LAND CAPABILITY MIS-ASSESSMENTS BY MISSING SOIL SODICITY AND WATERLOGGING

A LONG HISTORY

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A SHORT HISTORY OF MISADVENTURES AND MISDEEDS

Land Capability Assessments appear to be easy assignments and hence attract people into providing these services, but competition on price is fierce

In my experience, many LCA assessors have unsuitable or inadequate qualifications to carry out reliable LCA's

It is not uncommon for LCA providers to cut corners or even to provide false information

Local Government EHO's not infrequently are inadequately qualified to adjudge LCA's

It does appear to happen that Local Government EHO's act in cahoots with LCA providers

WHAT ARE THE FIELDS OF SCIENCE THAT ARE ESSENTIAL FOR A RELIABLE LCA?

- Soil Science, that must include:
  - Basic soil chemistry (pH, salinity, (Electrical conductivity), soil sodicity, clay mineralogy, behaviour of clay (dispersion or flocculation) in relation to sodicity and salinity
  - Basic soil physics (behaviour of water in the soil, how Darcy's Law controls the movement of water in the soil and how every soil permeability test method is related to this Law
  - Basic soil fertility issues that relate to a vegetative cover on effluent disposal fields
- Geology and geomorphology
  - How do soil types relate to the parent rock and to the alterations of the soil over long geological periods of weathering, erosion and sedimentation

WHAT DO GEOTECHNICAL ENGINEERS STUDY?

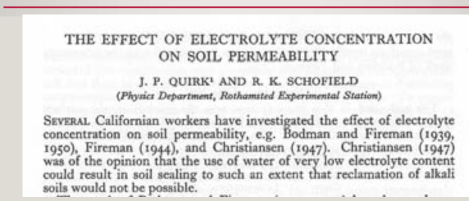
- Geotechnical engineering is the **study of the behaviour of soils under the influence of loading forces and soil-water interactions**. This knowledge is applied to the design of foundations, retaining walls, earth dams, clay liners, and geosynthetics for waste containment.
- **Geotechnical engineering**, also known as **geotechnics**, is the branch of civil engineering concerned with the engineering behaviour of earth materials. It uses the principles of soil mechanics and rock mechanics for the solution of its respective engineering problems. It also relies on knowledge of geology, hydrology, geophysics, and other related sciences.
- Geotechnical engineering studies include methods for measuring and predicting soil permeability
- Note that soil chemistry, soil mineralogy and soil biology or soil fertility are not mentioned

ARE THERE IMPERMEABLE WALLS BETWEEN DIFFERENT ACADEMIC FIELDS IN UNIVERSITIES?

- It very much looks like that!
- Soil science from an agricultural point of view is taught at Melbourne and La Trobe Universities and from a geographical perspective at Monash University and at RMIT
- From a perspective of soil contamination soil science is taught at RMIT and to some extent also by Monash
- Geotechnical engineering and soil mechanics is taught at Melbourne University and by Monash
- But I keep coming across Geotech and Civil Engineering reports that suggest there is zero cross fertilisation
- There is no university in Victoria, and maybe anywhere else in Australia, where a person can obtain a PhD in soil science whilst being exposed to almost the entire gamut of soils-related scientific fields, unlike the USA and Canada

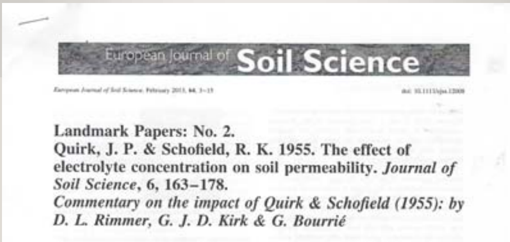
JOURNAL OF SOIL SCIENCE, VOL. 6, NO.2, 1955

1955: WHEN YOUR PARENTS WERE CHILDREN OR NOT YET BORN


THE EFFECT OF ELECTROLYTE CONCENTRATION ON SOIL PERMEABILITY

J. P. QUIRK[1] AND R. K. SCHOFIELD
(*Physics Department, Rothamsted Experimental Station*)

SEVERAL Californian workers have investigated the effect of electrolyte concentration on soil permeability, e.g. Bodman and Fireman (1939, 1950), Fireman (1944), and Christiansen (1947). Christiansen (1947) was of the opinion that the use of water of very low electrolyte content could result in soil sealing to such an extent that reclamation of alkali soils would not be possible.

