



DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Soil and land resource mapping for the Western Sydney Aerotropolis area

Derived from *Soil and Land Resources of the Hawkesbury-Nepean Catchment* (2008)



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Cover photo: Rolling low hills and hills typical of the Luddenham soil landscape, Western Sydney. Casey Murphy/DECC

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Environment, Energy and Science
Department of Planning, Industry and Environment
Locked Bag 5022, Parramatta NSW 2124
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment, Energy and Science enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
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1. Introduction

This report was prepared to support planning processes for Stage 1 of the Western Sydney Aerotropolis. The information provided has been extracted from the Soil and Land Resources of the Hawkesbury-Nepean Catchment dataset (DECC 2008), which can be accessed through the [eSPADE spatial viewer](#) and downloaded from the [Sharing and Enabling Environmental Data \(SEED\) portal](#).

The report identifies soil and landscape constraints and qualities present in the *Soil and Land Resources of the Hawkesbury-Nepean Catchment* mapping that occur in the Western Sydney Aerotropolis area, and discusses differences between this later soil landscape mapping and the earlier published *Soil Landscapes of the Penrith 1:100,000 sheet* product, produced in 1990 (Bannerman & Hazelton 1990).

Given the nature of the development proposed for the Western Sydney Aerotropolis study area, the report focuses on constraints and qualities most relevant to the management of urban environments rather than requirements for extensive agriculture.

No reassessment of the linework or review of the existing soil and landscape limitations have been carried out in preparing this report.

2. Background

2.1 Soil landscape mapping

Soil landscapes are areas of land that ‘have recognisable and specifiable topographies and soils, that are capable of presentation on maps, and can be described by concise statements’ (Northcote 1978).

Landscapes can be used to distinguish mappable areas of soils because similar causal factors are involved in the formation of both landscapes and soils. Similarly, constraints to rural and urban development of land are related to both landscape and soil limitations. The soil landscape concept permits the integration of both soil and landform constraints into a single mapping unit.

2.2 Soil landscape products

The NSW Soil Landscape Mapping Program ran from 1998 to 2005 and produced hard-copy maps and reports based on AUSLIG¹ topographic map sheet areas. The mapping was carried out at two scales:

- 1:250,000 scale for broadacre agriculture, mainly in the wheat–sheep belt of Central NSW, and
- 1:100,000 scale for areas under intense land use pressure or change, such as urban/peri-urban and coastal areas and regions of intensive agriculture.

The *Soil Landscape Series* was succeeded by the *Soil and Land Resources Series*, which integrates existing and new mapping into seamless areas and is based on large catchment areas. This mapping also streamlines the information it provides, focusing on characteristics and functionality of whole soil profiles rather than individual soil layers (known as ‘soil materials’).

¹ former Australian Surveying and Land Information Group

3. Soil landscape coverage of the Western Sydney Aerotropolis area

3.1 Soil and Land Resources of the Hawkesbury-Nepean Catchment

In recognition of rapidly changing and increasing land use pressures in the greater Sydney area, the then Hawkesbury-Nepean Catchment Management Authority (CMA) engaged the then Department of Environment, Climate Change and Water (DECCW) in 2005 to provide full seamless coverage of soil landscape mapping over the catchment at 1:100,000 scale. The intent was to better understand land capability for both rural and urban land uses and to identify soil and landscape constraints, thereby supporting more sustainable catchment and land use management decision-making.

While the soil and land resource mapping provided an assessment on salinity in general, a more detailed investigation called *Western Sydney Hydrogeological Landscapes 2011 (First Edition)* (DECCW 2011) was later published to better understand how salinity manifests across the landscape and how its effects may be better managed.

3.2 Soil Landscapes of the Penrith 1:100,000 sheet

This earlier soil landscape survey was published by the then NSW Soil Conservation Service in 1990. It was the second product produced in the *Soil Landscape Series* after the survey of the Sydney map sheet. Based on the CMA 1:100,000 topographic map series, these surveys were undertaken in response to the many enquiries from land planning authorities and the general public regarding the nature and limitations of soils in Sydney and surrounding areas.

