4 Salinity Management Options

At present, some regions within the PPWP catchment are undergoing intense land use change, in particular through urban growth of the metropolitan area and satellite centres, and the establishment of irrigated horticulture in conjunction with waste water reuse. Land use change is being led in strategies and programs such as Melbourne 2030 and Grow West. Projected land use change has significant implications for the management of salinity discharge in the PPWP CMA region, which must look beyond the traditional opportunities offered in typical dryland grazing/cropping regimes that are so relevant in other CMAs.

Taking account of this changing land use, the description of salinity management options for each relevant GFS includes a brief discussion of the implications of projected land use, in addition to the applicability of the various management options related to dryland agricultural systems. The dryland agricultural options are presented in tabular form (the general template used in the GFS descriptions in the neighbouring CMAs), whilst reference to other land uses and management options is of a descriptive nature. This difference in presentation reflects the relative mature knowledge that we have of salinity management for dryland agricultural systems compared to other land uses such as irrigated horticulture and urbanisation. For the latter land uses, the neat partitioning of solutions and opportunities is not possible, since the level of understanding of hydrologic impacts, and the tools to deal with these impacts, is lower.

4.1 Salinity management and groundwater flow systems

The temporal and spatial impacts of salinity management techniques in the landscape are principally a function of:

- whether it deals with the cause or effects of salinity

- the hydrogeological responsiveness of that landscape that is in turn, a function of the length of flow path, system permeability, depth of weathering etc.
- the scale of application of the management option relative to the extent of the flow system
- the climatic regime in which it is implemented
- land suitability for a particular control measure

The scale and responsiveness of the flow system frames the general land management response, especially the relative effectiveness of recharge management, discharge management, or planning/engineering to protect assets from degradation due to salinity. In respect to biological salinity control measures, climate and land suitability are important determinants as to their technical application.

The management opportunities suggested for each PPWCMA GFS are indicative and generalised, and certainly not definitive. Groundwater flow systems represent only a coarse and generalised classification, and at the implementation scale, GFS attributes may not accurately reflect the physical conditions (and therefore the opportunities) at a particular site. In addition, the management options are based on the salinity-affected parts of a GFS. In reality, where salinity is not a known issue within a GFS (not to say that there will not be an issue in the future), precautionary salinity management (e.g. recharge control) is considered impracticable, and is therefore not included.

Confidence in management options for the protection of different classes of assets requires confidence in the conceptual model of how the groundwater and salinity processes operate. This is not always the case, and, where this is such an issue, mention is made in the management option preamble for the GFS. One challenge in adopting the GFS approach to salinity management in the PPWCMA region is the emergence of a variety of conceptual models for salinity processes, even within a single GFS (a question of resolution).

There are a number of examples in the PPWCMA region where speculating on the applicability of various control options demonstrates some of the thought processes critical in making a decisions on salinity management in this region.

Pakenham

The urban growth corridor through Pakenham rests on the upper fringes of the Westernport Plain, where watertables are shallow and surface waterlogging is a common characteristic. The dense stands of waterlogging tolerant Melaleuca which existed in the low-lying areas indicate that the landscape was often saturated. Clearing of the plains and adjacent foothills has probably increased the waterlogging impacts and led to increased soil-salt accumulation. Without significant engineering intervention it is unrealistic to completely alleviate waterlogging from this landscape, and a degree of salinity is an inevitable feature, even when the landscape has been developed. On this basis there may be a need to strategically plan where urban development should occur and impose mandatory engineering standards to safeguard infrastructure from degradation due to salinity.

Clyde North

Isolated salinity occurs at the interface of a local fractured rock groundwater flow system, and a local flow system (believed to be naturally waterlogged) developed in Quaternary alluvium. The salinity tends to occur as break-of-slope discharge, but there the relative influence of the two adjacent GFSs is unclear. Strategic tree planting on the bedrock rises may not achieve the desired result and recharge control using pastures is unsuited due to the higher rainfall. There is pressure for intensive horticultural development and waste water reuse across this region. Without strategic planning based on land suitability, groundwater accessions from irrigation have the potential to exacerbate local waterlogging and salinity. There are implications for the sustainability of these enterprises themselves, in addition to other assets in the local environment.