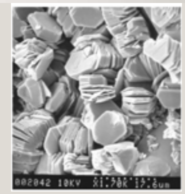

European Journal of **Soil Science**

Landmark Papers: No. 2.
Quirk, J. P. & Schofield, R. K. 1955. The effect of electrolyte concentration on soil permeability. *Journal of Soil Science*, 6, 163–178.
Commentary on the impact of Quirk & Schofield (1955): by D. L. Rimmer, G. J. D. Kirk & G. Bourrié

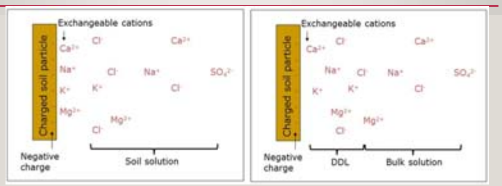
SCANNING ELECTRODE MICROGRAPH OF CLAY PLATELETS

Clay minerals are flat, like pages in a book, with the space between the platelets being variable and being filled with water and exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, H^{+}) and non-exchangeable anions (OH^{-}, CO_3^{-2}, SO_4^{-2}, etc.)

Some clay minerals, e.g. montmorillonite can be strongly swelling and shrinking, others not, e.g. kaolinite



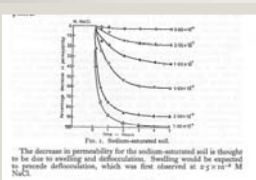
CLAY PARTICLES ARE LIKE PAGES IN A BOOK SURROUNDED BY WATER AND EXCHANGEABLE CATIONS



RESEARCH TO FIND OUT WHAT IS THE ROLE OF EACH OF THE POSSIBLE MAIN CATIONS IN THE SOIL?

1. Leach a soil sample many times with a single cation salt solution (e.g. NaCl, KCl, $MgCl_2$ and $CaCl_2$)to replace all exchangeable cations with a single species:
2. Sodium, Na^{+1} or potassium, K^{+1}, or magnesium, Mg^{+2} or calcium, Ca^{+2} and run a permeability test in each of these mono-species exch. Cation soils
3. Determine if during repeated tests, the permeability remains the same. Increases or decreases over time
4. A change of permeability indicates a change of soil structure (for the better or worse)

LOSS OF SOIL PERMEABILITY OF A SALINE SOIL WHEN PERCOLATED WITH SALINE WATER OF VARIOUS STRENGTHS -- FOR A SODIUM-SOIL SYSTEM



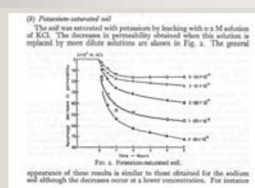
5.00×10^{-1} molar NaCl means 0.33 mg Na/Litre

1.00×10^{-1} molar NaCl means 0.066 mg Na/L

2.5x10-2 molar NaCL means 0.001,65 mg NaCl/L

The lower the salinity of the water used for percolation, the faster is the loss of permeability for a sodic soil

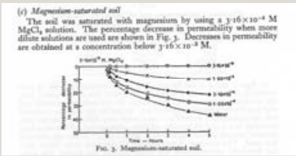
LOSS OF SOIL PERMEABILITY OF A SALINE SOIL WHEN PERCOLATED WITH SALINE WATER OF VARIOUS STRENGTHS -- FOR A P0TASSIUM-SOIL SYSTEM



