REGOLITH INFLUENCE ON SURFICIAL WATER CHEMISTRY AT HOVELLS CREEK, CENTRAL WEST NSW: DRYLAND SALINITY HAZARD MITIGATION IN HIGH-RELIEF GRANITIC LANDSCAPES

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INTRODUCTION

Hovells Creek Catchment is located in the central tablelands of New South Wales, approximately 40 km south east of Cowra and 35 km north of Boorowa (Figure 1). Hovells Creek is a sub-catchment of the larger Boorowa River catchment, which itself covers 1,820 km^2 (Evans 1994). A 200 km^2 study area in the upper Hovells Creek catchment is the focus of this study. In this area Hovells Creek flows north for approximately 16 km through high-relief granitic rock of the Wyangala Batholith.

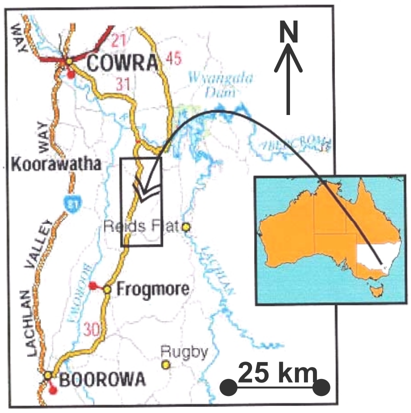


Figure 1: Location map of the Hovells Creek study area. Source: NRMA 2002.

Anecdotal evidence from landholders indicates that the runoff and shallow groundwater coming off the local ranges in the study area appears to be diluting the slightly saline water of Hovells Creek. Surficial water was sampled at three points: as it enters the granitic section of the catchment; prior to it leaving the study area; and below the confluence of a local spring-fed tributary (Oakey Creek) and Hovells Creek. This study explores whether it is in the best interest of the downstream catchments to allow water flow from Hovells Creek to flow freely and dilute the salt flux into the Boorowa River.

Understanding the regolith is imperative to understanding the shallow groundwater flow system of any area. Preliminary studies at Hovells Creek have highlighted the complex relationship between regolith distribution and surface and groundwater properties, occurring at a local scale. The regolith plays an important role in the infiltration, movement and storage of near surface water and source/storage of salts (Wilford *et al.* 2002). The location of recharge and discharge zones and the amount of time water has to interact with regolith materials depends on the distribution and physical characteristics of the regolith materials present. In the study area the residence time of water in the local groundwater system is approximately 2 months. At Hovells Creek, transport in the alluvial sediment is a lot slower as the fluid migrates via primary porosity in the unconsolidated silty sands, while in the slightly weathered bedrock water movement is faster and its direction is controlled by the orientation of the fractures and joints. The slow movement through the alluvial sediments does cause salinity problems elsewhere in the Boorowa shire. As salt is dominantly found in the shallow soil and weathered bedrock, the slow movement of water in these regolith types may mobilise salt as there is both time and the capacity to interact (Evans 1998).

REGIONAL REGOLITH AND GEOLOGY

Hovells Creek Catchment has its headwaters in regolith developed on Ordovician metasediments but largely flows northward through high-relief granodiorite of the Wyangala Batholith. The metasediments present south of the study area are predominantly turbiditic quartzose siltstone and sandstone with minor chert containing slivers of strongly foliated, black, laminated carbonaceous Warbisco Shale (Johnston *et al*. 2001). The Wyangala Batholith was emplaced during the Late Silurian to Early Devonian Bowning Orogeny, a major thermal and mountain building event (Morand 2000). The Batholith can be sub-divided into twelve intrusive units, with the Hovells Creek study area located on four of these. The dominant rock type is the Wyangala Granodiorite. The Wyangala Granodiorite is a massive to protomylonitic medium to coarse-grained biotite granodiorite with isolated sodium-rich muscovite granite and sodium-rich biotite granodiorite inclusions (Johnston *et al*. 2001). Silty sands form on the alluvial plains adjacent to Hovells Creek. In some reaches unweathered bedrock is exposed in the creek bed. The creek channels are dominantly comprised of an upper silt layer of up to 2 metres thick, overlying a layer of quartzofeldspathic sand and weathered granodiorite bedrock (Muller *et al*. 1998).

