Collaborative Water Planning: Howard East Water Planning Project Final Report

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Executive Summary

The ‘Collaborative Planning Tools’ project was undertaken in rural Darwin, Northern Territory between August 2008 and October 2009, as one of two prospective case studies for the Tropical Rivers and Coastal Knowledge (TRaCK) research hub. This case study, trialled two planning tools: an extended stakeholder analysis and a participatory Groundwater Visualisation Tool (GVT), in full consultation with the rural Darwin community. It contributes to best practice guidelines for national collaborative water planning drawn from the outputs of a desktop review and two retrospective case studies conducted in Queensland and Western Australia.

The case study aimed to supporting the Howard East water allocation planning process in rural Darwin, Northern Territory, Australia. The main objective of this study was to develop planning tools to assist the government agency responsible for water planning, the Department of Natural Resources, Environment, the Arts and Sport (NRETAS), to identify local stakeholders directly impacted by local planning processes and to better understand their needs and interests. A further aim was to develop a collaborative planning tool to prepare and engage stakeholders to participate in the public planning process. This report is therefore useful for water planners and researchers interested in the design and application of collaborative planning tools in local communities new to water allocation planning. Its findings are also relevant for water planners and researchers interested in community engagement, as a number of strategies for engagement are trialled and evaluated.

Five main activities were undertaken in the Howard East. Broadly, these were:

1. Determining which stakeholders were directly and indirectly affected by local water planning processes.
2. Identifying stakeholder issues of concern, knowledge about groundwater resources, capacity to participate in a public water planning process and preferences for engagement and communication. (Stakeholder analysis).
3. Testing and adapting findings from the Extended Stakeholder Analysis.
4. Selecting a tool to facilitate public participation in local water planning processes.
5. Developing a groundwater visualisation tool of the Howard East Aquifer in full consultation with the Howard Springs community.

Each step involved extensive consultation and community participation to maximise social learning outcomes and ensure that local hydrological knowledge contributed to the project aims. An extended stakeholder analysis was undertaken firstly to identify local stakeholder groups affected by planning and secondly to articulate their needs for participating in planning processes, their concerns about groundwater management and preferences for ongoing agency engagement. Findings showed that the preferred modes of communication within the community were face to face, such as public meetings, workshops and participatory mapping exercises, or web based being dedicated websites, electronic project newsletters, posters and information packages. Local media were also very useful for promoting case study

findings to the broader public. Information obtained from the extended stakeholder analysis was used in the selection of the second tool.

The GVT was developed through a research collaboration between NRETAS, Power and Water Corporation, CSIRO, Griffith University and the Queensland University of Technology between February and September 2009. The GVT was selected to address a number of stakeholder needs that were identified in the stakeholder analysis. These needs reflected a widespread lack of understanding of groundwater systems and processes within the community, leading to misconceptions about the management, extraction amounts and origins of local groundwater resources. When coupled with other findings, such as a legacy of mistrust of government-driven planning processes to manage groundwater resources, these attitudes were found to impact on the willingness of local stakeholders to engage in forthcoming water planning processes.

The GVT was developed to become an educational tool with full consultation with the Howard Springs community who rely on the Howard East aquifer. Through community meetings, stakeholder workshops, bore surveys and participatory mapping exercises, members of the community were encouraged to contribute information for the visualisation tool and participate in several meetings with researchers. As a result, the GVT contained information from a wide range of sources, drawing on bore monitoring data from NRETAS, industry groups as well as local land care groups, bore drillers, council members and community members with significant expertise. Project newsletters, information kits and community meetings kept the broader community informed of progress at all stages of the tool development. In addition, selected stakeholders were also offered an opportunity to give feedback on the utility of the visualisation in workshops held at CSIRO when it was 70% complete.

The final GVT was presented to the Howard East community in a public forum in early September 2009. At this meeting, the GVT was made freely available to the community. A training session was also offered to NRETAS agency staff and representatives from local government, Shire Councils, Landcare groups, industry groups, schools, universities and bore drillers. CDs housing the GVT application and training manuals were given to participants and made available for uploading onto community websites. In all cases, trainees nominated themselves as community volunteer focal points for others to seek assistance while learning to use the application.

Finally, the extended stakeholder analysis and GVT was evaluated with stakeholders and NRETAS staff through staged evaluative surveys, specialised meetings and a focus group. Results showed that the majority of participants considered the GVT to be of use in improving the ability of the community to make informed decisions about groundwater management. Further, the independence of the GVT constructed by Queensland University of Technology, the treatment of NRETAS staff as equal to other stakeholders and the involvement of stakeholders throughout its development increased the perceived public ‘trust’ of the model accuracy and improved the willingness of the public to utilise it.

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Table of Acronyms

GVT	Groundwater Visualisation Tool
HEWAC	Howard East Water Advisory Committee
NTCA	Northern Territory Cattlemen's Association
NTHA	Northern Territory Horticultural Association
NRETAS	Department of Natural Resources, Environment, The Arts and Sport

1. Background

1.1 Project scope

The ‘Collaborative Water Planning’ project is funded through TRaCK – the Tropical Rivers and Coastal Knowledge research hub. The project aim is to improve public participation in water planning for Australia’s tropical north. Findings from the project will assist water agencies to improve planning approaches by minimising conflicts between parties; providing models and case studies for good collaboration; and by helping build stronger, long term relationships between stakeholders.

Currently in its ‘second phase’, the project has developed and piloted planning tools that enhance community participation in water planning, as provided for under the National Water Initiative. This flows directly from work undertaken in the project’s ‘first phase’ which reviewed existing knowledge and previous water planning processes, to identify best practices for successful public participation in water planning. The work, including a comprehensive Literature Review, a Legal and Policy Analysis and two retrospective evaluations of planning experiences in Northern Queensland and Western Australia, laid the conceptual framework for undertaking the prospective case study described in this report.

Two water planning processes, one in the Northern Territory and one in Far North Queensland, were chosen as case study sites for trialling the planning tools for the second phase of the project. The research approach was influenced by Participatory Action Research (PAR) to maximise the social learning generated in both trials, and build in pathways for flexible involvement from the community at each stage of the research process.

In the Northern Territory, the Howard East water allocation planning process was selected as a case study site and a Memorandum of Understanding signed between staff from the Water Resource Management Branch of the Department of Natural Resources, Environment, the Arts and Sport (hereby known as NRETAS) and the project team, based at Griffith University and CSIRO in Darwin. An initial expectation of the collaboration was for the project to work closely with members of the Howard East Water Advisory Committee and water planning staff to support their efforts to engage the broader community in water planning. A number of delays caused the water allocation planning process to take far longer than anticipated and, at the time of writing, an Advisory Committee had not been convened.