Note: potassium, like sodium, is a monovalent cation and is almost as bad for maintaining soil permeability

Wastewater from vineyards often is high in potassium, K, as well as Na, because of their use as cleaning agents

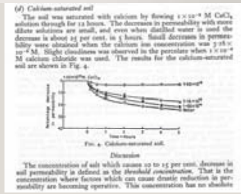
LOSS OF SOIL PERMEABILITY OF A SALINE SOIL WHEN PERCOLATED WITH SALINE WATER OF VARIOUS STRENGTHS -- FOR A MAGNESIUM-SOIL SYSTEM AND A CALCIUM-SOIL SYSTEM



(c) *Magnesium-saturated soil*

The soil was saturated with magnesium by using a $3 \cdot 16 \times 10^{-2}$ M $MgCl_2$ solution. The percentage decrease in permeability when more dilute solutions are used are shown in Fig. 3. Decreases in permeability are obtained at a concentration below $3 \cdot 16 \times 10^{-3}$ M.

Fig. 3. Magnesium-saturated soil.



(d) *Calcium-saturated soil*

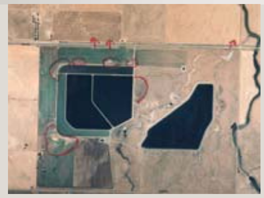
The soil was saturated with calcium by flowing 1×10^{-2} M $CaCl_2$ solution through for 12 hours. The decreases in permeability with more dilute solutions are small, and even when distilled water is used the decrease is about 25 per cent. in 5 hours. Small decreases in permeability were obtained when the calcium ion concentration was $3 \cdot 16 \times 10^{-4}$ M. Slight cloudiness was observed in the percolate when 1×10^{-4} M calcium chloride was used. The results for the calcium-saturated soil are shown in Fig. 4.

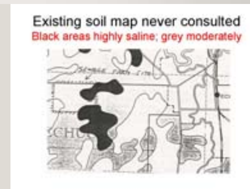
Fig. 4. Calcium-saturated soil.

Discussion

The concentration of salt which causes 10 to 15 per cent. decrease in soil permeability is defined as the *threshold concentration*. That is the concentration where factors which can cause drastic reduction in permeability are becoming operative. This concentration has no absolute

ECHUCA WASTE WATER TREATMENT PLANT, DESIGNED BY ENGINEERS, LEAKS SALTY EFFLUENT ONTO PRIVATE FARM LAND AND AROUND THE TURKEY'S NEST WALLS





WHAT HAPPENED AT ECHUCA? WHY?

Saline clay soil underlies the whole area

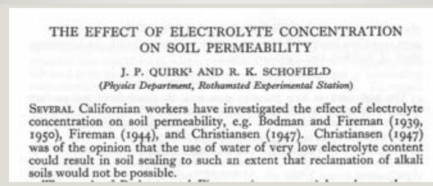
If an impermeable seal could be made from the natural underlying clay, much money would be saved. Engineers liked that.

Soil permeability was tested using de-ionized (salt-free) water as per engineering handbooks to predict leakage of wastewater. Result: base clay "impermeable"!

Hooray! The soil just needs compacting, no need for an impermeable lining!

Unfortunately, the wastewater was very saline from food processing and an abattoir in Echuca, it was not deionised, the turkeys nest dam leaks like sieve because the salinity makes the soil very permeable

QUIRK & SCHOFIELD'S 1955 PAPER RECOGNISED AS A "LAND MARK PAPER" BY EUROPEAN JOURNAL OF SOIL SCIENCE IN 2013



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WHAT HAS HAPPENED WITH THIS SCIENCE SINCE 1955?

Irrigation experts, internationally, have used this information to modify the quality of irrigation water where sodic soils are irrigated by adding calcium from gypsum (calcium sulphate) to the irrigation water, or incorporating gypsum in the soil. They have been correctly educated in soil chemistry.