Balliang

At Balliang the hydrogeological processes causing the salinity remain uncertain, lowering the confidence in the required solution, if recharge control is to be pursued. Rainfall is only moderate (<600 mm), so perennial pasture offers a possibility as a broad acre option. Cropping is practised in the region where soils are amenable, and it would probably be prudent to incorporate appropriate pasture phases that aid in recharge management. Despite the likely opportunities for recharge control, the salinity processes at Balliang have probably reached hydrological equilibrium, and there have been significant works over the years to stabilise the site. The questions arise: 'will the salinity get any worse?' and if not, 'is recharge control sellable?'

4.2 Salinity management opportunities in dryland agriculture

Dryland agricultural salinity management options are stated in terms of biological management of recharge, engineering intervention for watertable control and productive uses of saline land and water (i.e. discharge management).

Biological control of recharge: use or manipulation of vegetation to reduce recharge. In addition to direct recharge control, vegetation may reduce runoff and therefore waterlogging in the lower landscape (that may otherwise leave land unproductive, and be a source of indirect or flood recharge). Specific treatments include perennial pastures, crop management and trees/woody vegetation.

In the interpretation of biological recharge control opportunities for the PPWP region there are a number of important considerations:

- scale of flow and responsiveness of system
- rainfall
- soils and land suitability
- likely land use scenarios (e.g. how much land can be spared for trees?)

Much of the PPWCMA region experiences rainfall above 700 mm/yr, so that recharge control through perennial pastures within many GFSs is doubtful. However, the maintenance of healthy pastures will serve to somewhat reduce runoff and waterlogging (and therefore indirect recharge), and thereby reducing salt wash-off into streams. Given that dryland agriculture will remain dominant in these higher rainfall landscapes, an emphasis on risk minimisation rather than risk avoidance is the likely practicable approach.

Technically, the adoption of woody vegetation might resolve recharge, but practically, trees need to be nested into farming systems. In addition, reducing recharge can also reduce catchment run-off, which has implications for water supply. For this reason the interpreted impacts of woody vegetation are relatively tempered in the GFS management option assessments.

Engineering intervention: the use of mechanical means to reduce watertables or remove surface water that would otherwise lead to high watertables or waterlogging. In practice this generally relates to specific treatments that protect assets in zones of high watertables, salinity and waterlogging. Engineering solutions are typically used in discharge or waterlogged areas, but, theoretically could include operations up-catchment to prevent these hazardous conditions occurring. Specific treatments include surface and sub-surface drainage, and groundwater pumping.

In the interpretation of engineering intervention opportunities the following considerations are important:

- technical feasibility (e.g. aquifer permeability? hydraulic gradients?)
- economic feasibility
- disposal of effluent

Given the inability of farming systems to effectively control or mitigate salinity in many instances, engineering options are often put forward as an alternative solution. For instance, they are widely used in the northern irrigation districts. However, in the relatively more pristine and biodiverse environments in dryland areas, disposal of effluent is usually problematic. Another potential issue is the reduction in stream baseflows through groundwater pumping. In addition, the costs and benefit equation of employing an engineering option to protect or restore an asset in a dryland region has rarely been calculated, so that the appreciation of such options has not yet matured.

Productive uses of saline land and water: encompasses biological treatment of discharge areas and/or other productive uses. Specific treatments include salt tolerant pastures, halophytic vegetation, salt tolerant vegetation, saline aquaculture and salt harvesting.

In the interpretation of saline land management opportunities the following considerations are important:

- climate (e.g. does it suit halophytes?)
- technical feasibility (e.g. is there enough salt to harvest?)
- economic feasibility (e.g. does the saline land need to be developed?)
- social feasibility (e.g. does saline aquaculture suit the local environs?)

