AmC130mith Beveridge North West PSP – Panel Hearing

Expert Witness Statement Part B

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I, Robert van de Graaff, was approached by Mr Scott Seymour, whom I know from many years ago, when he was working with the Dandenong Valley Authority, at the time when I was a research officer with the Victorian Soil Conservation Authority (SCA), in relation to the great environmental risks associated with intensive urban development in an area with highly sodic and highly erodible soils. In the past year Mr Seymour took me on a couple of field trips in the Merrifield development area and the Mandalay subdivision in the Beveridge North West Precinct Structure Plan. We crisscrossed these areas by car and stopped frequently to get out of the vehicle and have a quick look at the soils and the signs of erosion and soil salinity along the road, taking photographs at some places.

I fully share with him his concern about the very high erosion risks of the soils in the NW Beveridge Precinct. Although, while a member of the SCA staff, I did not directly have to deal with soil erosion management, I certainly was aware of the enormous problems that my colleagues in the Field Division encountered with trying to stop gullying in sodic clay soils. Certain parts of Victoria have become complete wastelands because the gullying was so massive that there were no suitable engineering methods to stop the process and repair the land. The SCA would from time to time run an excursion for the other staff to see such destroyed land.

Within the SCA soil sodicity was recognised as a major soil problem, not just because of the erosion and gullying in the landscape and the loss of productive land and the loss of trafficability across gullied land, but also because runoff and the streams flowing from eroding land are highly charged with sediment and suspended fine clay. The SCA acted also in its capacity as Referral Authority charged with the protection of water quality in Proclaimed Catchments. I refer to that in my appendix.

Because I share Mr Seymour's views, I have joined his quest and do so *pro bono*.

The Merri Creek Management Committee invited me to present a PowerPoint discussion about sodic soils that was attended by representatives of Melbourne Water, Yarra Valley Water and local government and led to serious discussions of the issues. Melbourne Water then asked me to repeat more or less the same presentation at their HQ.

Soil sodicity is a serious issue across most or the entire Beveridge NW PSP and it is more severe than the Jacob Report makes it out, because their field work was too limited to be able to fully assess it.

It is my experience that soil sodicity is not well understood and appreciated beyond a relatively small cohort of soil scientists. I have expanded on that topic in my Appendix.

A comparable case is that of the severe building problems due from swelling clays (cracking clays). There is a lot of good information about how to build on cracking clays, but in practice it is often hardly used. By comparison, not much is known <u>and applied</u> about stabilising sodic clays and we can see that in the absence of any practical applied examples.

What actually seems to happen is that developers and builders do not know about the availability of good soil engineering practice or do not care. There also appears to be no supervision on their practices exercised by the Victorian State and no penalties.

The Jacob Report states (see italics):

Soil chemical ameliorants are recommended for short-term stabilisation of soils on construction sites. Three primary soil chemical ameliorants and their uses for stabilising dispersive soils on construction sites are:

- *Gypsum (CaSO4), primarily for stabilising dispersive topsoil or subsoil not intended for construction or geotechnical use. Gypsum flocculates soil and increases soil permeability, rendering materials less favourable for compaction and geotechnical use. Gypsum significantly reduces dispersion of clay and turbidity of runoff.*

- *Hydrated Lime (Ca(OH)2). When slaked in water, hydrated lime stabilises soil cations by supply of calcium (reducing or eliminating dispersion and sodicity) and increases soil strength. Hydrated lime is the favoured soil chemical ameliorant for stabilisation of soils in civil and geotechnical works such as around pipes, structures, roads, trenches and any works <u>requiring compaction upon reinstatement.</u>*

- *Agricultural Lime (CaCO3). Standard agricultural lime will provide minor soil stability however the solubility is low and immediate response is poor. Given that top soils are acidic (pH water average 5.88) agricultural lime could be used to support improving plant growing conditions by adjustment of soil pH, however the effect on soil stability is expected to be low or negligible in the short term by comparison with gypsum.*

Soil physical ameliorants are recommended for long-term structural stability of soils. Their effectiveness varies, depending on the nature of the ameliorant and how effective it is for protecting dispersive soils from direct contact with fresh water and erosion, or slowing down water flow. Examples of soil physical ameliorants and options include:

- *Geotextile fabrics and mattings that provide sodic soil protection, shrouding and assist with plant establishment.*

- *Organic matter. Used as a protective shroud on topsoils, improving soil physical structure and biological condition. Hydro-mulching is a form of stabilisation using organic matter. Organic matter is not suitable for stabilisation of soils for civil or geotechnical works unless it is a final layer of protection used for shrouding.*

- *Seeding of sites to fast-growing species, or application of instant turfs.*

I have done a short Google search to see what has been done to work safely with sodic clays and dispersion and have found exactly the same information that the Jacob Report has produced in about half an hour.