Civil engineers and Geotech engineers, evidently, are not taught about soil sodicity and how soil permeability is affected by the chemistry of the water in the soil, nor about the relationship between various common clay minerals and the chemistry of interstitial water in the soil. They keep making costly mistakes.

The science has been there for seven decades!!

*) HOW ABOUT ONSITE EFFLUENT MANAGEMENT CONSULTANTS?

*) HOW ABOUT EPA STAFF WHO DEAL WITH WORK APPROVALS?

*) HOW ABOUT EPA STAFF WHO WRITE THE CODE OF PRACTICE, PUB. NO 891.4 AND ALL PREVIOUS CODES?

EVIDENTLY MANY ARE LARGELY UNEDUCATED WITH RESPECT TO THE BEHAVIOUR OF SODIC SOILS WITH WATER

THE SAME MISTAKE OF NOT MEASURING THE SOIL'S SODICITY, ASSUMING IT DOESN'T AFFECT EFFLUENT DISPOSAL, AND OF ATTEMPTING TO MEASURE PERMEABILITY OF SODIC SOILS USING LOW SALINITY TAP WATER OR DEIONISED WATER IS BEING REPEATED ALL THE TIME

LCA ASSESSOR #1 & EPA WORKSAPPROVAL

- Bellbrae Primary School wastewater irrigation scheme on sports oval
- A long story of misery

BELBRAE PS DESIGN WASTEWATER DISPOSAL IN SPORTS AREA PASSES EPA WORKS APPROVAL

EFFLUENT EMERGES EVERY WINTER ON THIS HIGHLY SODIC CLAY SOIL

BELLBRAE PRIMARY SCHOOL

The LCA assessor was a Geotech engineer lacking a soil science background

Soil permeability measured by the old percolation test in the elevated land around the sports oval, not within the excavated space within the oval

Soil permeability was based on the quick manual guessing method as in AS:NZS 1547 2000, not on the constant head method in that same manual

The geology of the site was read off a geological map and presented as calcareous soil, whereas it was heavy sodic clay

No soil chemical tests were taken because the Codes of Practice have never required them

BELLBRAE OVAL TEST SITES

Initially in undisturbed soil on elevated ground during summer, then in excavated subsoil in oval during winter

Percol'n rate between trees: 35 mm/hr

Percol'n rate oval: 20 mm/hr

Percol'n data ultimately not used but as per AS/NZS 1547:2000 use loading rate of 20mm/day

MAJOR ENVIRONMENTAL FIRM ENGAGED CONCLUDES:

- Geomean Ksat Oval 0.0004 m/day
- Ksat adopted for oval (current disposal field);
- Note: this is below the range considered acceptable for a Talsma-Hallam test which is 0.009 – 2.6 m/day (AS NZS 1547:2012).
- Although use of gypsum solution showed an order of magnitude higher permeability than standard saline solution, the results indicate soil at depth is essentially impermeable. This poses a major constraint for the site wastewater application area and is a major driver behind the need for drainage collection as detailed in this design.
- Refer to attached laboratory reports

MORE CONCLUSIONS FROM MAJOR FIRM

- Entire project by original land capability assessor including appraisal by the regulator was just a "tick the box" exercise
- Code allows the assessor to merely "guess" the hydraulic conductivity of the subsoil
- Code does not require the assessor to demonstrate that the subsoil strata are permeable enough to enable excess water to drain towards the groundwater at a suitable rate
- In small systems the inexactness of the usual LCA methodology is rarely critical. For large irrigation systems it is fraught with major risks

RECOMMENDATIONS

- Sodicity (Exchangeable Sodium Percentage ESP)
- Effluent and greywater contain sodium which over time can cause damage to the soil structure when the ESP >6%. Lab soil results show sodic conditions at locations in the subsoil (clay), with strongly sodic conditions in the deeper subsoil.
- Soil amelioration recommended (gypsum/lime/dolomite).

THE SOLUTION BY ENGINEERS?

