17 August 2018

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NSW solar farms are likely to improve soil fertility

I have been asked by Terrain Solar to provide my opinion about whether or not a solar farm layout – with a minimal tracker cross section as shown in Figure 1 – would compromise an ability to sustain a healthy groundcover under the solar farm infrastructure, and what soil health impacts are likely.

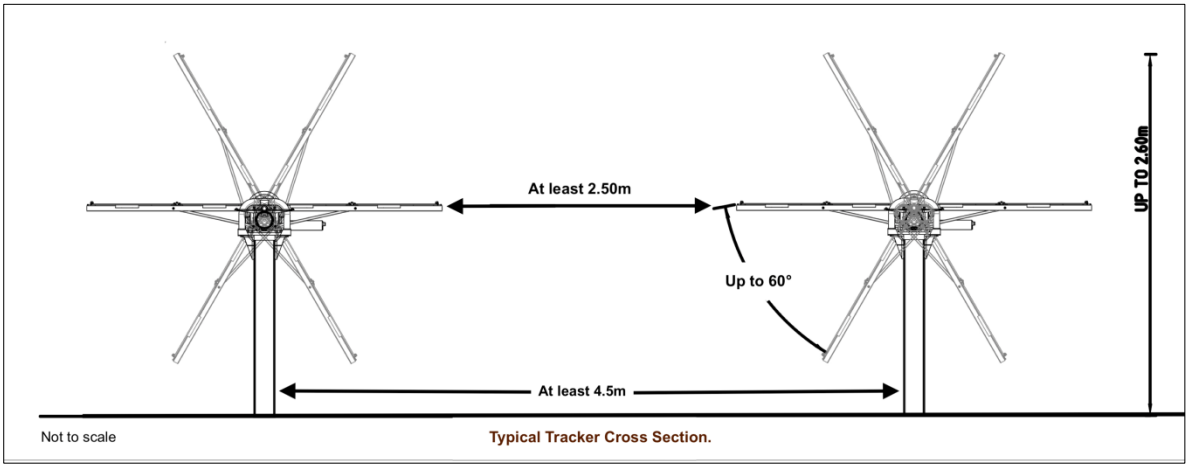


Figure 1. Typical tracker cross section (supplied by Terrain Solar).

I provide this opinion as a Certified Professional Soil Scientist with a Doctor of Philosophy (soil physics), Master of Science in Agriculture (soil chemistry / agronomy) and Bachelor of Natural Resources (Hons.). A copy of my CV is attached.

In my opinion, concern that paddocks under a solar farm could have a deleterious effect on groundcover through blocking UV light and disrupting soil microbiology is misplaced. To the contrary, subject to appropriate controls during operations, I consider that the opposite is more likely to be true, ie. an improvement in soil condition can be expected beneath NSW solar farms.

Shading of the land surface by solar panels

Single axis tracking allows light to be distributed across the surface of the ground. As the tracking technology rotates from east in the morning to west in the evening, it moves a band of sunlight from west to east across the entire surface area of the site. It is evident that on a cloudless day, all of the

pasture would receive at least some direct sunlight for photosynthesis. At other times of the day, there would also be a significant amount of reflected sunlight at ground level.

There are benefits, to the soil and pasture, from the shading of the solar panels. Near-surface soil temperatures will be reduced in summer, which will create the following benefits:

- Less water loss via evaporation.
- A reduction in soil carbon loss; the rate at which soil organic matter decomposes and releases CO_2 declines as soil temperature is lowered.

In years with favourable soil moisture conditions in Spring, the shading from panels may slow down plant growth, relative to unshaded pasture. However, the stored soil water not used at that time would allow pasture to continue to grow strongly in early summer when the soil usually is too dry for optimal plant growth.

Localised changes in rainfall distribution associated with solar panels

Night time rainfall on tilted 'parked' panels would produce runoff from the panels that will create plumes of water that penetrate quickly and deeply into the soil; this is analogous to soil water entry via drip irrigation lines. It is also noted that panels can be stowed in a safe position either east or west, usually at 30 degrees and this creates two settings for night rain.

