Development in the Merri Creek Catchment

Wholesale soil and surface hydrology disturbance
Soil sodicity and erosion, soil salinity, surface drains and saline groundwater, heat islands

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MCMC Workshop – 29 October 2019

Program points

- Why does the Merri Creek catchment have such salinity issues?
- How does the geological make up of the catchment affect current conditions?
- How does the massive change in covered impermeable surfaces affect runoff and erosion risk, groundwater levels and salinity?
- What controls groundwater conditions at the moment?
- What is the current stream flow regime in natural drainage ways?
- How does intensive development activity affect the land?
  - Enormous cut and fill of earth materials
  - Enormous trenching for services like sewers, power and gas
  - Enormous earth movement during building consruction

Soils are vertically organised bodies of minerals and organic matter

- Soil profiles develop by rainwater draining vertically downwards and by the weathering and change of mineral components
- That drainage water carries matter that is dissolved from upper strata
- The most soluble components may be washed out completely from the profile
- Lesser soluble matter may be moved down the soil profile and lodge at certain depths
- To understand the properties and behaviour of soils, one must consider the whole profile as an organic geological body

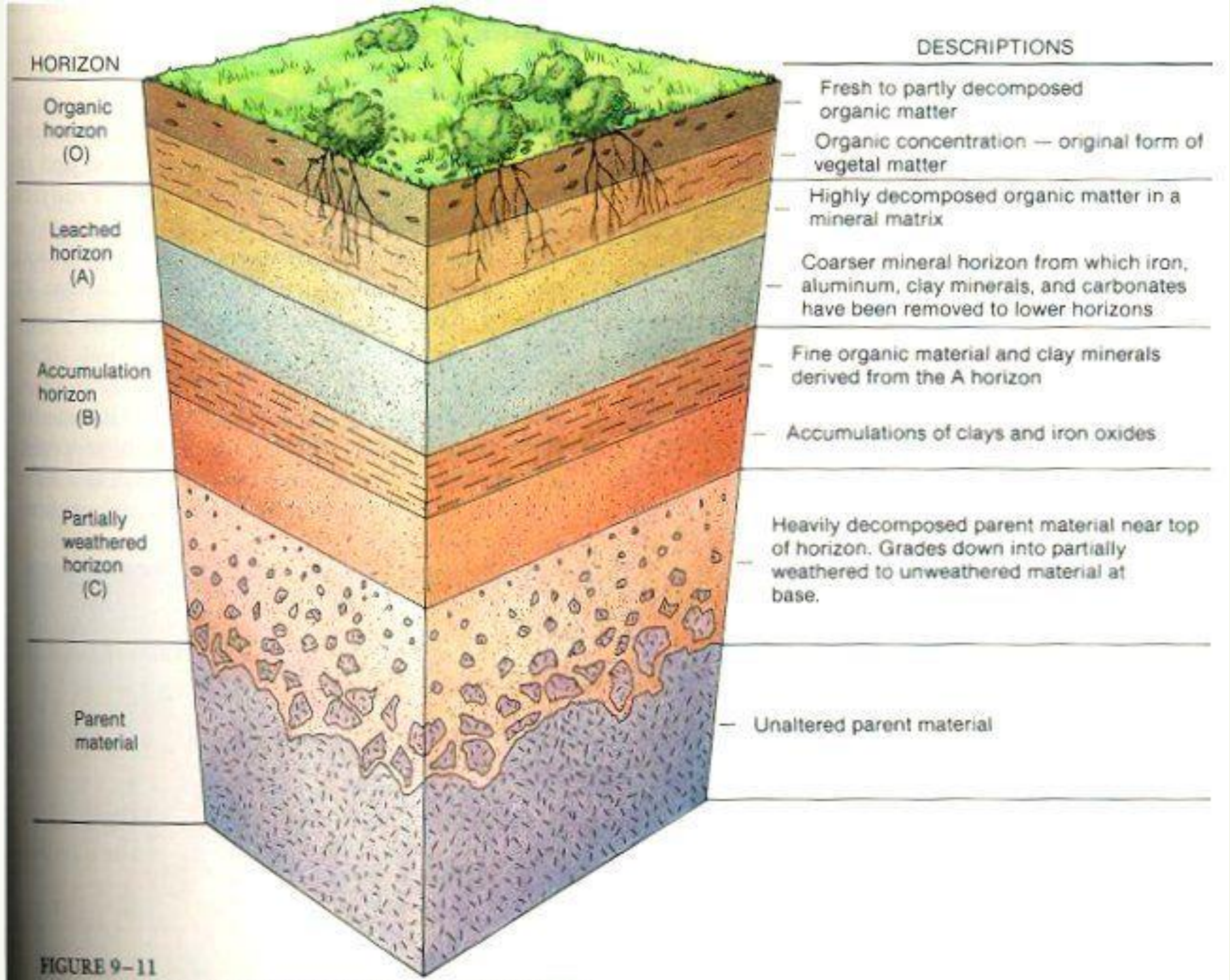


FIGURE 9–11
Cross section of a soil in the northeastern U.S. showing horizons.

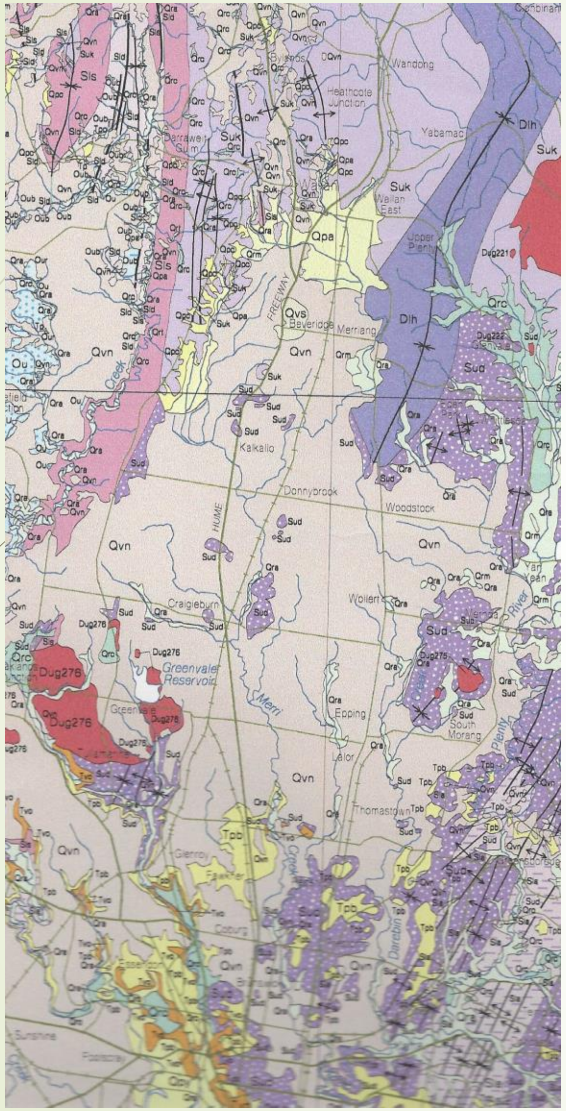
A soil profile is an “organically” vertically structured body of soil & therefore has predictable properties
Few geotech and civil engineers know this

- The topsoil is characterised by biological activity, organic matter accumulation, nutrient concentration
- Often a subsurface depleted of organic matter and solutes; if strongly bleached it means it is seasonally waterlogged
- A subsoil, sometimes depleted of solutes, but elsewhere also enriched with leached materials from the upper portion of the profile
- This results from the vertical movement of water, drainage or capillary rise

Soil profiles formed on basalt vary much depending on soil age and soil drainage but also show leaching effects

Deer Park

Tarneit



Geological Setting of the Merri Creek catchment

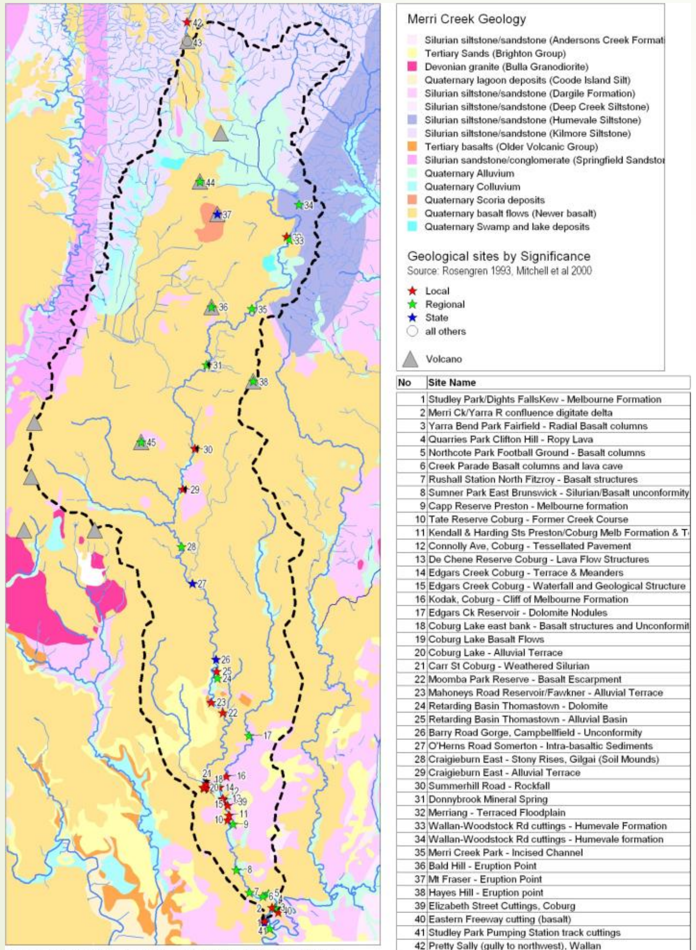
The western edge is determined by the Silurian Kilmore and Springfield Formations of marine silt- and sandstones.

The eastern edge is determined by the Silurian Kilmore and Devonian Humevale marine silt- and sandstones

These are all marine sediments and could have contributed salts to the catchment

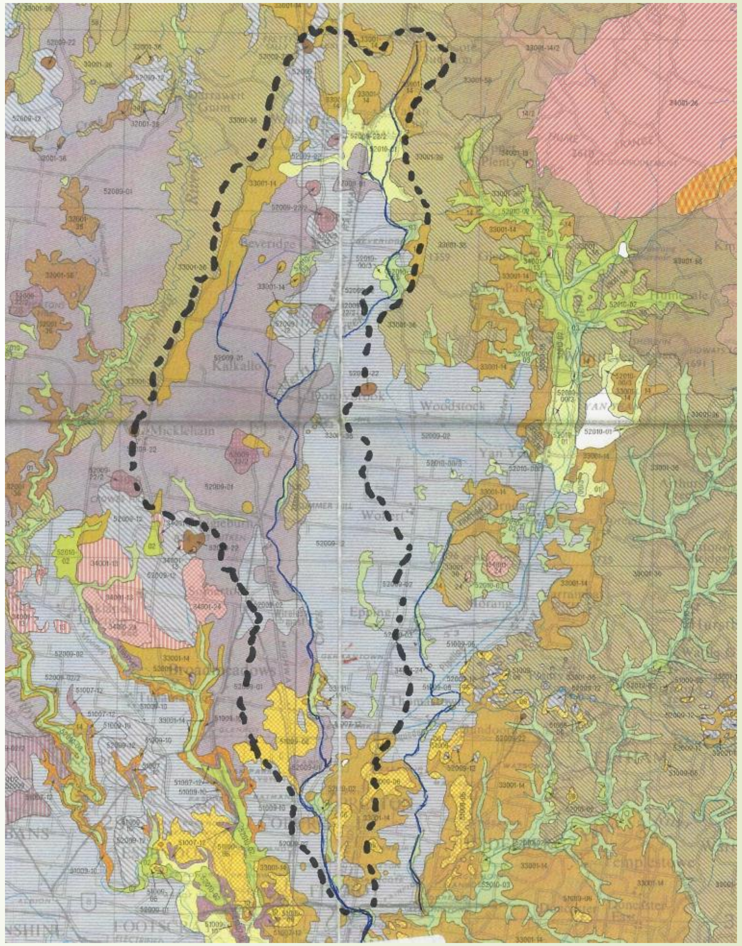
In the centre there are Quaternary basalts flows and eruption points of different ages

Geology: Lithology & Age of Basalt Extrusion as interpreted by CSIRO's Keith Grant



Geological information courtesy Government of Victoria (GeoVic Map)
Geological sites from Rosengren, N. (1993) and Mitchell et al (2000)
Map prepared by Merri Creek Management Committee Inc 2007