Brand new subsurface irrigation system costing several 100,000 dollars but seemingly zero spend on countering sodicity and fixing the soil

LCA ASSESSOR #2 - A MAN IN HURRY

- Quicky soil permeability testing when you are in hurry
- Auger the holes to varying depths and run water into them fast.
- Within seconds start measuring the loss of water over time intervals of 2.5 minutes
- Read volume of water loss
- After 10 minutes, pull equipment out and move on to next site
- Report data in a mathematical form that guarantees most EHO's haven't got a clue what they mean

LCA ASSESSOR #2

The Assessor's soil permeability measurements, by taking four readings of water infiltration with 2.5- minute intervals, are all completed in 10 minutes at a single site. This is an utterly incorrect methodology but claimed to be following the Standard.

It cannot be a reading of Ksat when it is unlikely stable infiltration is reached

Note that the test holes were only 0.5 m deep, but were filled with water to just 0.1 m below the soil surface. Thus, any water loss from the reservoir is water that infiltrated into the generally much more permeable topsoil with a smaller portion going through the tighter subsoil.

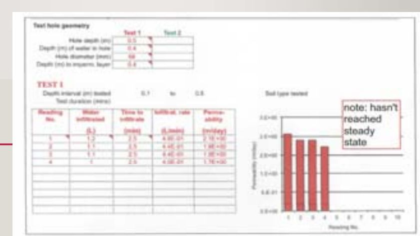
HOW MANY COUNCIL ENVIRONMENTAL HEALTH OFFICERS UNDERSTAND THESE LOGARITHMIC FUNCTIONS?

K_{SAT} = 2.1E+00 m/day

What is the purpose of the LCA provider in reporting his Ksat data like this?

E stands for 10, and 00 means 10 to the power of 00 meaning it is 1(one)

$1E6=10^6$ = 1,000,000



Permeability values are provided as power functions.

Any number can be expressed as a power of 10, in the form NEX where N (positive or negative) is a number with one or more digits, E means 10, and X (2 digit: positive or negative) is the power to which 10 is raised. If you are unfamiliar with this method, try entering a few numbers in the yellow box below to see how it works. A few examples:

1E+02 = 100
1.5E+02 = 150
2.3E+01 = 23
1E0+1 = 10
1E+00 = 1 (ie 1 x 10 raised to the power 0 = 1)
1E-01 = 0.1
1E-02 = 0.01
1E-03 = 0.001

The final permeability in m/day is given as 1.7E+00 m/day, a number form, such as this, is scientific format (commonly used in Microsoft Excel spreadsheets) for '10 to the power of negative 1'. So, in this case, 1.7E+00 m/day the result in common language is just 1.7 m/day, a very high value appropriate for a sandy soil. How will those Environmental Health Officers and planners, who have to deal with these numbers and most probably lack the mathematics, make sense of power functions like this?

LAND CAPABILITY ASSESSOR #3

- This assessor is trying to find an "official" excuse for not determining soil permeability by quoting a line from the Code as justification
- Note at the base of his Table A reference to a a note in the Code that says the percolation test method is not valid anymore, so obviously, he does not have to do any permeability testing
- But he is reading the Code selectively

LCA ASSESSOR #3

Note: in the Table, at the base line where "Percolation Rate" is listed, there is a Note: ND. "Not determined" (No longer recognised by EPA Victoria, Pub. 891.4). Therefore, the assessor absolves himself from any actual measurement

However, EPA Pub. 891.4, on page 34 says:

Soil permeability testing conducted in situ using the constant head well permeameter method (AS/NZS 1547) to determine the likely rate of flow of wastewater through the soil of the dispersal area is best practice. In situ permeability testing must be conducted on the limiting soil layer (frequently the B horizon) unless soil saturation or high swelling clays or cracked low to-moderate swelling clays are present.