Nonetheless, over the course of fifteen months, the project team worked closely with NRETAS staff, representatives from local stakeholder groups and members of the broader public to trial, promote and evaluate two planning tools: an extended stakeholder analysis and a GVT.

1.2 Profile of the Howard East study area[1]

The Howard East bore field is a geographically small, yet high yielding aquifer that is located approximately 20 kilometres from Darwin and Palmerston cities. Its groundwater provides for peri-urban communities in Howard Springs, Humpty Doo and Girraween lagoon areas, as well as 97% of the Northern Territory's horticultural and vegetable industries (NRETAS 2008b). In addition, it supplies 15% of Darwin's town water (Power Water 2009). Its boundaries can be seen in Figure 1.

The hydro geological framework of the Howard East is dominated by dolomite, shale, sandstone and schist (Haig and Townsend 2003). The two main aquifers, include an upper cretaceous aquifer (upper) made of clay and sand stone and a deeper dolomite (lower), known as the Koolpinyah Dolomite. Each has water bearing properties; this project focuses on the Koolpinyah Dolomite as it is the main source of water within the study area. The Koolpinyah dolomite is weathered, deformed and often cavernous, creating large, high yielding underground caverns that in some areas can produce up to 60L of high quality water per second. Naturally, these caverns form a key focus for horticultural and water dependent enterprises in the area. This is a complex system, as most bores in the area are lower yielding, with average outputs of between 0.5 to 5 litres per second (NRETAS 2008b).

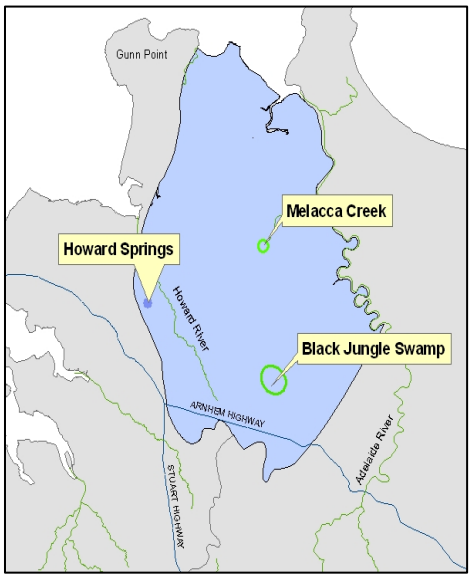

Figure 1: Map showing the boundaries of the Howard East aquifer, known as the Koolpinyah Dolomite Aquifer (Source: NRETAS 2008b)

Depending on the intended use, potable water of varying quality can be drawn from either the cretaceous (upper) or dolomite (lower) aquifers. Each performs similarly in terms of recharge, but display different water chemistry characteristics. The high rainfall experienced during the previous eight wet seasons has ensured that both aquifers have been sufficiently recharged. This is evident, by the presence of surface water bodies, such as the Howard and Berry Springs, which flow from water forced upwards from the dolomite through vertical fractures in the rock. Locals relay that

[1] Considering the recent and extensive reporting on the Howard East region by Woodward and Jackson (2008), the following section has been kept deliberately brief. Please refer to Woodward, E., et al (2008).

similar smaller springs or outflows are located along Pioneer Road, Humpty Doo. These outlets (springs) support unique vegetation and wildlife, such as spring-fed monsoon vine forests, that are highly valued by the community (Woodward *et al* 2008).

1.3 Regional growth, economy and competing uses for water supply

The Howard East area (also known as Howard Springs) hosts a range of economic activities. Located within the local government jurisdiction of the Litchfield Shire Council with a population of approximately 2,704 residents (ABS 2006) living around its natural lagoon systems. Many live on small 'bush' blocks of 2 – 5 hectares, however large scale horticultural production farms are still reasonably common.

Howard East's groundwater supply is under growing pressure from the demands of urban, industrial and horticultural development. The total ground water currently being extracted from the dolomite is estimated to be 20 000 GL, of which 55% is used for irrigation, 30% for residential 'stock and domestic' purposes and 15% to augment Darwin's urban water supply (NRETAS 2008b). The area's close proximity to Darwin and relative abundance of land has led to prolific development over the past fifteen years in the residential, horticultural, industrial and defence sectors.[2] Demand is thus predicted to rise between 100 to 200% over the next forty years,[3] reinforcing the need for a Howard East water allocation plan.

Using bore driller's records, over 3,300 productive bores are now estimated to be within the Howard East area. Of these, 600 belong to commercial horticultural licence holders who irrigate tree crops, cucumbers, melons and vegetables (NRETAS 2008b), the rest are used for 'stock and domestic' purposes to support residential dwellings. Currently bores for stock and domestic purposes and those that pump less then 15L per second are not required to be metered. This has resulted in an underestimation of the number of bores that are metered as well as the extraction rate (Woodward and Jackson, 2008). The under enforcement of meters on rural domestic bores, combined with the wide range of residential landscapes in peri urban areas make it difficult for government modellers to accurately estimate the total amount of water being consumed by rural residential households. It is estimated, that Darwin's residents use twice as much water per capita as those of other capital cities, and more than other tropical cities of comparable size (Power and Water Corporation 2006).

There is currently no requirement for domestic water users to pay for or conserve water. Efforts to address this and introduce metering or pricing for rural water have failed in the past with many rural residents citing the capital costs associated with the construction of their bores (between $12 000 and $20 000 dollars per bore[4]). This cost is incurred by the land holder. New dwellings in the area are required to be connected to reticulated water, supplied through Power and Water Corporation, the main supplier of town water in the Territory. The price differentials involved in this decision for landholders or developers are significant, reticulated water consumers

[2] Large scale projects in northern Australia now make up for 83% of new investment in Australia (ABS 2008).
[3] Pers comm., Power and Water Corporation staff member.
[4] Pers Comm. Three local bore drillers, note that this is the price for one bore, and that landowners may need to sink more than 2 bores to find water, significantly raising the costs.

pay more than 70c per KL, whereas private bore consumers pay an estimated 4c per KL[5]. Increasingly, the issue of rural residents switching to reticulated water or paying for bore water is viewed as contentious.

In 2007, NRETAS launched a voluntary metering project, offering to install free metres on private residential and commercial bores in order to gain a better estimate of water use in the Howard. The project has had mixed success as there was public misconception that the meter readings taken would eventually be used to charge rural residents for water (see Nolan, 2009). The information that has been included in recent modelling simulations supports the trend that groundwater levels in the dolomite are experiencing more pronounced drawdown effects over the dry season, despite their full recharge occurring during each of the good wet seasons. In a 'business as usual' scenario, it is likely that rural residents with older, shallow bores in the upper aquifer will run out of water earlier in years of low rainfall. These trends ensure that competition for water is rising and has prompted NRETAS to prioritise the aquifer for water allocation planning.

