Hydrologic Soil Group Mapping, Tasmania

This document contains two sections, the first outlining the metadata and methodology in the creation of the layer, the second a discussion on the use of the layer between the author of the layer and Ted Rigby.

1. METADATA AND METHODOLOGY

Author: Darren Kidd
Position: Senior Land Resource Analyst, Natural Assets, Spatial Intelligence
Organisation: DPIPWE, Tasmania
Layer: Hydrologic Soil Groups of Tasmania (Unpublished)
Layer Format: (GeoTiff, Raster)
Resolution: 80m
Creation Date: March, 2019
Extent: Whole of Tasmania, **North:** -39.0, **West:** 143.5, **East:** 149.0, **South:** -44.0
Coordinate System: Map Grid Of Australia (GDA 1994), Zone 55

Methodology

The mapping outputs were based on the Port Stephens Hydrologic Soil Group Mapping (NSW OEH) report, using the USA National Engineering Standards (United States. Soil Conservation 1992). This mapping was polygon-based soil mapping using a Great Soil Group (GSG) Classification, where each soil GSG was assigned a hydrologic group. The GSG is an outdated classification system, and not readily available as a soil mapping layer in Tasmania.

The Port Stevens GSGs were assigned four major soil hydrologic groups; (Adapted from the Port Stephens Council Report, http://www.portstephens.nsw.gov.au/grow/land-environment-and-heritage/flooding/hydrologic-soil-mapping).

> **Group A** - Group A soils have high infiltration rates, even when thoroughly wetted consist primarily of deep well drained sands or gravel. These soils have a high rate of water transmission. For design purposes, it is assumed that the Antecedent Moisture Condition is "rather wet" (refer to Australian Rainfall and Runoff (ARR) 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 83.6 mm/hr, the Minimum (Final) Infiltration Rate is 25 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).
>
> **Group B** - Group B soils have moderate infiltration rates when thoroughly wetted and consisting primarily of deep coarse textures. These soils have a moderate rate of water transmissions. For design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 66.3 mm/hr, the Minimum (Final) Infiltration Rate is 13 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12)
>
> **Group C** - Group C soils have slow infiltration rates when thoroughly wetted and consisting of primarily of soils with a layer that impedes downward movement of water, or soils with a moderately find texture. These soils have a slow rate of transmission. For design purposes, it

is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 33.7 mm/hr, the Minimum (Final) Infiltration Rate is 6 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

Group D - Group D soils have very slow infiltration rates when thoroughly wetted and consisting primarily of clay soils with a high swelling potential, soils with a high water table, soils with a clay layer, and shallow soils over nearly impenetrable materials. These soils have a very slow rate of transmission. For stormwater design purposes, it is assumed that the Antecedent Moisture Condition is "Rather wet" (refer to ARR 2016, Table 5.3.11) and the Horton Maximum (Initial) Infiltration Rate is 33.7 mm/hr, the Minimum (Final) Infiltration Rate is 6 mm/hr and the Shape Factor/Decay Rate k is 2 /hour (refer ARR 2016, Table 5.3.12).

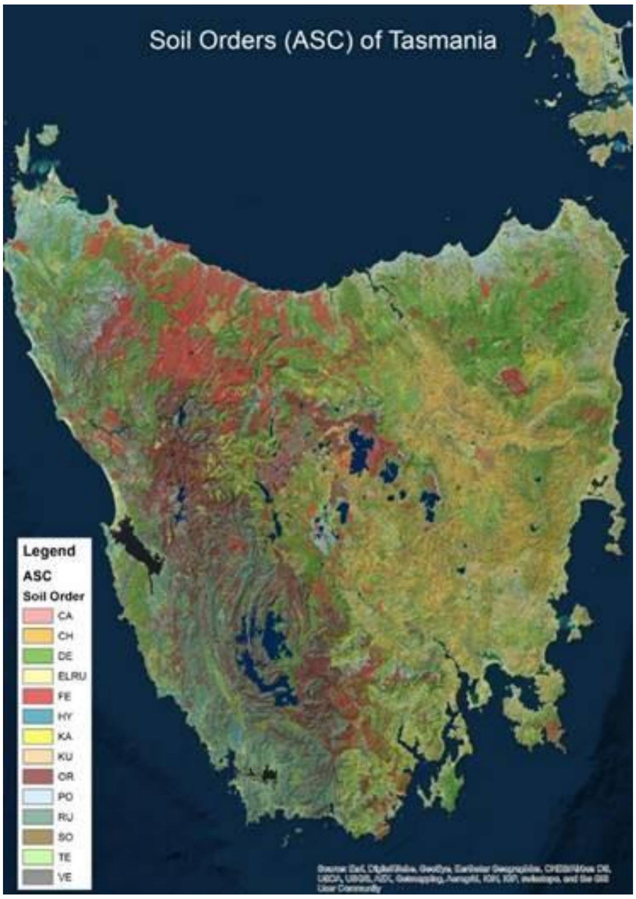
The hydrologic ratings applied to each soil group are listed in Table 1.