Emerson Test**	4, 6, 8	5	7	2, 3	1	4
EC (dS/m)**	< 0.3	0.3 - 0.8	0.8 - 2.0	2 - 4	> 4	1
pH	6-8	-	4.5-6	-	<4.5 and >8	3
Sodic Soil***	Low	-	Moderate	-	High	1
Gravel Fraction (%)**	< 10	10 - 20	20 - 40	-	>40	1
Percolation Rate** (mm/hr)	50 - 75	20 - 50 75 - 150	15 - 20 150 - 300	300 - 500	< 15 > 500	ND

ND - 'Not Determined' (No longer recognised by EPA Victoria, Pub 891.4)

Overall Site Rating: 3

** Relevant to soil layer(s) associated with disposal location
***Sodic Soil has been determined thru soil structure, dispersion, slaking and EC data

The Land Capability Class Rating (LCCR) was determined to be a '5', as a result of the site's shallower depth of soil encountered across the area(s) to be developed (ie: between 500-800mm). The soil type's slightly dispersive nature will also require to be considered with the placement of the irrigation disposal locality.

Subsequently, where primary treated effluent cannot be suitably disposed of at the site, a system generating the minimum 20/30 secondary effluent quality is seen as best practice management for the allotment.

LCA REPORT BY ASSESSOR #3

In further consideration of the soil types 'Slightly Dispersive Nature', it is said:

"Clay soils that have a tendency to be dispersive shall receive special design attention. During construction, gypsum should be applied at 1 kg/m2 to any disturbed soil surface area to prevent the clay from dispersing under constant moist conditions. The irrigation / disposal area should be closed in or recovered as soon as possible to protect the gypsum from raindrop impaction."

Why no lab test for sodicity and "gypsum requirement"? It is not expensive.

ASSESSOR #3 DOING THE EMERSON DISPERSION TEST

Results:

CLASS 2 AND CLASS 3

Evidently, dispersion in half of the tests can affect more than 50% o the soil aggregates, i.e. that half of soil aggregates is quite unstable. However, sodicity was not measured.

DISPERSION SUBCLASSES FOR TYPE 2 AND 3 AGGREGATES

1 Slight milkiness

2 Obvious milkiness, less than 50% of the aggregate affected

3 Obvious milkiness, greater than 50% of the aggregate affected

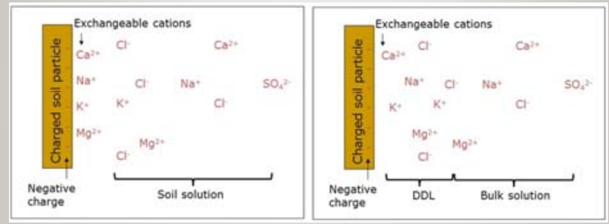
4 Total dispersion leaving only sand grains

ASSESSOR #3 WHO HAS A BA - CONVOLUTED PROSE

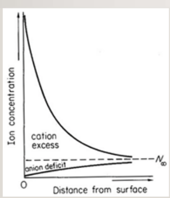
- Consequently, the irrigation area will require an adequate depth of topsoil to store the applied effluent
- and to support the growth of evergreen plants/vegetation to maximize evapo-transpiration practices.
- The likely importation of topsoil type material (ie: clayey loam – imperfectly drained as per
- AS1547:2012) will be required for the creation and slight raising of the disposal locality where a
- minimum of 600mm of soil is formally required below the installed depth of the irrigation line (typically
- 100mm below grounds surface).

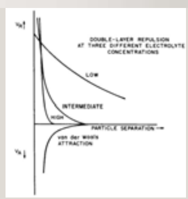
ASSESSOR #3

- There is a lot of dispersion in his samples, hence the soil is probably sodic
- If you don't know the degree of sodicity, how can you work out what to do about it and how much gypsum you may have to use for stabilising soil structure and protecting soil permeability?