Apart from an area of alluvial sediment in the valley floor, the study area is characterised by a fractured rock aquifer system. The bedrock is generally impermeable, due to the low porosity of the intact granitic rock matrix (approximately 1-2% porosity) compared to the fracture system in the same rock (approximately 2-5% porosity) (Gale *et al*. 1982). Water movement is restricted to fractures and joints in this rock type (Hayman 1996). Recharge occurs through these structures and water movement is controlled by the orientation of the fractures and joints (Beavis & Beavis 1997). Groundwater movement through the floodplain is slow, evaporation high and salts can concentrate, putting the floodplains at a higher risk of salinisation (Muller *et al*. 1998).

Recharge in the Hovells Creek catchment is from rainfall discharging as springs in the surrounding ranges and from local tributaries. Recognised as a local hydrogeological system, Hovells Creek catchment has been classified as a high-relief granitic groundwater flow system and may be compared with the groundwater flow systems in areas with similar terrain (Coram *et al*. 2000). Hovells Creek contains fairly fresh water with the highest electrical conductivity (EC) reading during the 9 months sampling period being 2100 μS/cm (compare with Table 1).

Table 1: Maximum permissible water electrical conductivity (EC) levels for various uses (Hook 1992).

Use	EC (μS/cm)
Desirable limit for humans	790
Lucerne yields reduced by 10%	2,200
Absolute limit for humans	2,500
Maximum levels for pigs and poultry before production decline	4,100
Absolute limit for poultry	5,800
Absolute limit for pigs	6,600
Maximum levels for horses before production decline	7,800
Absolute limit for horses	7,800
Maximum levels beef cattle before production decline	11,400
Maximum levels for sheep before production decline	15,700
Average measurement of sea water	50,000

Regional regolith mapping has been conducted in this area; in the north the area is mapped as moderately or slightly weathered bedrock and in the south into alluvial, colluvial or residual regolith material (Chan & Goldrick 1995, Johnston *et al*. 2001).

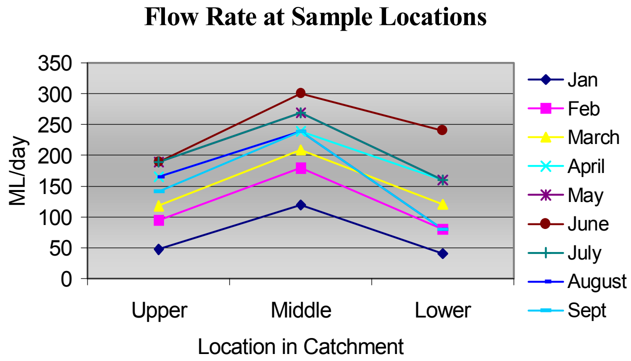
METHODS

A monthly water sampling program for nine months included collection of in-field measurements such as pH, EC, total dissolved solids (TDS) and water depth.

A transect was chosen to represent the slightly weathered bedrock, colluvial and alluvial materials. A representative catena was sampled from a hillcrest featuring large outcrops down to the well-developed soils of the alluvial plain. Only one sample was taken on the slightly weathered bedrock or *in situ* material, as the regolith only went down 10 cm. The samples were analysed using a range of techniques including: tests for salt in pore water; pH of both the soil and pore water; and total moisture content. The samples were also analysed using an X-Ray Diffractometer (XRD) for clay mineralogy.

RESULTS, SURFICIAL WATER ANALYSIS

The mid-reach sample location, below the confluence of Hovells and Oakey Creeks, consistently has the highest water flow (Figure 2a). For example in June the flow at this point is 300 ML/day, while the upper and lower reach sites have lower flow rates, 190 ML/day & 240 ML/day respectively. The highest EC readings are recorded for June. January had the lowest flow rates and the lowest EC readings for all sites (Figure 2b).



