ICE WaRM
International Centre of Excellence in Water Resources Management

THE AUSTRALIAN WATER PARTNERSHIP

Proposal
NHP (India) Capacity Development in Groundwater Management
June 2018

Executive Summary

This proposal offers Australia's expertise in groundwater management to the Government of India through the National Hydrology Project (NHP). Key features of this proposal are:

1. Three introductory courses in Groundwater Management are proposed, with a technical and management focus, with participants from the States' mid-level professionals
2. Each course would comprise approximately 20 participants each
3. Participants would be mid-level water professionals with around 10 years' experience in groundwater, drawn from State Government departments
4. Training would be conducted in NWA Pune, CGWB Faridabad and NGWRI Raipur
5. Each training course to run for approximately 1 week
6. Each course would include an assessment
7. The best 5 participants (measured by the assessment) from each course would qualify for a follow-up course in Australia
8. The Australian training would be 2 weeks in duration and provide more advanced technical content and also more management / planning content.
9. Graduates would be called "AWP Fellows" who would form an Alumni with ongoing support (eg online learning / support tools)

This proposal is seen as an initial way to get started with training / capacity building and foreshadow a larger programme in broader topics and more diverse target audiences.

Outcomes of the proposed training programme are:

- 60 water professionals receive a broad and rigorous understanding of groundwater management
- 15 high-achieving water professionals receive advanced knowledge and skills in groundwater management
- Strong alumni links are established between Australian and Indian water professionals on which to build future collaboration

Note: these numbers can be changed according to requirements, and courses may be repeated in subsequent years as required, subject to evaluation feedback from year 1 courses.

Background and Context

The National Hydrology Project (NHP) is third in a series of projects under the Indian Ministry of Water Resources supported by the World Bank. The project will include four components: (A) Water Resources Data Acquisition System; (B) Water Resources information system; (C) Water Resources Planning and Operations; and (D) Institutional Capacity Enhancement.

The development objective of the NHP is to improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of targeted water resources management

institutions in India. In this project, there is a strong need to build capacity in Indian water sector, for professionals and their institutions. The NHP Management Unit has invited the Australia, through the Australian Water Partnership (AWP), to provide a proposal for capacity building work under the NHP.

To explore the potential scope of the required capacity development, AWP requested ICE WaRM to conduct a workshop at the National Institute of Hydrology Roorke, India on 29 June 2017. This workshop involved key Australian water sector representatives, and key officials from the Indian water sector and the education and training sector in India. The aim of the workshop was to commence the development of a framework for capacity development in collaboration with the NHP Management Unit, representatives of the World Bank, DFAT (including Post, South & West Asia Division), Indian education and training providers, AWP partners and Australian providers of education and training in the water sector.

A further meeting was held in New Delhi on September 5, 2017 between the Ministry of Water Resources, River Development and Ganga Rejuvenation, the World Bank, AWP and ICE WaRM, whereby it was agreed that a proposal should be developed in direct response to the above requirements.

Subsequent discussions between AWP and NHP have indicated that an appropriate starting point would be a proposal for an initial training programme in groundwater management. AWP has requested ICE WaRM to put forward this proposal to meet that need.

The proposal

AWP and ICE WaRM have drawn on Australian extensive expertise in the conjunctive management of water resources and groundwater technologies to develop this proposal. Key agencies which will be directly involved are the National Centre for Groundwater Research and Training (NCGRT), Western Sydney University and the CSIRO.

Based at Flinders University, NCGRT was established with 12 partner universities, numerous government and industry partners, and formal linkages with some of the world's leading groundwater research organisations. Led by Professor Craig Simmons, the NCGRT has brought together nearly 200 Australian and international researchers to pool their knowledge and expertise. Professor Basant Maheshwari of Western Sydney University provides leadership in groundwater management with a strong focus on governance and community based approaches, such as Managed Aquifer Recharge through Village-level Intervention (MARVI). CSIRO provides leading-edge research expertise in groundwater science, particularly in the areas of aquifer connectivity, conjunctive use, characterising groundwater assets, environmental tracers in aquifers and climate change impacts on groundwater reserves.