No	Site Name
1	Studley Park/Dights FallsKew - Melbourne Formation
2	Merri Ck/Yarra R confluence digitate delta
3	Yarra Bend Park Fairfield - Radial Basalt columns
4	Quarries Park Clifton Hill - Ropy Lava
5	Northcote Park Football Ground - Basalt columns
6	Creek Parade Basalt columns and lava cave
7	Rushall Station North Fitzroy - Basalt structures
8	Sumner Park East Brunswick - Silurian/Basalt unconformity
9	Capp Reserve Preston - Melbourne formation
10	Tate Reserve Coburg - Former Creek Course
11	Kendall & Harding Sts Preston/Coburg Melb Formation & T
12	Connolly Ave, Coburg - Tessellated Pavement
13	De Chene Reserve Coburg - Lava Flow Structures
14	Edgars Creek Coburg - Terrace & Meanders
15	Edgars Creek Coburg - Waterfall and Geological Structure
16	Kodak, Coburg - Cliff of Melbourne Formation
17	Edgars Ck Reservoir - Dolomite Nodules
18	Coburg Lake east bank - Basalt structures and Unconformit
19	Coburg Lake Basalt Flows
20	Coburg Lake - Alluvial Terrace
21	Carr St Coburg - Weathered Silurian
22	Moomba Park Reserve - Basalt Escarpment
23	Mahoneys Road Reservoir/Fawkner - Alluvial Terrace
24	Retarding Basin Thomastown - Dolomite
25	Retarding Basin Thomastown - Alluvial Basin
26	Barry Road Gorge, Campbellfield - Unconformity
27	O'Herns Road Somerton - Intra-basaltic Sediments
28	Craigieburn East - Stony Rises, Gilgai (Soil Mounds)
29	Craigieburn East - Alluvial Terrace
30	Summerhill Road - Rockfall
31	Donnybrook Mineral Spring
32	Merriang - Terraced Floodplain
33	Wallan-Woodstock Rd cuttings - Humevale Formation
34	Wallan-Woodstock Rd cuttings - Humevale formation
35	Merri Creek Park - Incised Channel
36	Bald Hill - Eruption Point
37	Mt Fraser - Eruption Point
38	Hayes Hill - Eruption point
39	Elizabeth Street Cuttings, Coburg
40	Eastern Freeway cutting (basalt)
41	Studley Park Pumping Station track cuttings
42	Pretty Sally (gully to northwest), Wallan
43	Pretty Sally
44	Springs Hill, Wallan
45	Mount Ridley, Craigieburn



Part of Land System Map of the catchments north of Melbourne by P. Jeffery of the Soil Conservation Authority, 1981

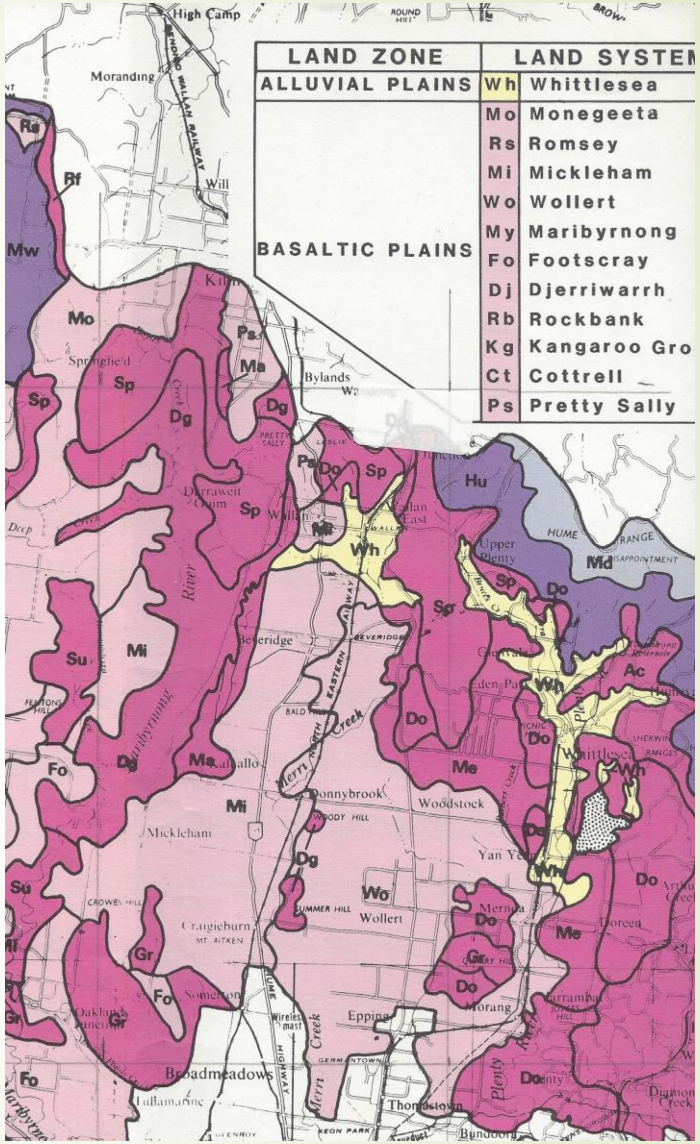
The different-aged basalts give rise to different soils

Mi = Mickleham Land System based on an older basalt flow and has **mainly mottled yellow grey sodic duplex soils**

Wo = Wollert Land System based on a younger basalt flow. Has stony rises and **mainly shallow stony red gradational soils**

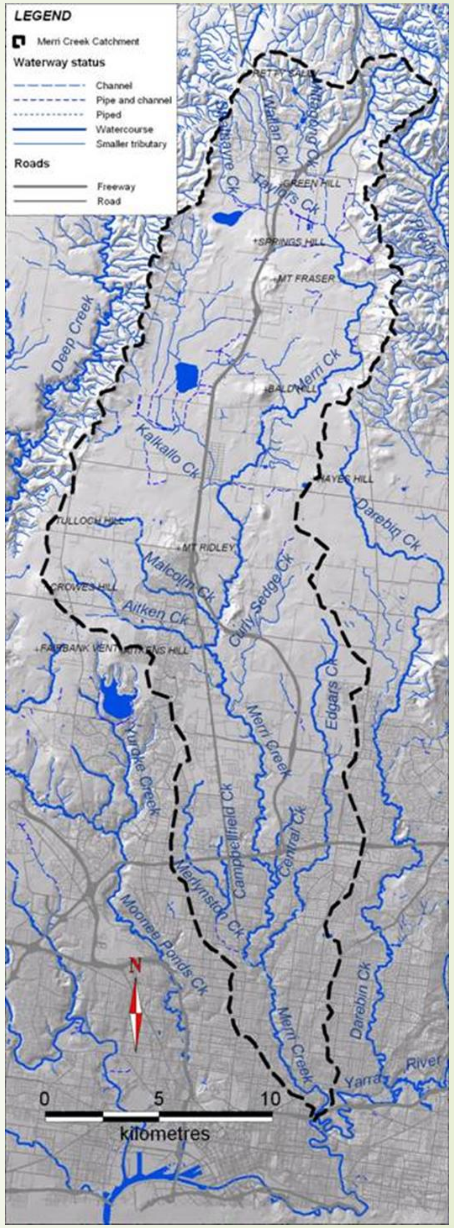
The dark purple areas are various land systems on sedimentary rocks and all have **yellow brown sodic duplex soils** and are highly erodible

The yellow Whittlesea LS is on an alluvial flood plain

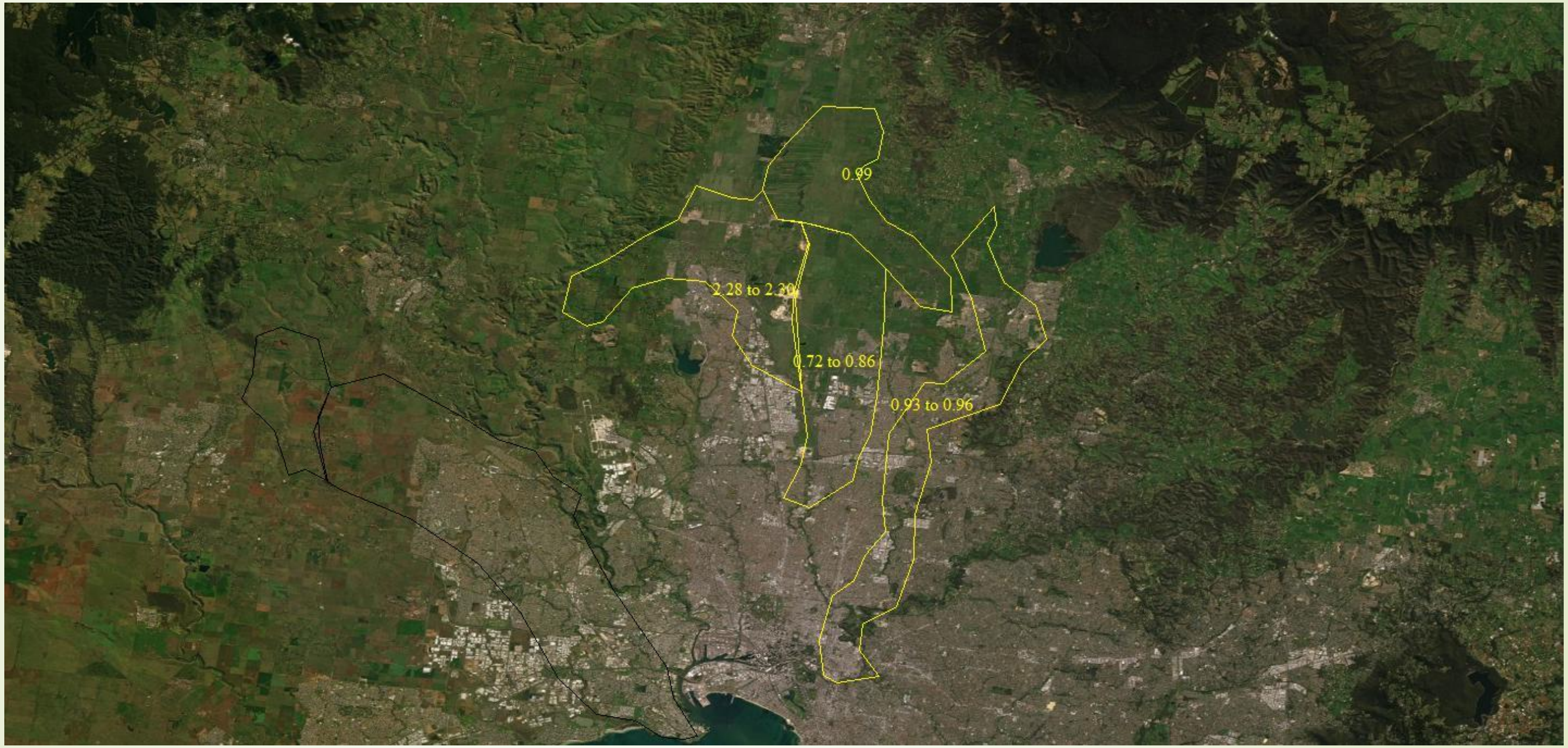


Merri Creek catchment

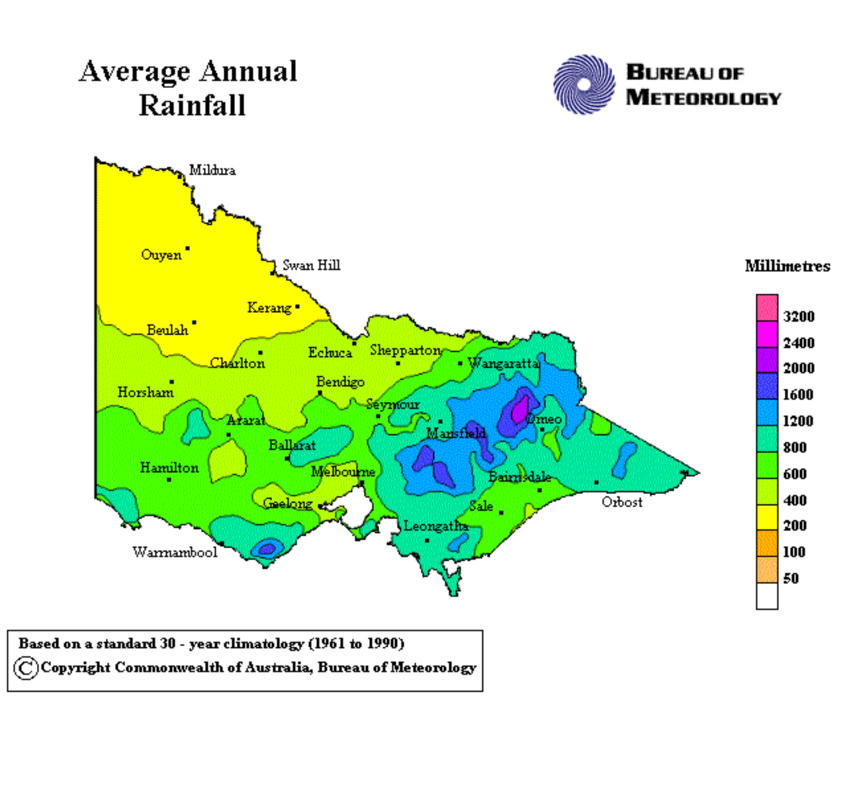
- Lava flows are controlled by topography and follow the natural drainage pattern. Hence, the path of flows can be fairly accurately predicted.
- Lava flows generally travel at slow speeds. (Typical Hawaiian flows move at about 0.25 miles/hr or about 6 miles/day)
- Where two or more adjacent flows meet, their boundaries form the lowest parts of the terrain, often the location of a stream
- The natural drainage system will follow these lowest valleys.