The report was later republished in 2011 as an interactive CD-ROM (Bannerman & Hazelton 2011) after stocks of the original books were exhausted. However, the content remained unchanged, and thus the observations about land use and the levels and extent of urban development and landscape disturbance are those made at the time the original report was compiled, in the late 1980s.

Though information from the *Soil and Land Resources of the Hawkesbury-Nepean Catchment* product was not included in the republished work, soil profile descriptions from the Hawkesbury-Nepean project were supplied as part of the interactive package to support the Penrith soil landscape mapping.

3.3 Limitations of existing information

The scale of mapping for the *Soil and Land Resources of the Hawkesbury Nepean Catchment* is 1:100,000. Like all *Soil Landscape Series* and *Soil and Land Resource Series* mapping in eastern New South Wales, this mapping is intended for planning and decision-making at a regional or catchment scale.

The soil landscape mapping produced by the *Soil and Land Resources of the Hawkesbury-Nepean Catchment* and the *Soil Landscapes of the Penrith 1:100,000 sheet* lacks the positional accuracy required for land use planning at a precinct or property scale. The required soil sampling density for a local scale product is also insufficient for fine scale use. Using it for these purposes without more detailed investigation and refinement at a local scale may lead to negative outcomes for infrastructure, development and environment if soil and land constraints are not properly identified or their impacts insufficiently managed. Additionally, some of the datasets used to define the soil landscape boundaries, such as geology and topography, are now out-of-date.

3.4 Potential for improvement

The existing soil landscape mapping could be readily applied at a finer scale by interpreting soil and landscape information at a facet (sub-landscape) level. This would be carried out in conjunction with further investigations to better target decision-making and management actions to the correct landscape components.

Any future revisions to the soil landscape mapping for this area would also incorporate the best available geological and digital elevation data, which would result in significant improvement to the boundaries, distribution and descriptions of soil landscapes.

4. Soils and landscapes of the Western Sydney Aerotropolis area

4.1 Soil landscape information

Six soil landscapes are mapped within the Western Sydney Aerotropolis area:

- Blacktown (**bty**)
- Luddenham (**luz**)
- Rickabys Creek (**rcz**)
- Picton variant a (**pnza**)
- South Creek (**scy**)
- Second Ponds Creek (**spz**).

The distribution of these soil landscapes is shown in **Figure 1** (below), whilst links to descriptions of the soil landscapes are provided in **Appendix A**. Key limitations are summarised in **Table 1** (below).

4.2 Using soil landscape information to manage urban environments

The mapping provided by the *Soil and Land Resources of the Hawkesbury-Nepean catchment* was a significant improvement over the earlier *Soil Landscapes of the Penrith 1:100,000 sheet* linework, both in accuracy and detail, as illustrated in **Figure 1**. This translates into greater confidence in the information, especially around the boundaries between soil landscapes.

The Hawkesbury-Nepean mapping also includes the mapping and description of an additional soil landscape, Second Ponds Creek (**spz**). This map unit is classified as having ‘transferral’ geomorphic processes (see **Section 4.3.3** below) and consists of footslopes and drainage plains. These features are very important to identify and manage in an urban environment: they receive high run-on, discharge groundwater and present significant hazards both in terms of dryland salinity and sodic soils, which present significant erosion, foundation and infrastructure risks.

The Second Ponds Creek (**spz**) soil landscape is shown in **orange** in **Figure 1**.

Because soil landscape boundaries and facets are based on geology, soils and landforms, they allow the associated soil and landscape constraints to be mapped and quantified.

Table 1 provides a summary of the key soil and landscape limitations and land capability classifications applicable to urban development, whilst **Section 4.3** describes these characteristics and limitations.

