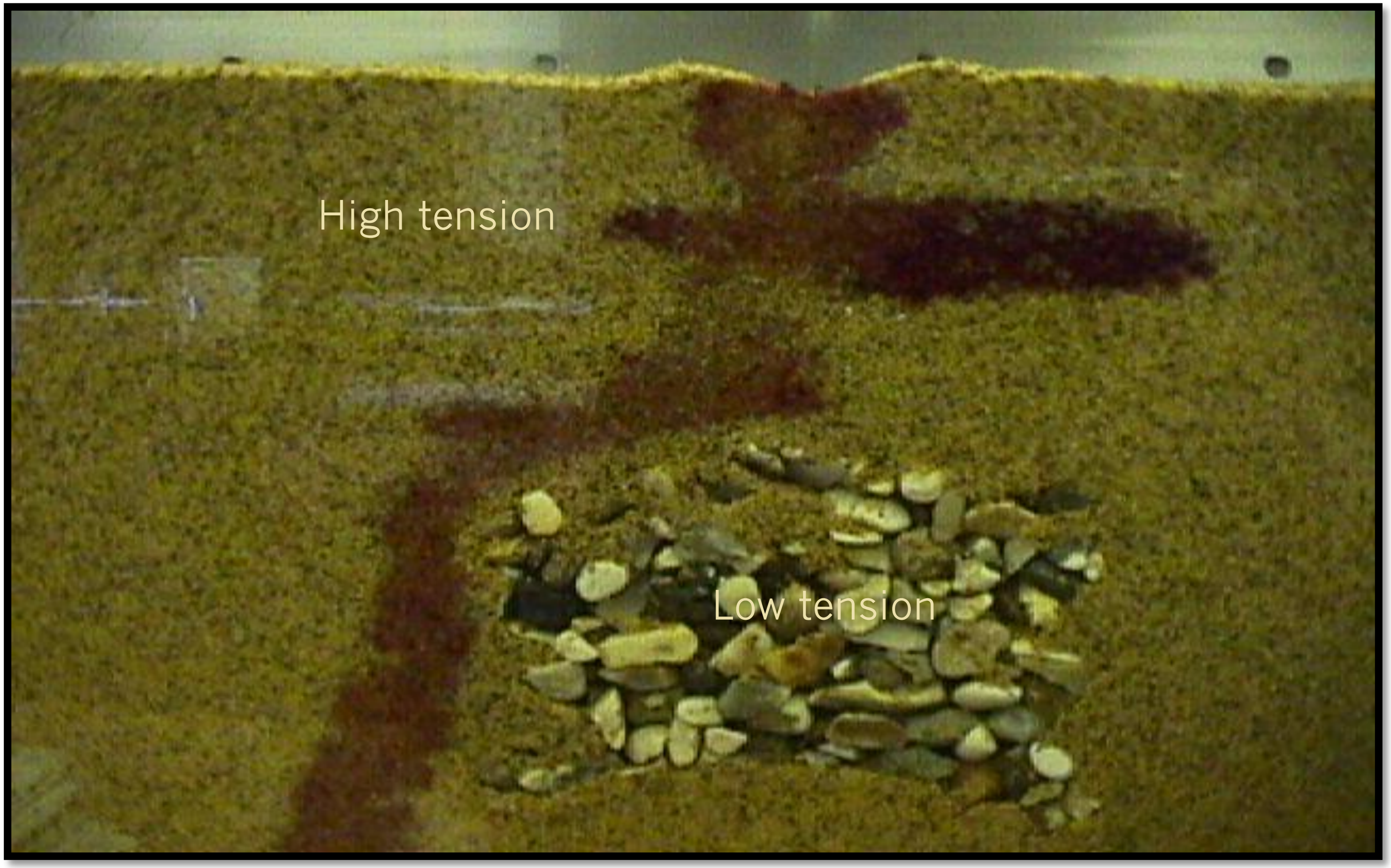
Physical principles of soil drainage



Inappropriate specifications

Orientation of surface drains

Grade/fall

Existing drainage infrastructure

Poor drainage practice

Poor
conditions

Poor drainage practice

Poor drainage practice

Deep drainage

Deep drainage

Removing water from at least 1m below burial depth

Water treatment – reed beds

Surface water drainage

Removing surface water using shallow drains

Removing surface water using shallow drains

Combining shallow drains with memorial headers

Combining shallow drains with memorial headers

Raising land

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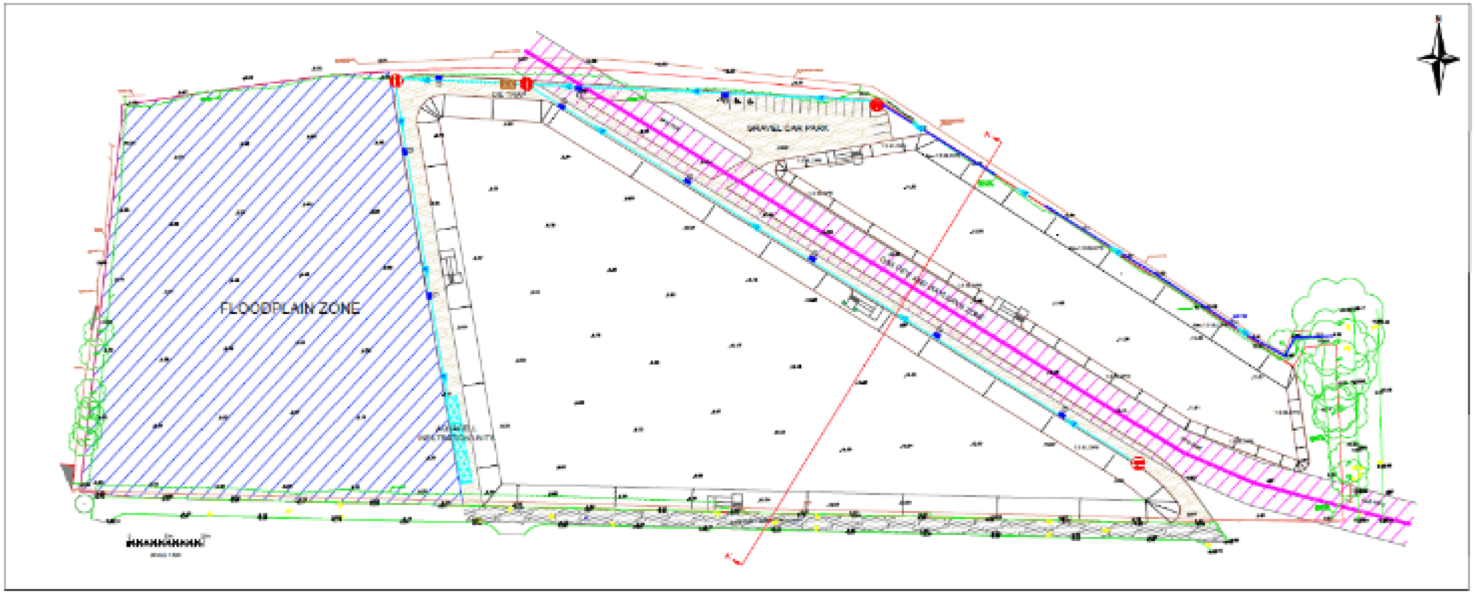
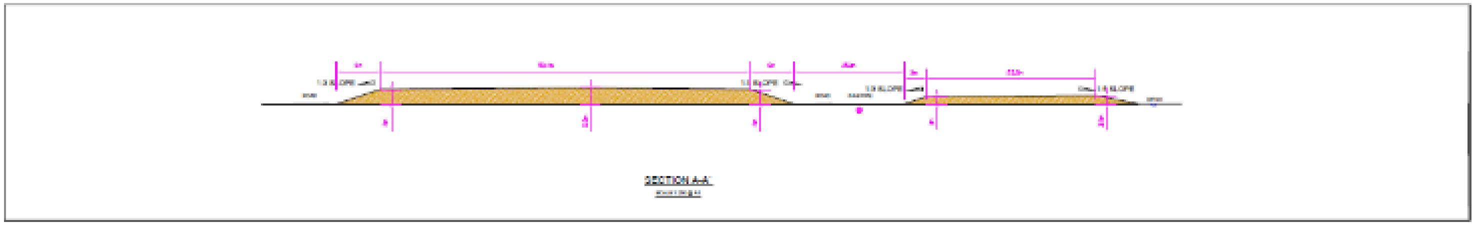