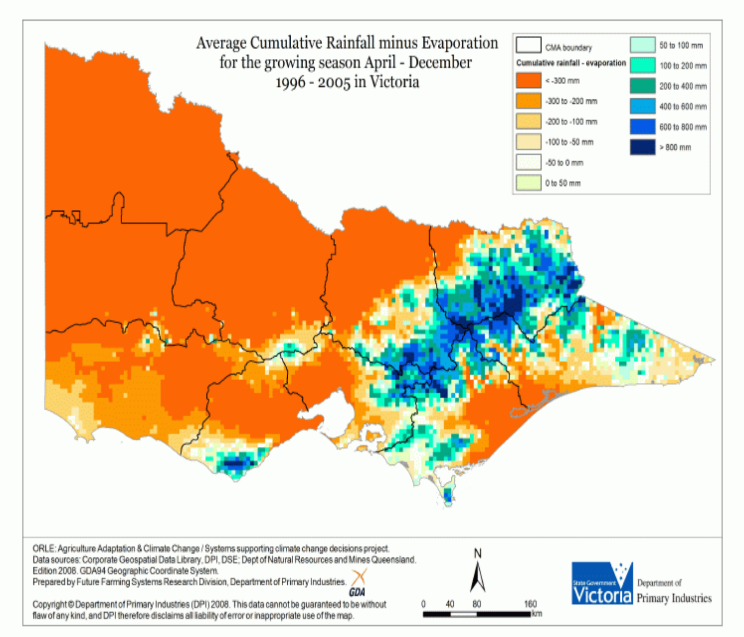


Ages of basalt extrusions north of Melbourne

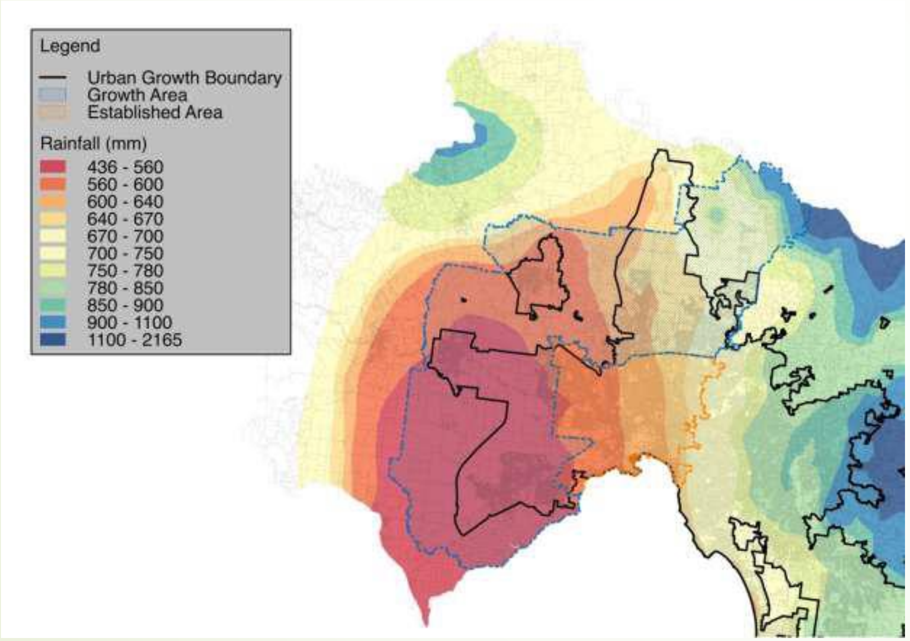


Annual rainfall and evaporation maps of Victoria





Climatic conditions of the Northern growth area #1



The lower the rainfall, the greater the risk of soils being

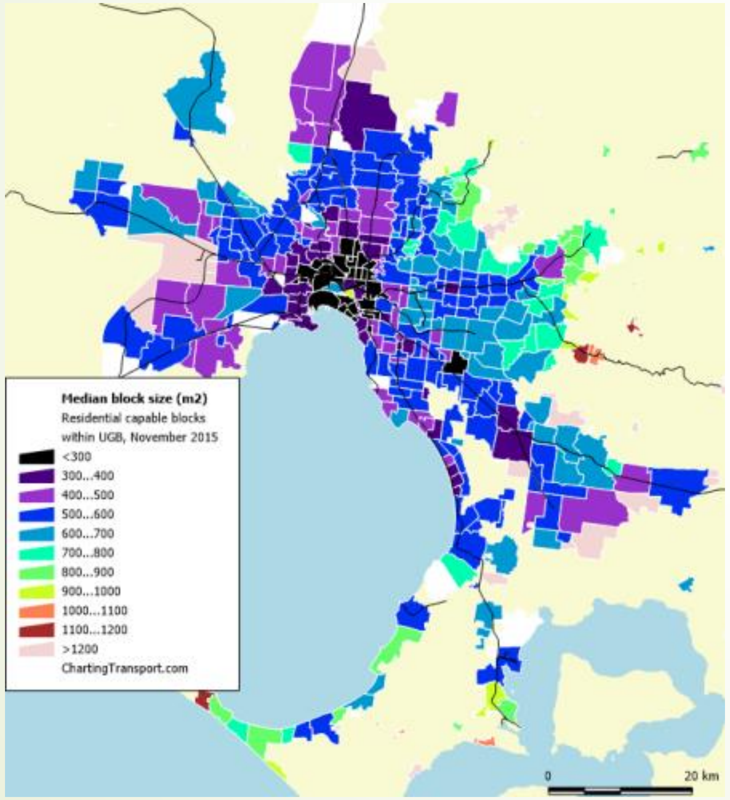
(a) saline and

(b) sodic

Climatic conditions of the Northern growth area #2. Only 57 mm available for leaching

Yan Yean, BOM station 086131	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall Median	40	32	38	48	49	48	48	54	57	66	54	50	653
Rainfall Mean	46	46	50	57	57	54	51	59	63	69	62	56	669
Evap'n Median	177	160	118	75	43	30	34	50	69	107	126	160	1183
Evap'n Mean	181	154	119	78	45	31	37	52	71	107	129	162	1184
Mean water shortage	135	108	69	21					9	38	67	106	552
Mean water excess					13	23	15	6					56

After residential development what will the water balance be?



- Lot size average: 350 m^2
- Average footprint of a house: 220 m^2
- Imperviousness probably 75%
- Rainwater shed from 75% of the lot now to infiltrate in much smaller garden or sent to road side drains
- Garden too small for trees hence little evapotranspiration
- What impact on groundwater levels?
- What impact on groundwater salinity?

Massive changes to the natural water balance

Imperviousness 75%: 75% x 330 x 489 mm rainfall = 121,027 L of rain water/year. Dispose to 25% of the lot, 87.5 m^2, to be added: 489 + 367 mm = 856 mm per year. Per m^2 this now receives 121,027/87.5 + 489 mm/year = 1872 mm/yr. It would also, *for the first time*, result in significant recharge of the groundwater

The low soil permeability will not allow that to happen, so off site drainage to stormwater must occur and can create flash flooding

What will happen to the salt groundwater table?

To store rainwater, a house requires a rainwater tank. If total roof area = foot print, 220 m2 of roof area will collect 220 x 489 = 107,580 L of water in one year. Where is the space on the lot for a large rainwater tank?

If excess rainwater is discharged stormwater, this stormwater system will need to be coping with very large short duration flows

Consequences of increased areal runoff production

Stormwater drains must be designed to cope with massive peak flows

Unprotected earthen surfaces in stormwater drains liable to severe immediate erosion

Highly turbid runoff destroying the quality of the water in receiving natural water bodies preventing sunlight penetration in the water

Impacts on aquatic vegetation and aquatic animals

The upper catchment is already prone to major soil erosion from sodic clays

Upper Merri Creek, a high intensity rainfall area

Merri Creek is already suffering from high suspended clay loads from eroding surfaces within the sedimentary rock parts of the catchment

The local bedrocks provide salts from the weathering of sodium-containing minerals

Left: Basalt -- right: Sandstone

Note the elevated Na and Mg in the basalt compared to the sandstone

Components	Percentage %
SiO_2	50~60
Al_2O_3	14-19
CaO	5-10
MgO	3-5
Na_2O+K_2O	3-5
TiO_2	0.5-3.0
Fe_2O_3+FeO	9-14
Others	0.05-1.0

SiO_2	93-94%
Alumina (Al_2O_3)	1.4 to 1.5%
Iron (Fe_2O_3)	1.5%-1.6%
Lime (CaO)	0.8% to 0.9%
Soda(Na_2O) & Potash (Kro)	1.0% to 1.2%
Loss On Ignition (LOI)	1.0% to 1.2%
Magnesia (MgO)	0.2 to 0.25%

Important facts

- On average all rainfall that enters the soil is transpired back to the atmosphere
- On few occasions during excessively wet winters can some rainfall passes through the entire soil profile and joins the groundwater table
- All rainfall brings a small amount of salt from the ocean:

$$Y = 0.99 \frac{1}{\sqrt[4]{d}} - 0.23$$

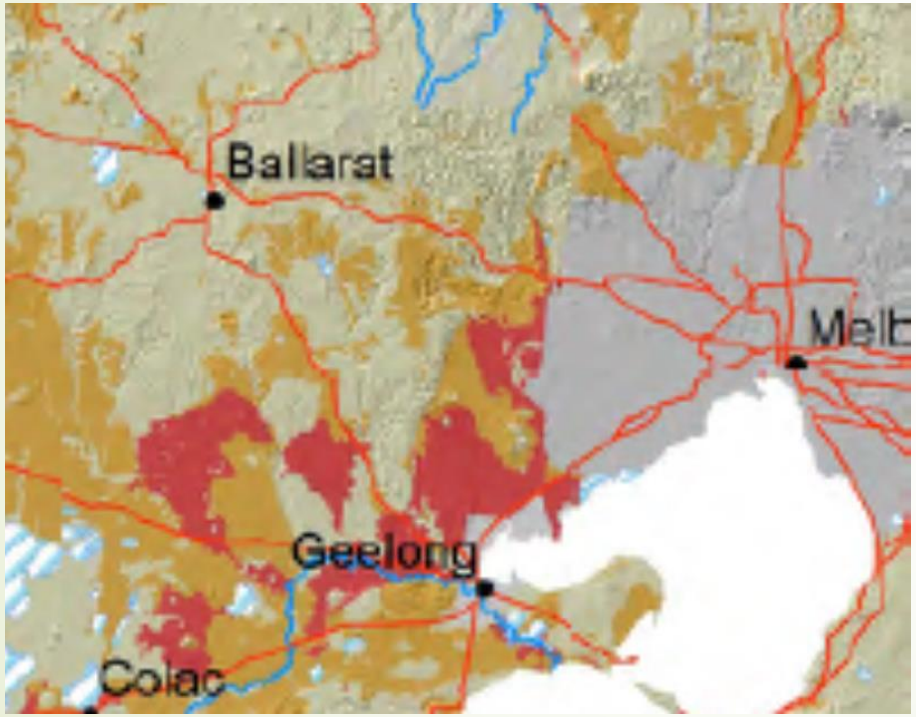
- Y = weighted mean chloride concentration in rainwater
- d = distance in km in the direction most likely to contribute maximum oceanic salt
- At Craigieburn and 500 mm rain some 20 kg of salt is added per hectare per year
- Much of that remains in the soil or gets stuck in the groundwater

- **Hutton, J.T., and Leslie, T.I. (1958). Accession of non-nitrogenous ions dissolved in rainwater to soils in Victoria. Aust. J. Agric. Research, No.9, p.492-507.**
- **See also: Isbell, R.F., Reeve, R., and Hutton, J.T. (1993). Salt and Sodicity. Chapter 9. In: Soils – An Australian Viewpoint. Div. Of Soils, CSIRO, p.107-117.**

How much atmospheric salt has been added over time?