In the PPWCMA region, as for most areas, the direct treatment and stabilisation of saline ground is a reasonable objective in its own right. Whilst there is a natural tendency to want to directly treat highly visual and geographically distinct issues (as opposed to the more problematic issue of dealing with the diffuse nature of recharge), treatment of discharge areas has the relatively short term benefit of reducing the amount of salt wash-off to streams, whilst other catchment management solutions take effect.

In the PPWCMA region there is probably more potential in the use of salt tolerant pastures rather than halophytes given the climatic constraints with respect to applying the latter. In and adjacent to urbanised areas and conservation areas there are questions in regards to the aesthetics of salinity discharge management, in addition to the potential invasiveness of salt tolerant species. In public open spaces such as golf courses, salt and waterlogging tolerant grasses present a management option (e.g. the use of Santa Anna Couch at the Pakenham Golf Course).

Productive uses of saline ground such as saline aquaculture and salt harvesting are highly problematic, and require strong economic foundation before they will proceed. Their overall impact on salinity management in the PPWCMA region will be minimal, though, technically, they nevertheless present local salinity management opportunities.

Other: other options to consider. Generally refers to the OPUS database, available on the National Dryland Salinity Program website.

4.3 Salinity management opportunities for irrigated agriculture and horticulture

Issues

The hydro(geo)logical issue with irrigated agriculture is the introduction of additional water into the landscape that would not otherwise be there (in volume and temporal distribution), that to varying degrees can be managed to minimise accessions to the watertable. In the PPWCMA region there a number of hydrogeological boundary conditions that are important in the consideration of irrigated cropping, including:

- Waterlogging and shallow watertables (in many instances a natural condition)
- Down-basin groundwater elevations maintained by permanent sea levels
- Variable, but often high annual rainfalls exceeding 700 mm

Dealing with current issues

Management strategies to deal with currently expressed salinity issues in irrigation environs include:

- isolating, stabilising and potentially increasing productivity from salinity affected areas
- increasing the efficiency of irrigation applications to reduce accessions
- where possible, improved drainage of excess surface and sub-surface water

Planning for future issues:

It is important that land suitability surveys are undertaken to focus development on the most appropriate soil, and where on and off-site damage will be minimised. Planning should establish safeguards in order to minimise impacts. In some circumstances avoidance of irrigated agriculture/horticulture may be the desirable choice rather than simply impact minimisation.

4.4 Salinity management opportunities for urbanised environments

Issues

The hydro(geo)logical issues associated with urbanised areas are complex. On the one hand, heavily paved areas limit the capacity for direct recharge and routes accumulated surface drainage through a highly engineered drainage network. On the other hand, garden irrigation (and potentially leaky drainage systems) increases the opportunity for localised recharge. Human Infrastructure may disrupt both natural surface and sub-surface drainage patterns with implications for salinity development.

Dealing with current issues

Management strategies to deal with currently expressed salinity issues in urbanised environs include:

- stabilisation and beautification of salinity affected areas by vegetative means
- surface and/or sub-surface drainage to protect assets
- reduction of recharge accessions by minimising garden watering and maintaining drainage infrastructure

Planning for future issues:

A satisfactory urban planning framework encompassing salinity would determine the protocols or guidelines under which development could occur (for instance based on the distribution of salinity and shallow watertables), and then construction regulations governing the nature of building for a particular set of physical environmental parameters. In some instances it may be decided that urban development is prevented in order to avoid the costs associated with the future salinisation impacts. Where development is in place or is planned to occur in the future, planning schemes might also consider urban watering restrictions.

4.5 Planning frameworks

Salinity management in the GFSs can be seen in terms of whether the measure *mitigates* salinity, *avoids* salinity (even if the hazard cannot be avoided, good planning may avoid assets being exposed to the hazard), or *adapts* to salinity. With significant land use pressures at play in the region, much of the emphasis will likely be on avoiding or adapting to salinity, in which case strategic planning of development is crucial.