Table 1: Hydrologic Group Classes of Great Soil Group soil types

Great Soil Group (GSG)	Australian Soil Classification (ASC) at Order level
Acid Peats	D
Alluvial Soils - Light Sandy Textured (Sands to Sandy Loams)	A
Alluvial Soils - Medium Textured (Loams, Clay Loams)	B
Alpine Humus soils	D
Black Earths	D
Brown Earths	D
Brown Podzolic Soils	B
Calcareous Red Earths	C
Calcareous Sands	B
Chernozems	B
Chocolate Soils	B
Desert Loams	C
Earthy Sands	A
Euchrozems	B
Gleyed Podzolic Soils	D
Grey Brown and Red Calcareous Soils	B
Grey Brown Podzolic Soils	C
Grey, Brown and Red Clays	D
Grey, Brown and Red Clays – good surface condition	D
Humic Gleys	D
Humus Podzols	B
Kraznozems	A
Lateritic Podzolic Soils	C
Lithosols	B
Neutral to Alkaline Peats	D
Non Calcic Brown Soils	C
Peaty Podzols	D
Podzols	A
Prairie Soils	B
Red and Brown Hardpan Soils	C
Red Brown Earths	C
Red Earths - less fertile (granites and metasediment)	B
Red Earths - more fertile (volcanics and granodiorites)	B
Red Podzolic Soils - less fertile (granites and metasediment)	C
Red Podzolic Soils - more fertile (volcanics and granodiorites)	C
Rendzinas	B
Siliceous Sands	A
Solodic Soils	D
Solodized Solonetz	D
Solonchaks	D
Solonetz	D
Solonized Brown Soils	D
Soloths	D
Terra Rossa Soils	B
Weisenboden	D
Xanthozems	B
Yellow Earths	B
Yellow Podzolic Soils - less fertile (granites and metasediment)	C
Yellow Podzolic Soils - more fertile (volcanics and granodiorites)	C

Application of Hydrologic Groupings to Tasmanian soil Mapping

The best resolution and most up to date soil mapping that would serve this purpose was a map created by the Tasmanian Department of Primary Industries Parks Water & Environment (DPIPWE) Natural Assets Spatial Intelligence Section, based on recent Digital Soil Mapping (DSM) approaches (McBratney, Mendonça Santos et al. 2003). DSM is a form of predictive spatial modelling, where 3-Dimensional soil attributes are modelled using existing soil sites (6,500 DPIPWE sites), spatially intersected with a range of soil-forming factor covariate layers, such as satellite multi-spectral data, digital elevation models and terrain derivatives, existing soil mapping, geology, vegetation and land use. The process produces high resolution maps of soil properties for a range of standard depths, as outlined in Kidd et al (2015). The standard soil classification system now used in Australia is the Australian Soil Classification System (ASC) (Isbell 2002), and is therefore used where classified maps are required for operational purposes. An ASC map of Tasmania was developed in 2016, using the 80m resolution soil property maps described above, existing broad-scale ASC Dominant Soil Orders of Tasmania Mapping (Cotching, Lynch et al. 2009), terrain derivatives, intersected with 6,500 ASC classified soil sites. Key diagnostic soil properties included topsoil and subsoil pH, EC, Clay %, Sand %, Coarse Fragments, Organic Carbon, Drainage and Depth. A DSM approach using Decision Tree Classifications (Quinlan 2014) was used to develop an ASC map of Tasmania at 80m resolution, which formed the basis of the soil-losses mapping (Figure 1). The methodology is described in detail in Kidd et al (2018).