The training courses in this proposal will be presented by leading researchers and practitioners in groundwater management. The NCGRT offers a very successful 5-day course, known as the Australian Groundwater School, which would be adapted for delivery in India. An outline of the content of this course, as it is offered in Australia, is in the Appendix. The Australian Groundwater School is considered vital for Australian professionals working with groundwater. It is the premier course of its type in Australasia, and provides participants with a broad but rigorous introduction to

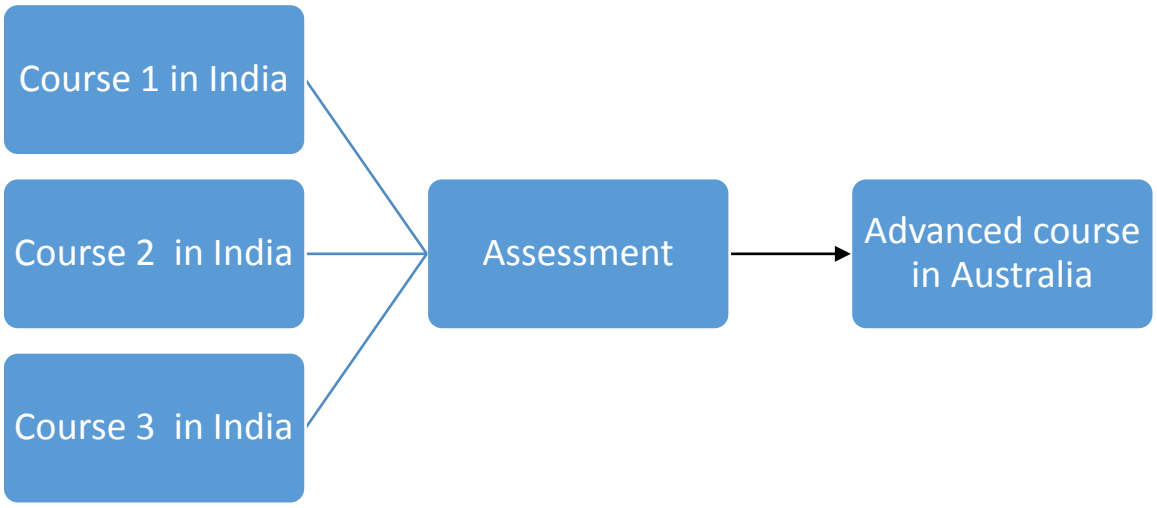
groundwater. It provides an ideal basis for developing groundwater expertise in Indian water professionals.

An initial offering of the above 5-day course in Groundwater Management is proposed, to be delivered in on 3 separate occasions in different locations to assist access. Initially it is proposed to offer these courses at NWA Pune, NIH Roorkee and NGWRI Raipur, but this is open for discussion. It is proposed that each institute host one course, with the host institute providing the training venue, with the cost of cost of trainers and logistics to be borne by NHP-NPMU. AWP will design the course and provide suitable trainers. If these institutes do not have appropriate hostel facilities, then it is recommended that they source hotel accommodation which can also be used as the training venue. The cost of accommodation of trainers, travel cost of trainers and venue costs will be provided by NHP-NPMU.

Each course would be designed to cater for 20 participants, to allow maximum interaction and learning efficacy. Participants would be mid-level water professionals with at least 10 years' experience in groundwater, drawn from State Government departments. It is not intended that this course provide a comprehensive coverage of all topics, but rather to provide an overview of the topics in a way that will bring all participants us to a common level that will prepare them for more advanced study.

Thus, after these courses were run, a total of 60 graduates will be available. These graduates will then have a solid and broad understanding of groundwater management. At the conclusion of the course, a formal assessment (examination) will be administered to assess the learning of the participants. From the 60 graduates, the top-scoring 15 participants will be eligible for an advanced training course, to be conducted in Australia.

The advanced course in Australia for 15 participants would be 2 weeks in length and provide more advanced learning in hydrogeology, assessment methods, managed aquifer recharge, management and governance including participatory methods, provide access to a wide range of Australian groundwater researchers and professionals, and include the opportunity put theory into practice, visiting field sites in Australia. The connection of the 3 introductory courses and the advanced course in Australia is shown below.



Course 1: Proposed date – 10-14 September 2018

Course 2: Proposed date – 17-21 September 2018

Course 3: Proposed date – 24-28 September 2018

The advance course in Australia will be organized in late October or early November 2018.

Graduates of the Advanced course would be awarded a certificate of achievement and be denoted "AWP Fellows". The Fellows would comprise an alumni group who, with their advanced knowledge, could act as specialist resources for their respective departments on their return to India. ICE WaRM would provide ongoing support to the Fellows with online webinars and peer support.

Budget

		$AUD
3 Introductory courses in India (1 week each)	Logistics for introductory courses (liaison with Indian logistics, arrangements for Australian presenters, etc)	3,000
	Course design and delivery arrangements	12,000
	Recruitment and fees of Australian course presenters	75,000
	Travel, accommodation and living expenses of Australian Presenters	42,000
	Assessment of participants and invitations to advanced course	18,500
Total cost of Indian component: $AUD150,500 Note: costs of venue, meals and accommodation in India for participants are not included.		
Advanced course in Australia (2 weeks)	Logistics and course management	15,000
	Course design and delivery arrangements	45,000
	Recruitment of Australian course presenters	3,000
	Travel, accommodation and fees of Australian Presenters	55,000
	Travel, accommodation and living expenses of Indian participants	57,700
	Ongoing online learning and support	10,000
Total cost of Australian component: $AUD 185,700		