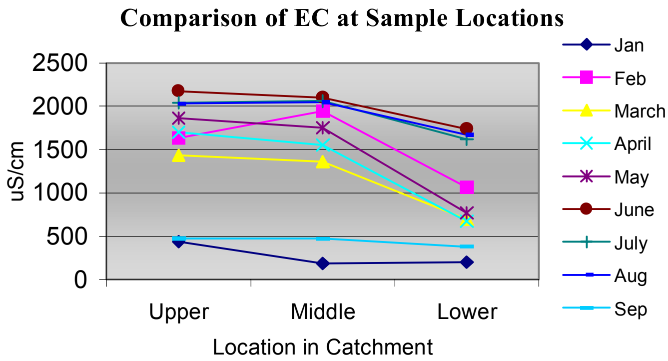
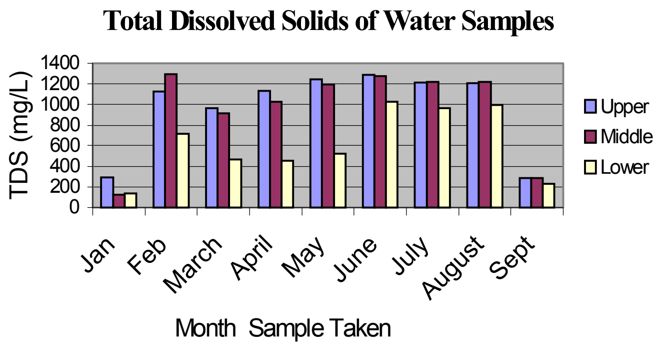


Figure 2a (upper): Flow rate for Hovells Creek at upper, middle and lower reach sample locations.

Figure 2b (lower): EC readings for Hovells Creek at upper, middle and lower reach sample locations.

The lowest TDS values are recorded for the lower reach, while the upper and middle reach areas are consistently higher (Figure 3a). The range of pH values at the upper site is 7.2-8.8, for the middle site is 7.2-8.6 and for the lower site is 7.7-8.2. The pH values do not show similar patterns for each sample site, but are all most alkaline for the July readings (Figure 3b). This corresponds with a drop in flow rate from July.



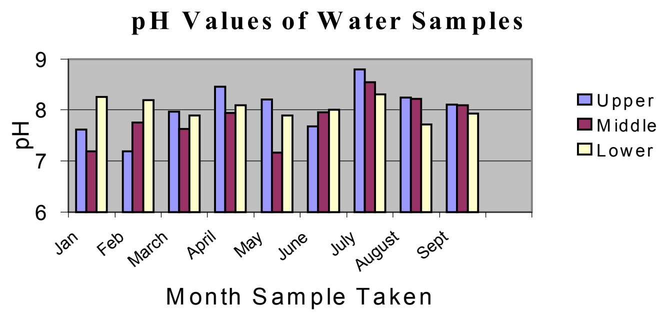
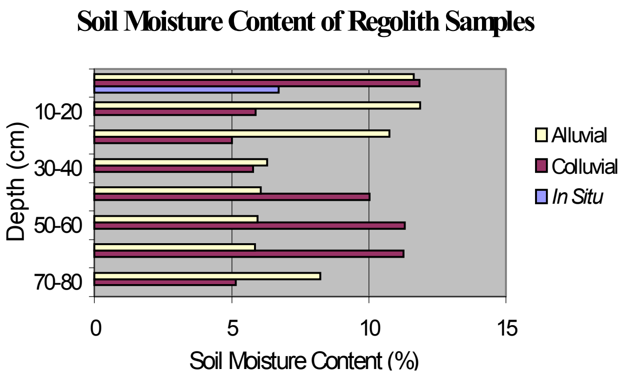


Figure 3a (upper): Total Dissolved Solids (TDS) for samples taken from January to September 2002.

Figure 3b (lower): pH values for samples taken from January to September 2002.

The soil moisture results show that there is generally more fluid held in the alluvial sediments in the upper 40 cm (up to 12 wt. %) (Figure 4a), and more fluid in the colluvial sediments in the 50-70 cm interval (up to 11.6 wt. %). Surficial colluvial soils (0-10 cm) also have high moisture contents (12 wt. %). The lowest soil moisture readings were for the 50-70 cm interval for alluvial sediments (5.8 wt. %) and the 20–30 cm interval for colluvial sediments (5 wt. %). Soil water EC values were highest in the colluvial top 10 cm (60 µS/cm) (Figure 4b). The alluvial soil water had the lowest EC readings on average as well as the lowest reading at 6.6 µS/cm in the 60–70 cm layer. On average all three samples showed an inverse correlation between EC readings and depth of collection.



