Project Plan SP 2016-005

Hydrological function of critical ecosystems

Ecosystem Science

Project Core Team

Supervising Scientist	Jasmine Rutherford
Data Custodian	Jasmine Rutherford
Site Custodian	

Project status as of June 16, 2020, 9:53 a.m.

Update requested

Document endorsements and approvals as of June 16, 2020, 9:53 a.m.

Project Team	granted
Program Leader	granted
Directorate	granted
Biometrician	granted
Herbarium Curator	not required
Animal Ethics Committee	not required

Hydrological function of critical ecosystems

Biodiversity and Conservation Science Program

Ecosystem Science

Departmental Service

Service 6: Conserving Habitats, Species and Communities

Project Staff

Role	Person	Time allocation (FTE)
Supervising Scientist	Jasmine Rutherford	0.2
Research Scientist	Gavan McGrath	0.9
Research Scientist	Lindsay Bourke	0.4
Research Scientist	Bart Huntley	0.1

Related Science Projects

The overarching aims and outcomes of this project are strongly aligned with current hydrological projects being undertaken within the Wetlands Conservation Program; SPP 2014-024 and SPP 2015-01

Proposed period of the project

May 23, 2016 – May 23, 2025

Relevance and Outcomes

Background

Biodiversity conservation requires an understanding of ecological processes, including balances and fluxes of water, energy and the biogeochemistry. Where there is limited information on these processes, it is difficult to develop robust predictions on how ecosystems will respond to change and therefore develop management responses. This is of concern particularly as changes to hydrology and water quality have been identified as one of the main threats to water dependent ecosystems in Western Australia (Department of Environment and Conservation 2006), including Ramsar wetlands, recovery catchment wetlands, many Threatened Ecological Communities and other high value wetlands identified in Regional Nature Conservation Plans.

A number of frameworks have been developed to help understand the hydrological function of water dependent ecosystems. Most coarse-scale classifications broadly group ecosystems on the basis of their physical settings and type, linked to their responsiveness and dominant water source reliance (e.g. Davis et al 2013). These frameworks are an important resource that underpins broad-scale (e.g. bio-regional, state and nationwide) investigations and coarse-scale numerical models. They also assist the development of high level policies and management actions. However, to manage ecosystems at finer scales, researchers have identified a need to understand hydrological variation, in particular the vertical and lateral connectivity of water sources, sediment structure and the systems' sensitivity to change (see, for example, Grundling 2014, Kettridge et al 2014, Friedman and Fryirs 2015, Robinson et al 2015, and Marino et al. 2016).

Numerous site-specific, fine scale hydrological frameworks have also been constructed to assist in managing ecosystems at local scales and prioritising on-ground actions. Their success has been dependent on the collection of sufficient data and information that permits the development of integrated models capable of predicting hydrologic partitioning across space and time. That requires detailed spatio-temporal studies of multiple parameters, including climate, landscapes, groundwater and surface water interactions, physico-chemical hydrological variation, emerging properties and anthropogenic induced hydrological change (Richardson et al 2011, Bertrand et al 2012, Larnad and Datry 2013 and Bertrand et al 2014). Researching all ecological parameters requires the engagement of scientists from different sub-disciplines. This can be difficult to achieve and arguably has delayed the development of effective finer-scale management frameworks and research outcomes which are accessible to water and land managers. To address this global problem, a research network of *critical zone* (CZ - extending from the top of the canopy to the base of groundwater) observatories has been established in a number of countries to improve understanding and better communicate the science in the Earths' most hydrodynamic and biochemically active zone (Lin 2010 and Lin et al 2015). Researchers from different hydrology sub-disciplines are now working with physical and ecological scientists on complementary datasets to reassess hydrological process and to develop conceptual and numerical models that will help better manage this zone.