The work conducted through this project aims to support this process and find locally appropriate ways to engage stakeholders within the planning process and overcome public misconceptions.

1.4 Water planning in the Northern Territory

Like other jurisdictions, the Northern Territory has signed up to the National Water Initiative and has agreed to undertake transparent, statutory based water planning that allocates water according to a number of declared and locally agreed upon *beneficial uses*. Six water control districts across the Territory have now been declared, with each water plan in various stages of completion. As water planning is relatively new in the Territory, a number of detailed reports examining the NT experience have recently been published in an effort to offer guidance and tailored recommendations for NT water planners. This section refers the reader to the following reports which have been commissioned through the National Water Commission, NRETAS and Land and Water Australia.

- Tan, P.L. (2008), Collaborative Water Planning: *Legal and Policy Analysis*, Tropical Rivers and Coastal Knowledge <http://waterplanning.org.au/phase-one/legal-and-policy-frameworks-for-collaborative-waterplanning-in-northern-australia>. In this work Tan presents a legal and policy review of the legislation, case-law and policy on water planning, with a focus on the process of planning and community engagement rather than the content of the actual water plans. Written for a broad audience, Tan provides a critical analysis of the water planning framework in the Northern Territory, Western Australia and Queensland and makes recommendations for reform of law and policy.

- Hamstead, M., Baldwin, C. and O'Keefe, V. (2008). *Water Planning Practices and Lessons Learned*, National Water Commission, Canberra. A key body of work for the NWC, the report assesses the NT water planning framework and water plans against a number of thematic areas such as planning provisions for the environment, other public benefits,

[5] Pers. Comm., NRETAS modellers. Pricing factors in average costs for fuel and maintenance of bores, however does not include the capital costs to install the bore. Interestingly, despite the higher prices paid in urban areas, water use per capita is double that of other cities

resource security, risk management, community consultation and the ability to address conflicts and tradeoffs.

- Hamstead, M., O'Keefe, V. and Baldwin, C. (2008). *An approach to water planning in the Northern Territory.* Commissioned by NRETAS, the study comprehensively examines current Northern Territory (NT) water planning practices in the context of the National Water Initiative using the draft Tindall Limestone Aquifer (Katherine) Water Allocation Plan. Importantly, it uses the specific NWI themes as the basis for outlining recommendations for improving performance in future allocation planning.

- Woodward, E., Jackson, S. and Straton, A. (2008). *Water resources of the Howard River region, Northern Territory: A report on the social and cultural values and a stakeholder assessment of water use scenarios,* CSIRO Darwin*.* This report was provided specifically to identify the social and cultural values held by the public to assist NRETAS in its allocation planning for beneficial uses.

1.5 Water planning in the Howard East Aquifer

Similar to other catchment areas in northern Australia, the water allocation planning process in Howard East has taken longer than anticipated to get started. At the time of writing, the declaration of the process remains uncertain. A chronology outlining NRETAS efforts to progress water planning in the region during the course of this project is presented in Annex A. As well as illustrating the strong relationship built between project researchers and government agency staff, it also helps demonstrate the complexity of water planning and the challenge of managing short term participatory research project timelines within a government planning process.

2. General Methodology

Five steps were undertaken under two over-arching activities or tools: Stakeholder Analysis and a Visualisation tool:

Extended Stakeholder Analysis

- Determining which stakeholders were directly and indirectly affected by local water planning processes (i.e. stakeholder selection).
- Identifying stakeholder issues of concern, knowledge about groundwater resources, as well as assessing each groups capacity to participate in public water planning (i.e. stakeholder needs and issues analysis).
- Analysis and evaluation of findings

Groundwater visualisation tool

- Selecting a tool to facilitate public participation in local water planning processes.
- Development of an engagement strategy to ensure community participation in the development of a groundwater visualisation tool of the Howard East Aquifer.

The processes involved in developing, trialling and evaluating each 'tool' form the body of this report. The details of each tool are described in full (methods, results and analysis), with synthesis and recommendations of the case study at the end.

2.1 Building in community engagement: a participatory action research approach

Given the goals of the case study, and the uncertainties of the political decision to commence the water planning process, a flexible and adaptable research approach was needed. A participatory action research framework was chosen to inform the planning process, for its emphasis on social learning and an ability to enhance the different participants sense of 'ownership' of the research through the iterative act of planning, acting and reflecting on the research together with the researcher.

Participatory action research involves stakeholders as joint researchers, feeding local and community knowledge into the research and decision making process. In this case study, local knowledge incorporated into the research process included bore drillers logs and information and values revealed through participatory mapping of the productive and non-productive zones of the aquifer. The integration of local knowledge into the project served to maximise the social learning outcomes and ensure that the tools incorporated a diversity of data as it emerged through the ongoing consultation with community stakeholders.

Due to the time constraints on the project resulting from the government planning process, the project was not wholly one of PAR, but one heavily influenced and guided by the principles embedded within PAR theory and that of adaptive management.

2.2. Tool Selection

A number of well known planning tools were shortlisted and evaluated for their appropriateness for the Howard East case study, including:

- Extended stakeholder analysis
- Groundwater visualisation tool
- Joint fact finding
- Citizens jury
- Scenario planning
- Multi criteria analysis (MCA) to rank community concerns.

A citizens jury and multi criteria analysis had already been piloted in the case study area by CSIRO researchers in 2008, eliminating these tools from further consideration. Given the time and resource constraints of the case study, the project team decided that developing a greater understanding of the stakeholders and groundwater systems within the Howard East community was essential before key stakeholders would be able to capably discuss or build consensus around key water issues. Without a shared understanding, other tools, such as scenario planning, would likely be unsuccessful.

With this in mind, the research team selected to trial an extended stakeholder analysis and participatory groundwater visualisation tool within the Howard East water planning area. Individual tool reports have already been published and more detail about each tool can be found in the following documents:

- Mackenzie J, Nolan S and Whelan J. (2009). Collaborative Water Planning: Guide to Monitoring and Evaluating Public Participation. Charles Darwin University, Darwin.

- Nolan S. (2009). *Collaborative Water Planning Project, Rural Darwin (NT) Case: Analysis of Stakeholder Interests in the Ground Water Resources of the Howard East Aquifer*, CSIRO Sustainable Ecosystems, Darwin. Available for download at URL:http://www.track.gov.au/project-portals/participatory-modelling-howard-east-aquifer.