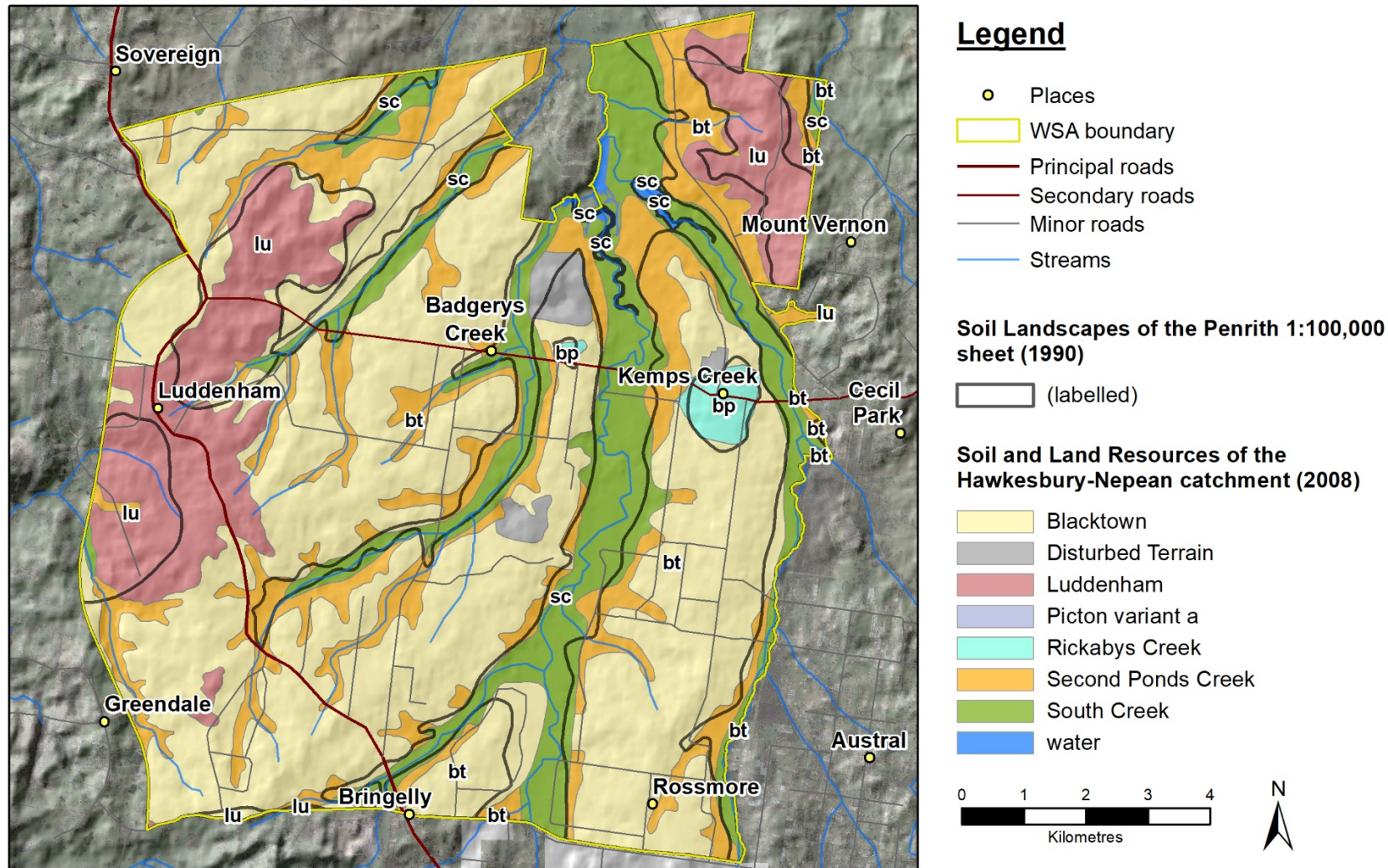


Figure 1 Soil landscape (1990) and soil and land resource mapping (2008) covering the Western Sydney Aerotropolis area
Department of Finance, Services and Innovation (DFSI)

