Australia's National Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Progress report

Decision support framework for future groundwater development scenarios in the southeast South Australia

Progress against project milestones

Progress against milestones/tasks are approved by the GISERA Director, acting with authority in accordance with the GISERA Alliance Agreement.

Progress against project milestones/tasks is indicated by two methods: Traffic light reports and descriptive Project schedule reports.

1. Traffic light reports in the Project Schedule Table below show progress using a simple colour code:

- **Green**:
  - Milestone fully met according to schedule.
  - Project is expected to continue to deliver according to plan.
  - Milestone payment is approved.
- **Amber**:
  - Milestone largely met according to schedule.
  - Project has experienced delays or difficulties that will be overcome by next milestone, enabling project to return to delivery according to plan by next milestone.
  - Milestone payment is withheld.
  - Milestone payment withheld for second of two successive amber lights; project review initiated and undertaken by GISERA Director.
- **Red**:
  - Milestone not met according to schedule.
  - Problems in meeting milestone are likely to impact subsequent project delivery, such that revisions to project timing, scope or budget must be considered.
  - Milestone payment is withheld.
  - Project review initiated by GISERA Director.

2. Progress Schedule Reports outline task objectives and outputs and describe, in the ‘progress report’ section, the means and extent to which progress towards tasks has been made.

Project schedule table

TASK NUMBER	TASK DESCRIPTION	SCHEDULED START	SCHEDULED FINISH	COMMENT
1	Stakeholder workshop	Jul-20	Sept-20	Completed
2	WAVES modelling	Oct-20	Apr-21	Completed
3	Integrated analysis of groundwater with water-energy-carbon balance	Apr-21	Aug-21	Completed
4	Propagation of uncertainty through the model chain	Jun-21	Dec-21	Completed
5	Scenario analysis and optimisation	Oct-21	Feb-22	Completed
6	Multi Criteria Analysis workshop	Jan-22	Jun-22	Completed
7	Final Report, Knowledge transfer, Journal paper	Mar-22	Aug-22	Completed

Project schedule report

TASK 1: Stakeholder workshop and scenario elicitation

BACKGROUND

A stakeholder workshop will be conducted at the start of the project with key stakeholders identified from the Government, Industry and other relevant stakeholders to discuss the overarching goals of the project and intended outcomes. The stakeholder workshop will facilitate an initial elicitation of scenarios, including climate and other developmental scenarios of future groundwater use for agriculture and other industrial purposes in the southeast including those that the stakeholders consider as potential responses to climate change

TASK OBJECTIVES

Establish the project commencement and elicit the scenarios

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

List of scenarios to be modelled

PROGRESS REPORT

The stakeholder workshop was held on 6th November 2020. Stakeholders and CSIRO SA staff attended the workshop in person at Chardonnay Lodge in Penola and interstate participants joined through videoconferencing facility. A total of 15 people including stakeholders from the community, academia, Government, and relevant industries attended the workshop. Project team presentations provided overview of the objectives and scope of the project as a research exercise that integrates biophysical scenario analysis with participatory multi-criteria analysis to provide a valuable tool that can be used for exploring and informing stakeholder perspectives for groundwater management and decision making. Stakeholder presentations provided an overview of the industry insights about groundwater management in the region. Discussions focussed on opportunities for scenarios of groundwater development and management and potential criteria that could be used for the MCA. Notes from the workshop were collated and shared with all participants. This milestone is now complete

TASK 2: Simulation of water-energy-carbon balances for future climate scenarios using WAVES model

BACKGROUND

The WAVES model (Zhang et al, 1996) will be used for the simulation of the vertical movement of water in the soil column under the influence of energy-water balance and dynamic plant growth resulting in groundwater recharge. An important advantage of the WAVES model is the ability to couple the energy-water-carbon balances. This enables the model to simulate Carbon assimilation and respiration from roots, stems and leaves using an empirical representation of the vegetation response allowing the leaf area to change dynamically with environmental conditions like soil moisture, solar radiation, and atmospheric temperature.

TASK OBJECTIVES

Simulation of water-energy-carbon balance for the southeast SA using Waves model

TASK OUTPUTS AND SPECIFIC DELIVERABLES

WAVES model outputs

PROGRESS REPORT

This milestone is complete.

The WAVES modelling for the southeast was completed. The WAVES model developed can simulate the water, energy and carbon dynamics above the land surface and is a critical component for assessing the water balance for current and future climatic conditions. In the following tasks, this model will be used in conjunction with a groundwater model for investigating the land surface and groundwater balance in the southeast region. The model set up can be used for investigating changes in recharge and consumptive use and its impacts on groundwater balance. The scenarios for simulation of these water balances have been shortlisted based on the stakeholder discussions undertaken as part of the initial project workshop.

TASK 3: Integrated water-energy-carbon and groundwater balance analysis

BACKGROUND

Groundwater recharge rates and evapotranspiration will be quantified in conjunction with the simulation of groundwater levels and fluxes using the groundwater model. A novel algorithm and workflow will be developed and tested in this study for computationally efficient characterization of the dynamic interaction of water-energy-carbon balances in quantifying climate impacts of groundwater balance. The method will use, as its basis, the WAVES model (Zhang et al, 1996) and the net recharge package for MODFLOW developed in CSIRO (Doble et al, 2017, Doble et al. 2009). Computational efficiency in modelling the dynamic linkage between net recharge and groundwater balance will be achieved by using the look-up table approach developed for the netR package

TASK OBJECTIVES

Integrated analysis of groundwater balance together with water-energy-carbon balance

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Finalized workflow for simulation model, algorithms, computer programs; Chapters 1,2 and 3 of the report

PROGRESS REPORT

This milestone is complete.