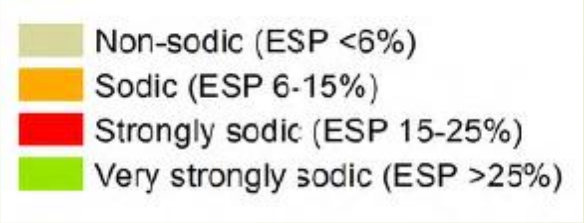
- Time since end of last Ice Age, the Holocene Epoch: 18,000 years
- Salt added since end of last Ice Age: 360,000 kgs or 360 tonne/hectare
- During last Ice Age the climate was drier but not a desert climate
- The Pleistocene is the youngest geological epoch, including the Holocene, lasted for 2.5 million years, had similar climatic sequences as the Holocene
- How much salt was blown inland and deposited on the soils in all that time?
- How much salt could have been washed out of the soil into the groundwater, and how much salt could have been returned to the sea by very slow lateral seepage?

Extent of sodic soils in the Merri Creek catchment



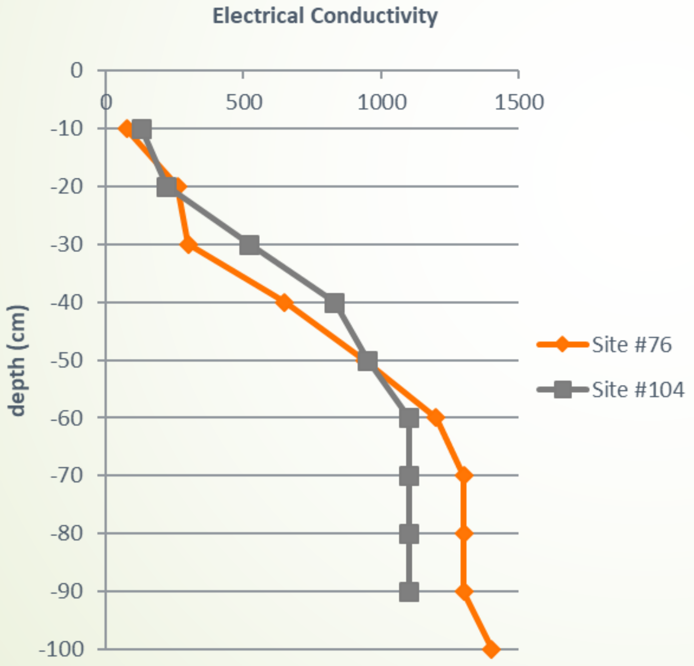
Note: This map portrays a selected portion of the State sodic soils map.

The built up urban and peri-urban areas have not been assessed and mapped for sodicity

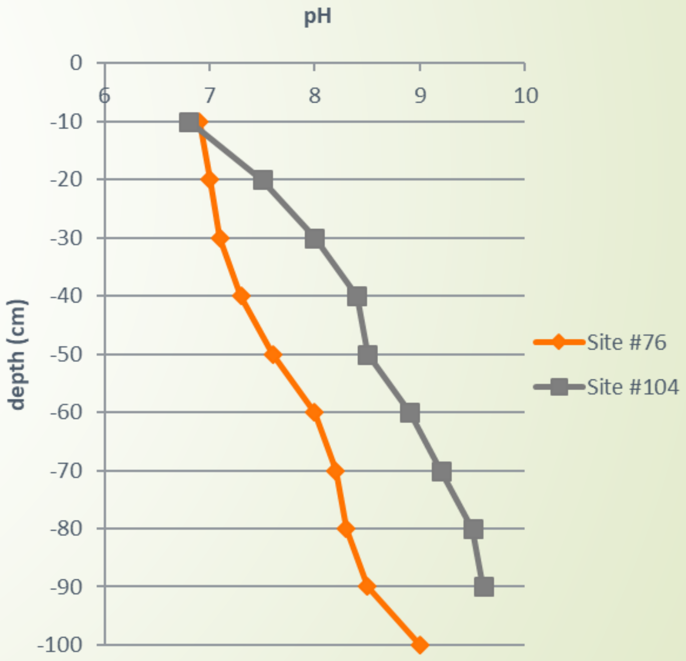


Vertical trends of soil chemistry in basaltic clay at Deer Park: salts and pH are "organically" distributed in the profile, hence offering a degree of predictability

Poorly leached salts build up with depth

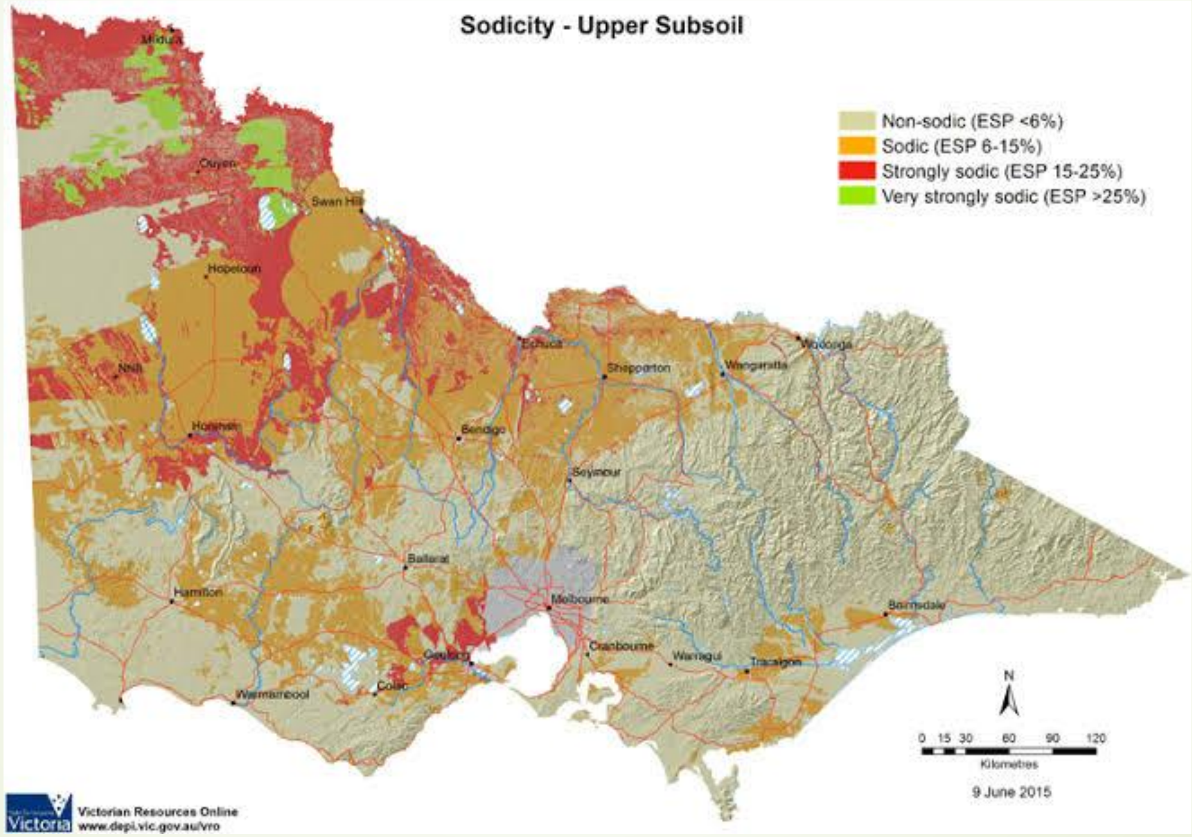


Increasing pH indicative of increasing sodicity

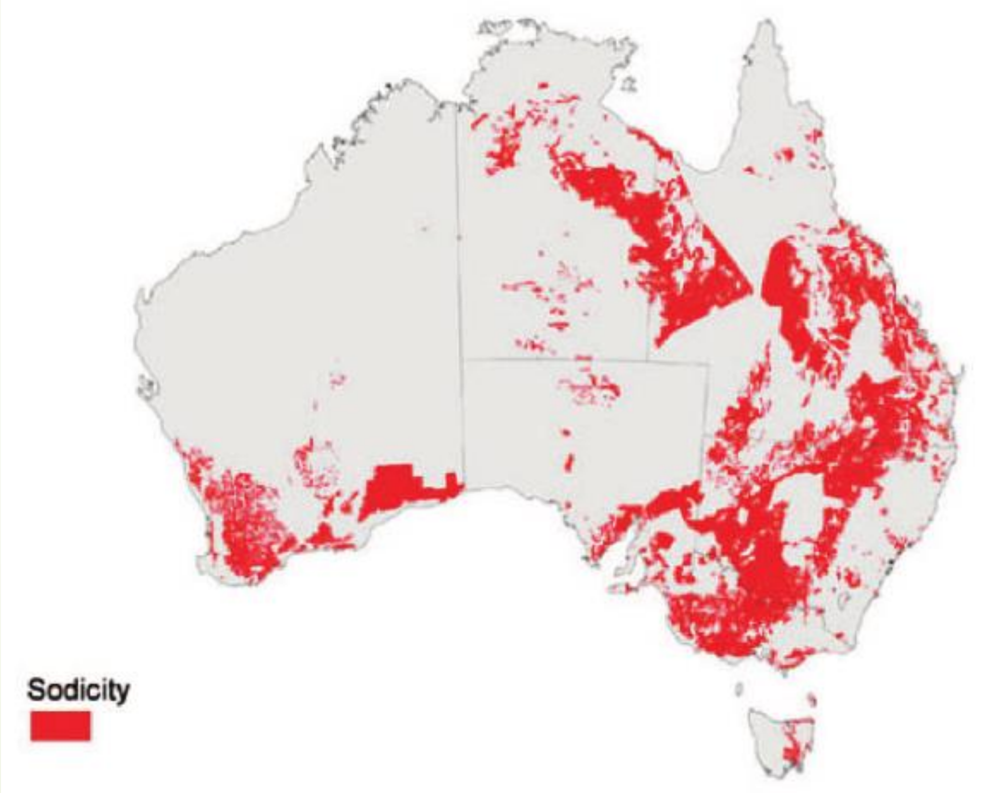


Sodic soils occurrence in Victoria

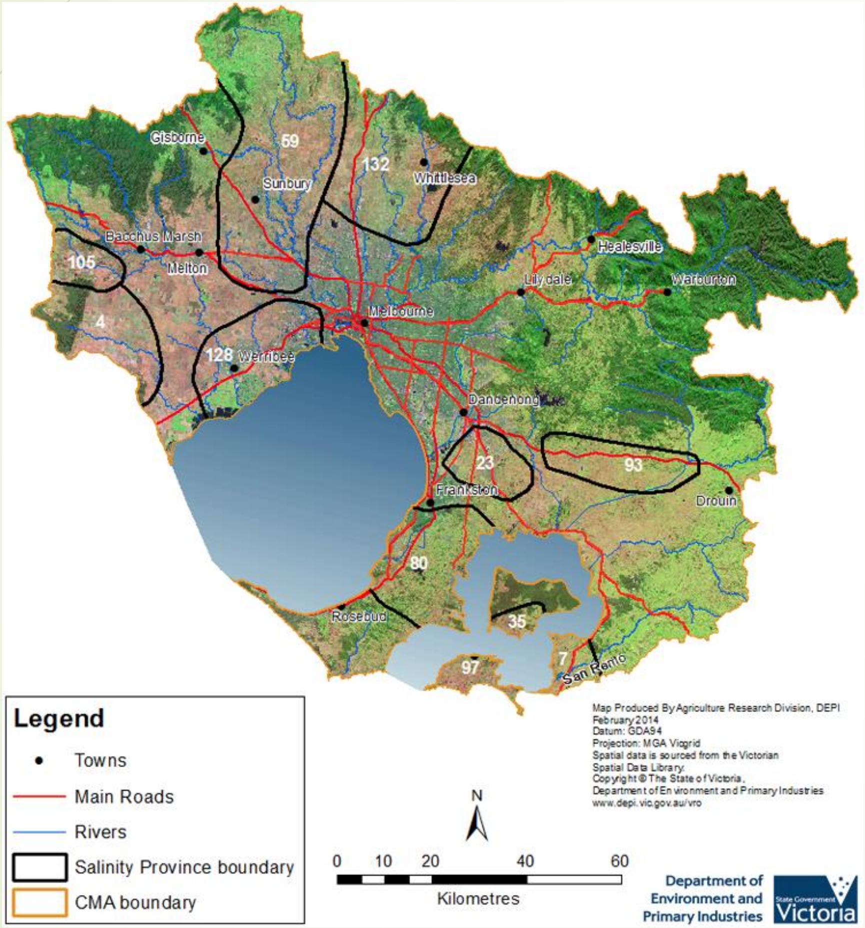
Note the relationship with climate (rainfall & evaporation)



No continent has more sodic soils that Australia



Soil salinity provinces



Salinity Provinces (SPs) provide a framework for describing land and water (both surface and groundwater) salinity in Victoria. These are specific geographic areas where the landscape setting and physical processes contributing to salinity are similar, and where salinity management options are also similar. Each Province contains discrete salinity impacted areas where there is a concentration or higher incidence of land and/or water salinisation, which may or may not have been mapped. This may be "primary" or "secondary" salinity, the development of which can be explained by a particular landscape setting, groundwater process or most commonly, Groundwater Flow System(s) (GFS(s)).