The experience with salinity overlays in municipal planning frameworks across Victoria has generally been an unsatisfactory one. How does one use a salinity overlay? How do you define boundaries on the ground? How does it link to process? How can you form a sound planning argument? The answers to such questions are not possible with such limited information provided in a traditional salinity overlay, and there is usually no process in place to allow a planning officer to answer these in order to develop a sound planning argument.

The keys to an effective planning scheme that considers salinity are:

- a set of informative overlays, not restricted to the distribution of salinity, but incorporating watertable information, GFS characteristics, etc.
- a framework that allows a pathway to interpreting of this information to make a sound planning decision. This would likely require the onus to disprove, manage or avoid salinity hazard to be with the developer.

Port Phillip and Westernport Groundwater Flow Systems

Number	Dominant Flow System	Sub-dominant Flow System	Description
GFS 1	Local		Quaternary sediments
GFS 2	Local		Gravel and sand sediments
GFS 3	Local		Nepean barrier dunes
GFS 4	Local		Greenstone ranges
GFS 5	Local	Intermediate	Swamps and back-dune wetlands
GFS 6	Local	Intermediate	Weathered Older Volcanics
GFS 7	Local	Intermediate	Fractured Older Volcanics
GFS 8	Local	Intermediate	Acid volcanics
GFS 9	Local	Intermediate	Granitic rocks
GFS 10	Local	Intermediate	Brighton Group sediments
GFS 11	Local	Intermediate	Werribee Delta
GFS 12	Local	Intermediate	Rowsley Valley complex
GFS 13	Local	Intermediate	Mornington fractured bedrock
GFS 14	Local	Intermediate	Strzelecki Group rocks
GFS 15	Local	Intermediate	Fractured Palaeozoic rocks
GFS 16	Intermediate	Local	Weathered Palaeozoic rocks
GFS 17	Intermediate	Regional	Westernport plain
GFS 18	Regional	Intermediate	Volcanic Plains

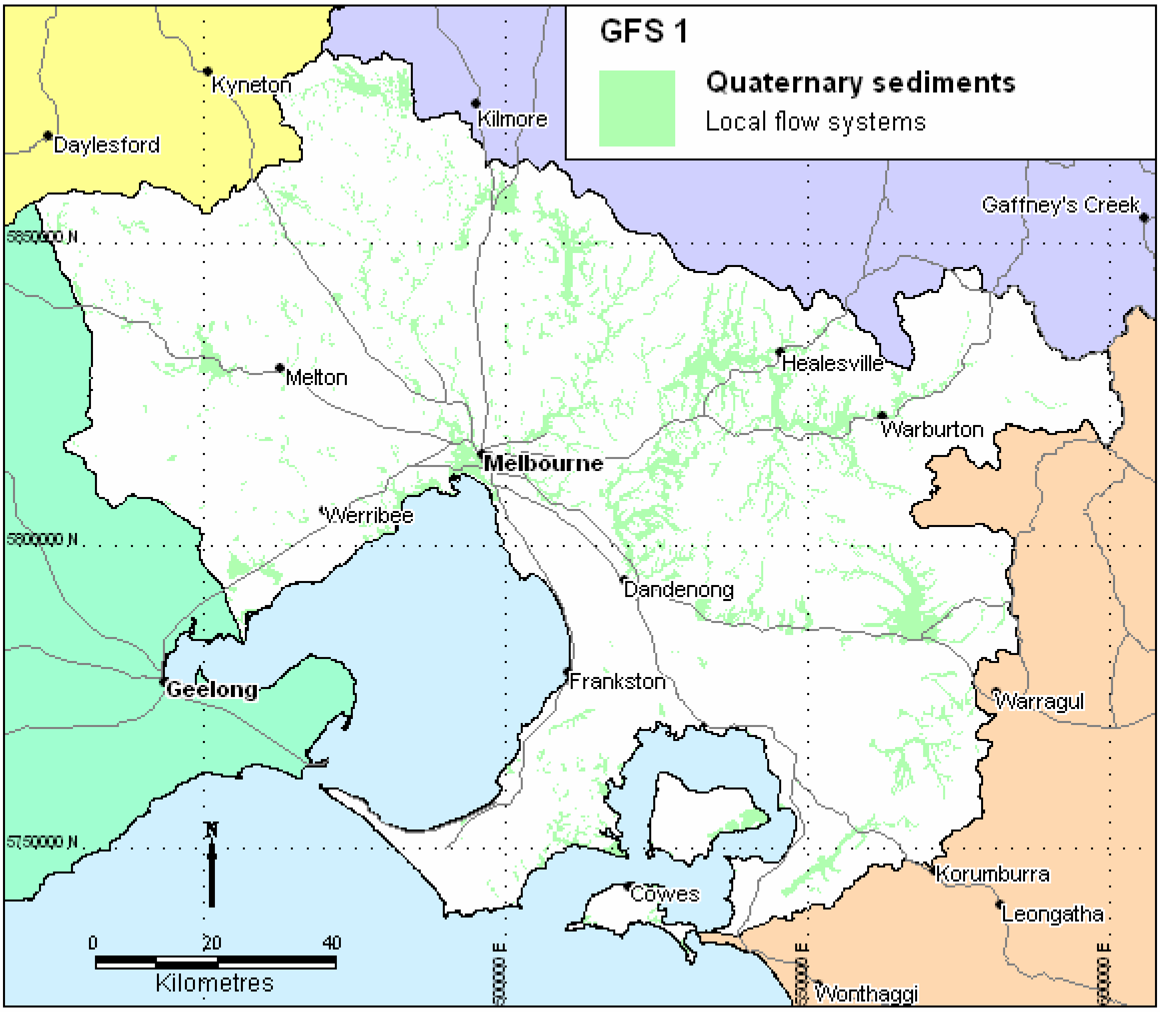
Local flow systems in Quaternary sediments