The construction failures I saw in Merrifield, where there were massive soil slips in a large drain, seem to indicate that engineers have not foreseen these and do not know how to prevent them.

Why should we put a high level of plausibility on the Jacob Report?

Mr Scott Seymour forwarded a section of the SEPP 2018 Gov. Gazette that reads as follows.

> **42. Management of construction activities**
> A person responsible for a construction activity must –
> (a) ensure their activities are managed to minimise the risks to beneficial uses, so far as reasonably practicable, including risks from dewatering, land disturbance, soil erosion or the discharge of sediments and other pollutants to waters; and
> (b) monitor surface waters where the construction activity adjoins or crosses surface waters to assess if beneficial uses are being protected; and
> (c) comply with guidelines published or approved by the Authority in relation to the construction activity.

This raises two questions which I cannot answer: "What penalties are there to punish a person involved in construction who fails to adhere to these guidelines?" and "What supervision is there to identify cases where a constructor does not obey these guidelines?"

If the VPA allows itself to be convinced that sodicity problems in the BNW PSP can be easily overcome using gypsum, slaked lime, etc., perhaps it can enter a contract with home buyers, developers or builders that indemnifies the purchaser of the home against any subsequent structural failures or other damages.

In my opinion there is insufficient precise or detailed information on the soils of the BNW PSP for the amendment to proceed with any degree of certainty. The planned developments for the BNW PSP must be supported by a thorough land capability assessment before any engineering works are carried out.

Land capability assessments must collect and interpret data on the land for specified land uses. The data include geology, geomorphology (the processes of sedimentation, alluviation, in other words the movement of all earth materials in the landscape by water, wind, and gravity, as well as the movement of solutes throughout the landscape, and finally the impacts of material alteration by weathering), and the climate of the area. The detail of the required data depends on the intensity of the proposed land use. It varies from a more general requirement of establishing a general inventory of soil or it may have very specific purposes, such as assessing land suitability for irrigation or urban uses. The Table below is a good example of the detail and scale of mapping of land (or soil) required for a variety of land uses. I have coloured those survey objectives that are included in the Beveridge North West PSP in yellow.

Table 1 Guideline specifications for soil or land resource mapping (van de Graaff, 2003[1])

Orders of soil or land survey	Appropriate map scale	Minimum delineation[1] (ha)	Mapping units[2,3,4]	Component units[2,3,4] (Not mapped)	Survey objectives
Very high intensity (Very large scale)	1:5 000 1:10 000	0.05 – 0.07 0.20 – 0.27	Land facets, soil phases and soil types, PPF, PPF+	- soil phases	Agriculture research areas, irrigation implementation, urban development, highway planning, mine site rehabilitation, property planning
High intensity	1:20 000 1:25 000	0.8 – 1.1 1.2 – 1.7	Land facets, soil types, soil complexes, PPF	- soil types, PPF	Agriculture production, urban development, highway planning, mine site rehab., shire planning, catchment management
Medium intensity	1:50 000	5.0 – 6.7	Land systems, soil series, soil associations	Land facets Soil series, PPF	Agriculture production, irrigation feasibility, shire planning, catchment management
Low intensity	1:100 000	20 - 27	Land systems, soil associations,	Land facets Soil series, PPF, soil associations	Agriculture & irrigation feasibility, shire planning, large catchment management
Reconnaissance	1:250 000 1:500 000 1:1 000 000	120 – 170 500 - 675	Land systems Great Soil Groups	Land facets PPF, Soil associations	Land resource inventory, agriculture development potential, infrastructure planning
Synthesis (Very small scale)	1:2 000 000	8000 – 11000	Regions or provinces; no soil equivalent	Land systems Great Soil Groups	Natural resource inventory, continental scale mapping