Using a random hold-back of 30% of database sites, this mapping validated at an accuracy of about 70%. It was then necessary to convert the ASC classes to approximate GSG classes, using the following criteria;

Order	Great Soil Group
CALCAROSOLS	Solonised brown soils, grey-brown and red calcareous soils.
CHROMOSOLS	Non-calcic brown soils, some red-brown earths and a range of podzolic soils
DERMOSOLS	Prairie soils, chocolate soils, some red and yellow podzolic soils
FERROSOLS	Krasnozems, euchrozems, chocolate soils
HYDROSOLS	Humic gleys, gleyed podzolic soils, solonchaks and some alluvial soils
KANDOSOLS	Red, yellow and grey earths, calcareous red earths
KUROSOLS	Many podzolic soils and soloths
ORGANOSOLS	Neutral to alkaline, and acid peats
PODOSOLS	Podzols, humus podzols, peaty podsols
RUDOSOLS	Lithosols, alluvial soils, calcareous and siliceous sands, some solonchaks
SODOSOLS	Solodized solonetz and solodic soils, some soloths and red-brown earths, desert loams
TENOSOLS	Lithosols, siliceous and earthly sands, alpine humus soils and some alluvial soils
VERTOSOLS	Black earths, grey, brown and red clays

Table 2. Approximate Conversions from ASC to GSG (http://www.clw.csiro.au/aclep/asc_re_on_line_V2/append5.htm).

From these new GSG groupings, the corresponding soil hydrologic groups, as specified in the Port Stephen's Report (Table 1), were applied to the ASC Soil Orders mapped at 80m resolution in Tasmania, to produce a map of approximate hydrologic soil groupings for Tasmania (Table 3, Figure 2).

ASC Order	Hydrologic Group Classes
Organosols	D
Tenosols	A
Calcerosols	B
Chromosols	C
Kurosols	D
Hydrosols	D
Ferrosols	A
Rudosols	B
Podosols	A
Sodosols	D
Vertosols	D
Kandosols	C
Dermosols	B
*Arenosols	A

Table 3. ASC Order – Hydrologic Soil Grouping

*Arenosols (deep sandy profiles, usually coastal sands and dunes in Tasmania) are a new ASC order which will be appearing in the next iteration of the ASC handbook, later in 2019.

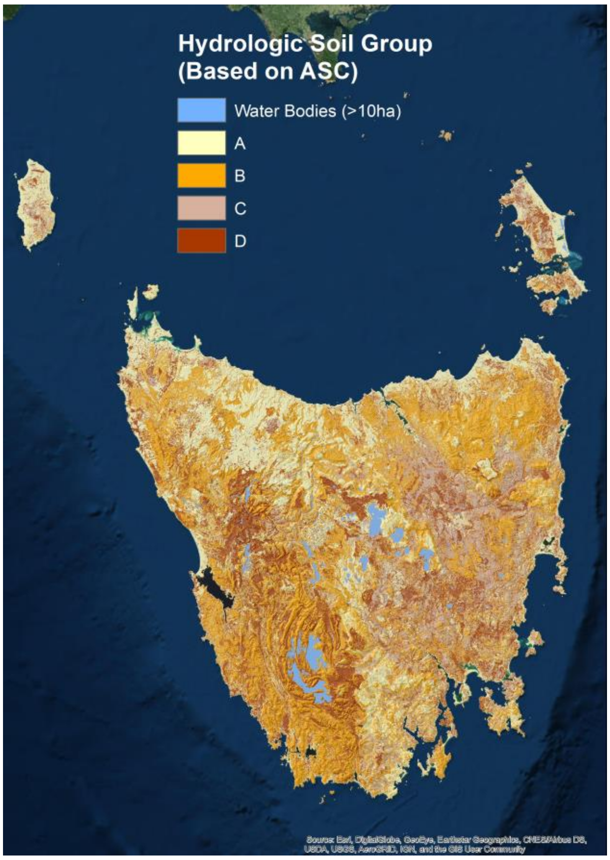


Figure 2. Hydrologic Soil Groups of Tasmania

References

Cotching, W. E., S. Lynch and D. B. Kidd (2009). "Dominant soil orders in Tasmania: distribution and selected properties." Soil Research **47**(5): 537-548.