Region: All of PPWP CMA

Type areas: Bacchus Marsh, Yarra Glen, Longwarry North.

Brief description: Deposits of Quaternary age sediments are widespread over the PPWP CMA region. These include stream alluvium, hillside colluvium, swamp and lake deposits, lunettes, recent marine sediments and coastal dunes. Although these deposits vary in thickness, formation and materials, they are grouped together by similar hydrogeological processes. Some deposits of coarse-grained materials and the larger regional deposits of the Westernport coastal plain, Bass coastal plain, Werribee Delta, Nepean Peninsula, Carrum Swamp and Koo-wee-rup Swamp are either designated as separate groundwater flow systems or included with other groundwater flow systems. A notable exception is the Yarra Delta, which is included in this GFS even though it is composed of sequences of units and has a more complex flow regime than the other Quaternary flow systems.

Groundwater moves at varying rates through the unconsolidated deposits in local flow systems that generally develop at shallow depths below the ground surface. Salinity is strongly correlated with this GFS, particularly in the Upper Maribyrnong River catchment. Along the western shore of Port Phillip Bay, primary salinity is a feature of the coastal and estuarine environments of Point Cook and Point Wilson.



Problem statement: In general, changes in the water balance resulting from land-use change has increased soil waterlogging, changed regolith hydrology, and increased groundwater recharge and discharge.

Landscape attributes

Geology: Quaternary alluvium (Qra, Qpa, Qp2), Duetgam Silt flood plain deposits (Qpw), Coode Island Silt lagoon deposits (Qpy), alluviual terraces (Qrt); Quaternary colluvium and gully alluvium (Qrc, Qpc); Neogene post Newer Volcanics alluvium (Tpe) and hillwash (Tpo);

Topography: River flats, swamps, lakes, lunettes, marshes, valley floors, river terraces, gentle colluvial slopes, tidal lagoons, recent marine lowlands, beach dunes.

