8 Groundwater Flow Systems of the North East Region

As discussed earlier groundwater flow systems are entities defined on the basis of geological and geomorphic attributes. These geological and geomorphic attributes that combine to form a GFS give an insight in to those areas within the landscape that are more likely to contribute to salinity or be affected by salinity.

The taxonomy given to each GFS conveys a sense of the scale of flow, and a sense of the nature of aquifers and rock types. The scale of flow is represented by terms that include ‘local’, ‘intermediate’ and ‘regional’. These are broadly defined as follows:

Local GFS - these generally operate in local sub-catchments over distances seldom greater than five kilometres.

Intermediate GFS – these include larger (sub-regional) functioning over distances typically ranging from ten to fifty kilometres.

Regional GFS – comprise large groundwater systems functioning over distances in excess of fifty kilometres.

8.1 Overview of the North East

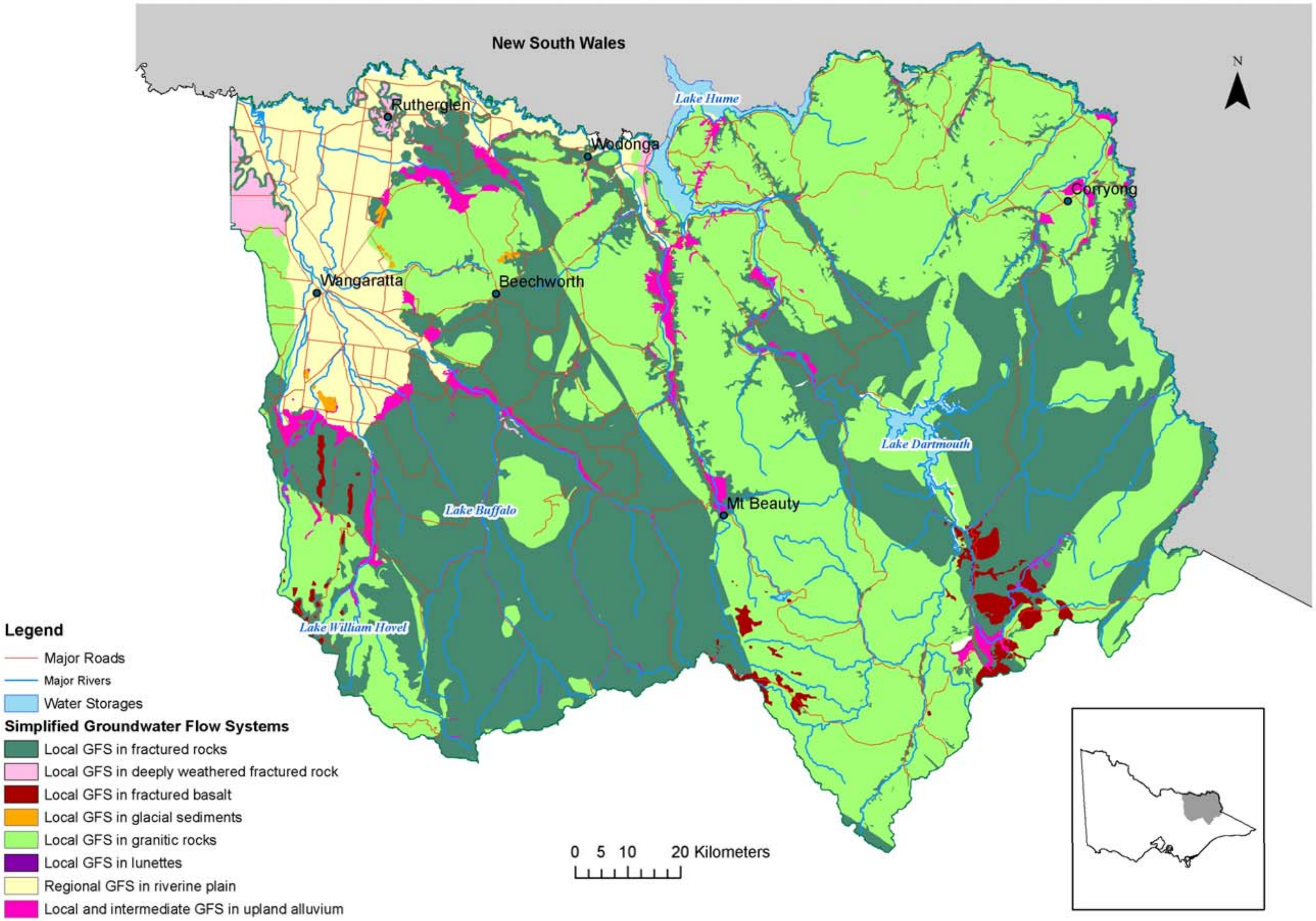
Some sixteen GFS have been identified within the North East region. These, however, exist as subsets of some four main systems that include:

- Large regional and sub-regional GFS comprising alluvial aquifers in the floodplains of major river systems in both Riverine Plains and the upland alluvium.
- Local and intermediate (sub-regional) scale groundwater systems comprising fractured rock aquifers.
- Local GFS perched in granites and granite-like rocks.
- Local perched GFS in glacial sediments.

The sixteen GFS that have been identified within the North East region through the MDBC Tools Project, have been simplified to eight in the development of this plan (Figure 31). This occurred as part of a review process, with GFS with similar characteristics being grouped together.

Within this plan GFS are used as a decision making tool for the placement of on-ground works in the landscape. By understanding the GFS it is possible to target works where they are considered to be the most effective to reduce and prevent salinity (or the GFS considered to be most responsive to the change in land management). A more comprehensive consideration of GFS together with consideration of appropriate and specific salinity management strategies is presented in below.

Figure 31 – Simplified Groundwater Flow Systems within the North East.



Note that the local GFS in fractured basalt, lunettes and upland alluvium are referred to in the map but limited detailed in the descriptions below. This is due to the small extent and suggested minor influence on salinity processes that they have in the region. The diagrams presented in this section refer specifically to the processes occurring within priority areas and are not descriptive of all the processes for all areas mentioned below.

8.2 Local GFS in granitic rocks

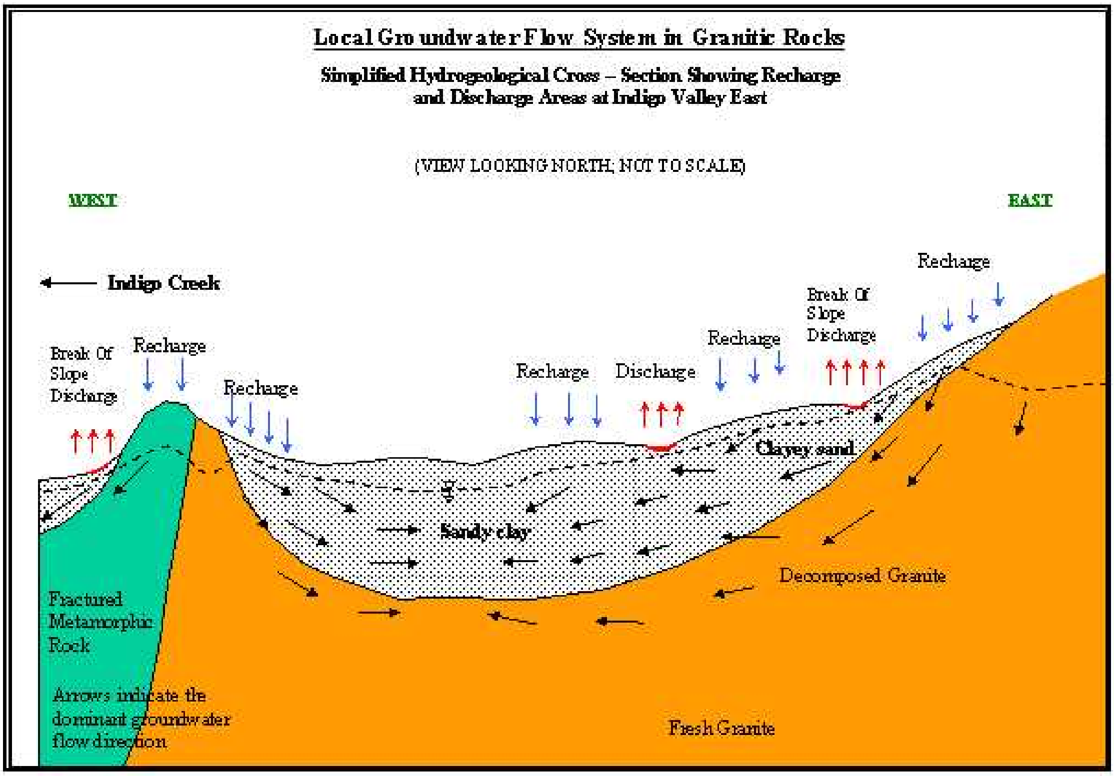
Local GFS occur in the more massive weathered granitic and coarse-grained metamorphic rocks that form the steeper hilly lands in the central and northern parts of the region. Typical examples are found in the area around the Beechworth Hills, Warby Ranges, Barnawartha and within the eastern sector of the Indigo Valley.