- Nolan S., Tan P-L., and Cox, M. (2010). Collaborative Water Planning: Groundwater Visualisation Tool Guide. Charles Darwin University, Darwin.

3. Extended Stakeholder Analysis

3.1 Extended Stakeholder Methodology

3.1.1 Selection of stakeholders

The Howard East extended stakeholder analysis aimed to identify and account for all local stakeholders and community groups who had a 'stake' in local groundwater resources. An initial list of potential stakeholder groups in the Howard East was created with government agency staff, local council members and CSIRO researchers who had longstanding experience with the case study area. Other stakeholders were found through searches of local newspapers and ABC radio programs to identify spokespeople and community 'experts' with an interest in water issues. Traditional owners, environmental, land care and recreational user groups were contacted directly.

During the stakeholder interviews a contact list of potential stakeholders was shared with participants who were asked to add community stakeholders or spokespeople whom they thought should be contacted. The list remained open throughout the interview process, culminating in 37 interviews from seven different community sectors. Following stakeholder recommendations also served to build trust between the project team and stakeholders by showing them that researchers trusted their information and took their recommendations seriously. Stakeholder categories, and the number of interviews undertaken within each grouping, are briefly described in the table presented below.

Table 2: Stakeholder groups interviewed for stakeholder analysis

Stakeholder groups	Number of Interviews undertaken
Traditional Owners	2
Industry and Commercial interests	8
Community groups	5
Environmental groups	3
Local government	6
Territory and Federal government	9
Research and Tertiary Education interests	4
Total	37

3.1.2 Stakeholder Interviews

Building on the stakeholder selection process, a key objective of the Howard East extended stakeholder analysis was to identify the needs, issues, attitudes and barriers for engaging local community members in the local water planning process. Considering the lack of resource planning experience in the case study area, the analysis was considered to be an important first step for 'setting the scene' for future community and stakeholder engagement.

A series of semi-structured interviews with key stakeholders were undertaken between August and November in 2008. The lack of information about the interests of many of the stakeholders selected, prompted the project researcher to develop a

series of open-ended interview questions to elicit a large amount of qualitative data (see Annex A). Questions were developed to understand stakeholder concerns and attitudes toward water planning and identify trusted sources of information about the aquifer within the community. Open-ended questions were followed by a short quantitative survey, which asked stakeholders to nominate the areas where they had enough information and/or areas where they would like more information. Interviews were recorded digitally, transcribed, and sent to stakeholders for review and approval to use in the final report (Nolan, 2009)

A range of secondary data resources were also drawn upon to build understanding of stakeholder and community perspectives. A comprehensive list of references can be viewed on pages 11 & 12 in Nolan (2009).

3.2 Results of the Extended Stakeholder Analysis

3.2.1 Issues of concern identified

Questions asking stakeholders about the main issues for local groundwater allocation and management elicited a wide range of responses. Each was asked to discuss their answers from a local and regional water planning perspective. Those issues that were raised repeatedly and discussed at length indicated that these were causing the most concern within the Howard Springs community. Answers were grouped into categories that had emerged throughout the data collection process and participants were asked to rank their concerns via email, when interview transcripts were sent for approval. Answers were entered into Table 3 below, which describes the issue along with the number and type of stakeholder groups that raised them. The results are intended to be indicative only, as equal numbers of stakeholder groups were not interviewed in each stakeholder category which could potentially bias the result. Despite this, the results were considered important to enable government agency staff to understand concerns around groundwater management throughout the community and informed the decision making process for the second tool (GVT) trialled in this case study.

Table 3: Key issues raised by stakeholders in the Howard East

Key Issue raised by stakeholders	Number of stakeholders raising the issue	Type of stakeholder group
1. A wide spread lack of understanding of groundwater systems and related pressures, and a lack of confidence in the science underpinning decision making	8	**Industry** (Commercial water users - NT Horticultural Association, Power and Water), **Government** (Local Shire Councils, Government Departments), **Community** (Community groups), **Environmental Groups**, Research Agencies
2. Concern about the environmental, social and economic trade-offs involved to meet current and future urban and rural water needs	8	**Industry** (Power and Water Corporation, Development Consent Authority, NT Horticultural Association) **Government** (Local government Departments, Shire Councils representatives), **Environmental groups** (ECNT, WWF) **Community** (Rural residents and recreational user groups)

3. Lack of confidence or trust of government driven planning and decision making processes	6	**Industry** (Development Consent Authority, NT Horticultural Association), **Community and residential groups**, **Environmental groups** (Greening Australia) **Darwin Harbour Advisory Committee representatives**
4. Concern around licensing procedures, rules and potential caps on water use for commercial licenses and developers	7	**Industry** (Development Consent Authority, NT Resources Council, NT Horticultural Association, NT Cattlemen's Association) **Government** (Shire Councils, Government representatives)
5. An absence of social, economic or environmental incentives to save water or manage demand for water.	8	**Environmental Groups** (Greening Australia, ECNT), **Government** (Local Council members, Government Departments), **Community groups**, **Industry** (Power and Water Corporation, NT Horticultural Association), **Research Agencies**
6. The absence of a strategic planning framework and Territory Water Plan to ensure the protection of community environmental assets.	6	**Government** (Local Council members, Government Departments), **Environmental Groups, Recreational User groups, Community groups, Research Agencies**

In discussions with stakeholders, agency staff and other researchers, as well as feedback from community meetings, three main themes emerged (as outlined in Table 3).

Firstly, it was noted there is a *wide-spread lack of understanding of how groundwater systems work*, or the impact of current residential commercial and environmental water requirements both now and into the future. The aquifer was difficult for community members to understand due to its complex hydro geology and highly variable yields. Little agency based information about the aquifer was being utilised by the broader community, leading to common misconceptions among the community about the origins and current state of groundwater resources. Further, the large monsoonal rainfall experienced in the Northern Territory and the recent growth of residential and industrial development of the area had led many to believe that the resource was in abundance, reducing the perceived need for water planning among the community. Subsequently, some stakeholders had difficulty understanding agency models that stated that the system was over allocated and that shallower bores were in danger of running dry during years of low rainfall.

Secondly, there was a strong *need for trust to be built between the broader community and government agencies* around the need for groundwater management. At the inception of the project, community members were wary of being associated with planning processes that are government driven, thinking that it would lead to the charging of rural residents for their water. Community members were also looking for assurances that their participation and input into planning would be meaningful and influential.

Lastly, the research determined that pathways need to be developed to enable a range of stakeholders to come together and *make informed decisions around the tradeoffs* involved in addressing growing urban and rural demands for water. This

issue, among many, is contentious in rural areas and it is hoped can be partially addressed through an engagement strategy that builds understanding and trust into the planning process.