What is soil salinity?

- Salts become ionised in water, rendering the solution electrically conductive
- E.g. NaCl splits in water to create a positively charged Na^+ ion and a negatively charged CL^- ion
- Putting two electrodes in water, an electric current can flow from one electrode to the other by the CL^- ions moving to the positive electrode and the Na^+ ion moving to the negative electrode
- Saline soils are those which have an electrical conductivity of the saturation soil extract of more than 4 dS/m at 25°C (Richards 1954). Soluble salts most commonly present are the chlorides and sulphates of sodium, calcium and magnesium. Nitrates may be present in appreciable quantities only rarely. Sodium and chloride are by far the most dominant ions, particularly in highly saline soils, although calcium and magnesium are usually present in sufficient quantities to meet the nutritional needs of crops. Many saline soils contain appreciable quantities of gypsum ($CaSO_4$, $2H_2O$) in the profile.

Soil salinity classes

Salinity class	ECe (dS/m)	Salinity effects on crops
Non-saline	< 2	Salinity effects are negligible
Slightly saline	2–4	Yields of very sensitive crops may be restricted
Moderately saline	4–8	Yields of many crops restricted
Very saline	8–16	Only tolerant crops yield satisfactory
Extremely saline	>16	Only a few very tolerant crops yield satisfactorily

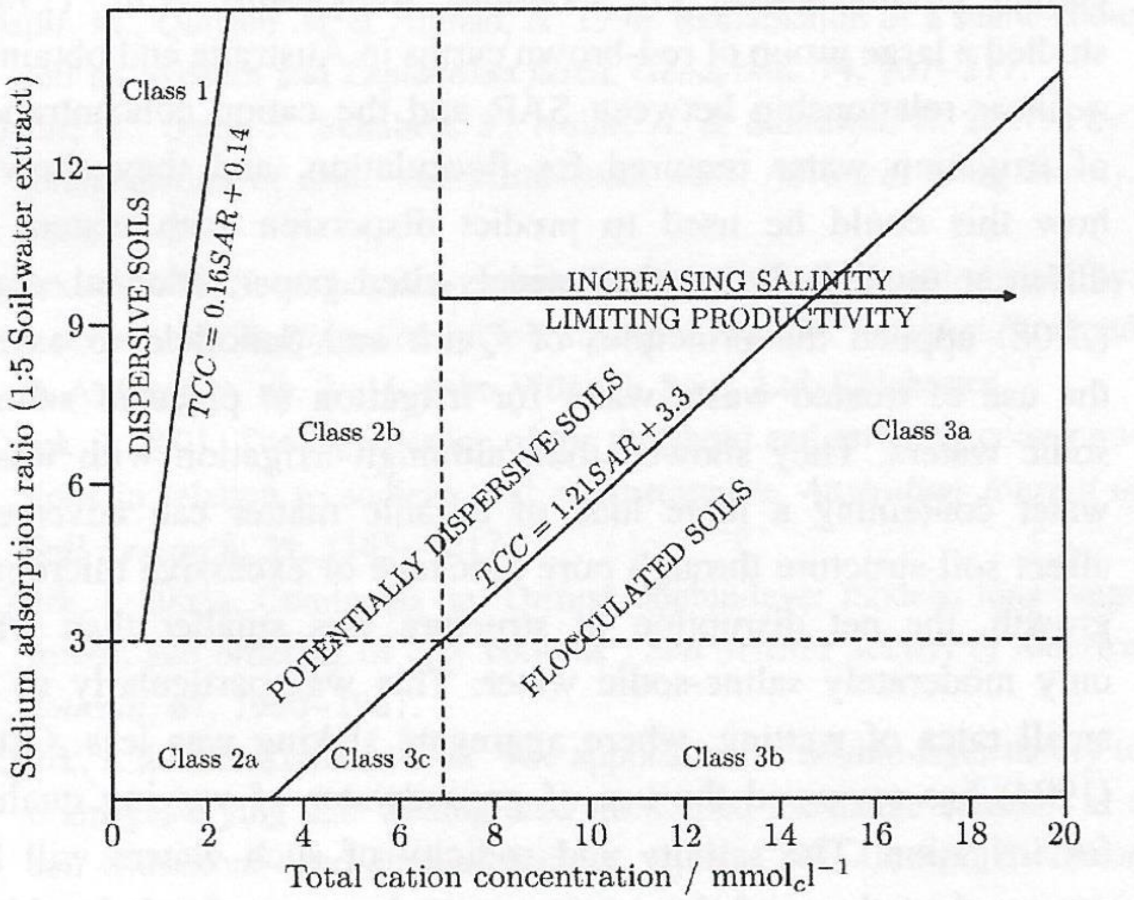


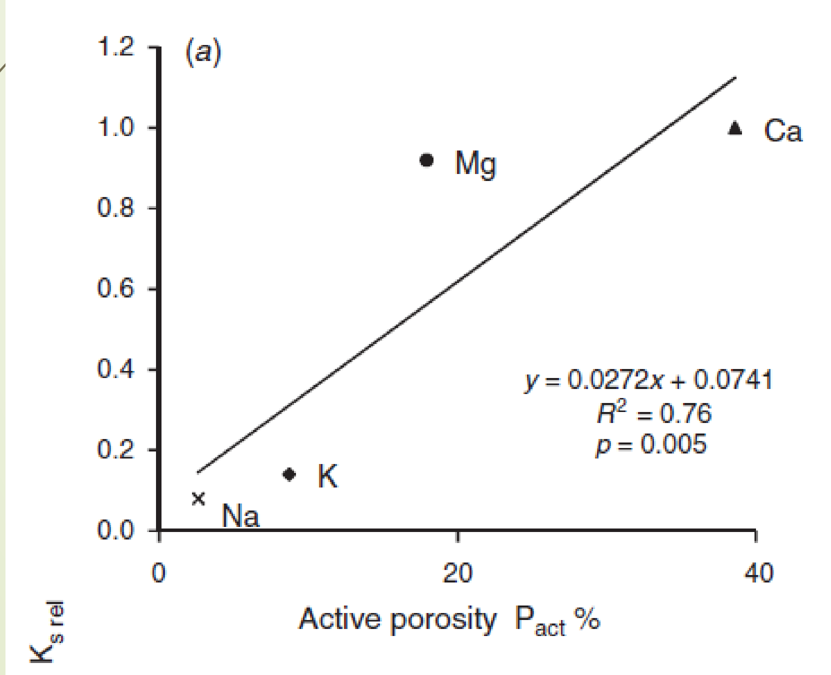
Figure 2 A classification scheme for the prediction of dispersive behaviour of the A-horizon of red-brown earths: redrawn from Rengasamy *et al.* (1984). TCC is the total cation concentration (mmol$_c$ l^{-1}).

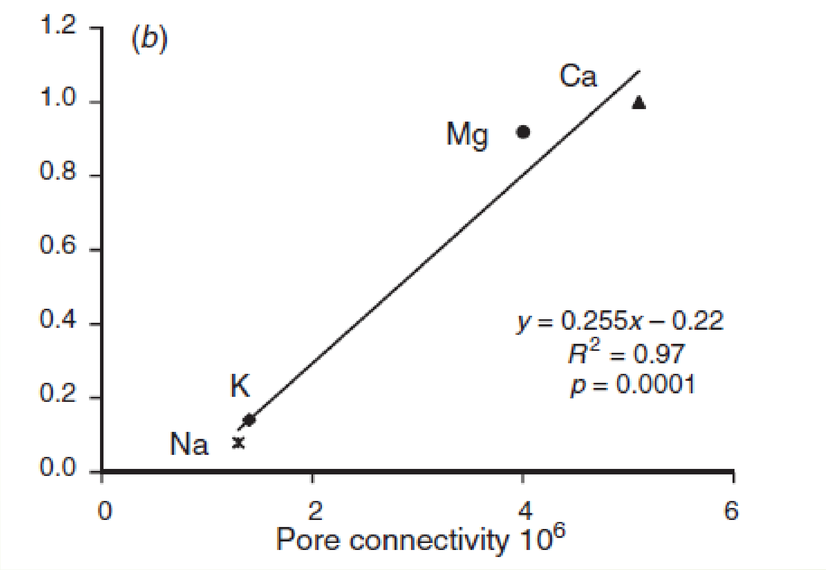
Impact of different cations on hydraulic conductivity of the soil

Alla Marchuk[A,C], Pichu Rengasamy[A], Ann McNeill[A], and Anupama Kumar[B]

Y-axis: Relative saturated hydraulic conductivity

Y-axis: Relative saturated hydraulic conductivity





Hydraulic conductivity affected by chemistry (sodicity) and gypsum amendments

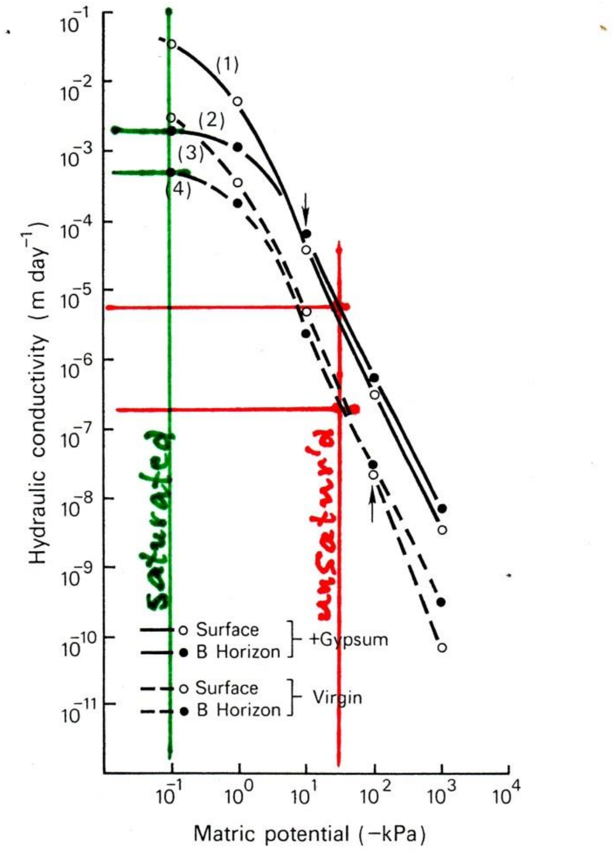


Fig. 32.13. Effect of gypsum and structural stability on the hydraulic conductivity–matric potential relationship for Billabong grey cracking clay. (Johnston 1952; Bridge 1968.)