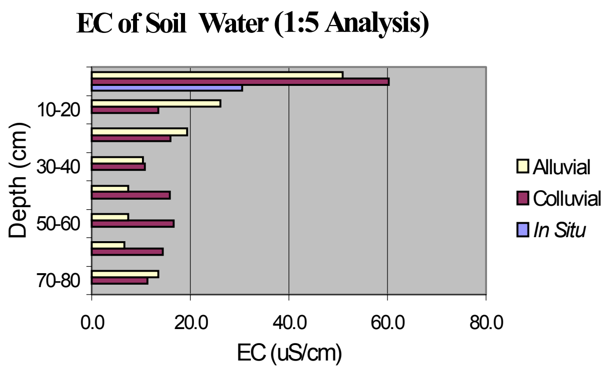


Figure 4a (upper): Soil moisture (wt. %) for regolith samples from alluvial, colluvial and *in situ* profiles.

Figure 4b (lower): Electrical Conductivity (EC) (µS/cm) of soil water values for regolith samples from alluvial, colluvial and *in situ* profiles.

XRD analyses were conducted for three clay separates (< 4 µm) (Table 2). The secondary mineral assemblage on the *in situ* material was muscovite dominant, on the colluvial material was chlorite dominant and on the alluvial material was kaolinite dominant.

Table 2: Results from the XRD analysis of clay separates from the regolith samples.

Sample	Total depth of samples	Minerals identified
Alluvial	80 cm	Kaolinite, muscovite, smectite, goethite
Colluvial	80 cm	Chlorite, sepiolite, kaolinite,
In situ	10 cm	Muscovite, kaolinite

DISCUSSION AND CONCLUSION

Observations from the water data support the anecdotal evidence that the study area at Hovells Creek is part of a net dilution catchment. The water leaving the study area is fresher than the water entering from the upper part of the catchment. At the middle site solutes should, in theory, be more concentrated. However, due to the Creek being diluted by fresh runoff and shallow groundwater, water moving out of the study area is fresher than that entering. The surrounding landscape of high relief granodiorite with shallow regolith cover limits the residence time of water in contact with regolith material prior to entering the stream. Water sampled in the lower reach contains less total dissolved solids than that in the upper catchment, supporting the theory that dissolved salts are not becoming more concentrated.

Understanding the weathering rate of the local basement rocks and the type of weathering patterns involved is an important feature of the research project. The granitic landscape features large amounts of outcrop with a minimum amount of regolith present. As such, potential salt storage areas are limited. Transit time in the aquifers of the catchment is typically less than two months from recharge to discharge. This short time frame hampers completion of equilibrium reactions and mobilisation of salts.

Although the alluvial material situated in the valleys slows the lateral movement of water considerably, the volume of sediments on the plain is relatively small and fresh rock occurs at a maximum of 10 m depth below alluvial cover in the lower study area. The EC of pore water indicates that the salt concentration in the alluvial sediments is extremely low (the highest pore water EC reading was only 60 µS/cm). Combined, these observations support the idea that salt is not being added locally. Further, the salt content of the granitic regolith and bedrock decreases with depth as the rock material becomes less weathered.

The likely source of the salt in Hovells Creek is from the uppermost reaches of tributary streams, because they flow through an area of subdued relief in small shallow channels on salt-bearing Ordovician metasediments. Interaction between groundwater, stream water and regolith developed on the Ordovician metasedimentary rocks provides a greater influx of salt into Hovells Creek prior to reaching the study area than the 16 km stretch of Hovell's Creek that flows through the study area.

The transition from the surface water travelling over weathered sedimentary bedrock onto fresher fractured granitic rock is a characteristic of the area and strongly correlates with the upper catchment river flow being more saline than the water in the middle catchment areas.

Current literature discusses the benefits of intercepting water in the landscape for land management benefits. Stronger emphasis must be placed on the behaviour of the regolith, as there are some catchments in which it is better practice to allow the natural drainage systems to introduce a fresh flux of water, benefiting the local and downstream catchments.

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