Isbell, R. (2002). The Australian Soil Classification - Revised Edition. Australian Soil and Land Survey Handbooks Series 4. Australia, CSIRO PUBLISHING.

Kidd, D., D. Field, A. McBratney and M. Webb (2018). "A preliminary spatial quantification of the soil security dimensions for Tasmania." Geoderma **322**: 184-200.

Kidd, D., M. Webb, B. Malone, B. Minasny and A. McBratney (2015). "Eighty-metre resolution 3D soil-attribute maps for Tasmania, Australia." Soil Research **53**(8): 932-955.

McBratney, A. B., M. L. Mendonça Santos and B. Minasny (2003). "On digital soil mapping." Geoderma **117**(1-2): 3-52.

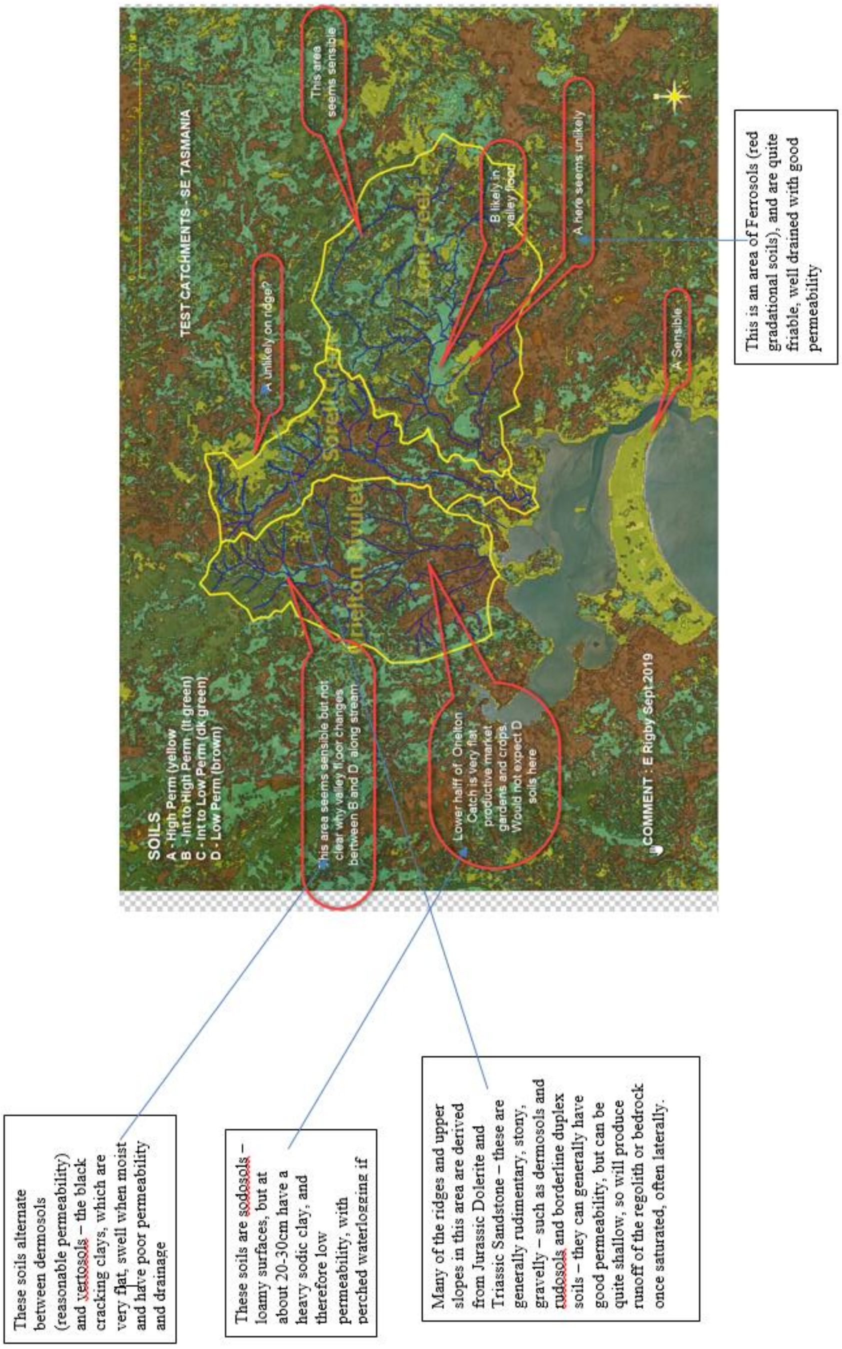
Quinlan, J. R. (2014). C4. 5: programs for machine learning, Elsevier.