Results of the CZ research conducted to-date have significantly enhanced our understanding of connectivity (also known as coupling, with the converse being partitioning and compartmentalisation) and the physico-chemical sensitivity of CZ hydrological systems. For example, Brooks et al (2015) identified that an improved knowledge of the biogeophysical structure of the CZ helped constrain rainfall partitioning (e.g. water storages, routing and residence time), that are critical inputs to attaining robust predictive hydrodynamic climate and landuse change models. Functional biodiversity research by Kusel and others (2016) demonstrated that connectivity between the near and subsurface occurs, and can be traced vertically through changes in aquifer chemistry and microbial community compositions. They recommend future work requiring the use of specific bacteriophages (phages) as tracers to improve understanding how organisms and genetic information is transported through the CZ. Geophysical and geochemical methods have both proved successful in mapping CZ fine scale variation in water quality storages and fluxes (inferred fluxes with respect to geophysical methods) (Parsekian et al 2015 and Shand et al 2016).

The application of geochemistry and environmental tracers in mound spring environments has resolved the localised fine scale hydrochemical processes that partition different water qualities during spring water discharge and help create the unique mound spring ecosystems (Love et al 2013). Advances in numerical modelling, using Reactive Transport Models (RTMs), has followed and allowed for an improved understanding of CZ processes through developing *fit for purpose* fine-scale, process-based, models. These are capable of modelling the complexity of these natural, nonlinear coupled earth systems (e.g. suitable to model interactions among roots, micro-organisms, carbon, water, minerals, genomics, transcriptomics, proteomics, metabolomics, elemental concentration, speciation, and isotope data) and as a consequence increase confidence that modelling outputs are pertinent to the environment and can be used to develop sound management actions (Li et al 2016).

This relatively recent establishment of CZ research laboratories focused on understanding fine scale ecological processes is of great value to biodiversity researchers and managers as it confirms that local scale investigations are essential. It also provides a resource where the latest methods and published results (that deliver information on sensitive hydrological and hydrochemical parameters of different water dependent ecosystems), can be sourced. Combining this information helps fast track hydrological investigations, which is of particular benefit for hydrological work undertaken in DPaW, not least as most hydrological questions relating to water dependent ecosystems tend to arise when a change to the hydrology is proposed or under way (e.g. urban development, agriculture expansion and mining), and there is limited time and budget to undertake spatio-temporal investigations.

Aims

The overarching aim of this project is develop hydrological function investigations, at appropriate scales, of key water dependent ecosystems which improve our understanding of critical processes and provide enough information to assess their physico-chemical sensitivity and likely responses to change. This meets objectives outlined in the 2006 Department of Environment and Conservation 100-year Biodiversty Conservation Strategy for Western Australia, specifically, to maximise scientific research that improves knowledge of biodiversity and ecological processes, integrates research with management requirements and improves predictions of changes in hydrology as a threatening process.

Most proposed hydrological changes to water dependent ecosystems alter the water budget and fluxes, which have consequence for water quality and soil chemistry. To understand if the predicted changes are acceptable, information on hydrological connectivity and the physico-chemical sensitivity is required. This can be achieved within a limited time frame and budget if fine scale work is undertaken at 'type' locations. Study sites need to be selected to both optimise the transferability of hydrological results and outcomes to other areas. If the work is carried out with other DPaW officers it ensures that hydrological results are integrated with other biophysical data and information, to the benefit of the Department's stated objectives.

This is the approach currently being followed in three 'type' locations, as detailed below. This project has been developed to bring short-term hydrological function assessment studies under one umbrella project.

Walyarta (Mandora Marsh) mound springs TEC resilience study (6/2015 to 6/2017)

A change to the hydrology through increased groundwater abstraction has been identified as a potential threat to the sustainability of the Walyarta mound springs (Department of Parks and Wildlife 2016) - a State-listed threatened ecological community (TEC). This study will be carried out over two years and due to the lack of hydrological infrastructure, will focus on applying novel methods to determine the vertical hydrological connectivity of the springs with different aquifers, as well as assess vertical and lateral hydrogeochemical gradients that control groundwater and spring substrate geochemistry. Water level and quality data loggers (surface water and groundwater) will be installed at Eil Eil spring to collect high resolution data to help understand the role of the hydrology in maintaining the unique invertebrate community (Quinlan et al 2016).