Through conversations and input from key stakeholders the other main issues raised in the stakeholder interviews, were seen to be better able to be addressed through the planning process itself. For more discussion and quotes related to these issues see, Nolan, 2009.

3.3 Analysis and Evaluation of the Extended Stakeholder Analysis

3.3.1 Classifying stakeholder groups for improving collaboration

To support NRETAS agency staff to establish a water advisory committee, stakeholder group representatives were asked to indicate their level of interest and experience in participating in regional water allocation planning on a sliding scale of 1 – 4 (1 being not interested, 4 being very interested). This was coupled with questions to ascertain the experience and capacity of each group to participate in water planning (e.g. acknowledging the time, resources, information sources each group had). The result (Table 4) placed individual stakeholders into four broad categories:

a) Interested in participating in local water planning however inexperienced in government planning processes,
b) Interested in participating and experienced in local water planning processes,
c) Not experienced and not interested in water planning processes,
d) Experienced in water planning, however not interested in getting involved.

Table 4: Stakeholder interest in local water planning processes

Stakeholder Categories	Description	Stakeholder groups
A	Interested but less experienced	Landcare groups (LC) Northern Territory Field and Game (NTFG)
B	Interested and experienced	NRETAS Department of Regional Development, Primary Industries, Fisheries and Resources (DRDPIFR) Department of Planning and Infrastructure (DPI) Power Water Corporation (PWC) Northern Territory Horticultural Association Environmental Groups (Environmental Centre Northern Territory / World Wildlife Foundation) Local Council Member (Goyder and Nelson electorates) Amateur Fishermans Association Northern Territory Larrakia Harbour Committee(LHC) Litchfield Shire Council Charles Darwin University Parks (and Wildlife Commission)

C	Not experienced and not interested	Northern Territory Resources Council Northern Territory Tourism Association
D	Experienced but not interested	Greening Australia Northern Territory Cattlemen's Association

Any successful engagement strategy within the area would need to develop activities and communication tools that are targeted to each of these sup-groups, especially categories A and B.

Stakeholders included in Category A required additional support, such as administration assistance, technical training or more flexible meeting arrangements, to facilitate their involvement in a water advisory committee. Those stakeholders in category B were the initial focus of community engagement strategy, as they required less support and were already interested and involved in groundwater resource issues within the area.

Stakeholders were also asked to identify the enablers and barriers to their participation based on previous planning experiences, and detail their preferred method of engagement. This feedback is presented and discussed at length in the 'Stakeholder Needs Assessment' chapter of Nolan (2009). A short summary of suggestions for improving community participation in planning is outlined below:

- An independent technical advisory group to summarise and present information, growth trends and communicate environmental information and complex groundwater concepts in a manner that empowers members of the Howard East Water Advisory Committee to make informed and unbiased decisions.
- Training and educational opportunities that build understanding of groundwater systems for committee members and the broader public.
- Employing full-time administrative and technical staff to support HEWAC members.
- Ensuring industry is well represented and the group has a good balance between industrial, residential and environmental interests.
- Selecting an experienced and independent Chair.
- Increasing the accountability of the Ministers office to HEWAC members and ensuring the group has clear guidelines and terms of reference.
- Developing a comprehensive community engagement and communication strategy with a dedicated and regularly updated HEWAC website.
- Information sessions and training opportunities to build capacity around regional hydrology and the effects of current and future water use, enabling more informed group discussions and outputs.
- Distribution of newsletters and meeting minutes in electronic form and/or hardcopy with an appropriate response period – particularly suited to community groups with stretched time and resources.
- Uploading documents and project documentation on dedicated websites and internet portholes that combine interactive and educational features – increasingly, more rural, remote and peri-urban stakeholders are online, for instance 90% of NTHA (Northern Territory Horticultural Association) and NTCA (Northern Territory Cattlemen's Association) members.

- Using commentary and talkback radio shows on popular programs such as ABC Rural Country Hour, Territory FM, etc. to generate community discussion.

These suggestions were useful for informing NRETAS' consideration of engagement methods and approaches for the Howard East community in water planning. Suggestions made by stakeholders that identified the stakeholders preferred modes of engagement were also useful for framing the second step of the project, the trial and development of a groundwater visualisation tool.

3.3.2 Evaluating the effectiveness of the Extended Stakeholder Analysis

The stakeholder analysis was evaluated through its impact (i.e. the number of times its results were referred to in other documents or justified subsequent actions) and through a structured questionnaire with key government agency staff.

Findings from stakeholder interviews were reviewed and discussed in the following:

- Four meetings with NRETAS water resource management staff.
- One meeting with the Darwin Harbour Advisory Committee Executive Officer.
- Presentations and discussions in an open community forum on rural water, held by researchers at Girraween Primary School in Howard Springs in April, 2009.
- Meetings with key stakeholder groups (Northern Territory Horticultural Association, Environmental Centre Northern Territory, Amateur Fishing Association, Northern Territory).
- Discussions with researchers at CSIRO and Charles Darwin University familiar with the case study area.
- An executive summary of key findings was emailed to all research participants for feedback and comment.
- An evaluative survey was distributed to all participants at the conclusion of the report

The method employed to identify individuals and groups who had a 'stake' in local water allocation planning processes was considered successful by NRETAS agency staff, researchers and other stakeholders.

In terms of impact, the findings were published as a standalone document at the request of NRETAS. This was distributed amongst agency staff at the Water Management Resources Branch and to key stakeholder groups. An executive summary was also presented as an attachment by NRETAS to the Chief Ministers Office in the form of a Cabinet Submission in October 2008, detailing the proposed membership, terms of reference and engagement preferences for stakeholders in the Howard East. Excerpts from the document are considered very useful for the NRETAS community engagement plan, a forthcoming issues paper focusing on Darwin, Palmerston and the Howard East, and for generating initial discussions about key issues of concern to be discussed by the forthcoming Howard East water advisory committee. Its recommendations have also led to the creation of two new roles within NRETAS; a full time Community Engagement Officer position, and a part time Stakeholder Manager position.

4. Groundwater Visualisation Tool

A research collaboration was developed between the Groundwater visualisation tool unit of the Queensland University of Technology (QUT), the project management team based at Griffith University, Darwin's CSIRO, NRETAS and Power and Water Corporation to create a basic 3D groundwater visualisation tool of the Howard Springs aquifer. The agreed goal of the collaboration was to develop a modelling product that could be installed and operated on household computers to answer basic questions such as the origin of groundwater resources, the connectivity between ground and surface water, how rain and abstraction impact on recharge of the aquifer and the impact of increased demand on the system.