Total cost of proposal: $AUD 336,200

Appendix

Draft content outline of 5-day groundwater course – to be adapted for the Indian setting

Day 1

	THEME/TOPIC **Surface Water – Groundwater Interactions & GDEs**
	Welcome and Introduction
1	**Surface Water – Groundwater Interactions** • Introduction to surface water hydrology • Locations and modes of interaction between surface water and groundwater • Principles of conjunctive water management • Baseflow
2	**Surface Water – Groundwater Interactions** • Water balance • Canal leakage • Human impacts • Recharge/discharge definitions and estimation
	Morning Tea
3	**Surface Water – Groundwater Interactions** • What is salinity and why is it a groundwater issue • Primary and secondary salinity & its sources • Dryland and Irrigation salinity, water logging • Impacts and management of salinity
	Lunch
4	**Groundwater Dependent Ecosystems** • Introduction and definition • Types of GDEs • Hydrogeological framework • Ecological impacts
	Afternoon Tea
5	**Groundwater Dependent Ecosystems** • Methods and indicators used in the determination of GDEs • Level of dependency
	Overview session
	End Day 1

Day 2

	THEME/TOPIC Introduction to Managed Aquifer Recharge (MAR)
6	**MAR Setting** • Introduction to Managed Aquifer Recharge (MAR) • MAR Case Studies - Australia & International. • Siting and establishing a MAR project
	Morning Tea
7	**MAR uses** • Drinking Water • Storm Water • Components of MAR projects
	Lunch
8	**MAR implementation** • Reclaimed Water • Siting of projects • Risk assessments for aquifer replenishment • Hydraulic characteristics of aquifers
	Afternoon Tea
9	**MAR impacts** • Water quality requirements and treatments • Clogging and its management Ongoing management of MAR • Recovery efficiency • Social / policy / regulatory aspects
10	**Implications of MAR projects** • Geochemical compatibility • Economics of MAR • Fate of pathogens and organics • Step by step implementation of MAR
	End Day 2

Day 3

	THEME/TOPIC Introduction to Groundwater Modelling
11	**Groundwater Modelling** • What is a model and what is its purpose? • Modelling groundwater flow • Modelling process • Groundwater modeling codes
12	**Groundwater Modelling Application** • Modelling guidelines • Limitations and pitfalls in modelling • Modelling case study • Management, regulatory issues
	Morning Tea
13	**Groundwater Modelling Tutorial** • Simple 2D Model
14	**Groundwater Modelling Tutorial** *(continued)* • Simple 2D Model
	Lunch
15	**Groundwater Modelling Practical** • Attendees to bring along their own Practical project from work in which they are currently engaged.
	Afternoon Tea
16	**Groundwater Modelling Practical** *(continued)* • Attendees to bring along their own Practical project from work in which they are currently engaged.
17	**Groundwater Modelling Practical** *(continued)* • Attendees to bring along their own Practical project from work in which they are currently engaged.
	End Day 3

Day 4

	THEME/TOPIC Groundwater Chemistry, Pollution, Remediation
18	**Groundwater Chemistry** • Why study groundwater chemistry? • Physical and chemical composition of GW • Origin of solutes, evolution in groundwater • Field parameters
19	**Environmental Isotopes in Groundwater** • What are isotopes and their use? • Types of isotopes • Indian examples
	Morning Tea
20	**Groundwater Microbiology** • Introduction to microbiology • Pathogens in groundwater • Microbial metabolism in groundwater • Bioremediation
21	**Groundwater Contamination** • Introduction and definitions • Sources of contamination
	Lunch
22	**Groundwater Contamination** • Fate of contaminants in the sub surface • Groundwater remediation
	Afternoon Tea
23	**Groundwater Contamination & Remediation: Case Studies** • India
23	**Groundwater Contamination & Remediation: Case Studies** • Internationally
	End Day 4

Day 5

	THEME/TOPIC Groundwater Management and Governance
24	**Groundwater Management** • What, why, when and how we manage groundwater? • Principles • Community centric approaches to groundwater management
25	**Groundwater Management** • Tools for groundwater management • Management issues
	Morning Tea
26	**Groundwater Management** • Climate change
27	**Groundwater Governance – Water Law** • Development of water resources law in India • Development of water resources law in Australia
	Lunch
28	**Groundwater Governance – Water Law** • Essential aspects of the current legal framework in India • Groundwater and water trading
	Afternoon Tea
29	**Groundwater Governance – Case Studies**
30	**Final examination (1 hour)**
	End Day 5 END of COURSE

Draft content outline of 10-day advanced groundwater course – to be adapted for the Indian setting

Week 1 – Managed Aquifer Recharge (MAR)

This course will increase participants understanding of the issues involved with injecting water into aquifers for storage and reuse.