[1] The size delineation depends on whether the area shown has uniform or elongated occurrence, such as a narrow floodplain following a river.
[2] Mapping units and component units are defined in Gunn *et al*. (1988)
[3] PPF, Primary Profile Form; PPF+, subdivisions of a Primary Profile Form (Northcote 1979)
[4] Great Soil Groups as described in Stace *et al.* (1972)

The BNW PSP is focused on intense residential and urban development with a housing density of up to 20 home lots per hectare and therefore ought to be surveyed in detail at a scale of 1:25,000 as a minimum and perhaps down 1:5000, which requires a field survey effort of appropriate intensity. There are internationally accepted standards for surveys at various scales which have been generalised by Bie

[1] R.H.M. van de Graaff. Principles of soil surveying: Theoretical considerations. Soil Surveying in Agriculture: Current Practices and Future Directions. *A symposium organised jointly by the Australian Soil Science Society Inc. (Victorian branch) and the Department of Primary Industries (Tatura Centre). Tatura, 3 October 2003***.** The Table in that paper was a combination of similar Tables in Reid RE, Gunn RH, Stackhouse KM, Galloway RW (1988) Chapter 2 'Framework for soil and land resource surveys', Gunn RH, Beattie JA, Reid RE, van de Graaff RHM (Eds) (1988) 'Australian Soil and Land Survey Handbook: Guidelines for Conducting Surveys'. (Inkata Press, Melbourne), and Soil Survey Staff (1951) 'Soil Survey Manual'. (U. S. Department of Agriculture, Soil Conservation Service)

and Beckett (1970, 1971). Obviously, to the extent that high quality suitably scaled aerial photography is available, a surveyor can cover more terrain per day of field work without losing accuracy of data.

Bie and Beckett (1970, 1971) summarised their findings in the form of a logarithmic function:

$$\log_{10}E = 7.41 + 1.57 \log_{10}S \quad (1)$$

where E is survey effort in man-days per km^2 in the field and S is map scale expressed as a fraction. This function can be portrayed on double logarithmic paper to facilitate reading off the value of E for any chosen scale S.

For example, assuming a map scale of 1:25 000, then:

$$\log E = 7.41 + 1.57 \log (1/25{,}000) \quad (2)$$

Hence, the survey effort (E) on this scale is approximately 3.2 man-days per km^2.

The BNWPSP cover 1250 hectares or 12.5 km^2 and by Bie and Becket's standards a field survey effort of 40 days is warranted – not 2 as per the Jacobs Study.

The field survey carried out for Jacobs by their subconsultant, Christian Bannan, of South East Soil and Water, on the 3rd and 4th of June 2020 following above-average rainfall conditions in the previous months of March, April and May, prevented him from accessing all the parts of the PSP. In other words, by the Bie and Beckett standards, the Jacob soil survey, aided by a statistical program that smears out (interpolates) the few data available over the whole area, as if there are no sharp borders between its constituent land elements, achieved its results in one twentieth of the time it should have taken.

My concern is raised by the fact that in the procedures followed by the VPA the matter of land capability and the very high erosion risks from the prevalent condition of soil sodicity was only raised, seemingly as an afterthought, after the VPA became aware that Mr Scott Seymour and others had objected to the planning amendment process.

The entire BNW PSP background document contains virtually no references to the land, the soils, and the degradation of the land though widespread erosion and the water quality in streams that is already strongly impacted by suspended clay.

Because the land and soil conditions are much more limiting to development than, for example the presence of Aboriginal sites or the current vegetative cover or the presence of a few contaminated sites, why have the latter been investigated in preference to the former? The prime limitation to urban development of land surely must be the land itself. I can only offer the explanation for this that the planners simply do not understand the importance of the physical state in which the land occurs and just became aware of that later.

The Mitchell Planning Scheme, Amendment C106, Explanatory Report also skates superficially over the matter of sodicity and turbid water runoff.

How does the Amendment address any environmental, social and economic effects? *Environmental effects*

There is not a single word on the impact of sodicity on the behaviour of the soils in this section.

Further on:

The PSP builds upon these landscape characteristics by setting aside a significant amount of land to protect and enhance existing landscape values in the northern portion of the precinct and by enhancing Kalkallo Creek. The natural features of the precinct will provide a unique and important context for the future community.

Kalkallo Creek is already running through a deeply eroded channel where some tributaries are provided with gully dams. What landscape value is meant here?