8.2.1 Landscape processes causing salinity

Local GFS cause salinity within the granites and coarse-grained metamorphic rocks in North East Victoria. Groundwater migrates from the slopes of catchments toward valley floors through-
(a) abundant coarse-grained colluvium (sediment) present in mid to lower slopes regions, and;
(b) underlying weathered and occasionally fractured rock (Figure 32).

Shallow perched groundwater flowing in the colluvium/weathered rock migrates down the landscape where it either discharges at the break of slope or feeds poorly defined aquifers that extend beneath adjacent valleys. In the latter case groundwater pressures may build up under the alluvium causing saline groundwater to discharge. Groundwater recharge occurs primarily through the colluvium, although it may also occur to a lesser extent through minimal soils and rock fractures on the upper slopes.

Figure 32 – Conceptual diagram of local groundwater flow systems in granitic rocks.



8.2.2 Salinity Priority Areas with this GFS

Indigo Valley/Wodonga/Baranduda, Talgarno, Chiltern, Everton-Tarrawingee, Springhurst and Murmungee.

8.3 Local GFS in fractured rocks

Local GFS occur in the fractured sedimentary and finer grained metamorphic rocks of the North East region. Salinity issues occurring at Everton are included in the former, and salinity occurring at Talgarno is an example of the latter.

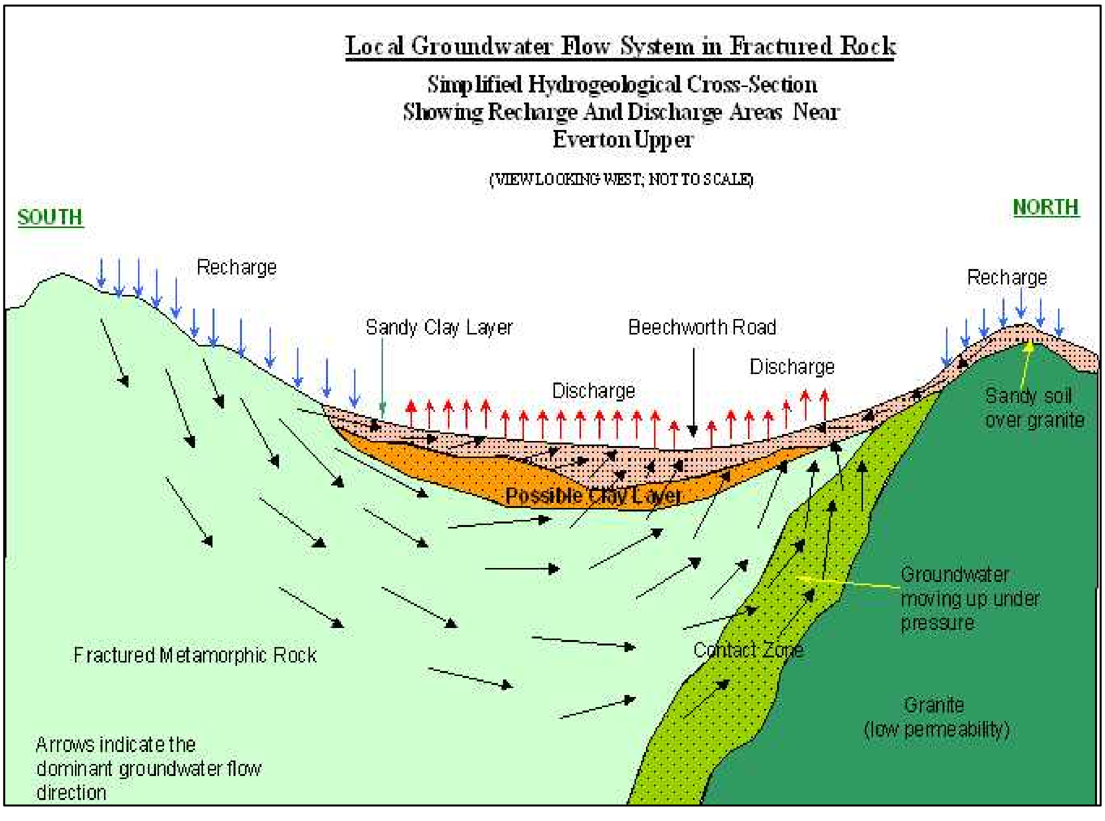
8.3.1 Landscape processes causing salinity