United States. Soil Conservation, S. (1992). National engineering handbook. Part 651, Agricultural waste management field manual, [Washington, D.C.] (P.O. Box 2890, Washington 20013) : U.S. Dept. of Agriculture, Soil Conservation Service, [1992].

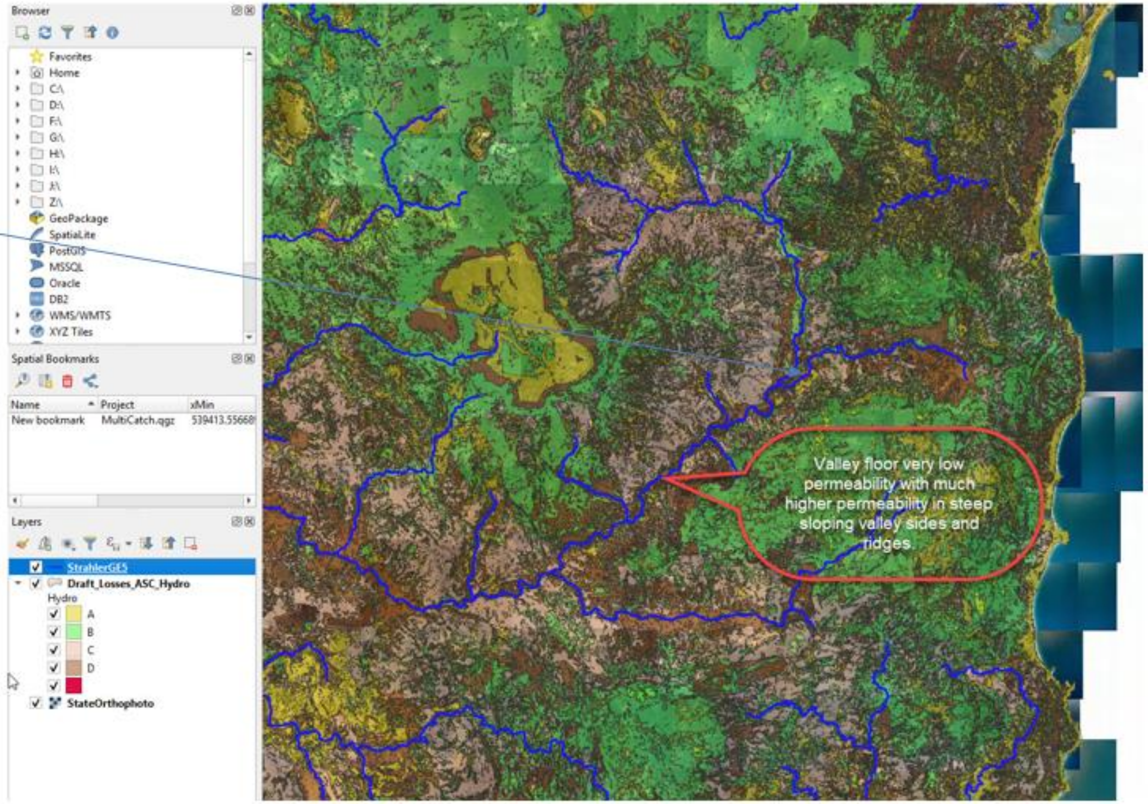
2. DISCUSSION ON THE USE OF THE HYDROLOGICAL SOIL MAPPING:

This section is an extract of a discussion between the author of the soil mapping (Darren Kidd) and Ted Rigby. It is provided to support the interpretation and use of the mapping. The discussion centres around two test areas (shown below) with red text boxes being questions/ statements from Ted, and the white text boxes are the responses from Darren. The mapping should be read in the context of the emails to follow the test areas.