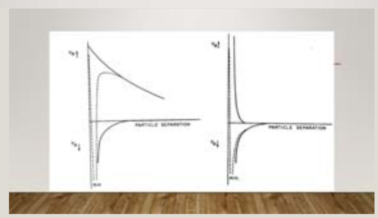


HOW THE THICKNESS OF THE ELECTRIC DOUBLE LAYER CONTROLS THE DISTANCE BETWEEN CLAY PARTICLES - WATER INSIDE THE EDL IS NOT FREE TO MOVE





LEFT: LOW SALINITY WATER BETWEEN CLAY PARTICLES; RIGHT HIGH SALINITY WATER SO PARTICLES CAN GET CLOSE. CLAY SOIL CAN BECOME FLOCCULATED AND FORM STABLE STRUCTURE



ASSESSOR #4

Additional site/soil investigations to determine soil permeability

Two further site inspections were conducted on 23rd January and Wednesday 27th March.

Undisturbed core samples were collected and submitted to laboratory for Ksat tests. The samples were collected from approximately 450mm below ground level and were preserved by encapsulating in plastic wrapping to maintain moisture and prevent cross contamination. The undisturbed samples were subject to constant head permeability tests, triaxial method AS1289.6.7.3*. Only one sample was analysed. The results indicated a soil permeability of 1 x10^{-9} ms-1. Refer to Appendix 1.27th March

• Additional boreholes were drilled to undertake further inspection of soil conditions. Tests were conducted on subsurface soils.

• Insitu soil permeability tests were conducted on two of these boreholes.

All testing carried out according to procedures outlined in AS 1547:2012. Not true!!

ASSESSOR #4 - SOIL PERMEABILITY RESULTS

- Both in-situ test boreholes provided similar values (within experimental error) for the saturated soil permeability, Ksat, of 5.9(1) ± 0.2) x 10^{-5} cm/min or [~3.5 x 10^{-9} m/sec]. Such values are consistent with borehole logs indicative of Silty Clay – Clay.
- Specimen details after lab test - Moisture content 21.8%
- Permeant used -= Distilled water
- PERMEABILITY (k) = 1 x 1^{-10} m/sec
- Sample description: CLAY, medium to high plasticity, yellow-brown/brown.

ENGINEER TALK VERSUS LAYMAN TALK

- What does Ksat = 1×10^{-10} m/sec mean in practical day to day units?
- 1×10^{-10} m/sec = $1 \times 10^{-10} \times 60 \times 60 \times 24$ m/day = $86{,}400 \times 10^{-10}$ m/day which is

  0.000.00864 m/day = 0.000,864 cm/day in other words: impermeable!!!

Put this value in the water balance spreadsheet and now work out the size of your irrigation field! The assessor used a value of 0.35 cm/day in his irrigation spreadsheet, more than 4 billion times the Ksat value.

Both the field in situ tests and the lab test were done with distilled water, as per various Official Handbooks, but the sodic soil immediately closed up when distilled (zero solutes) water was used

ASSESSOR #4

- Like a host of Geotech engineers this assessor had never read the literature with respect to the effects of sodic clay when in contact with salt-free water.
- He was told by the Council EHO to create a watery testing solution with approximately the same levels of calcium, sodium, magnesium and potassium as you find in sewage from predominantly domestic neighbourhoods, which you can get from Sewage Authorities. Any lab can do this for you. Then he got meaningful results.
- It is the only way to obtain useful and realistic test results and Assessor #4 carried this out and had useful results for designing his absorption field

ASSESSOR # 5 CONDUCTING AN LCA ON THE BACKPLAIN OF THE BASS RIVER

HE WAS NOT A GEOTECH ENGINEER BUT HAD A BAgSc DEGREE

- Unable or unwilling to recognise predominantly waterlogged soil
- When this was pointed out, unwilling to go to client with the bad news and continuing with the LCA so as not to miss out on a hefty consultancy fee
- Suggesting that pressurised subsurface irrigation with non-return valves could be used when the soils were saturated or even temporarily covered by surface water in winter
- Unable to use a surveyed (contour) map to work out the actual slope of the terrain but used an inaccurate clinometer instead and classed it to be 1%, when it was 0.05 % in reality (1 in one hundred as opposed to 0.5 in a thousand)