Local fractured rock aquifers occur in catchments that have moderate to high relief. Groundwater migrates from the mid to upper slope regions and converges on adjacent valley floors (Figure 33). Flow occurs through a network of fractures open to depths of fifty metres or more. Local perched groundwater systems may also function within colluvial fans formed on the mid to lower slopes.

Groundwater recharge occurs seasonally in response to winter rainfall throughout the landscape but is much higher where the fractured rock aquifer is exposed or has minimal soil cover. These conditions are typically found in mid to upper slope regions.

Salinity occurs most commonly where saline groundwater is forced to the surface in response to rising groundwater pressures beneath valley floors, although it may also occasionally occur where perched groundwater discharges from the toe of colluvial fans. The salinity of groundwater is generally low to moderate ranging from ranging from about 3,000 to 5,000 uS/cm.

Figure 33 – Conceptual diagram of local groundwater flow system in fractured rock.



8.3.2 Salinity Priority Areas with this GFS

Indigo Valley/Wodonga/Baranduda, Talgarno, Everton-Tarrawingee, Greta, Carboor Bobinawarrah, Whorouly, Chiltern, Rutherglen, Springhurst and Murmungee.

8.4 Local GFS in glacial sediments

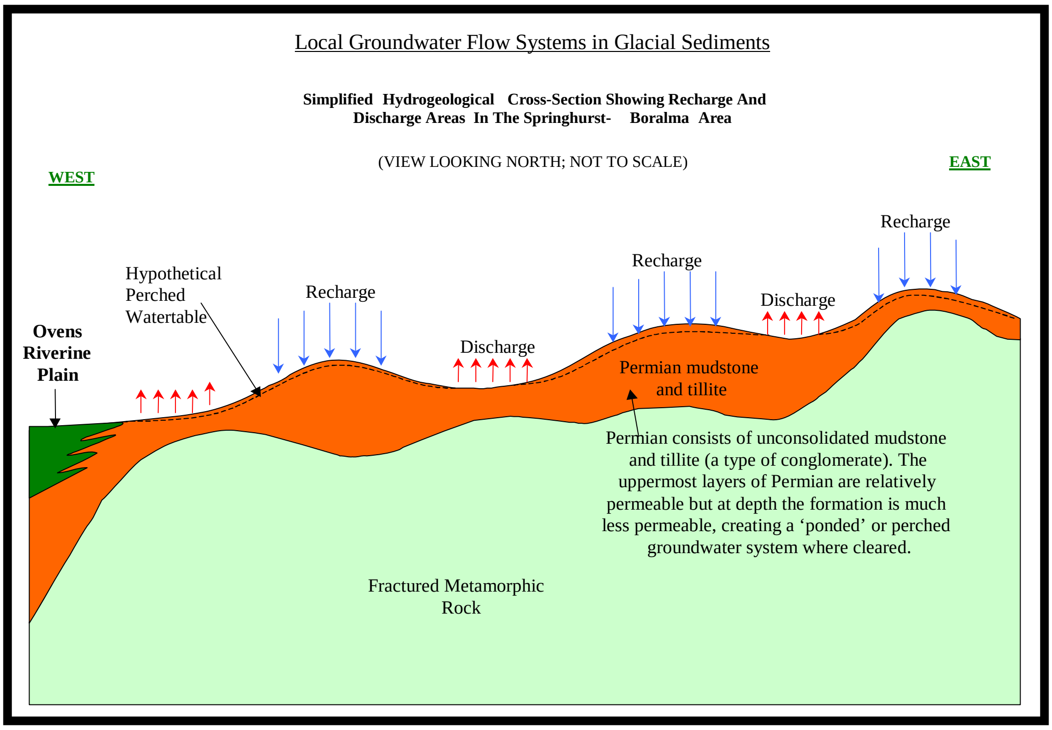
Local perched groundwater systems function where the sediments deposited during the melting of ancient glaciers occur over older weathered rocks. These most commonly occur as 'hill caps' on gently undulating terrain.