Assessment of the hydrological function of the Brixton Street wetland complex (12/2015 to 6/2017)

The Brixton Street wetlands are located within the Swan Coastal Plain and contain a number of clay pans that are State and federally-listed TECs, and also contain rare and endangered flora. The number of clay pans in the Plain has greatly diminished in number, the occurrences are fragmented and the condition of many is under threat due to them being located on the margins of urban environments where anthropogenic structures have changed the volume and quality of surface and groundwater flows (Department of Parks and Wildlife 2015). This project will be carried out over eighteen months and involves an initial desktop study followed by the design of a field program with other DPaW scientists and officers to collect surface water observations and install groundwater monitoring bores to assess surface water and groundwater connectivity and quality.

Swan Estuary Marine Park - Lucky Bay hydrogeological investigation (6/2016 to 6/2017)

Recent analyses of nutrients in seagrass identified high concentrations in grasses sampled from Lucky Bay, within the Alfred Cove area of the Swan Estuary (Department of Water 2015). This report suggests groundwater is the likely source due to previous hydrogeological investigations in the 1980's discovering that groundwater nutrient concentrations in the Applecross and Attadale areas were elevated from the leakage of effluent from septic tanks, application of high levels of fertiliser and/or the leaching of nutrient rich contaminants from landfill. The area is known to contain landfill and the main aim of this project is to map the thickness of the Superficial aquifer discharging groundwater into Lucky Bay and to determine if landfill changes the direction and rates of groundwater flow and delivery of nutrients. The hydrogeological investigation will be designed in collaboration with DPaW Rivers and Estuaries scientists to ensure that data collected is aligned with the seagrass sampling sites to allow for the integration of biophysical datasets in the final report.

Future projects

A number of other projects have been identified in the Kimberley Region where we have limited understanding of the hydrological function of many water dependent ecosystems (e.g. State and federally listed monsoon vine thickets MVT and State-listed northern Kimberley mound springs TECs) (see Barrett and English in prep) in areas where there is increasing pressure on developing water and land for pastoralism, mining and energy. Objectives of new projects will vary, but the key aims will follow those addressed above; that is to develop appropriate scale hydrological function investigations of water dependent ecosystems that improve our understanding of key processes and provide enough information to assess their physico-chemical sensitivity and likely responses to change, and help guide future management.

Expected outcome

Project outputs are intended to provide a basis for more informed decision making with respect to prioritising conservation actions and assessing environmental impacts of land and water use proposals. By reducing hydrological knowledge gaps this project will help build an improved, statewide understanding of the ecohydrology of TECs, and other ecosystems under threat and their critical hydrological parameters, helping secure their future in an environment of change.

Outcomes from current projects are detailed below:

Walyarta (Mandora Marsh) mound springs TEC resilience study (6/2015 to 6/2017)

The outputs of this work will provide a basis on which to interpret the potential impacts of water resource development in the associated aquifers. The outcome will be more informed management approaches to assist in the preservation of elements of a critical ecosystem and information will be included in the recovery plan for the TEC.

Assessment of the hydrological function of the Brixton Street wetland complex (12/2015 to 6/2017)

To-date this work has seen preliminary surface water and hydrochemical data being used to develop a track remediation plan on DPaW estate and provide advice on the potential environmental impact of developing land within this locality (areas of Guildford Clay Formation on the Swan Coastal Plain). The outcome of the study will be management that will reduce the development induced environmental impacts on TECs, other significant ephemeral wetlands, and threatened flora located within the Swan Coastal Plain.

Swan Estuary Marine Park - Lucky Bay hydrogeological investigation (6/2016 to 6/2017)

The main outcome of this study will be increased confidence in the development of management actions in the Lucky Bay area of the Swan Estuary Marine Park due to an improved understanding of dynamics of the connected shallow aquifer system.

Future projects

Over time the incorporation of results from multiple projects will provide data, information and knowledge to help develop a fine scale hydrological framework that assists the management of ecosystems at local scale and the prioritisation of on-ground actions.

Knowledge transfer

Internal and external stakeholders will be identified at the inception of individual studies to ensure knowledge transfer commences at the outset, from the investigation design through to the integration with other biophysical data and information. Studies will be developed and undertaken collaboratively with a multi-disciplinary team of scientific researchers and specialists from universities, government departments and DPaW to maximise the opportunity for the publication of results and communication of outcomes.