While the model did not have predictive capability, it was expected to assist users to become more comfortable with modelling and appreciate the complexity of the science underlying NRETAS groundwater models. It aimed to build recognition among community members of the need for comprehensive water resource data and groundwater management. The visualisation was developed as a software package to enable users to 'see' the aquifer's spatial configuration, show cross sections of the aquifer at specific points of interest and view past water level measurements at different points in time across seasons and over 24 hour periods. This capability would allow the user to observe a number of items, including:

- the geographical structure and boundaries of the aquifer in easy-to-understand cross sections;
- measured time series of local and regional levels of extraction and water levels in observation bores over time and season;
- the relationship between rainfall and aquifer recharge over time and season, displayed using animation software;
- the growing number of productive bores in the area; and
- the relationship between bore depth and yield.

4.1 Methodology for the GVT

4.1.1 Incorporating a participatory element into the building of the groundwater model

The collaborative water planning team was responsible for ensuring that the model was built in a participatory manner, the development of the technical model was undertaken by the QUT and details of this process can be found in Hawke et al, 2009.

To do this a community engagement strategy was developed to encourage members of the Howard East community to contribute information about local groundwater systems. The main tools used for capturing this information included a bore survey (available for download and submission electronically), semi structured interviews with local experts and the outputs of participatory mapping exercises undertaken with local bore drillers and ex agency staff using high resolution topographic maps[6].

[6] See Annex 2 which contains the guiding document and questions asked to bore drillers during the participatory mapping exercise

These activities were completed at different stages of the GVT's development to optimise public participation and feed community knowledge and comments to the models creators (at the models inception, and when it was 30%, 50%, 70% and 100% complete). The following diagram briefly outlines each activity, which are described at length in Nolan and Tan (2010).

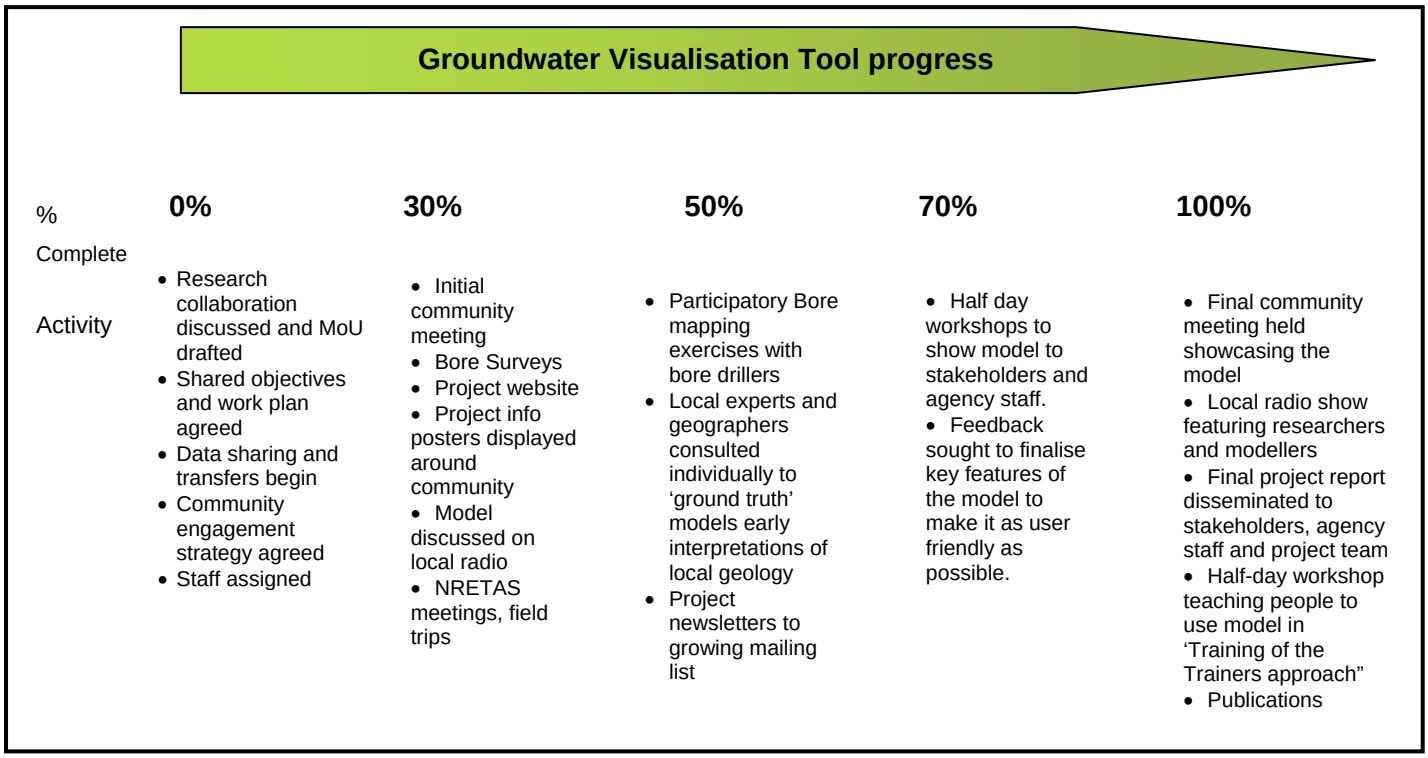

Figure 2: Community engagement activities undertaken at different stages of the models development

To complement this, and to promote the involvement of the Howard East community to contribute information about their bores and water needs, a number of communication documents and web based content were developed to increase the projects outreach. The most important of these were:

1. Hosting two public forums on rural water at the Girraween Primary School, Howard Springs.
2. Distributing newsletters and meeting minutes in electronic form and hardcopy mail out.
3. Creating and uploading project documentation on a dedicated project website. The project website was then linked to other popular websites that were used by the Howard community.
4. Using commentary and talkback radio shows on popular programs such as ABC Rural Country Hour, Territory FM, etc. to generate community discussion and interest.
5. Creating information sheets and posters, and displaying these in prominent locations and local festivals held within the community (e.g. shopping centres, community notice boards, local rural shows, etc).

An evaluation of the success of each communication activity is provided in the results section of this report.

4.1.2 Gaining agency and stakeholder feedback in the visualisation when 70% complete

Two workshops were held when the GVT was 70% complete (August 2009), inviting stakeholders from local councils, key stakeholder associations and NRETAS agency staff. Meetings were approximately 3 hours in duration and aimed to 'road test' the visualisation aspect to generate insights as to which features of the model would be most useful to community members. Feedback was also sought for the planned training program intended to teach stakeholders how to use the GVT.