8.4.1 Landscape processes causing salinity

Groundwater moves down-slope through the glacial sediment and saline discharge occurs where the interface with the underlying rock is exposed on hill slopes (Figure 34).

In some areas perched groundwater may seep into deeper groundwater systems adding to salinity issues lower in the catchment. Perched groundwater within the glacial sediments is low in salinity (less than 1,000 uS/cm) and occurs close to the surface of the land.

Figure 34 – Conceptual diagram of local groundwater flow systems in Glacial Sediments.



8.4.2 Salinity Priority Areas with this GFS

Everton-Tarrawingee, Greta, and Springhurst.

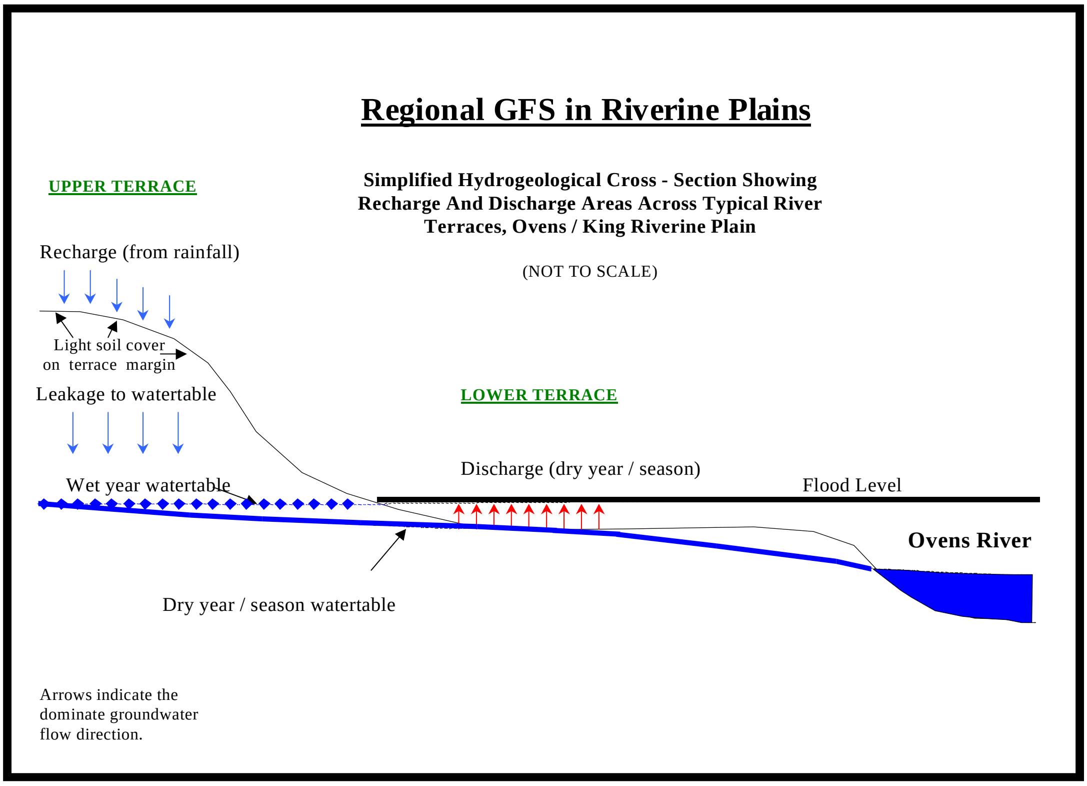
8.5 Regional GFS Riverine Plains

Regional GFS function within the Riverine Plains. The plains are underlain by gravel and sand aquifers that lie within the trench of an ancient river system (deep lead). Smaller 'shoestring' sand deposits also occur within the alluvium above the regional aquifer, and together this network of coarse sediment supports groundwater migration over large distances.