If the soil is acidic, long narrow strips of lime ($CaCO_3$) could be placed on the soil surface along the panel drip lines to encourage deep movement of lime into the subsoil, possibly in conjunction with gypsum ($CaSO_4$) and/or compost/mulch. If soil testing indicates the presence of sodic subsoil, the risk of tunnel erosion will be reduced by adding gypsum.

The end result would be more efficient water entry, and better rainfall storage efficiency, than with rain falling onto paddocks without solar panels. Near-surface soil moisture often is lost via evaporation.

Deeply penetrating plumes of non-acidic water would encourage earthworms and other beneficial soil organisms.

Deep water movement and the creation of vertical worm channels will promote root growth into the deep subsoil, where the potential for carbon sequestration is greater than near the surface because of lower soil temperatures and slower decomposition rates for deposited organic matter.

Improvement of soil conditions following comprehensive soil testing to a depth of one metre.

Most NSW farms do not have comprehensive soil test results for the upper one metre of the root zones of the crops and pastures that they produce. Soil degradation is widespread.

Pre-development soil surveys for solar farm development almost certainly will highlight constraints to pasture production. Fortunately, soil constraints are fixable through amelioration with techniques such as lime application, gypsum spreading, deep loosening and nutrient application. An alternative approach is selection of pasture species/varieties that have a natural adaptation to the prevailing soil conditions.

Therefore, an improvement in soil assessment and management following conversion to solar farms almost certainly will lead to an improvement in soil conditions for plant growth. The roots and fungi associated with diverse and vigorous pasture assist with soil aggregation and carbon sequestration.

The creation of baseline soil data will allow improvements in soil fertility to be demonstrated in later years. Regular on-going soil testing will allow the soil management programs for solar farms to be fine-tuned.

Grazing management of the pasture by sheep

Pasture beneath solar panels ideally will consist of a mix of legumes (eg. lucerne, medics, clover), herbs and grasses. Although fire hazards need to be minimised, it is essential that 100% groundcover be maintained through conservative grazing practices (or slashing) so that erosion risk is minimised. The use of pasture species that create plenty of food/seed for burrow-creating soil fauna (eg. ants) will provide extra vertical biopores that will assist with water entry and subsoil aeration.

The pasture beneath and near solar panels should only be grazed when the soil is dry and firm enough to avoid compaction via sheep trampling. With the principal land use and economic return being generation of solar power, there is more flexibility to achieve a grazing regime that protects groundcover and the soil resource.

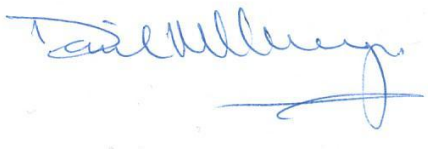
Consider surrounding solar farm sites with Oldman Saltbush

Oldman Saltbush (*Atriplex nummularia*) is a native shrub with fire retarding foliage that can be used in broad strips around the perimeter of solar farm to reduce the rate of spread of grass fires that may enter via neighbouring farms.

Deep water extraction by saltbush will minimise the risk of secondary salinisation from neighbouring land.

Oldman Saltbush provides valuable fodder for sheep. It will persist for many decades provided that the grazing pressure is not too heavy.

Yours sincerely



Dr David McKenzie
Soil Scientist
Soil Management Designs

CV: Dr David C. McKenzie, SOILmgt, Orange NSW

Soil Science / Land Management Qualifications

Doctor of Philosophy (Soil physics: *Compaction assessment and management under irrigated cotton*)	University of Sydney, 1997
Master of Science in Agriculture (Soil chemistry / agronomy: *Sodic soil amelioration under dryland wheat*)	University of New England, Armidale, 1983
Bachelor of Natural Resources (Hons.)	University of New England, Armidale, 1977
Certificate IV: Training & assessment	Business Enterprise Centre, Orange, 2008
Fulfilled requirements of NSW Enterprise Workshop (Business plan entitled: '*LandWise – a yield map interpretation service*')	NSW Entrepreneurship Centre Ltd, Sydney, 1996

Accreditations

'*Certified Professional Soil Scientist*', Soil Science Australia;
and '*CPSS Competent in Australian Soil Survey*'.

'*Chartered Scientist*', Institute of Professional Soil Scientists, British Society of Soil Science.