FAILURE TO RECOGNISE PERMANENTLY WATERLOGGED SOIL CONDITIONS

- Entirely light grey due to lack of oxygen

- Dark grey fully un-oxidised clay

SOILS WHERE OXYGEN HARDLY EVER PENETRATES BEYOND THE ROOTZONE OF THE GRASS

SURFACE PONDING OVER MOST OF THE SITE

UNIFORM DARK GREY BROWN CLAY

SURFACE WATER EVERYWHERE IN OCTOBER, FARMER HAS A FEW SHALLOW SURFACE DRAINS TO MOVE WATER OUT.

UNDERSTATEMENTS IN THE LCA
"THE SITE IS AWFUL BUT IF YOU JUST PUMP THE EFFLUENT INTO THE SUBSOIL SHE'LL BE RIGHT MATE!"

- "The measured subsoil permeability is acceptable for wastewater application, though site drainage is likely to be limited across most of the property, given the evidence of periodic waterlogging in the soil. Despite the evidence of minor periodic waterlogging, these soils are suitable for wastewater application to land provided the application area is sized conservatively according to rainfall, such that the land dispersal system is able to function effectively after lengthy periods of wet weather. Pressure compensated subsurface irrigation with secondary treated wastewater is recommended to assist in overcoming these drainage limitations.

WHY CAN WATERLOGGED SOILS NOT BE USED FOR EFFLUENT DISPOSAL?

- 1. Lack of free pore space to accommodate more water
- 2. Lack of oxygen to assist soil micro-organisms to break down human and other organic waste
- 3. Lack of oxygen to assist soil micro-organisms to destroy human-derived bacteria, viruses and other parasites
- 4. To avoid generating bad odours

ASSESSOR # 6 DOING AN EL CHEAPO LCA
A VERY LARGE WASTEWATER IRRIGATION ON SODIC SOIL – 50 ML/YEAR
JUST EIGHT (8) TESTS FOR SOIL PERMEABILITY OF WHICH MOST "FAILED"

- All soils on the project site are sodic to varying extent, slightly sodic in the top 10 cm, but from 20 cm depth to 50 cm depth they go through "sodic" to "strongly sodic".
- Soil permeability (Ksat) in m/day was measured with the Talsma-Hallam method as described in the AS/NZS -1547:2012 using presumably tap water (potable water). Only 8 tests were done, is that enough? And more than half failed. How and why did they fail? It is not explained

Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Fail	2.3	Fail	Fail	0.008	Fail	0.022	Fail

PERMEABILITY TEST RESULTS CONVERTED TO A GEOMETRIC MEAN VALUE FOR THE SITE

- No information on how and why tests failed
- Soils were classed as sodic, what low salinity water was used for the tests?
- What does it mean if out of 8 tests 2 gave very low results, 1 a very high result. Are the soils being tested all the same?
- Geomean is multiplying all *n* results together and then taking the n^{th} root of the total
- Geomeans are used when you have large numbers that vary between themselves so as to avoid having the occasional peak value dominate the overall outcome
- Here, the geomean "inflates" the overall results as opposed to the plain average value

WHAT HAVE WE FOUND FROM PROBLEMATIC LCA'S

- Many LCA assessors lack a soil science education and do not educate themselves
- It has been impossible to convince the EPA to mandate proper soil permeability testing methods
- It also has been impossible to convince the EPA to ensure that adequate soil sodicity testing is carried out as part of all LCA's.
- It has been impossible to convince the EPA to abandon the use of AS/NZS 1547:2012 and older for allowing LCA providers to guess the texture, structure and most of all the indicative soil permeability from looking pensively at a sample of soil in one's hand