- Compare the B-horizons
- The virgin B-horizon at saturation has a permeability between 10^{-4} and 10^{-3} m/day
- The gypsum amended B-horizon is nearly 10 times more permeable at saturation than the virgin B-horizon
- In the unsaturated condition the gypsum amended B-horizon is almost 2 orders of magnitude (100 times) more permeable than the virgin one

Malvern example: Leaking salt water swimming pool from neighbouring garden brings salt to paving and brick walls

SAMPLE ID : PULVERISED BRICK **REF**
DEPTH OF SAMPLE (cm): N/A **DAT**
ANA

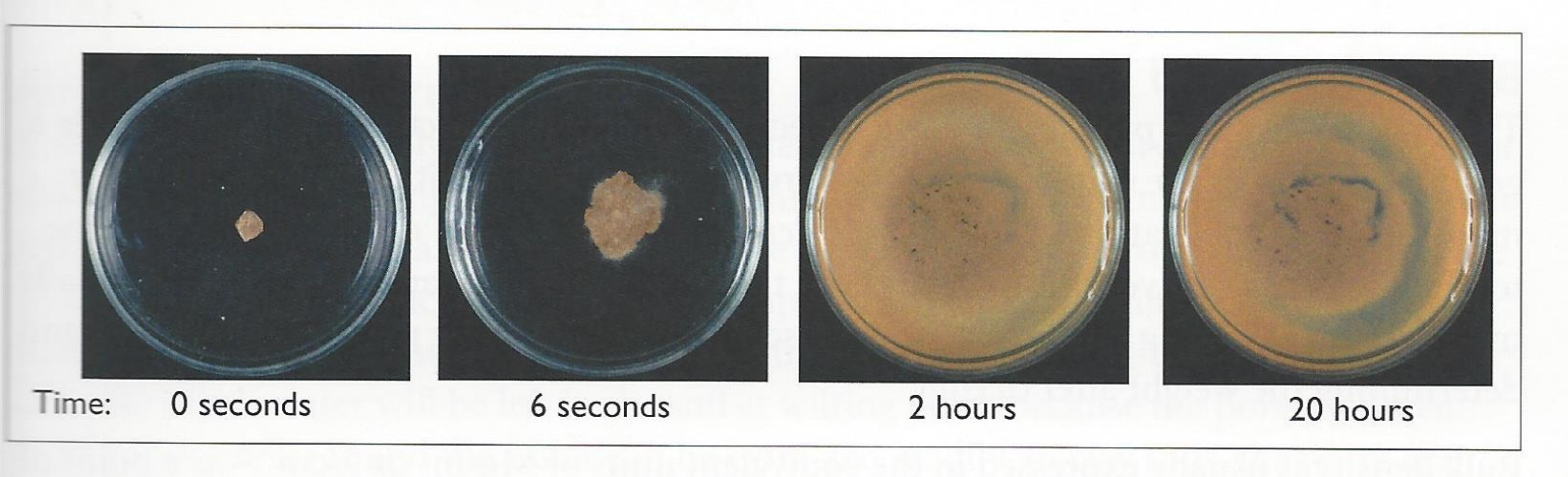
ITEMS			RESULT
pH(1:5 Water)			8.5
pH(1:5 0.01M $CaCl_2$)			8.1
Electrical Conductivity	EC	µS/cm	3720
TOTAL SOLUBLE SALT	TSS	ppm	12276
AVAILABLE CALCIUM	Ca	ppm	3720
AVAILABLE MAGNESIUM	Mg	ppm	311
AVAILABLE SODIUM	Na	ppm	3310
AVAILABLE POTASSIUM	K	ppm	1520
AVAILABLE SULPHUR	S	ppm	391
SULPHATE	SO_4	ppm	1170
TOTAL ORGANIC MATTER	OM	%	0.9
CHLORIDE	Cl	ppm	4200

Saline water uptake in porous bricks causing salt crystals to pulverise the brick

What is dispersion and how is it related to soil sodicity?

Small crumb of clay dropped in distilled water "explodes" and its individual clay particles disperse as microscopic fragments

Emerson, W.W., 2002. Emerson dispersion test. In "Australian Soil and Land Survey Handbook, Vol. 5. CSIRO, Melbourne



Soil slaking test in water

Soils differ in their sensitivity to dispersion

The impact of the salinity and sodium adsorption ratio (SAR) of the water in contact with the soil:
- deionised top row & weak saline solution (bottom row)

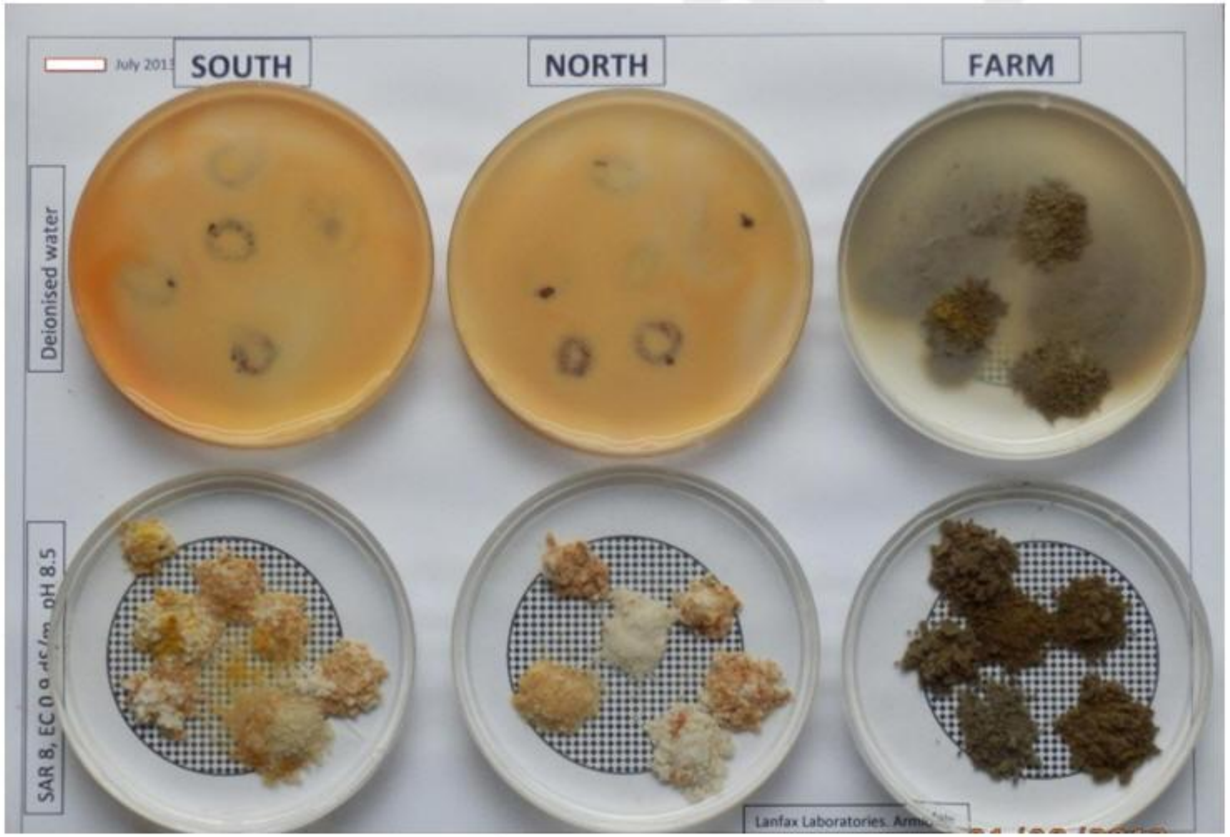
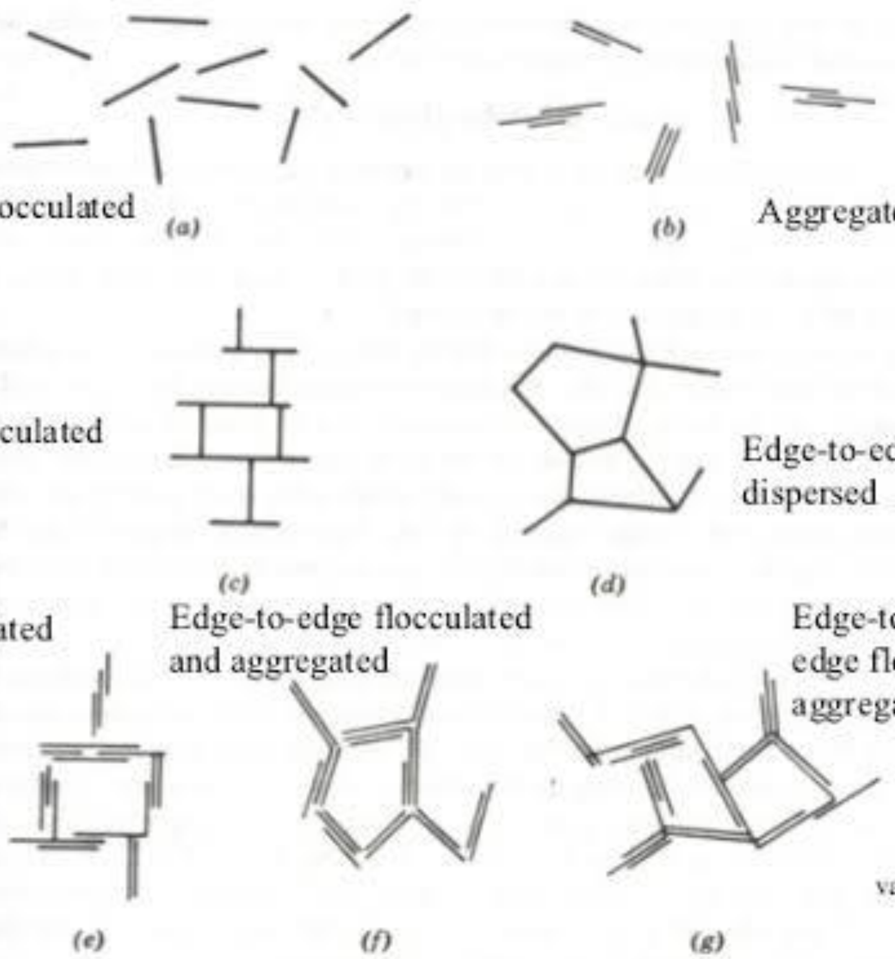


Figure 4 Comparison of water chemistry with dispersion

8.2 Particle Associations

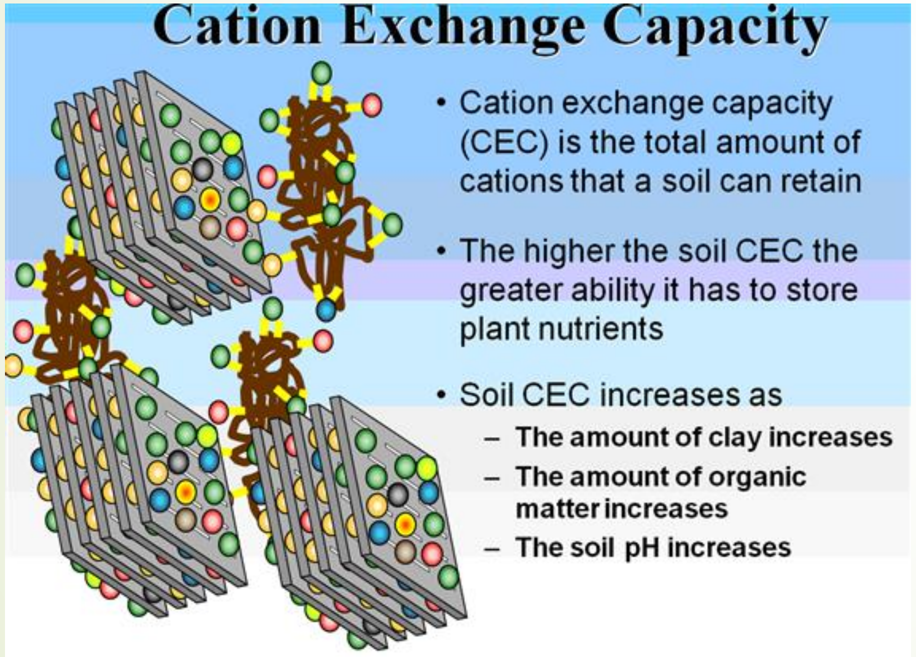


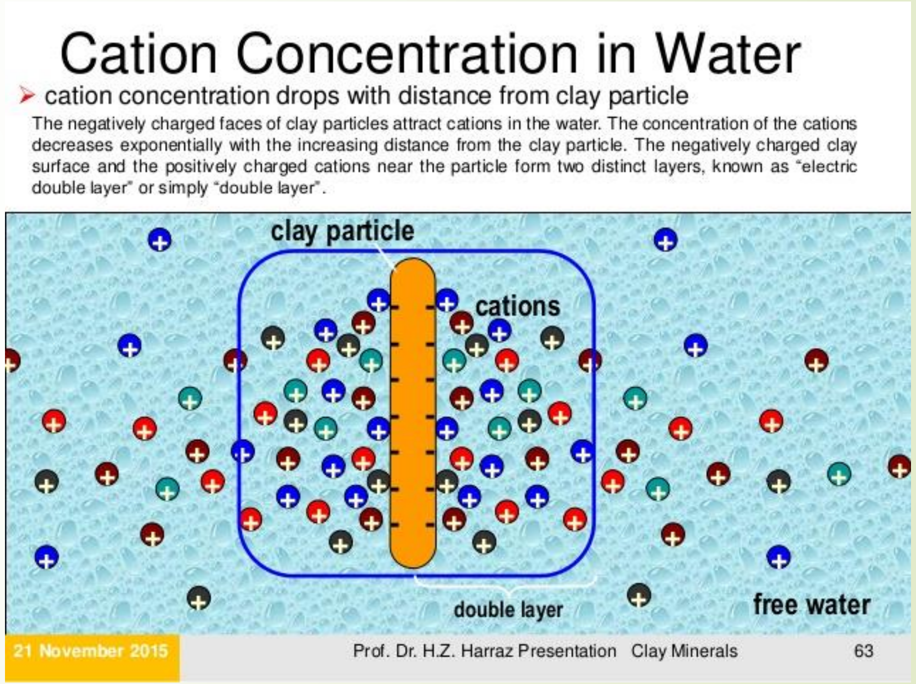
van Olphen, 1991

What is a sodic clay? What is dispersion?