The integrated modelling method and implementation is now documented in chapters 1, 2 and 3 of the draft report. The WAVES model and netR package development is complete and is documented in chapter 3of the draft report. The groundwater model set up using the netR package and future climate outputs from WAVES models is documented in chapter 4.

Task 4: Propagation of uncertainty through the model chain

BACKGROUND

Calibration and uncertainty analysis will be undertaken simultaneously for the model suite in such a way that parameters that influence the net recharge and hydraulic properties that affect groundwater levels and fluxes will be simultaneously estimated to ensure that observed and forecast trends in water-energy-carbon balances are maintained while the estimated future groundwater levels are also accounted and honored when estimating revised net recharge. The groundwater flow models available from SA Department of Environment and Water and/or CSIRO (GISERA project W14) will be used for this purpose. Formal uncertainty analysis will be undertaken to quantify both the hydrological uncertainty and the deep uncertainty caused by significantly diverse climate outcomes.

TASK OBJECTIVES

Quantifying the climate impact and hydrological uncertainties

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Posterior distribution of parameters and state variables for use in scenario analyses

PROGRESS REPORT

This milestone is complete.

Propagation of uncertainty through the model chain has been completed. The Waves model outputs were linked to the MODFLOW model through the netR package and calibration and uncertainty analysis of the MODFLOW model including the netR parameters were undertaken using the PEST-Iterative Ensemble Smoother framework implemented in PEST++. A large ensemble of posterior parameter set comprising ~450 parameter fields that provided improved match to the calibration objective function to match observed groundwater heads and drain fluxes. The resultant ensemble of parameter sets were used for undertaking scenario analyses.

TASK 5: Scenario analyses and optimisation

BACKGROUND

The revised rates of groundwater recharge, evapotranspiration (and hence the net recharge) will be estimated for a range of selected climate and developmental scenarios and used in conjunction with the groundwater model to estimate plausible states of future groundwater balance. Scenarios other than climate may include plausible developmental scenarios for agriculture and industry and potential coordinated response to hydrological impacts of climate change. All selected scenarios will be used to estimate changes in groundwater levels, flows and water balance components for the selected aquifer. An optimisation model will be developed to investigate optimal groundwater management for chosen scenarios.

TASK OBJECTIVES

Quantify the groundwater response to scenarios

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Groundwater levels and water balance components for selected scenarios; chapter 4, 5 of the report

PROGRESS REPORT

This task is completed. The numerical groundwater was calibrated to obtain an ensemble of optimized model parameters including for the netR package simulating climate change effects on net recharge in the study area. Optimized posterior parameter sets were used for scenario simulation. Nine different scenarios comprising combinations of climate and pumping scenarios were simulated.

TASK 6: Multi Criteria Analysis

BACKGROUND

Multi-criteria Analysis offers a decision support methodology that is primarily used to rank or select options from a given portfolio of alternatives based on an assessment of how they would perform according to a range of relevant criteria and assumptions. Hydrological, socioeconomic and environmental sustainability criteria will be selected, then weighted by stakeholder participants in order to assess development scenarios comprising three combinations of groundwater use for onshore gas, forestry and irrigation uses. This final task will result in at least three selected scenarios of development, the corresponding groundwater balance and dynamics and stakeholder evaluation of these scenarios in terms of hydrological socioeconomic and environmental sustainability criteria.

TASK OBJECTIVES

Undertake multi-criteria analysis

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Participatory MCA workshop and chapter for the final report

PROGRESS REPORT

This task is complete. The workshop was undertaken on 29th June 2022. Given the nature of the scenarios developed dominated by climate change and associated changes in groundwater use, the workshop methodology focussed on groundwater management objectives and actions for climate change adaptation instead of the multi-criteria analysis approach that was originally planned. The chapter corresponding to the workshop and analysis of the identified objectives/actions is included in the draft final report provided. The final report will be delivered after peer reviewed by 1st week of October as the last milestone of the project.

Task 7 TASK NAME: Final report, Knowledge transfer and Journal papers

TASK LEADER: Sreekanth Janardhanan and Rebecca Doble

OVERALL TIMEFRAME: March-August 2022

BACKGROUND: Consolidate the developed methodology for integrated modelling analysis in the final report and a high-ranking international journal paper.

TASK OBJECTIVES: Dissemination of the scientific method and key findings

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Final report, knowledge transfer workshop completed.

PROGRESS REPORT

The final report titled *Groundwater in the South East SA under climate change: scenario modelling and stakeholder perspectives of impacts, adaptation and management* has been publicly released and is available on the GISERA website.

Variations to Project Order

Changes to research Project Orders are approved by the GISERA Director, acting with authority, in accordance with the GISERA Alliance Agreement. Any variations above the GISERA Director's delegation require the approval of the relevant GISERA Research Advisory Committee.

The table below details variations to research Project Order.

Register of changes to Research Project Order

DATE	ISSUE	ACTION	AUTHORISATION

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GISERA is a collaboration between CSIRO, Commonwealth and state governments and industry established to undertake publicly-reported independent research. The purpose of GISERA is to provide quality assured scientific research and information to communities living in gas development regions focusing on social and environmental topics including: groundwater and surface water, greenhouse gas emissions, biodiversity, land management, the marine environment, and socio-economic impacts. The governance structure for GISERA is designed to provide for and protect research independence and transparency of research.