Coal river test area



Fingal Valley test area



Many of the steep sloping valleys sides are derived from Jurassic Dolerite, and key out as dermosols, which have reasonably good drainage and permeability, while many of the valley floor systems through the Fingal Valley and Northern Midlands in Tasmania consist of a series of flood plain terraces – the lowest is usually the black cracking clay vertosols, with other terraces shallow duplex soils which are sodosols and hydrosols – these have heavy clay sodic subsoils to about 20 to 30 cm from the surface, overlayed by loams – so the topsoil is permeable, while the subsoils are very low permeability, so perched water and flooding is common once the topsoil becomes saturated.

From: Ted
Sent: Friday, 20 September 2019 10:54 AM
To: 'Kidd, Darren (DPIPWE)' <Darren.Kidd@dpipwe.tas.gov.au>
Cc: 'Mazengarb, Colin' <Colin.Mazengarb@stategrowth.tas.gov.au>; Luke (SES) <Luke.Roberts@ses.tas.gov.au>
Subject: RE: Draft Hydrologic Soils Map Tasmania

Hi Darren

Thank you for your thoughts on the logic behind the present hydrologic soils mapping.
I am beginning to think that my concerns are as you have suggested associated with how the mapping deals with the three parameter (at least) concept of permeability.
As indicated in the NSW mapping, permeability is described in Hortonian terms by initial infiltration rate parameter (F0), a terminal rate parameter (Finfinity) and a decay time parameter.
Most other hydrological loss models (like Green-Ampt, SCS_CN, Boughton) use something similar but frequently also refer to one or more layers of soil storage potential (depth).
The present mapping appears to mostly reflect the initial infiltration rate parameter without consideration of the decay time parameter (e^{-kt}) or the terminal infiltration rate.
I don't think a simple email or two will easily resolve this question but at an appropriate time I think it would be worth a round table discussion (luke - with the adopted Consultant?) about how best to reflect potential hydrologic losses in this mapping.
Darren if you have any questions in the interim, I am happy to continue this discussion, as it impacts on a modelling question I am currently researching.

Yours
Ted

From: Kidd, Darren (DPIPWE) <Darren.Kidd@dpipwe.tas.gov.au>
Sent: Friday, 20 September 2019 9:53 AM
To: Ted <ted.rigby@rienco.com.au>
Cc: Roberts, Luke (SES) <Luke.Roberts@ses.tas.gov.au>; Mazengarb, Colin (StateGrowth) <Colin.Mazengarb@stategrowth.tas.gov.au>
Subject: RE: Draft Hydrologic Soils Map Tasmania

Hi Ted

I've had a look at your test areas, and attached a document with some additional comments.

The valley floor systems do have significant areas of black cracking clays, which are poorly drained and low permeability – these are usually the lowest level river flats. Above these are a series of terrace systems, which are often classed as sodosols – so they have loam surfaces to about 20 to 30cm, over a heavy clay subsoil with low permeability and poor drainage. Many of the valley slopes do have better permeability, derived from Jurassic Dolerite and Triassic Sandstone – these are usually podzolic in the old system, or dermosols and chromosols in the new classification system – so do have better permeability. Many of the ridge tops are rudimentary, colluvial stony/ gravelly soils, which will have high permeability – but these are usually shallow, so will run-off once saturated (either overland or laterally).

So if this doesn't agree with your expectations, it could be due to the terminology - our definitions of permeability mightn't exactly align? There is also the fact that the NSW hydrologic groups are derived from the old Great Soil Group classification system, which we don't use or map anymore, so have had to be converted to the Australian Soil Classification system (as per the method document I circulated). These new soil orders are very broad groupings, so some level of detail might be lost here. For example, some podosols (Table 3 in the methods document) can be both permeable (aeric podosols) and impermeable (aquic podosols) due to an impeding layer at depth, however, this would require some new modelling to the sub-order level to differentiate, which we don't yet have.

There is also the possibility that the Tasmanian soil catenas are quite different to NSW – our alluvial soils in the areas you highlighted are generally low in permeability in the low rainfall areas, with sodic subsoils – so the surfaces can be quite permeable, but the subsoils are not, meaning whole of profile permeability is classed as low (high initial permeability, low delayed permeability).