- Conventionally, a clay is sodic when 6% or more of the exchangeable cations on the clay consist of sodium, Na. This value represents the proportion of exch. Na compared to exch. Ca, Mg, K and H, not the amount of Na in the soil
- In water, a sodic clay tends to draw water to itself to allow a proportion of the exchangeable Na cations to occupy the mantle of water around individual clay particles; it swells at the same time
- These particles then separate from one another and enter the bulk water individually, causing the water to become turbid. This is called **dispersion**
- Consequently, sodic clays are highly susceptible to erosion
- Is soil chemistry of sodicity taught in engineering courses at university?

Sodicity is a function of the proportion, not the total amount of exch. sodium





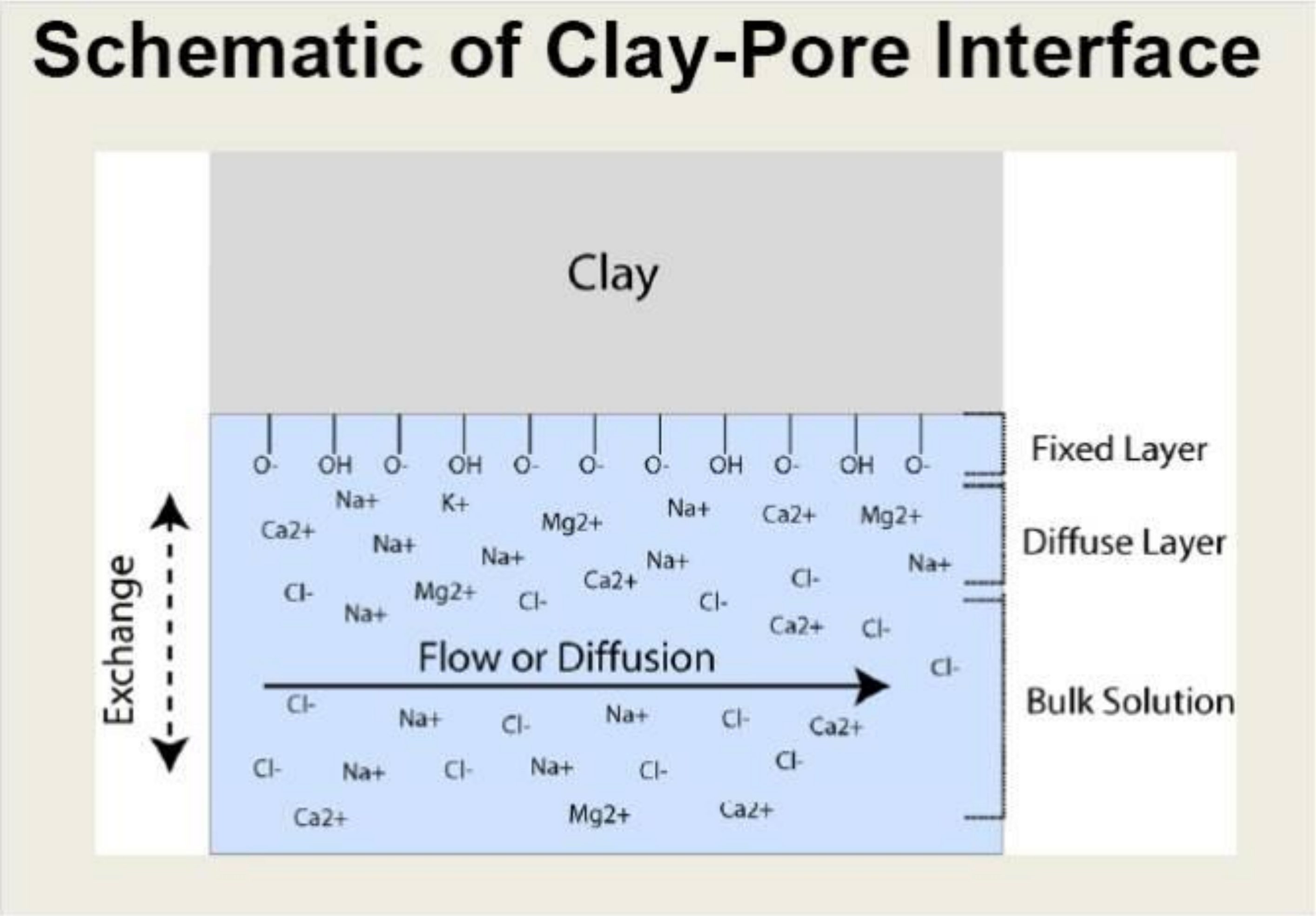
Soil permeability depends on chief exchangeable cation

In a Ca^{2+} dominant system, the full negative charge on the clay particle can be neutralised by a thin diffuse layer

Water in the diffuse layers is very viscous and cannot readily move

Water in the bulk solution between adjacent clay particles is free to move

The soil is permeable



Some geotech/civil engineers do not understand soil sodicity and report sodium levels in mg/kg instead of % of exchangeable cations as if sodium is a contaminant. This soil sampling program looks like a haphazard approach to site characterisation

Test pit ID	TP01	TP03	TP06	TP10	TP11	TP12
Sample depth (m)	0.5 – 0.6	1.8 – 1.9	2.5 – 2.6	0.3 – 0.4	3.6 – 3.8	2.0 – 2.1
pH	7.5	8.6	8.4	7.4	5.7	5.3
Moisture content (%)	35.1	18.8	22.4	31.1	26.1	25.8
Resistivity at 25°C (ohm.cm)	14 700	1530	1690	13 900	962	781
Sulfate as SO_4 (mg/kg)	<10	160	100	30	330	290
Chloride (mg/kg)	1050	760	910	730	2010	2760
Major cations (mg/kg)						
. Calcium	120	220	250	480	<10	30
. Magnesium	440	840	980	990	20	50
. Sodium	250	1090	1030	310	1160	1460
. Potassium	510	640	790	970	<10	<10
Organic matter (%)	1.5	<0.5	<0.5	2.9	<0.5	<0.5
Total organic carbon (%)	0.9	<0.5	<0.5	1.7	<0.5	<0.5

School's effluent disposal field is a swamp every winter

- 7 percolation tests in summer and 7 percolation tests in winter; the means vary by factor of 7!
- Zero soil chemistry testing
- "Indicative permeability" ultimately determined by manual soil assessment (texture & structure) as per AS/NZS 1547:2012 and EPA Code of Practice
- Design complies 100% with EPA Works Approval process, EPA Code of Practice and Aust. Standard! Yet is a total failure.
- No appreciation of subsoil sodicity and very low permeability

Large scale dispersive clays in construction

Donnybrook Creek residential development - #1

Dispersive clays in construction
Donnybrook Creek residential development - #2

Geofabrics have little benefit in sodic clays - Donnybrook Creek south of Donnybrook Road, Mickleham. The effect of high velocity flows plus sodic soils

Brand new development where subsoil is saline and inhibits grass growth on lower slope towards drains

Nice new "water features" in sodic clay soils

Eroding surface & turbid water which is low salinity

Note clear water layer due to high salinity of seepage

Bare lower slope areas due to soil salinity

What is going on? A question investigated in 1955

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.

The work of Bodman and Fireman (1939, 1950) has shown that a satisfactory permeability can be maintained with a soil which is 30 per cent. saturated with sodium, by using a high concentration of electrolyte. They did not investigate the region between the initial high salt concentration and distilled water, the use of which resulted in a drastic reduction in permeability.

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5113.6.2 M

Electrolyte

Dissolved substances having electrical charges, e.g. Na^{+},

Ca^{2+}, Cl^{-},

SO_4^{2-}

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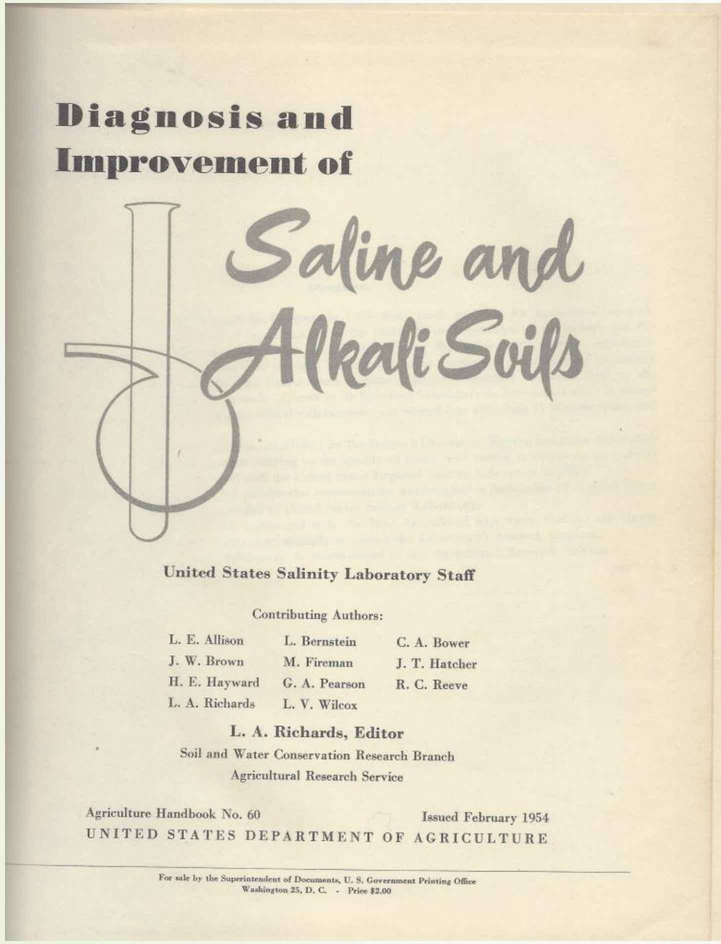
(Received 3 January 1955)

Early American work on saline – alkaline soils


Diagnosis and Improvement of

Saline and Alkali Soils

United States Salinity Laboratory Staff

Contributing Authors:

L. E. Allison, L. Bernstein, C. A. Bower, J. W. Brown, M. Fireman, J. T. Hatcher, H. E. Hayward, G. A. Pearson, R. C. Reeve, L. A. Richards, L. V. Wilcox

L. A. Richards, Editor
Soil and Water Conservation Research Branch
Agricultural Research Service

Agriculture Handbook No. 60 — Issued February 1954
UNITED STATES DEPARTMENT OF AGRICULTURE

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $2.00

- Published in 1947
- republished in 1954
- My 1958 student project was on saline and alkaline soils in Pakistan's irrigation lands in the Indus River Valley under Professor Zuur, who was an FAO expert assisting the reclamation of these soils. I purchased the book and still have it

Water movement through soil – infiltration controlled by EC and SAR

Sodium Absorption Ratio (SAR)