Land Systems:

Central Victorian Uplands

1.1 East Victorian Dissected Uplands

2.1 West Victorian Dissected Uplands – Midlands

South Victorian Uplands

3.3 Moderate Ridge – Mornington Peninsula

3.4 *Dissected Fault Block – South Gippsland Ranges*

Western Victorian Volcanic Plains

7.1 Undulating Plains – Western District

7.2 Stony Undulating Plains – Western District

South Victorian Coastal Plains

8.3 Sand and Clay Plains - Moorabbin

8.4 Fans and Terraces – Westernport

8.5 Barrier Complexes – Discovery Bay, Gippsland Lakes

South Victorian Riverine Plains

9.1 Present Flood Plain - Gippsland

Regolith: Unconsolidated gravel, sand, silt and clay.

Annual rainfall: 500 mm to 1700 mm

Dominant mid-1800s vegetation type: Rushland, Grassland, Heathland, Shrubland, Scrub, Woodland and Forest, depending on location.

Current dominant land uses: Urban and industrial development (including City CBD and Docklands), waterways, parkland, horticulture, viticulture, grazing, conservation.

Mapping method: Outcrop geology, landform and local knowledge.

Saline wetlands at Kirk Point, near Avalon, an example of primary salinity as an environmental asset.

Hydrogeology

Aquifer type (porosity): Unconsolidated gravel, sand, silt and clay (primary porosity).

Aquifer type (conditions): Unconfined and semi-confined.

Hydraulic Conductivity (lateral permeability): Extremely variable. Probable range from 10^{-6} m/d to 10^{2} m/d, with clayey facies less than 1 m/d and sandy facies up to 100 m/d.

Aquifer Transmissivity: Variable, in the moderate range. Estimated to be generally less than 20 m^2/d.

Aquifer Storativity: Extremely variable. Estimated to be from 0.05 to 0.3.

Hydraulic gradient: Varies with landscape and topography. Very low to low in river and swamps, and moderate to locally steep in colluvial slopes.

Flow length: Generally short, but highly variable depending on local conditions. Ranges from a few metres up to one or two kilometres.

Catchment size: Generally small (<1 Ha to 100 Ha).

Recharge estimate: Probably 10% to 20% of local rainfall, but would vary with the landscape setting at any location.

Temporal distribution of recharge: Seasonal (winter and spring), with more recharge in wetter years. Extensive periods of soil waterlogging may add to local recharge.

Spatial distribution of recharge: Catchment wide.

Aquifer uses: Irrigation, and minor stock and domestic use from shallow bores.

Salinity

Groundwater salinity (TDS): Generally in the range of <1,000 mg/L to 10,000 mg/L TDS.

Salt store: Moderate to high.

Salinity occurrence: Secondary salinity occurs in low lying and flat areas, drainage lines, swampy wetlands, and at the foot of colluvial slopes. Some primary salinity associated with the estuarine environments.

Soil Salinity Rating: S2, S3

Salt export: Wash off from surface.

Salt impacts: Both on-site and off-site.

Risk

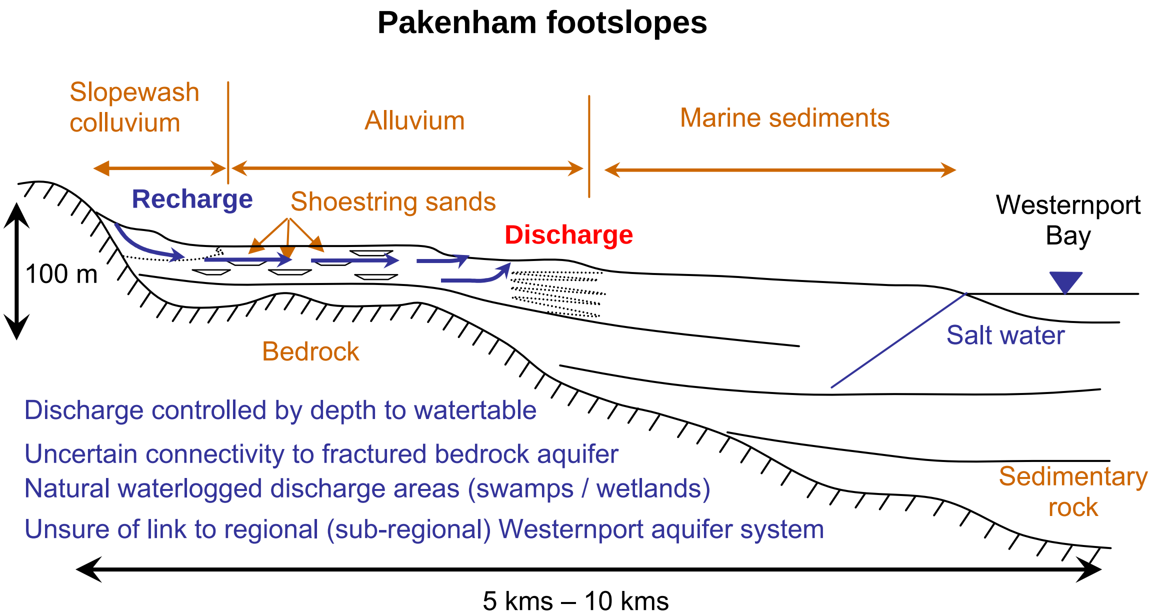
Soil salinity hazard: High.