Permit requirement for Earthworks Land

Earthworks which change the rate of flow or the discharge point of water across a property boundary None specified	Earthworks which increase the discharge of saline groundwater None specified

Why is it not necessary to specify how these earthworks must be carried out when the soils could be highly sodic?

A Stormwater Management Strategy that assesses the existing surface and subsurface drainage conditions on the site, addresses the provision, staging and timing of stormwater drainage works, including temporary outfall provisions, to the satisfaction of Mitchell Shire Council and Melbourne Water.

No mention here of managing specific problems that will be encountered by the sodic, dispersive and often saline soils.

Stormwater facilities that are compliant with the relevant approved drainage strategy; and11. –

My question is: “Are the examples of what I saw in Merrifield compliant with an approved drainage strategy?

The proposed amendment to the Mitchell Shire Planning Scheme Urban Growth zone then goes on:

Sodic and dispersive soils management plan

An application to subdivide land or undertake earthworks must be accompanied by a sodic and dispersive soils management plan, prepared by a suitably qualified professional, that includes: ~~The retention and removal of vegetation and any revegetation.~~

- The existing site conditions, including extent of sodic and dispersive soils based on soil samples in the works area, land gradient and the extent of any existing erosion, landslip or other land degradation;
- The extent of any proposed earthworks;
- Recommendation for soil management practices with consideration of anticipated sodic/dispersive soil exposure;
- The staging of development; and
- Recommendations that inform a site management plan including:
  - The volume and location of any stockpiles.
  - Vehicle access and movement within the site area.
  - Any treatment to manage the soil while works are undertaken.

These guidelines need to be much more prescriptive to be effective as there is no other guidelines in Victoria. There has to be a requirement to contain **all** runoff, even in exceptionally wet years with the runoff to be treated to 50 NTU before offsite discharge. Also, where will soil to be treated for sodicity be taken to? Will it be off site or onsite?

A new Rural Conservation Zone Schedule is proposed to be applied to the 'landscape values' area of Springhill Cone and the western hilltop. Schedule 2 of the Zone is applied to identify and protect the landscape value of these hilltops specifically.

At the Merrifield site I was involved with, the geotechnical engineers had sampled the clay soil in what appeared to me as a haphazard program, here a soil sample from close to the surface but at another sampling spot a sample from the deep subsoil, and somewhere else again a sample from the middle. I could not find a case where the entire profile had been sampled systematically. I believe that is because in geotechnical and civil engineering there is no such thing as a vertically arranged soil profile. If there is no soil profile, then all soil must be the same, no matter where one samples it.

The chemical lab work for Merrifield also suggested an absence of knowledge of soil chemistry as it applies to sodicity and dispersion. Sodium content is reported in mg/kg, as if it is a contaminant like arsenic.

I return now to the BNW PSP.

Jones et al. (1996) was used to establish Erosion Management Overlay Zones for Class 4 and 5 which would indicate there was a serious risk to land use. For reasons unknown to me, Mitchell Shire later removed the Class 4 Erosion Risk Zone.

We do not have a detailed map at a suitable scale, say 1:20,000, of the entire area within the PSP. We do know that there are several distinct, well delineated different geological formations and topographies. There are basaltic flows from Spring Hill and Mt Fraser and these are probably of different ages and different degrees of weathering and soil formation and soil chemistry. Across the portions of the PSP that are based on sedimentary rock there is a range of topographies, degrees of soil loss from the steeper parts and soil accumulation along the base of the slopes, with attendant changes in hydrology.

We do not know in detail how the chemistry of the soil changes with depth in the soil profile or with soil horizonation. Therefore we do not know what parts of the soil profile are highly dispersive and erodible and so we do not know what part of the soil profile can be stockpiled safely and when and where it is necessary to apply gypsum immediately upon baring the dispersive lower soil layers. Gypsum is initially required to elevate the electrical conductivity[2] of the water inside the soil to bring about rapid flocculation of clay particles.

Most of the Jacob soil samples come from the 0 – 40 cm depth, so avoid the most sodic portions of the soil profile. The 15 samples taken from depths greater than 40 cm mostly show a very high sodicity. Services like sewers, stormwater drains, gas pipes and water pipes probably are largely in the zone below 40 cm.