Employment History

1997 ⇒ Present	Soil Science Consultant, Orange, NSW; Director of McKenzie Soil Management Pty. Ltd., trading as '***Soil Management Designs***' A.B.N. 37 076 676 616 **www.soilmgt.com.au**
1981 – 1996	Senior Soil Scientist, NSW Agriculture, Trangie & Rydalmere NSW

Examples of Consultancies Conducted by David McKenzie

Provided Resource Strategies Pty Ltd, Brisbane with soil surveys, agricultural resource assessments, rehabilitation ideas and offset-property management plans at proposed and existing mine sites in northern NSW managed by Barrick Gold, BHP Billiton, Whitehaven Coal, Peabody Energy and Yancoal. Similar services were supplied in conjunction with RW Corkery & Co (Bowdens Silver Project, Lue; McPhillamy Gold Project, Blayney; Jervois Nickel-Cobalt Project, Young; Platina Scandium Project, Tullamore).

Assessed soil constraints and 'biophysical strategic agricultural land' (BSAL) status for a proposed solar farm near Dunedoo (ib vogt GmbH).

Expert Witness in soil-related legal cases:

- Land & Environment Court NSW, 2013 (*represented Ashton Coal*);
- District Court of South Australia, 2008-09 (*represented Raschella Pty Ltd/SA Potato Co*);
- Federal Magistrates Court of Australia, 2008-09 *(represented TigerTurf Pty Ltd*);
- Federal Court of Australia, 2008-09 (*represented Commissioner of Taxation*);
- Land & Environment Court NSW, 2007 (*represented Hub Action Group, Molong*);
- Land Board hearing, 2002 (*represented RG&H Investments, Orange*);
- Land & Environment Court NSW, 2000 (*represented Clyde Agriculture, Bourke*).

Assisted NSW Trade & Investment with an assessment of agricultural land quality on floodplains affected by opal mining near Lightning Ridge NSW.

Federal government representative on two review panels evaluating soil-related Cooperative Research Centres (one existing, one proposed).

Adviser to TFS Corporation, Perth regarding soil survey and soil management issues in their existing 'Indian Sandalwood' plantations in the Ord Irrigation Area, northern WA, and in new development areas in NT (Katherine, Douglas Daly) and North Qld (Burdekin district).

Produced >100 soil survey & management reports for landholders associated with winegrape, wheat, citrus, olive, nut, vegetable, cotton and dryland pasture production in the Murray-Darling Basin. The production of 'key soil factor maps' – and accompanying 'variable rate soil amelioration maps' – for clients was a unique feature of these reports.

Conducted >65 soil management workshops in NSW, QLD and WA for Lachlan and Central West Catchment Management Authorities, WA No-Till Farmers Association, Cotton Research & Development Corporation, Twynam Agriculture, and AGnVET Services. Approximately 900 farmers and advisers were trained in soil assessment and management at these courses.

Principal Investigator on the AUSVEG / Land & Water Australia project entitled '*Ute Guide & Soil Health Interpretation Courses for Vegetable Growers'*.

Editor of '*SOILpak for Cotton Growers, Third Edition*' and '*SOILpak for Dryland Farmers on the Red Soil of Central Western NSW'* (co-productions with NSW Agriculture).

Prepared a 'plain-English' report for Dairy Australia about soil carbon sequestration under pasture in Australia. This information was presented by David at the IDF 'World Dairy Summit' Environment Conference, Auckland New Zealand in November 2010.

Carried out carbon sequestration studies under 'Oldman saltbush' in rangelands near Hay NSW for Deutsche Bank.

International experience includes:

- Vineyard soil assessment for 'Grupo Osborne' in Central Spain, 2000;
- Market development planning for a gypsum importer in Auckland, New Zealand, 1996;
- Dryland soil management inputs for a World Bank project in the Nusa Tenggara region of Indonesia, 1988-89.

Voluntary Contributions to the Soil Science Community

Soil physics theme co-leader, Soil Science Australia 'National Soil Conference', Canberra, Nov. 2018. One of three judges appointed to the Soil Science Australia CG Stephens award committee for annual determination of the best soil-related PhD thesis in Australia in 2015-17. Assisted with the inaugural Australian Soil Judging Competition in Hobart, December 2012, and was coach of the winning University of Tasmania team. Chairman of the Board, Certified Professional Soil Scientist (CPSS) accreditation scheme, 2009; Board member 2008 and 2010-11.