8.5.1 Landscape processes causing salinity

Salinity issues occurs in some areas, along the breaks of slope where the higher-level terraces of the plains give way to the lower level terraces that form the modern flood plains adjacent to most rivers (Figure 35). Groundwater migrating out of the plains toward the river intersects the land surface at this position on the floodplain. This discharge process is influenced, in some instances, by river groundwater interactions occurring in sympathy with high and low stream flow.

Figure 35 – Conceptual diagram of regional groundwater flow system in riverine plains.



8.5.2 Salinity Priority Areas with this GFS

Indigo Valley/Wodonga – Baranduda, Everton-Tarrawingee, Greta, Chiltern, Carboor Bobinawarrah, Rutherglen, Springhurst and Riverine Plains.

8.6 Local GFS in deeply weathered fractured rock

Local GFS in deeply weathered fractured rocks occur in the Rutherglen, Peechelba, and Talgarno areas. Here the fractured sedimentary and metamorphic rocks, commonly found in the more southerly uplands, are deeply decayed in the uppermost fifty metres or more of the landscape. Exposure to the elements and water circulation over many millions of years has reduced the rock mass to pale kaolinite rich clays.

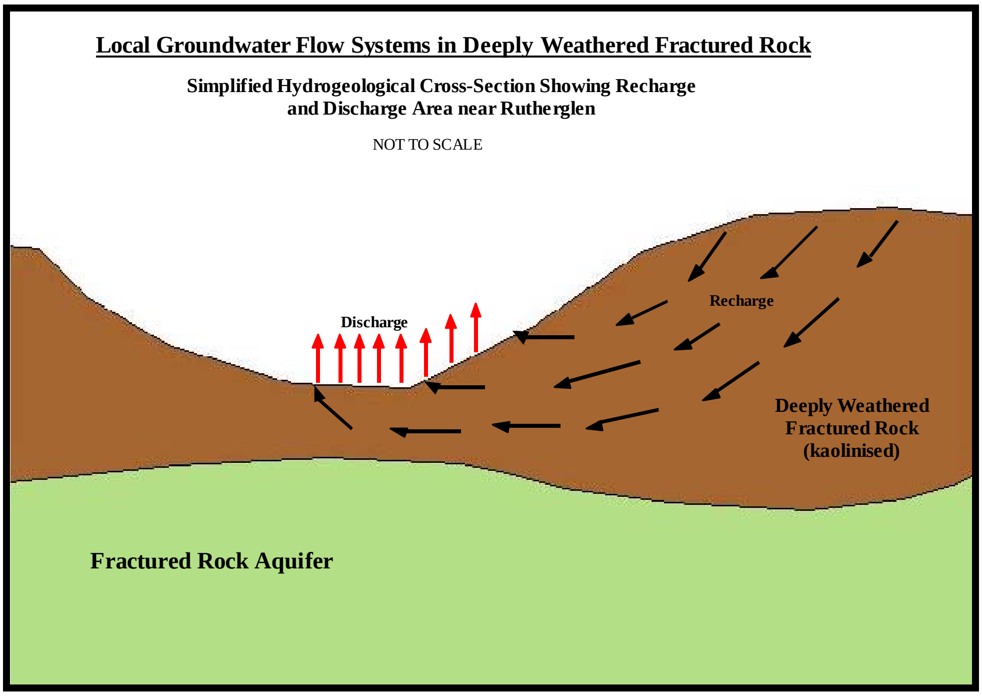
8.6.1 Landscape processes causing salinity

The clay rich decayed rocks readily stores salt introduced in small quantities in the rainfall. Salts excluded by the roots of native vegetation during transpiration accumulate in the regolith (i.e.: soil profile and decomposed rock) over long periods of geological time. These landscapes have much higher salt stores than other rock types in the North East region and groundwater commonly exceeds 10,000 mg/l.