There is mention of "sodic and dispersive soil management plans" in the proposed amendment Mitchell Shire Planning Scheme for the UGZ, but Victoria never had such plans. The DPI in NSW does, but it relates to agriculture as does the Queensland plan. Tasmania has a sodic soil management plan that recommends not to build homes on them.

[2] A saturated gypsum solution will have an EC of 2000 µS/cm and contain about 2.4 g of $CaSO_4.2H_2O$ per Litre at 25°C.

Which Victorian State body or industry body would be able to set up, monitor and enforce such a sodic and dispersive soil management plan? The proposed Mitchell Shire Planning Scheme amendment for the UGZ, mentions one, but has it been ever applied?

I am not aware of municipalities having the expertise in house for administering and enforcing erosion management controls.

What we have is a two-day soil survey in the area that was hamstrung by inaccessibility of much of the land due to wet and muddy conditions. Statistical analyses of limited data do not improve precision but only extend inadequate information over a larger area of land.

Conclusion

I conclude that the planning amendment should not proceed and that no further earthworks ought to be commenced in the BNW PSP until a suitably detailed land capability investigations have been completed and understood as to the full land capabilities and associated risks.

I also conclude that the proposed approach of later discovery of soil characteristics through a later investigation after the land is rezoned, is fraught with grave risks of potential failures. Associated with the VPA proposal is the proposal to establish Sodic and Dispersive Soils Management Plans, a proposal I believe is fraught with a vast amount of unknown risks and lack of prescriptive detail. It is a proposal that is likely to fail as there is no known successful applications in Victoria, nor any suitable regulatory environment for their administration.

Note

I have made the comments above based on my own professional experience that was greatly enriched by working in CSIRO's "Land System & Regional Survey" Section in Canberra for 4 years from 1959 to 1963. We always worked with a minimum interdisciplinary team of 3 specialists:
a geomorphologist/geologist, an ecologist/botanist and a soil scientist.

Working in this way I learned to understand soils as components within a geomorphological and geochemical framework that produces laterites and silcretes in upland areas and cracking clay soils in basin areas. I also learned that plant communities accurately reflect these different soil and climatic environments. I was involved in the mapping of the whole Hunter Valley Catchment and a large part of the Daly River – Katherine River catchment, each area taking 2 years of our time.

Whilst we published maps of land systems at scale 1:250,000 much of the field work was done at a much larger scale to improve our understanding of the land.

After my employment with CSIRO, I took up a Graduate Assistantship at Cornell University, Ithaca, NY, where I joined the Department of Agronomy. In American universities a graduate student working towards a PhD must take advanced course work in his own Department and in other Departments to broaden his/her academic horizon. I had a minor in the Geology Department where I took course work in geomorphology, mineralogy, petrology which complemented all the course work in various specialised components of soil science (soil chemistry, soil physics, soil genesis and geography, organic soils, soil mineralogy). I also had a minor in the Department of Civil Engineering where I took soil mechanics, aerial photography interpretation, and terrain analysis. Several of my teachers had consulting experience. Terrain analysis was taught by a professor who had, amongst other things, been a consultant to one of the big Australian mining companies to work out the best route for heavy iron-ore loaded trains to transport the ore to a harbour site for shipment. Railway gradients must be very low to prevent the trains from travelling too fast downhill and wearing out their brakes. He still had all the maps, aerial photographs and a stereoscope, and after giving me some hints, had me do the job all over again.

Another interesting fact about good American universities is that no one will be allowed to obtain all three degrees, BSc. MSc and PhD from the same school. Intellectual inbreeding is not wanted.

To have enough income I worked for the Agronomy Department 20 hours/week during the academic years and full time during the 3 summer months. That work was detailed soil mapping at scale 1:20,000. I am quite familiar with mapping at that scale.

Appendix

In the 1950's CSIRO's Division of Geomechanics also started to research the problems posed by cracking clays, reactive soils, and how they affect foundations and concrete slabs. The first of this research was done in the Adelaide area and especially at Elizabeth, SA, where the factories for Holden Motors were being built, and where a town had to be established for the workers. I understand that a lot of experience was gained in how to limit the movement of moisture in the soil below the structures and safeguard their integrity. Mr G.D. Atchison was its Head when I worked with the SCA. In 1985 the International Society for Soil Mechanics and Foundation Engineering held its Golden Jubilee and published a Commemorative Volume of papers on these subjects. It includes papers on the problems of expansive soils, such as:

"Design and performance of mat foundations on expansive clay" by R.L. Lytton, PhD of Texas A & M University and J. A Woodburn B.Sc. M. Sc, M.I.E., consulting engineer, Adelaide, SA.

