Current and a pre-clearing reconstruction of the water and salt balance of a wetland system using chloride, bromide, and stable isotopes in the wheatbelt, Western Australia

Lindsay Bourke[1], Ryan Vogwill[1,2] and Matt Forbes[1]

[1]Department of Environment and Conservation, [2]University of Western Australia

The clearing of native perennial vegetation has resulted in significant changes to the water balance of many wetlands throughout the Western Australian wheatbelt region, an area which is within one of the worlds 'biodiversity hotspots'. Altered hydrology creates many negative impacts including; salinisation, waterlogging, changes to the hydroperiod of wetlands, along with undesirable changes in water quality (nutrients, pesticides, etc.). This altered hydrology has resulted in impacts to biodiversity, particularly aquatic invertebrate fauna and riparian vegetation.

This study was conducted in a 1,000 ha sub-catchment in the Buntine-Marchagee Natural Diversity Recovery Catchment, located 260 km north of Perth in the Northern Agricultural Region of the Western Australian wheatbelt. The study area contains six wetlands, with distinct hydrological and hydrochemical characteristics. Wetlands located adjacent to a regional drainage channel are characterised by a shallow hypersaline watertable, while up gradient the wetlands become progressively fresher. Annual rainfall has declined considerably in the last decade; however, altered hydrology continues a trend of increased groundwater discharge from the surficial aquifer and deeper, semi-confined aquifer resulting in saturated and saline conditions across much of the sub-catchments lower lying areas.

The aim of this study was to determine the current water balance and to reconstruct a historical pre-clearing water balance for each of the six wetlands in order to understand their functioning. A three-dimensional hydro-stratigraphic model of the study area was produced by integrating lithological data from drill logs, geological mapping and remote sensing data. The evapotranspiration rates for each of the wetlands was determined using a single-stage batch evaporation model and hydraulic conductivities were derived using slug-test analysis. Groundwater, surface water and rainfall interactions were characterised using physical hydrogeological and geochemical sampling methods. This consisted of monthly sampling of groundwater, and surface water between April and November 2009, and event-based rainfall sampling over the same period. All water samples were analysed for bromide, major cations and anions and the stable isotopes $\delta^{18}O$ and $\delta^{2}H$.

Given the large salinity gradient of <250 mg/L to >250,000 mg/L TDS across the sub-catchment, watertable contours and cross sections were generated using groundwater flow and solute transport modelling incorporating the effect of variable groundwater density. Water flow and quantity were validated against geochemical tracers to ensure a unique numerical solution. This numerical analysis supports the hypothesis that the regional groundwater is diffusing as a salt-water wedge beneath the fresher surficial and semi-confined aquifers. The presence of this fresher lens is preventing discharge of hypersaline groundwater into the fresher wetland system; however, this could change for some of the sites. In contrast, the primarily saline wetland was dominated by mixing cells of hypersaline groundwater with seasonal inputs of brackish surface water.

Rainfall, groundwater and surface water fluxes within the study area showed distinct seasonal and spatial characteristics, therefore facilitating the use of hydrogeological, hydrochemical and aqueous stable isotopic data to estimate current and pre-clearing water balances. In spite of the proximity of the wetland suite to a shallow regional hypersaline groundwater system, the water balance is dominated by fresher groundwater and surface water sourced from the local sub-catchment. Waterlogging and increased salinity through increased groundwater levels and evapotranspiration rates appears the greatest contributor to the decline of the associated biota. Thus, there is potential for management intervention (such as revegetation and engineering) at the local sub-catchment scale to mitigate the threats to biodiversity assets.