Table 1 Summary of soil and land constraints for soil landscapes in the Western Sydney Aerotropolis area

Soil landscape	Geomorphic process group	Soil regolith stability	Flood hazard	Foundation hazard	Gully erosion risk	High run-on	Mass movement hazard	Permanent water-logging	Poor drainage	Seasonal water-logging	Shallow soils	Subsoil sodicity	Urban capability (A–E)
Blacktown (bty)	Residual (erosional)	R3	–	L	L	–	–	–	L	L	–	L	B (C)
Luddenham (luz)	Erosional	R3	–	L	L	–	L	–	L	–	L	L	B (C)
Picton variant a (pnza)	Colluvial	R3	–	W	L	L	W	–	L	–	L	L	D
Rickabys Creek (rcz)	Stagnant alluvial	R3	L	W	–	L	L	L	L	L	–	L	B (C)
South Creek (scy)	Alluvial	R4	W	L	L	W	–	L	W	L	–	W	D (E)
Second Ponds Creek (spz)	Transferral	R4	L	W	W	W	–	L	W	W	–	W	D

W = widespread occurrences, L = localised occurrences, – = not observed

4.3 Characteristics and limitations

The limitations and classifications summarised in **Table 1** include the following.

4.3.1 Flood hazard

Areas subject to periodic flooding by stormwater runoff and overland flow by rivers and streams. These areas should be retained as drainage reserves.

4.3.2 Foundation hazard

The susceptibility of a parcel of land to prevailing soil and landscape limitations that will affect the foundation stability of roads, buildings and related infrastructure. It is primarily determined by soil movement, which in turn is related to the soil's physical properties, soil moisture regime and weight loadings. Soil chemical properties such as extreme acidity and salinity can also affect foundations through corrosion of concrete and services.

Inappropriately designed buildings, structures and services built on or in land with high foundation hazard may experience cracks and deformations, whilst in some areas whole houses have been demolished through mass movement. These conditions are expensive to overcome but can often be avoided through appropriate planning and design. When moderate to high foundation hazards occur, you should seek advice from a professional geotechnical engineer. Further investigation to identify and locate the whereabouts of these significant hazards to foundation stability is required.

In this context, foundation hazard refers to foundations placed on or within *in situ* soil materials. It does not refer to structures placed on fill or into bedrock, or for large structures that require detailed site investigation.

4.3.3 Geomorphic process group

Geomorphic process groups describe either: the current or recent land-forming processes; the conditions that influence soil parent material or soil type; or environments where soil formation is influenced by current and recent processes. Each group is determined by interpretation of landform, topographic, soil material and soil parent material features.

Where more than one landscape grouping is significant, compound geomorphic process groups have been used. The first group indicates the process considered most influential in affecting prevailing soil and landscape qualities and limitations.

Those geomorphic process groups occurring in the Western Sydney Aerotropolis area are described below:

Alluvial. Formed by deposition along rivers and streams. Soil parent material is usually deep, sorted and often stratified or previously stratified alluvium. Alluvial soil landscapes include current floodplains and alluvial deposits. Typical landform elements include those found on meander plains including bars, backplains, scrolls, scroll plains, flood-outs, oxbows, levees, lower terraces, prior and current stream channels.

Colluvial. Affected by mass movement. Soil parent material consists mostly of colluvial mass movement debris, including scree and talus along with other landslide, mudflow and creep deposits. Colluvial soil landscapes usually include alcoves, cliffs, cliff-footslopes, scarps, landslides, talus, some moderately inclined to precipitous hillslopes and areas with commonplace evidence of mass movement. Slope wash processes are considered less dominant.