Deleted: *M.Sc*

Lytton and Woodburn found that stiffened mats had been successfully employed both in the USA and in Australia in the design of school building foundations.

No doubt that since 1985 further work has been done that would have yielded useful designs for cracking clay soils.

One of my oldest and closest friends is geotechnical engineer Dr Len Walker, who was the Managing Director of Golder Associates for several years and he confirms this. He has mentioned the existence of major foundation problems in the Melton area on cracking clay soils.

Yet today in the west, particularly in the Tarneit area, a large number of new homes have been damaged by the soil heaving up and down and home-owners are faced with major costs and probably no ultimate solutions. As The Age reported in June 2014: "*Estimates suggest up to 4300 homes in Wyndham, Melton and Hume local government areas may be suffering from ''slab heave'' where volatile soil movements under a home's foundations cause walls to crack, doors and windows to jam, and floors to tilt."*

Consulting engineer Peter Yttrup is reported to believe the actual number to be far higher. Professor Peter Dahlhaus[3] has also written extensively about the swelling and shrinking clay soils and the damage they cause to buildings and roads. He also has been supervising doctoral students researching these soils.

Similar lack of real action typifies the current situation with respect to erosion from sodic soils.

The Parwan Valley is one of the most eroded and damaged landscapes on sodic soils in Victoria where the SCA has worked for decades. Victoria Resources online has the next paragraph about this area:

> The Parwan Creek valley is located near Glenmore in the north-west of the region and contains some of the most severe sites of water erosion in Victoria. The Parwan Hydrological Experimental Area was established in 1953 by the Soil Conservation Authority and forms part of the White Elephant Reserve (Hartland and Papworth 1995). Extensive, deep tunnel erosion was recognized by Hexter *et al*. (1956) as the main problem on the White Elephant Hill.

[3] Principal Research Fellow | Centre for eResearch and Digital Innovation (CeRDI), Research and Innovation Portfolio Federation University Australia, Global Enterprise Centre | Technology Park, Mt Helen Campus, Ballarat.

The SCA employed an excellent hydrologist on this and other programs and it shared hydrological experience with hydrologists employed by the then MMBW. It also employed an excellent soil chemist, T.I. Leslie[4], and operated its own soil chemical and soil engineering laboratory to support its soil scientists and other staff involved in earthworks, including dam design. Leslie and Hutton also discovered where the salt and sodium that is found in the soils over such large parts of southern Victoria came from. He and a co-worker, J.T. Hutton, CSIRO Division of Soils[5], followed by Hutton (1976)[6] and Isbell, Reeve and Hutton (1993)[7] analysed the composition of rainwater from a large number of rainwater gauges over Victoria and analysed their salt composition. From these data they calculated a mathematical function relating salt enrichment, cations and chloride, of the land to distance from the coast.

As sodium chloride is the dominant salt in seawater, it is also the dominant salt in rainwater. The accessions of salt decrease rapidly with distance from the sea. Victorian research indicated that the chloride content of rainwater was a highly significant function of distance from the ocean:

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

where:

Y = weighted mean chloride concentration in rainwater
d = distance in km in the direction most likely to contribute maximum oceanic salt.

With Kalkallo some 80 km from the ocean, the area would have received 6 mg/L of sodium chloride per year. Taking the mean annual rainfall of 588 mm for Sunbury as an example, each hectare would receive 5.588 kg/year of sodium chloride salt. Let's assume that the Victorian climate has not changed dramatically since the last Ice Age, 14,000 years ago. In all that time each hectare of land has received 70.56 tonne of sodium chloride. However, even though the climate during the last Ice Age would have been drier, there would still have been rainfall, and there would have been rainfall prior to the last Ice Age. All of the western and northern areas of Melbourne have had relatively less rain than the eastern area. The salt added to the soil in the west and north has been partially leached down the profile and has become concentrated in the lower reaches of the profile. That is why sodicity is the dominant condition of all or most of the soils in those parts.

It would always have been the mode of working in the SCA to find solutions to land degradation and methods of land improvement by means of basic research that leads to understanding the actual mode of active landscape processes.