Assisted with soil-related components of 'Senate inquiry into agribusiness managed investment schemes', July 2009, Parliament of Australia.

Chairman of Working Group F (Visual soil examination and evaluation), International Soil and Tillage Research Organisation, 2000-09. Successful activities included a 'Visual soil structure assessment' methods comparison workshop near Peronne, France in May 2005.

Referee of papers for Geoderma, Soil Use & Management, Soil Research, Plant and Soil, Soil & Tillage Research.

Examples of Publications

McKenzie D 2016. '*SOILpak in 2016: What information is still relevant, what needs updating, what needs to go?'* Prepared for Cotton Research & Development Corporation, Narrabri.

McKenzie, DC, Pulido Moncada, MA, Ball, BC 2015, 'Reduction of yield gaps and improvement of ecological function through local-to-global applications of visual soil assessment' in *Visual Soil Evaluation: Realising Potential Crop Production with Minimum Environmental Impact*, eds. BC Ball, LJ Munkholm, CABI Publishing, Wallingford UK, pp. 31-48.

McKenzie, D 2015. '*Impact of opal mining on soils of the alluvial plains near Lightning Ridge, and possible procedures for minimising their degradation*.' Prepared for NSW Department of Industry – Division of Resources and Energy.

McKenzie, DC 2013, 'Visual soil examination techniques as part of a soil appraisal framework for farm evaluation in Australia', *Soil & Tillage Research,* vol. 127, pp. 26-33. http://www.sciencedirect.com/science/article/pii/S0167198712001080

McKenzie, D 2013, '*Peer review and assessment of the interim protocol for identifying and mapping biophysical strategic agricultural land*.' Report prepared for NSW Department of Trade & Investment.

McKenzie, D, Mason, W 2010, '*Soil carbon sequestration under pasture in Australia'*, Dairy Australia, Melbourne.

Cattle, S, Malone, B, McKenzie, D 2009, 'The effect of dust on soil variation in the Orange wine region', *The Australian & New Zealand Grapegrower & Winemaker,* vol. 550, pp. 22-24.

McKenzie, DC, Rasic, J, Hulme, PJ 2008, 'Intensive survey for agricultural management' in *Guidelines for surveying soil and land resources, second edition,* eds. NJ McKenzie, MJ Grundy, R Webster, AJ Ringrose-Voase, CSIRO Publishing, Collingwood, pp. 469-490.

McKenzie, D 2005, 'Vineyard variability – implications for soil surveys and vineyard design', *The Australian & New Zealand Grapegrower & Winemaker,* vol. 492, pp. 20-23.

McKenzie, DC 2005, 'Soil assessment for pasture production that considers both physical and chemical factors in the topsoil and subsoil' in *Proceedings of the 20th Annual Conference of the Grasslands Society of NSW*, pp. 26-28.

McKenzie, DC 2002, 'Amendments/ameliorants' in *Encyclopaedia of Soil Science,* ed R Lal, Marcel Dekker, New York, pp. 53–55.

McKenzie, DC, McBratney, AB 2001, 'Cotton root growth in a compacted Vertisol (Grey Vertosol). I Prediction using strength measuring devices and 'limiting water ranges'', *Australian Journal of Soil Research,* vol. 39, 1157–1168.

McKenzie, DC (ed.) 1998, *SOILpak for cotton growers, third edition,* NSW Agriculture, Orange.

McKenzie, DC, Abbott, TS, Chan, KY, Slavich, PG, Hall, DJM 1993, 'The nature, distribution and management of sodic soils in New South Wales', *Australian Journal of Soil Research,* vol. 31, pp. 839-68.

McKenzie, DC, Abbott, TS, Anthony, DTW, Hulme, PJ, MacLeod, DA, Higginson, FR 1990, 'Management of subsoil degradation in an Australian Vertisol used for irrigated cotton production', *Transactions of 14th Int. Congress of Soil Science, Kyoto, Japan,* VI, 176-181.