Disturbed. Dominated by ground surfaces arising from human activity. Soil parent materials have been moved, accumulated, removed or replaced (with soil or other items). Landform elements include fill-tops, embankments, cut faces, cut-over surfaces, dams, mounds and pits.

Erosional. Formed primarily by the erosive action of running water. Streams are well defined and capable of transporting their sediment load. Soil depth is usually shallow (with occasional deep patches) and mode of origin is variable and complex. Soils may be either absent, derived from water-washed parent materials or derived from *in situ* weathered bedrock. In many instances, subsoils have formed *in situ* while topsoils have formed from materials washed from further upslope. Erosional soil landscapes usually consist of steep to undulating hillslopes and may include tors, benches and areas of rock outcrop. Evidence of mass movement is rare.

Residual. Dominated by sites where deep soils have formed from *in situ* weathering of parent materials. Residual soil landscapes typically have level to undulating elevated landforms. Landform elements include some summit surfaces, plateaux, terrace plains, peneplains and old ground surfaces. Stream channels are usually poorly defined.

Stagnant alluvial. Alluvial plains where erosion and aggregation by channel and over-bank flow is barely active because of reduced water flow and stream migration. Typical landform elements are usually subdued and often inactive. They include plains, some higher terraces, prior streams, backplains and swamps.

Transferral. Deep deposits of mostly eroded parent materials washed from areas upslope. Stream channels are often discontinuous, and slopes are generally concave. Transferral landscapes include footslopes, valley flats, fans and piedmonts.

4.3.4 Gully erosion risk

Areas with erodible and/or sodic or dispersible soils, high run-on, highly intensive rainfall, and locations where groundcover or surface soils have been disturbed or removed are vulnerable to tunnelling and gully erosion.

4.3.5 High run-on

High run-on is described when concentrated large volumes of overland flow move onto an area. It often occurs in an urban context as a contributing factor to increased erosion hazard. Areas with high run-on are often prone to temporary localised flooding.

4.3.6 Mass movement hazard

Mass movement is a general term for a number of forms of slope failure. It includes rock falls and earth slumps, slips and flows on steep, and often wet, slopes. It may lead to severe damage to buildings, roads and services, or may result in recurrent problems such as shifting foundations.

4.3.7 Permanent waterlogging

Waterlogged soils have permanent water tables at or near the surface. They may also be non-cohesive, organic, saline, acidic, infertile and have low bearing strength. They are unsuitable for septic effluent disposal.

4.3.8 Poor drainage

Drainage is affected by soil permeability, hydraulic gradient and the permeability of materials below the soil profile. Drainage is assessed as per NCST (2009). The categories are:

- very poorly drained
- poorly drained
- imperfectly drained
- moderately well-drained
- well-drained
- rapidly drained.

Poor drainage limitation indicates very poorly or poorly drained soils. In very poorly drained or poorly drained soils, water moves from the soil very slowly. These soils are likely to pond water for long periods. They have generally clayey textures and are mottled and greyish or gleyed in colour.

4.3.9 Seasonal waterlogging

Seasonally high water tables result in similar problems to permanently waterlogged soils. Soils in landscapes with this limitation can become extremely dry for long periods.

4.3.10 Shallow soils

Shallow soils are defined as those being less than 50 centimetres deep. Shallow soils restrict plant growth and increase the difficulty and expense of installing underground services. Soil depth is measured from the current soil surface to weathered parent material, or bedrock, or the top of any hard pan layers that would not be considered as soil for plant growth or construction.

4.3.11 Soil regolith stability

Soil regolith stability is an expression of combined soil and substrate erodibility and sediment delivery potential. The classification was developed as one of the input variables to the soil erosion and water pollution hazard assessment for the NSW Environment Protection Authority (EPA) 1998–99 Pollution Control Licence for State Forests' logging operations.

Soil regolith stability is also a useful classification to apply in urban and rural environments, to help understand and manage erosion and sediment control of exposed soils. Sub-dominant classes if present, are provided in brackets after the dominant class.