Lifting the base of a grave at least 1m above the groundwater





Need relevant EA approvals.

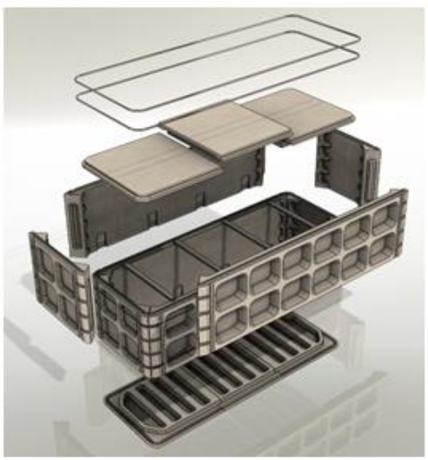
Must avoid contaminating the land

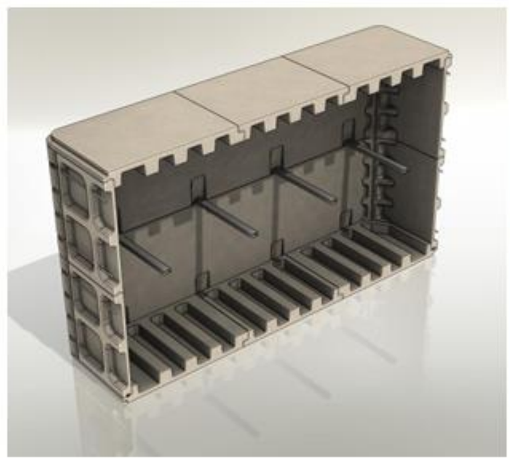
Chambers

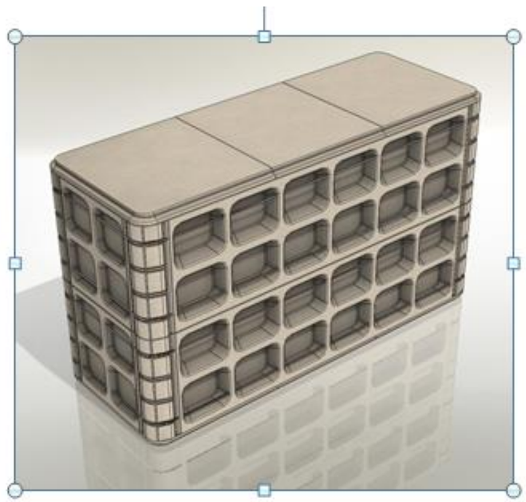
- Increased capacity by 2.5 times
- Can be used on ground unsuitable for earth burials
- Allow use on common grave land
- Maintenance cost low
- Ensure design and construction is going to last

Question mark on use over sensitive groundwater stocks and supplies

Latest construction materials and casting methods







Resin based cementitious materials 2.5 x strength of concrete 100% waterproof, inert.

Thank you and any questions?

The Institute of Cemetery and Crematorium Management

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