SAR is defined as:

$$SAR = Na/\sqrt{(Ca + Mg)/2}$$

with all concentrations in milli-equivalents per L

EC is the electrical conductivity of the water phase in dS/m or µS/cm

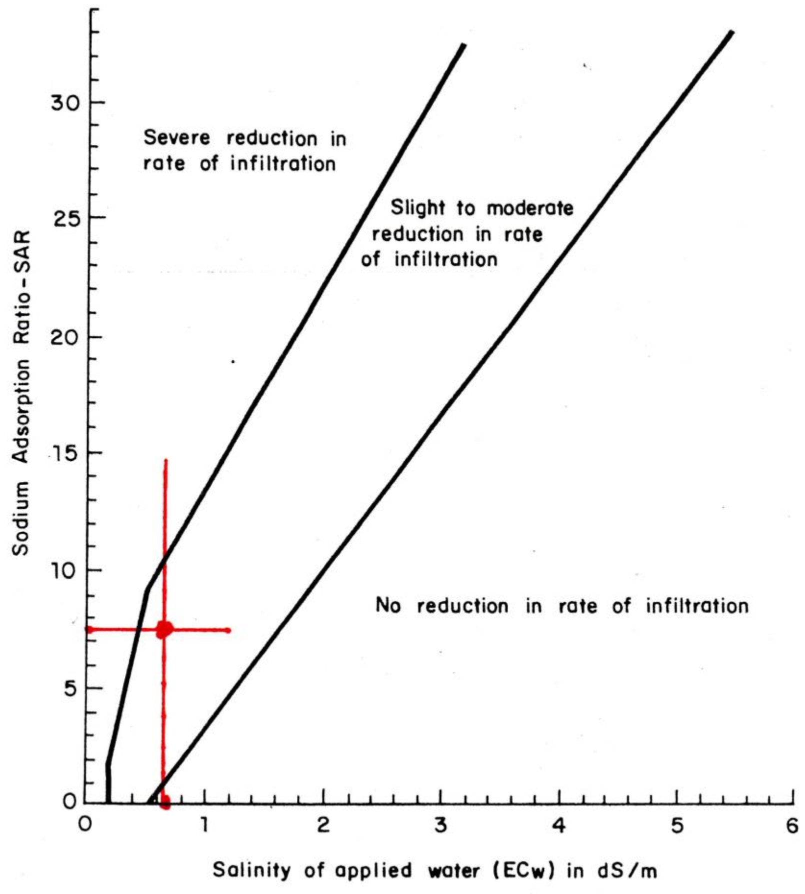


Fig. 21 Relative rate of water infiltration as affected by salinity and sodium adsorption ratio (Adapted from Rhoades 1977; and Oster and Schroer 1979)

Low salt water falling on a highly sodic soil will infiltrate very slowly, hence causing bad runoff (Quirk & Schofield, CSIRO, 1955)

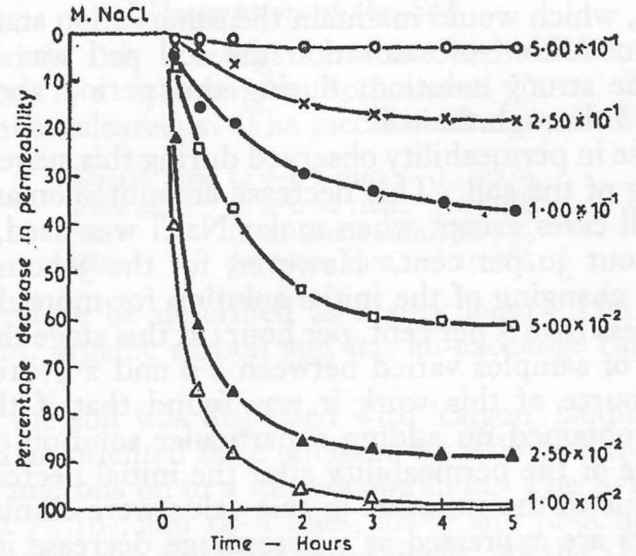


FIG. 1. Sodium-saturated soil.

The decrease in permeability for the sodium-saturated soil is thought to be due to swelling and deflocculation. Swelling would be expected to precede deflocculation, which was first observed at $2{\cdot}5 \times 10^{-2}$ M NaCl.

Take a soil and turn it into a fully 100% sodic soil, then measure permeability with different salinity water

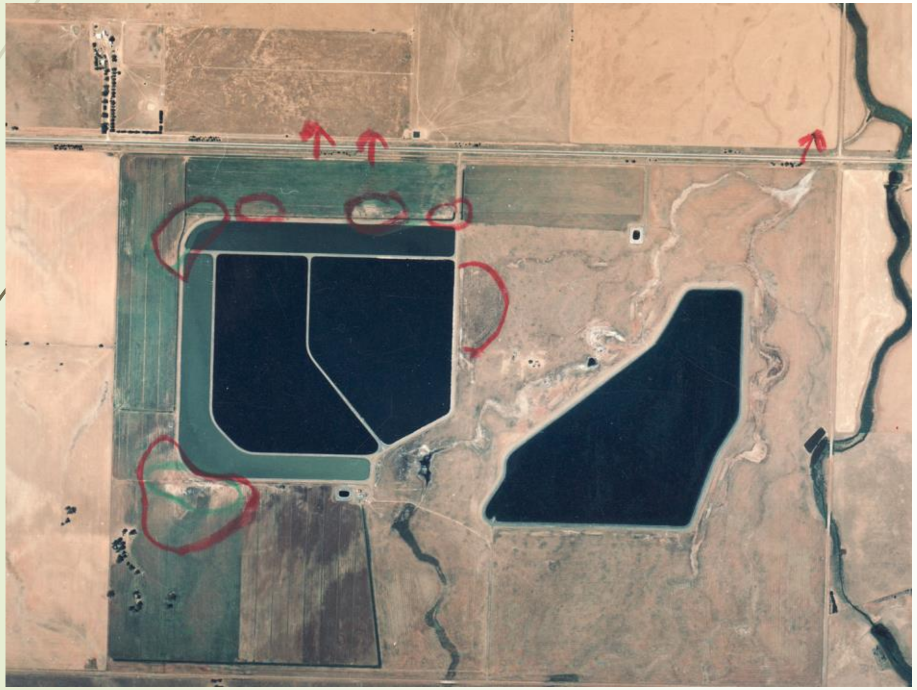
The most saline solution suffers hardly any decrease in soil permeability; as the salinity of the water put on this soil decreases, the infiltration rate decreases (a) very quickly and (b) very dramatically

The impact? A sodic clay at the surface impacted by a rain storm will cause a rapid and major run off event and highly turbid runoff

Geotechnical measurement of sodic soil permeability using deionised water as per Australian Standard
a $1,00,000 disaster

- Echuca Wastewater Treatment Plant 1986

Wastewater contained in turkey's nest



- Heathcote onsite effluent disposal study 2019

Specimen details before test		
Length of specimen	*mm*	50.5
Diameter of specimen	*mm*	43.6
Length to diameter ratio		1: 0.9
Dry density	*t/m³*	1.79
Moisture content	*%*	12.6
Specimen details after test		
Moisture content	*%*	21.8
Mean effective stress	*kPa*	50
Permeant used		Distilled water
PERMEABILITY (k)	*m/sec*	1×10^{-10}
Sample description		CLAY, medium to high plasticity, yellow-brown/brown.

* **Low salinity water falling on sodic clay causes an immediate drop in permeability**
* Therefore an immediate drop in infiltration
* Therefore an immediate increase in runoff
* Therefore an immediate increased risk of erosion,
* which exposes more sodic soil underneath, hence causes more erosion,
* which can become unstoppable

Engineering work in dispersive clays causes massive turbidity in water bodies

Merrifield drains

"Big Hill" proposed Golf Course Resort, Bendigo

Unstoppable gully erosion in sodic clay soils at the proposed "Big Hill Golf Course Resort", Belvoir Park Road, Bendigo. These sodic soils developed on Ordovician sedimentary rocks

Tunnel erosion of sodic dispersive subsoils near Jacksons Creek, Sunbury

Potential future problems with using treated sewage for irrigating public and private green areas

Will Class A treated sewage be made available for irrigation of public green areas?

Will it be available to householders?

What will be its salt content?

What will be its Sodium Absorption Ratio (SAR)

What will be its nutrient content?

How will its chemistry affect the local soils?

Typical Treated Wastewater Composition									
		Source A				Source B			
pH			nd				nd		
EC	µS/cm		746				740		
Ca	mg/L		20				13		
Cl	mg/L		109				1.2	??	
Mg	mg/L		18				5		
K	mg/L		nd				nd		
Na	mg/L		95				118		
SO4	mg/L		nd				nd		
TDS	mg/L		nd				nd		
SAR	Reported		4.5	Safe!!			7	High!!	
SAR	Calcul'd		4.1				7.5		

The minimum soil chemical laboratory work a soil scientist should require

pH(1:5 Water)			8.8	5.5-7.5
pH(1:5 0.01M $CaCl_2$)			8.36	
Electrical Conductivity	EC	µS/cm	171	< 300
TOTAL SOLUBLE SALT	TSS	ppm	564.3	< 990
DISPERSION INDEX	DI		16	
EXCHANGEABLE CALCIUM	Ca	meq/100 of soil	9.58	22.66
EXCHANGEABLE MAGNESIUM	Mg	meq/100 of soil	18.79	5.23
EXCHANGEABLE SODIUM	Na	meq/100 of soil	5.18	< 1.74
EXCHANGEABLE POTASSIUM	K	meq/100 of soil	1.31	1.74
EXCHANGEABLE HYDROGEN	H	meq/100 of soil	0.01	< 5.23
ADJ. EXCHANG. HYDROGEN	H	meq/100 of soil	0	
AVAILABLE SULPHUR	S	ppm	10.4	
TOTAL ORGANIC MATTER	OM	%	0.03	
CATION EXCHANGE CAPACITY	CEC	meq/100g of soil	34.87	
ADJUSTED CEC	ACEC	meq/100g of soil	34.86	
EXCH. SODIUM PERCENTAGE	ESP		14.86	< 5
CALCIUM / MAGNESIUM RATIO	Ca/Mg		0.51	2 - 4

RECOMMENDATION

GYPSUM REQUIREMENT 27.22 t/ha

What is necessary to plan land use in the Merri Creek catchment?

- 1. Realise that the behaviour of sodic soils is an intricate process depending on soil mineralogy, soil chemistry, and water chemistry. These scientific aspects must be understood or acknowledged by all agencies involved.
- 2. Land and soil investigations for urban development must develop a data base that considers the entire soil profile within which chemical and physical properties exhibit logical and natural depth functions
- 3. Avoid development of the sedimentary rock areas where soils are extremely prone to erosion
- 4. Technologies for stabilising highly sensitive, dispersive sodic clays, in bulk, after they have been displaced or in the natural state, need to be developed

All engineering work on dispersive clays must be adapted to their behaviour

- Massive applications of gypsum may be required on top of disturbed soil to induce flocculation and improved infiltration of water
- Applications of straw or hay may be required to minimise mechanical rain drop impact on the soil surface
- Perhaps geotextile covers can serve to minimise rain drop impact
- All good topsoil should be saved and used as temporary cover over dispersive clay

Future urban land use must continue to consider the special physico-chemical behaviour of these soils

- Parks and gardens, nature strips, etc., if irrigated by treated sewage from the new urban areas must ensure the clay soil remains flocculated and permeable
- Surface gypsum applications should become routine and repeated at fixed intervals to keep the exchangeable sodium levels low (<6%)
- The local Wastewater Treatment Plants should consider adding gypsum or soluble calcium to the effluent prior to delivery to the client to keep the Sodium Absorption Ratio at a suitable low value
- Residential users of treated wastewater should be adequately educated about soil dispersion and soil treatment to prevent dispersion

What to do to stop excessive soil sodicity in a new development?

- Ensure all good quality topsoil is conserved; do not mix with subsoil
- Establish by soil testing at what depth in the soil profile sodicity becomes a problem
- Import soluble forms of calcium, such as gypsum, at correct dosage (lab determination) and ensure intimate mixing with soil
- Promote good internal drainage
- Promote biological soil structure development from plants with strong root growth
- Keep groundwater table levels down, at least below 1.5 m, preferably more
- Do not irrigate parks, gardens or sports fields with treated municipal wastewater unless the SAR and EC are modified by adding calcium to safe levels

Conclusions

- 1. There are several distinct kinds of soil in the Merri Creek Catchment. These kinds of soil do not occur haphazardly in the catchment, they are mappable
- 3. The differences between these kinds of soil are related to the nature of the parent rocks and the age and intensity of subaerial weathering these have undergone
- 4. Geological and climate history in the Merri Creek catchment have resulted in most soils being sodic to varying degrees
- 5. A complete and new inventory of the land and soils of the catchment is desirable – A **Land System Survey**
- 6. The behaviour of sodic clays in terms of dispersion, erosion and permeability has been fairly well understood in Australia since 1955 and the understanding of it has been greatly increased since
- 7. Somehow numbers of geotechnical and civil engineers as well as planners and developers have no idea of the sodicity issues they are dealing with. We could be heading towards horrendous environmental damage. Do universities not teach the subject?