Deep weathering destroys much of the fracture network in fractured rock aquifers and, accordingly, groundwater movement through the decayed rock mass is sluggish. Indeed, the volume of lateral groundwater flow can sometimes be exceeded by groundwater recharge causing saline discharge to occur quite high in the landscape.

The overall flow of groundwater is from the slopes of sub-catchments toward valley floors. Saline groundwater discharge tends to occur where the hydraulic gradient reduces at breaks of slope. Saline groundwater discharge areas within such landscapes are severely degraded by salinity (Figure 36).

Figure 36 – Conceptual diagram of local groundwater flow system in deeply weathered fractured rock.



8.6.2 Salinity Priority Areas with this GFS

Rutherglen

8.7 Local GFS in basaltic rocks

Basaltic rocks occur to a limited extent in the upper landscape in many cases on ridge tops of the Hansonville/Myrrhee area. Ancient lava flows once poured down drainage depressions and valley floors filling them with molten rock that quickly cooled forming the present volcanic rock mass. Over long periods of time softer rocks lateral to this volcanic material eroded away leaving the more resistant basalts high in the landscape.

8.7.1 Landscape processes causing salinity

The basaltic rocks behave as an efficient fractured rock aquifer. They have moderate permeability established through extensive cracking and fracturing resulting from rapid cooling of the lava. In most instances the permeability of the volcanic rock is greater than that of underlying rocks causing groundwater to perch over and flow along the interface and discharge between the two. Springs and seeps occur at the margins of the flow where the interface is exposed in hill-slopes.

The perching of groundwater over less permeable substrates and consequent discharge in the form of springs marginal to basalt flows is extremely common in basalt flows of eastern Australia. They processes vary somewhat in scale in accordance with the extent of individual flows and landscape relief, but as a general rule they are more local where the relief is higher. In some instances extensive lava flows with moderate relief may comprise intermediate flow systems with potential to function over tens of kilometres.

Groundwater salinity varies in sympathy with the extent of weathering. Fractured basaltic that are not extensively weathered generally comprise very low salt stores and fresh groundwater. Conversely rock weathering, produces moderate amounts of sodium, calcium, and bicarbonate rich ions and provides a medium for storing cyclic salt introduced through rainfall.

Recharge to the volcanic systems occurs seasonally in response to winter rainfall. It is believed to be highest where the fractured rock aquifer is either exposed at the land surface or where there is minimal soil cover. These conditions are common on the upper slopes and crests of many regions.

Localised outbreaks of salinity are manifest as small areas of barren saline land occurring where the volcanic rocks terminate at the break of slope or foot-slopes.

8.8 Local GFS in lunettes and source bordering dunes

Dunes and lunettes occur in a limited extent along the floodplain of the Murray River, sitting on top of the Riverine Plain GFS examples are found east of Wahgunyah and near Brimin.

8.8.1 Landscape processes causing salinity

They comprise ancient wind blown sediments winnowed out of the floor of streams and wetlands during periods of great aridity. They often appear as low crescent shaped hills or mounds formed on the eastern margins of the stream from which they formed. Given their immediate proximity relative to the streams and wetlands they were derived from they are sometimes referred to as 'source bordering dunes'.

The dunes and/or lunettes are commonly formed of fine-grained sands that readily accept rainfall. Low water holding capacity and a propensity for deep percolation below the root zone affords the development of localised groundwater systems that perch over less permeable materials at the base of the Aeolian sediments. These circumstances promote the development of springs along the lower margins of dunes. Groundwater is usually fresh, but salinity and waterlogging can sometimes be an issue where there is significant opportunity for evaporation.

The water balance of dune/lunette seepages is usually not difficult to manipulate in favour of a reduction in groundwater recharge and consequent mitigation of groundwater seepage. Deep rooted perennial vegetation dryland lucerne and break of slope tree planting are among the options that may be deployed.