Walyarta (Mandora Marsh) mound springs TEC resilience study (6/2015 to 6/2017)

Research results will be delivered through the production of three reports, a DPaW information sheet and a journal and/or conference publication. The latter will be produced from the third and final DPaW report which will integrate interpreted results from datasets (remote sensing data, hydrochemistry and environmental tracers and geophysics (airborne electromagnetics)) collected during the two year project. Information and recommendations will be included in the recovery plan for the TEC.

Assessment of the hydrological function of the Brixton Street wetland complex (12/2015 to 6/2017)

Investigation results will be delivered through the production of three DPaW reports and a DPaW information sheet and a conference publication. Information and recommendations will be included in future updates of the recovery plan for the claypans, and recovery plans for other TECs that occur in the Greater Brixton St Wetlands.

Swan Estuary Marine Park - Lucky Bay hydrogeological investigation (6/2016 to 6/2017)

The hydrogeological investigation results will be included in a DPaW Rivers and Estuaries report, a DPaW information sheet and a conference publication.

Future projects

It is anticipated that future hydrological function studies will produce a minimum of one DPaW report and information sheet and a conference publication. Where relevant to TECs, information and recommendations will be included in future recovery plans (eg for the North Kimberley mound springs TEC).

Tasks and Milestones

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Study design

Methodology

The overarching project aim requires that sufficient background (global, national and local) knowledge is available to investigate key processes at the appropriate scale, thereby providing information on the system function and sensitivity.

The approach for each project will initially involve a thorough review of available literature (including recent CZ research), an assessment of existing biophysical data, followed by the development, or updating, of the conceptual hydrological model to determine the key research parameters. Where further data is required, investigation(s) will be designed, in consultation with stakeholders, ensuring they match timeframes, available skillsets and budgets. Physico-chemical data collected will be interpreted to define empirical relationships and to develop conceptual models primarily for assessing hydrological connectivity (e.g. soil mineralogy and elemental relationships, moisture, bulk density and texture, water age, quality and movement). The collection of spatio-temporal data will enable the development of more complex conceptual and numerical models to assess physico-chemical sensitivity.

This methodology is being observed in the two current projects detailed below. Both projects have completed the data collection phase, and the data interpretation phase has commenced.

Walyarta (Mandora Marsh) mound springs TEC resilience study (6/2015 to 6/2017)

A review of relevant literature has been completed, with the investigation scale and key research issues identified. Data acquisition, processing and interpretation of multi-temporal remote sensing data has been completed, and relevant hydrochemistry and environmental tracer data required were determined. Other major tasks undertaken have involved the reprocessing and interpretation of geological information resolvable in geophysical (airborne electromagnetic) data, and the conduct of two field programs to collect mound spring hydrochemistry and environmental tracer data. The November 2016 field program also involved installing water level and quality data loggers (surface water and groundwater) at Eil Eil spring to collect high resolution temporal data to help understand the role of the hydrology in maintaining the unique invertebrate community (Quinlan et al 2016).

Assessment of the hydrological function of the Brixton Street wetland complex (12/2015 to 6/2017)

A literature review/desktop study and data sourcing project was undertaken and a strawman conceptual hydrological model developed. An investigation was then planned in consultation with internal stakeholders to align a planned surface water and groundwater monitoring program with areas associated with threatened flora. Surface water observation sites and groundwater monitoring bores were installed to assess surface water and groundwater connectivity. Connectivity will be assessed through an interpretation of surface water levels, regolith-soil chemistry and high resolution groundwater level data from data loggers.

Future projects

It is envisaged that each hydrological function project will follow a similar approach to that detailed above. Knowledge gained over time will feed back into projects and improve the methodology and subsequent outputs and outcomes.

Biometrician’s Endorsement

granted

Data management

No. specimens

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

not required

Data management

It is planned that all data collected in individual projects will be provided to internal and external stakeholders and will be uploaded onto the Department of Parks and Wildlife Data Catalogue and archived for future investigations

Budget

Consolidated Funds

Source	Year 1	Year 2	Year 3
FTE Scientist	0.4	0.4	
FTE Technical			
Equipment			
Vehicle			
Travel			
Other			
Total			

External Funds

Source	Year 1	Year 2	Year 3
Salaries, Wages, Overtime		3 000	
Overheads			
Equipment			
Vehicle	2 000		
Travel	5 000		
Other	53 000	77 000	
Total	60 000	80 000	