Hope this helps clarify a few things, but we have some other more detailed products such as 30m resolution soil permeability mapping that might work better. (The NSW people I contacted regarding this mapping said their system wasn't ideal, and they'd be interested to see whether I could improve on things).

Cheers
Darren

From: Ted <ted.rigby@rienco.com.au>
Sent: Thursday, 19 September 2019 12:25 PM
To: Kidd, Darren (DPIPWE) <Darren.Kidd@dpipwe.tas.gov.au>
Cc: Roberts, Luke (SES) <Luke.Roberts@ses.tas.gov.au>; Mazengarb, Colin (StateGrowth) <Colin.Mazengarb@stategrowth.tas.gov.au>
Subject: RE: Draft Hydrologic Soils Map Tasmania

Hi Darren

Thanks for taking the time to consider my comments.
I can imagine locations where valley slopes and ridges might involve deep permeable soils (high initial permeability and slow delay in permeability) but would expect these to be reasonably rare.
Likewise while valley floors could certainly have shallow low permeability deposits (like the black soils) I would expect these to be also rare rather than common.
I attach a shot of the Fingal Valley where the similar trend of deep highly permeable soils exist on the valley slopes and ridges with shallow very low permeability soils in the alluvial valley floors. I accept these conditions are certainly possible but based on my (largely NSW based) experience are not what I expected.

Yours
Ted

From: Kidd, Darren (DPIPWE) <Darren.Kidd@dpipwe.tas.gov.au>
Sent: Thursday, 19 September 2019 10:50 AM

To: Roberts, Luke (SES) <Luke.Roberts@ses.tas.gov.au>; Ted <ted.rigby@rienco.com.au>
Subject: RE: Draft Hydrologic Soils Map Tasmania

HI Luke and Ted

Sorry for the slow response – just got back from Adelaide - I'll have a quick look this afternoon.

Mightn't be too much to worry about, there are some rudimentary soils on upper slopes/ ridges that do have high permeability (many rocks and gravels), also many of our alluvial soils do have low permeability (black-cracking clays, heavy duplex clay subsoils), but I'll have a closer look at Ted's map comments to see if this is the case.....

Cheers
Darren

From: Roberts, Luke (SES) <Luke.Roberts@ses.tas.gov.au>
Sent: Tuesday, 17 September 2019 6:38 PM
To: Kidd, Darren (DPIPWE) <Darren.Kidd@dpipwe.tas.gov.au>; Ted <ted.rigby@rienco.com.au>
Cc: Mazengarb, Colin (StateGrowth) <Colin.Mazengarb@stategrowth.tas.gov.au>
Subject: FW: Draft Hydrologic Soils Map Tasmania

Hi Ted
I had planned to leave the QA on this until the lead consultant was engaged, in the meantime could you talk to Darren re the classifications and you expectations.

Cheers

Luke

Luke Roberts
Project Manager, Flood Policy Unit

State Emergency Service, Department of Police, Fire and Emergency Management
Cnr Argyle and Melville Streets Hobart
GPO Box 1290, Hobart TAS 7001
m: 0428 863 158
e: Luke.roberts@ses.tas.gov.au I w: www.ses.tas.gov.au

Professionalism. Respect. Commitment. Integrity.

From: Ted [mailto:ted.rigby@rienco.com.au]
Sent: Tuesday, September 17, 2019 11:22 AM
To: Roberts, Luke (SES) <Luke.Roberts@ses.tas.gov.au>; Mazengarb, Colin (StateGrowth) <Colin.Mazengarb@stategrowth.tas.gov.au>
Subject: Draft Hydrologic Soils Map Tasmania

Hi Luke/Colin

I have been comparing my own assessment of hydrologic soil type in three catchments I am using as a test bed for ARR testing with the draft hydrologic soils type map and have difficulty understanding the categorization in some areas. I don't understand the categorisation methodology adopted, but the high permeability areas on ridgelines and low permeability areas in flat highly cultivated flood plain areas don't seem likely. I appreciate that there is little time to look into the reasons behind these assignments before tendering but it would I think be useful to ask for comment on my comment (attached) while the tenders are processed. As a general question was any sanity testing done on the present categorization – I do recollect that it was all a bit rushed and can imagine time for testing would have been minimal.

Yours
Ted

Ps I have shapefiles of all layers if that helps.