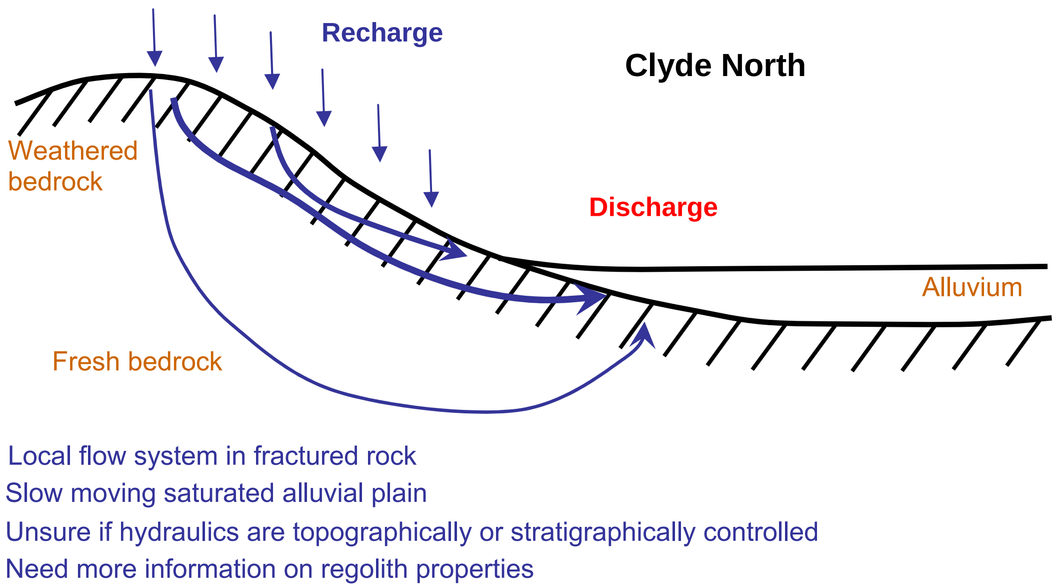
Water salinity hazard: High.

Assets at risk: Water quality and aquatic biodiversity (Maribyrnong River system), urban infrastructure (Pakenham), agricultural land (Rockbank, Lancefield, Tyabb), wetlands and conservation areas (Phillip Island, Point Cook, Pelican Point), engineering infrastructure.

Responsiveness to land management: Varied, but generally should be very responsive. In some areas, the influence of the underlying groundwater flow systems is more significant, and land management in this groundwater flow system is not as effective.

Conceptual models





Two conceptual models of groundwater movement and salinity processes associated with Quaternary sediments.

At Sanctuary Lakes, an Environmental Audit for large residential development associated the salinity with the former salt condensers, concluded that a slug of high salinity groundwater (>40,000 mg/L TDS) is present under the lake, complete with a salt water / fresh water wedge.