- R1 High coherence soils with low sediment delivery potential.** Stable soils with no appreciable erosion. Generally well-drained, permeable soils. Earth batters are stable. Little or no general evidence of coarse or fine sediment movement.
- R2 Low coherence soils (when wet) with low sediment delivery potential.** Sandy soils that, when exposed, commonly exhibit sheet wash and evidence of coarse sediment movement, such as sediment fans at drain outlets and in gutters. Little sediment transport into drainage network.
- R3 High coherence soils with high sediment delivery potential.** Clayey and silty soils that are liable to sheet erosion. Typically slowly permeable and drainage generally impeded. Earth batters and exposed surfaces are subject to minor to moderately extensive rill erosion and minor slumping. Minor gully erosion may develop in drainage lines, and incision may occur along road drains. Localised films of fine sediment at drain outlets and in drainage lines.
- R4 Low coherence soils (when wet) with very high fine sediment delivery potential.** Unstable, dispersible soils that are prone to severe sheet and rill erosion and gully erosion. Rilling and/or slumping is common on batters and gully erosion is common in drainage lines and along road drains. Snig tracks display frequent rill erosion. Drainage lines show extensive fine sediment films.

4.3.12 Subsoil sodicity

Sodic soils have an exchangeable sodium percentage (ESP) greater than 6%. They have low stability when wet, and they set hard when dry, reducing permeability and available water capacity. When exposed at the soil surface, they form surface crusts that restrict plant establishment and growth and thereby inhibit revegetation.

In the field, diagnostically, they typically exhibit high bulk density and strength, a strong coarse blocky or columnar structure, and are both highly erodible and dispersible. However, their degree of dispersion in the field depends on a number of other factors such as salinity, pH, clay content, mineralogy and organic matter. Not all sodic soils are dispersible, nor are all dispersible soils sodic.

Only subsoils (B soil horizon) have been assessed in this analysis.

4.3.13 Urban capability

Urban capability is the ability of a parcel of land to support a particular intensity of urban development without serious erosion and sedimentation occurring during construction, as well as possible instability and drainage problems in the long term. (Houghton & Charman 1986). Urban capability is ranked according to the severity of the limitations that are likely to affect urban land uses (Hicks & Hird 2007). Five classes (A – E) are described below.

- A** Areas with little or no limitations to urban development.
- B** Areas with minor to moderate physical limitations to development. These limitations may influence design and impose certain management requirements on developments to ensure a stable land surface is maintained both during and after development.
- C** Areas with moderate physical limitations to urban development. These limitations can be overcome by careful design and by adoption of site management techniques to ensure the maintenance of a stable land surface.
- D** Areas with high to severe physical limitations to urban development which will be difficult to overcome, requiring detailed site investigation and engineering design.
- E** Areas where no form of urban development is recommended because of very severe limitations to such development that would be very difficult and costly to overcome.

Capability statements in this report are intended for regional planning purposes only. Although the information given may be of sufficient accuracy and detail for the planning of small scale, low value, low impact developments, detailed planning at the local level and more intensive capability assessments dependent on additional information are often necessary. Additional site-specific factors such as slope angle, position on slope, terrain element and specific soil conditions need to be examined and, where necessary, geotechnical engineering reports obtained.

5. References

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Appendix A: Soil landscape descriptions

Soil landscape and soil and land resource distribution and descriptions can be accessed through the [eSPADE spatial viewer](#).

Individual eSPADE descriptions for each soil landscape in the Aerotropolis area can be reached through the following links:

- [Blacktown \(PDF 322KB\)](#) (bty)
- [Luddenham \(PDF 113KB\)](#) (luz)
- [Picton variant a \(PDF 130KB\)](#) (pnza)
- [Rickabys Creek \(PDF 227KB\)](#) (rcz)
- [Second Ponds Creek \(PDF 101KB\)](#) (spz)
- [South Creek \(PDF 95KB\)](#) (scy).