It will also address the practical steps of siting, designing, and implementing projects, from commissioning to operation and maintenance.

MAR can:

- provide the cheapest new source of water
- provide low cost delivery
- offset the costs of the sustainable return of treated wastewater to the environment
- offset the costs of detention storages for flood protection in urbanising catchments
- put wastewater to productive use
- replenish depleted aquifers
- develop emergency water supplies
- protect aquifers from saline intrusion

Local regulators and water resource managers will provide advice on MAR requirements as they are implemented in Australia, and discussion will focus on the relevance and transferability to the Indian context.

Topics

1. Introduction to Managed Aquifer Recharge (MAR)
2. MAR Case Studies - Australia & International.
3. Siting and establishing a MAR project
4. Drinking Water
5. Storm Water
6. Components of MAR projects
7. Reclaimed Water
8. Siting of projects
9. Risk assessments for aquifer replenishment
10. Hydraulic characteristics of aquifers
11. Water quality requirements and treatments

12. Clogging and its management Ongoing management of MAR
13. Recovery efficiency
14. Social / policy / regulatory aspects
15. Geochemical compatibility
16. Economics of MAR
17. Fate of pathogens and organics
18. Step by step implementation of MAR

Expected Outcomes

At the completion of the course participants will:

- be able to identify opportunities for use of MAR methods within their organisations
- know how to assess the viability of an MAR project
- understand the key issues in designing and implementing an MAR project
- know the public health and environmental requirements where MAR is practised
- be fully aware of best practice in MAR projects
- understand the impact of MAR projects for catchments and groundwater management

Week 2 - Soil and Groundwater Pollution Module
Monitoring, Characterisation, Remediation & Risk Management

The module is principally aimed at groundwater consultants, engineers, project managers, and regulatory/compliance officers in the public and private sectors. A basic understanding of the principles of groundwater flow is desirable. However, the module introduces all the required concepts pertaining to Soil and Groundwater Pollution from first principles.

Module Description
Industry and government are struggling with issues related to contaminated land and water resources. Recent initiatives have highlighted a risk-based approach for defining optimum remediation options for subsurface contamination. The prime objective of this module is to provide understanding of the important facets of subsurface pollution. The module will review the fundamentals of groundwater hydrology, contamination mechanisms of soil and groundwater and the implications of contamination. The state-of-the-art in contaminant hydrology will be explored through the use of case studies. Module content will thoroughly cover remediation with focus on the most important methodologies for the various contamination types and phases. The presenters will teach correct methods to collect hydrogeochemical data, and look at advanced characterisation in three-dimensions. Attendees will be led through the process of selecting and designing remediation systems based on geological, chemical, and biological factors, as well as an in-depth study of the integration of risk into the remediation process. This specialist module offers excellent teaching on contaminant investigation and remediation, by eminent presenters and organisations.

Module Outline
Fundamentals of Hydrogeology and Contamination

- Important concepts in contaminant hydrogeology
- Fate and transport of dissolved contamination
- DNAPLs in the subsurface
- LNAPLs in the subsurface
- Groundwater plumes in the subsurface
- Microbiological contaminants, metals (e.g. Fluoride, arsenic)
- Organic geochemistry
- Inorganic geochemistry
- Field methods to determine remediation design hydraulic parameters
- Monitoring methods

Remediation of Groundwater

- Bioremediation: Pathways, stoichiometry, reaction kinetics
- Mobilisation issues (natural and anthropogenic)
- Engineering design for bioremediation
- Modelling for bioremediation
- Monitored natural attenuation
- Pump and treat systems
- Factors controlling the performance of pump and treat
- Assessing capture zones
- Case histories

Remediation of Soil and Vapour

- Methods to address inorganic contamination
- Vapour extraction systems, vacuum enhanced systems
- Practical design and operation of soil vapour extraction systems
- Thermal technologies
- In-situ and ex-situ treatment technologies
- Case histories

Source Zone Remediation

- Zero valent iron barriers
- Nano-scale zero valent iron
- Use of surfactant flooding, water flooding, and alcohol flooding
- Thermal technologies for NAPL removal
- Oxidation and reduction approaches

Risk Assessment, Legislative Considerations, Case Studies and Practical Experience

- Advanced 3D site characterisation field methods
- Case Study: The importance of the Site Conceptual Model
- Case Study – The process of remedial investigation and remediation feasibility – flux based approaches for remediation

Expected Outcomes

- Become aware of up-to-date techniques for investigation of subsurface contamination and potential impacts
- Receive a firm guide on the basis and approach to assessment of risk from contamination of soil and groundwater
- Be exposed to national and international experience with a range of in-situ and ex-situ remediation techniques for organic and inorganic contamination
- Become aware of societal issues relating to contaminated sites and their remediation