8.9 Local GFS in upland alluvium

8.9.1 Landscape processes causing salinity

The landscape processes associated with this GFS are very similar to the Riverine Plain terraces.

These groundwater flow systems occur within large tracts of alluvial sediments that comprise the valley floors and terraced floodplains of many of the major river valleys in the uplands of North East Victoria. They occur, for example at Greta South, Upper Black Dog and Indigo Creeks, and within the main valleys of the Ovens, King, Kiewa, Mitta and Upper Murray catchments.

The alluvial sediments generally comprise a mix of sands and gravels inter-bedded with finer grained silts and clays, with the coarser grained sediments often occurring at depth.

The alluvium comprises both local and intermediate groundwater systems resulting from two components of flow within the same system. The 'local' component involves groundwater flow toward the river, whilst the 'intermediate component refers to the potential for down-basin groundwater flow parallel to the river.

Local flows may occur across the floodplain over distances less than five kilometres, whilst down-basin flow through buried sands and gravels may occur over distances as great as 50 kilometres.

Groundwater within the alluvial aquifers is generally fresh and considered a valuable resource. Local flow systems lateral to the river do not appear to pose any significant threat of dryland salinity. Watertables are generally not rising within the local flow system.

The significance of down-basin (intermediate) groundwater flow to salinity in the future is uncertain. Groundwater in some places appears to be rising in response to flows that could be attributed to sub-regional (intermediate) down-basin flows, but in other regions this trend is not yet apparent.

Groundwater recharge to the alluvial aquifers is generally seasonal, occurring mainly over the winter months, although, occasional episodes of exceptionally high rainfall may also be very significant particularly where widespread flooding occurs.

Groundwater discharge occasionally occurs at break of slope below the terraces, but salt stores are low and the incidence of salinity is generally quite low, and is mostly associated with irrigation.

8.10 Extent of Groundwater Flow Systems within Salinity Priority Areas

The GFS qualitatively believed to be contributing the most to salinity occurring within each priority area is highlighted in Table 34. Figure 37 show the distribution of GFS and salinity priority areas.

Table 34 – Area of each groundwater flow system within each salinity priority area (pink lights dominate GFS).

Priority Salinity Region	Area of Priority Salinity Region (Ha)	LGFS Fractured Rock (ha)	LGFS Granitic Rock (Ha)	LGFS Deeply weathered fractured rock (Ha)	LGFS Glacial Sediment (Ha)	L&IGFS Upland alluvium (Ha)	LGFS Basalt (Ha)	RGFS in Riverine Plains (Ha)
CARBOOR BOBINAWARRAH	15705	13482.1	0.00	0.0	0.0	1480.7	0.0	742.6
CHILTERN	36052	7230.8	19102.34	31.9	26.3	4289.5	0.0	5370.8
EVERTON TARRAWINGEE	17000	4958.7	6987.77	0.0	28.7	1104.2	0.0	3920.6
GRETA	18994	7768.7	143.92	0.0	898.7	3558.0	444.7	6142.0
INDIGO VALLEY	19237	9833.2	4099.16	0.0	0.0	2045.3	0.0	3259.0
MURMUNGEE	11934	4644.6	83.97	0.0	0.0	7.6	0.0	0.0
RIVERINE PLAIN	58060	3136.8	949.12	436.6	102.1	188.1	0.0	49901.9
RUTHERGLEN	14588	10175.9	0.00	1803.2	0.0	126.3	0.0	2482.4
SPRINGHURST	14517	1128.6	10887.39	0.0	766.5	442.6	0.0	1292.1
TALGARNO-WISES CREEK	12892	1393.9	9828.15	0.0	0.0	956.4	0.0	113.1
WHOROULY	14108	12240.3	0.00	0.0	0.0	1189.1	0.0	678.6
WODONGA – BARANDUDA	6134	1465.1	4418.35	0.0	0.0	208.1	0.0	42.5
TOTAL	239221	77458.7	56500.16	2271.7	1822.2	15596.0	444.7	73945.5
Note: LGFS = Local Groundwater Flow System, IGFS = Intermediate Groundwater Flow System, RGFS = Regional Groundwater Flow system								

Figure 37 – Map of groundwater flow systems and salinity priority areas.