4.2 Results of the GVT

4.2.1 Outputs from the participatory groundwater visualisation tool

The GVT was finalised and presented to the community in a public meeting held on the 9th of September 2009. A training session was held the next morning at Charles Darwin University to teach interested stakeholders and agency staff how to use the GVT and related data sets. The session was taught by the models creator and leading geographical scientist Malcolm Cox (QUT) and involved community representatives from a number of sectors, including:

- NRETAS
- Power Water Corporation
- Land care groups
- Environmental groups (Environmental Centre Northern Territory)
- Recreational User Groups (Amateur Fishing Association Northern Territory)
- Local councils (Goyder and Nelson)
- Local bore drillers
- Ex – Water resource management staff
- Local secondary schools
- Northern Territory Horticultural Association

Community participants were selected for training based on the sector they represented and their ability to increase the models outreach. Each was provided with a copy of the model on CD, instructions on how to copy it, and a hard and soft copy operational manual.

In all cases, trainees nominated themselves as community volunteer focal points for other community members to seek assistance while learning to use the visualisation.

4.3 Analysis and Evaluation of the GVT

4.3.1 Participant evaluations of the groundwater visualisation tool

Evaluative surveys were conducted twice during the GVT's progress: at the end of the community and agency workshop held in August, and at the end of the training session held in September. A focus group, involving stakeholders and agency staff was also held at the end of the training exercise and facilitated by the project researcher. Here, participants evaluated the outcomes of the model, in a facilitated

discussion, against the original objectives of the GVT, *to build understanding and trust in the need for groundwater management for the Howard East aquifer*.

The main strength of the GVT, relayed by participants was a strong sense of ownership and acceptance of the final product by stakeholders. Participants in the focus group relayed that they were more likely to use the GVT because they trusted the sources of information upon which it was based, and had felt included and consulted throughout its development. Additional strengths lay within its ability to be cheaply and quickly downloaded and installed onto local and home computers. Other advantages were that users could examine the GVT in their own time, at their own pace with the guidance of an operational manual. Lastly, users appreciated the interactive capacity of the GVT, which could be interrogated by a range of users from different interest groups and was thus able to answer a number of questions about the system and its resources. The quotes below were noted during a focus group session held in the training session.

> "Yes, this model will help people want to engage with water planning. We all have a very centric view of our immediate surrounds. Very few have a holistic view of what is going on over the full scale and what impacts what and how integrated it all is."
>
> "It's a great tool from an industry perspective. I will be able to show the engineers at work how the system works and be able to have a conversation with colleagues from different areas."

The main weakness of the groundwater visualisation tool was that the community engagement process undertaken to ensure it was 'participatory' was too expensive and time intensive for most agency staff, and required ongoing full-time support. As one agency staff commented "*with a model of this type, it's not usually an overnight success and most stakeholders need to work with it for some months*". Ideally the GVT can be delivered over a longer process by dedicated agency staff that can establish long standing links with the community and use the visualisation to its educational potential for the long term.

4.3.2 Evaluating the community engagement strategy to develop the visualisation tool

The adaptive research approach undertaken, allowed for new information products and data to be developed and incorporated into the visualisation from a diverse range of sources. This created a sense of community 'ownership' over the visualisation tool. Ownership and subsequent acceptance of the visualisation tool was further enhanced through seeking stakeholder feedback in a number of participatory meetings before finalisation.

Evaluation of the different communication activities was obtained, through evaluative surveys, focus groups and via direct consultation with NRETAS agency staff, stakeholder groups, researchers and community members. A more comprehensive evaluation of the groundwater visualisation tool can be found in the guiding document written for water planners (Nolan and Tan 2009).

- Project website - Successful: the website received over 350 hits during the course of the project.
- Mailing lists of interested stakeholders - Successful: the number of people requesting to be on the projects mailing list grew exponentially after researchers featured on local radio shows and subsequently visited the project website.
- Project newsletters - Successful: the project newsletters were read by stakeholders and community members and often resulted in focused questions to the researcher by phone and email.
- Project information packages - Successful: feedback from the information package was positive. Stakeholders stated that it helped them form focused questions to ask researchers.
- Information posters - Unsuccessful. While people often stopped and read the poster, generally no effort was made by community members to take action or become involved in the project.
- Open community forums - Successful: Each was well attended in both instances, with approximately thirty-five people attending the first meeting and over forty in the second.
- Participatory mapping exercises - Successful: the exercise helped modellers ensure that the GVT matched local observations of the dolomitic aquifer and included local observations that were difficult to capture in NRETAS data sets.
- Direct stakeholder consultation - Successful: by inviting stakeholder representatives to regular meetings and workshops at CSIRO, the projects mailing list and website visits grew significantly. This gained important feedback throughout the development of the GVT and ensured continued participation of major stakeholder groups and their members in the project.

5. Synthesis and Recommendations

The results of the two tools trialed during the Howard case study were disseminated and adopted by the broader community via agency and stakeholder representatives who participated in each tool trial. During the projects progress a number of findings and lessons emerged from each tool trial that may be useful for water planners thinking of undertaking an extended stakeholder analysis or GVT in their own jurisdictions.

1. **The value of understanding stakeholder interests and needs.** The extended stakeholder analysis assisted researchers to identify the preferences for communication products and modes of communication that were useful to different stakeholders, moving away from a 'one size fits all' approach. When creating information products, the project team tried to reflect stakeholder issues of concern and to reflect stakeholders interests. . Consideration should be also given to the different ways planners would like to gain feedback from their communication efforts (for instance, through evaluative surveys or focus groups) to help them plan future community activities.
2. **Stakeholder and agency ownership of the process.** At the beginning of the tool trials, each stakeholder group was asked to contribute their expectations for the trial. Shared objectives were agreed upon early and project participants were kept informed of how the project was performing against these objectives at key stages of the project. Thus, stakeholder expectations were managed from outset and stakeholders related that they felt actively listened to. This resulted in a greater likelihood of participation in community engagement activities and adoption of the final tool.
3. **Use of independent local and scientific 'experts' during the course of the trial.** Drawing on local knowledge within the community gave the project legitimacy and contributed to a satisfactory process for the wider community. Using independent researchers in both trials was on one hand considered to be important for consulting community members on contentious issues and ensuring that their reporting was considered neutral and unbiased. On the other hand this project recommends that a GVT should be delivered over a longer period by dedicated agency staff that can establish long-standing links with the community and use the GVT to its full educational potential for the long term, instead of by funded research projects that are restricted by tight project deadlines. If both options are unrealistic, this project showed that water planners can build in mechanisms for gaining community feedback by sharing interim results or final reports written in simple language to assist planners promote transparency in their management actions. This can go a long way to improving public trust of scientific information from government agencies.