I remember that from time to the SCA organised field excursions for most of its staff to assist the research section and the field division to interact better with one another. It was also to show that

[4] Hexter GW, Leslie TI, Pels S (1956) `A land-use class survey of the Parwan Valley, Victoria'. (Soil Conservation Authority of Victoria) (Government Printer: Melbourne)
[5] Hutton J.Y., Leslie T.I. (1958) Accession of non-nitrogenous ions dissolved in rainwater to soils in Victoria. *Australian Journal of Agricultural Research* **9**, 492–507.
[6] 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.
[7] Hutton, J.T. (1976). Chloride in rainfall in relation to distance from the ocean. Search 7, 207-208.

when tunnel erosion and gully erosion becomes extreme, there are no ways to stop further erosion or to reclaim eroded country.

Even the Victorian EPA is not well informed about soil sodicity as I have found out through my involvement in wastewater disposal on sodic soils. There are only two minor references to sodic soils in the 72 pages of Publication 891.4, the Code of Practice – "On Site Wastewater Management", there are just 4 references to sodicity in the 89 pages of Publication 464.2 "The Use of Reclaimed Water", without any suggestions as how to overcome the problems from sodicity.

The EPA in recent years enabled a treated sewage scheme for a school in country Victoria to be established on sodic clay soils which has turned into a full and costly disaster. The Works Approval document was accepted even though there was no information on the chemistry of the soil. I know this because I was part of the team that produced the Domestic Wastewater Management Plan for this township and much later became involved with the school's problems through a contact in Cardno.

Engineers designing and building a large sewage system for Echuca in the late eighties created two turkeys nests for holding the sewage to be irrigated on surrounding land that leaked like a sieve because the permeability of the clay soil base was measured with deionised water, resulting in an outcome of "impermeable soil". Sodic clay swells and disperses in pure water. That soil, however, became highly permeable because the water inside the turkey's nest was rather saline due to Echuca's food industry and an abattoir that used salt to preserve skins. It was my good friend, Dr Roger Wrigley, who discovered this. At the time I was also engaged by the Campaspe Water Authority and discovered that the irrigation scheme using the treated wastewater immediately around the turkey's nest (green zones) contravened the basic design premise by adding water on land that was to act as a sacrificial evapotranspiration zone and would become saline from a locally raised water table.

This case went to the Supreme Court and only finished up with an instruction for both parties to arbitrate an outcome when the insurance funds were exhausted.

In 1966, some twenty years before Echuca, when the Adelaide Bolivar Sewage Treatment Plant was established a similar problem was encountered, that measuring hydraulic conductivity in a sodic clay soil with deionised water gives a result that will be different from what happens if that same soil is exposed to saline water. I understand that it was CSIRO[8] that saved the plant from becoming a disaster.

[8] CSIRO was the first organization in Australia that researched and understood the phenomena around sodic clay soils and their behaviour. I am told CSIRO assisted with the research for the Bolivar Plant establishment. In 1955 it published a paper: Quirk, J.P. and Schofield, R.K., The effect of electrolyte concentration on soil permeability". J. of Soil Science, Vol. 7, No. 2, 1955.

Somehow different scientific fields seem to have impenetrable walls around them.

The large winding lake separating the Jaw Bone Reserve at the Rifle Range, Williamstown, from the new urban areas to the north was excavated sometime around 1992-94 and the spoil was used to create an embankment that was planted with specially grown indigenous species from the location. It was a $900,000 project and became a total failure because to the best of my knowledge no one in the State Government body that commissioned the lake bothered to find out what the soil was like. Instead, that Government body blamed the earthmoving contractor and company that did the planting for the disaster.

A brief glance at the geological map would show the lake was dug out from a marine saline and sodic swamp. The embankment consisted entirely of saturated saline clay and walking on it was like walking on gelatine pudding. The plants had their roots in saturated soil, zero oxygen plus salt as well. Depressions filled with rainwater immediately result in dispersed clay.

I have been a part-time soil science teacher at RMIT in the Landscape Architecture department, teaching the first-year students, for almost 20 years. It is evident that any design on paper must sooner or later be built upon real ground, but to be lasting and successful it must cope with the dynamics of the site: waterlogging, slope instability, salinity, depth of soil over a barrier layer, etc. I have gratefully been using the Jaw Bone Reserve, and other places where unnecessary mistakes in assessing soils were made, for excursions with my students.