4. **Adequate planning to transition resources and knowledge from project to agency staff.** At the end of the GVT process, it was clear that more resources were needed to sustain the community educational process, and to update the GVT once better information is sourced. This was not written into the original budget allocated for the GVT and needed to be resourced by NRETAS.

Finally, findings and lessons from this work and additional project case studies will be pooled and contribute to a national toolkit and synthesis paper. In doing so, the project researchers hope to outline a number of methods, strategies and workshops that can be used to elicit community engagement and confidence in future water allocation planning.

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Annnex A: Chronology of events related to Howard East water planning during the course of this project (June 2008 – Sept 2009)

June 2007 to July 2008	Initiated in June 2007, Phase One of the Collaborative Water Planning project began, aiming to review the literature around public participation in water planning and provide a foundation for trialling planning tools in case-studies of water planning in northern Australia. Two retrospective studies were completed and five reports were published from this stage of the work.
July 2008.	Phase Two of the 'Collaborative Water Planning project began. Two planning processes were selected as case study sites, one in Cape York, far north Queensland and the other in rural Darwin, Northern Territory. A MoU was signed between NRETAS and the TRaCK project team, outlining joint aspirations for the project.
August 2008.	A Territory-wide election saw a new Minister appointed to the Environment portfolio which was expanded from the Department of Natural Resources, Environment, and the Arts (NRETA) to include Sport (thus becoming NRETAS).
August – November 2008	A stakeholder analysis was undertaken to understand stakeholder views, interests and knowledge around water issues and planning. A TRaCK researcher interviewed 37 local stakeholders across a range of sectors (government, commercial, environmental indigenous, residential, recreational users and community groups)
September 2008.	NRETAS water planners drafted a Cabinet submission asking the Northern Territory government to support its declaration of a Top End Water Control District (representing four top-end catchments) and, within it, a Darwin Rural Water Control District (bounded by the Howard East Aquifer). The proposed membership and TORs for each water advisory committee members was submitted with input from TRaCK researchers, based on the results of the Stakeholder Analysis. A Top End Expert Group was also recommended as a technical subcommittee to give specific, technical and practicable advice. While contacting stakeholders for interviews, TRaCK researchers planned a community workshop in Howard East for 8th November 2009 to introduce the concept of water allocation planning and discuss the membership application process for local water advisory group.
October - November 2008.	Government Ministers did not endorse the Cabinet submission due to the contentious nature of water planning in rural Darwin. A second submission was drafted and presented to government, along with an executive summary of the key findings from the stakeholder analysis. As a result, TRaCK researchers cancelled the planned community workshop
December 2008	At the request of NRETAS, the Stakeholder Analysis was written as a standalone publication. Copies were distributed to all interviewed stakeholders, and several hard copies printed for government agency staff.

Jan-Feb 2009.	NRETAS hired a Community Engagement Officer in anticipation of the establishment of a Howard East Water Advisory Committee (HEWAC). The second Cabinet submission was partially accepted but the announcement of the HEWAC was delayed until further notice.
Feb 2009.	A final stakeholder analysis was presented to NRETAS with recommendations that were adopted in NRETAS's subsequent communication and engagement strategy. The TRaCK project developed a work plan to focus on building a community education tool in the remaining five months it had left. A research collaboration was forged between Griffith University, CSIRO, Queensland University of Technology, NRETAS and Power and Water to develop an ground water visualisation tool as a community education tool to prepare key stakeholders for the forthcoming water planning process.
March 2009.	Pressure from rural residents lead to the establishment of a 'Friends of Howard Springs' group to discuss options for Howard Springs to be reopened as a public swimming area. High bacterial levels compounded by low flow rates prevent this, resulting in funding being pledged to open a water park and investigate Howard flow rates further. Low flow rates were attributed to the overdrawing of water for urban and industrial use from Power Water, despite government claims to the contrary.
April 2009	With representations from NRETAS, the second Cabinet submission to initiate a water allocation planning was accepted. The announcement of a HEWAC was delayed pending a full resource assessment and the submission of a white paper outlining the key issues for Darwin, Palmerston and Howard East. The 'Living Rivers' discussion paper was posted for discussion and comment, detailing new guidelines to govern surface waters.
August 2009.	Environment Minister Alison Anderson suddenly resigned from the Labor party, allowing the opposition to table a no confidence vote in Parliament. The balance of power was given to the Independent member for Nelson (including the Howard East planning area), Gerry Wood, who established an executive governmental committee. Minister Gerry McCarthy was given the environment portfolio and, at the time of writing, it remained unclear when the Howard water allocation planning would proceed.

Annex B: Stakeholder Analysis Questionnaire

NB: Sub-questions are to be used as prompts where necessary.

1. What do you think are the main issues for water allocation and management in this area?
    a. **At a local level? At a regional levels?**

2. **How are you affected by these issues? How concerned are you about these issues?**
    a. In what ways is water important to your organisation?
    b. How important is water to your livelihood/business? Recreation? Culture?
    c. How is it likely to affect you in the future? The future of the region?

3. **Who else in your local area or in the region is involved in decisions about water allocation and management? Do you think they share the same concerns as you? What other concerns do they have?**
    a. Are they concerned about how much water they use, either not being able to access enough or others using too much?
    b. Water quality and the environment?
    c. Costs and pricing?
    d. Anything else?

4. **Aside from business and recreation, what activities do you currently take part in with regards to water?**
    a. For instance, are you involved in community waterway monitoring or re-vegetation? Are you a member of a Landcare group, volunteer group or industry body?

5. **How do you get information about water issues or policy/planning?**
    a. What access to information do you have? Is it sufficient?
    b. Could it be improved?

6. **Have you ever been consulted or taken part in a government resource or environment planning process?**
    a. If yes, based on your experience, what were the best and worst parts of this experience?
    b. Can you think of ways to improve this process?

7. **How much do you know water planning? (Use Handout)**
    a. Are there areas of water management that you would like to know more about?

8. **In addition to more information, what else would assist you to participate in the water planning process?**

9. **Are there other groups or people who in your community that you think I should speak to?**

Please indicate which of the following areas you know about, and which you would like more information on:

		I have sufficient knowledge about…	I would like more information about…
Institutional arrangements for water	State water laws and regulations	❒	❒
	The water allocation planning process	❒	❒
	National priorities for water security and allocation	❒	❒
	Existing licensing arrangements	❒	❒
	Water trading	❒	❒
	Water pricing	❒	❒
	Regional natural resource planning and management	❒	❒
Technical information	The science of hydrology including surface and groundwater flows	❒	❒
	River ecology and biology	❒	❒
	Surface/groundwater interactions	❒	❒
	Environmental flow requirements	❒	❒
	Hydrological modelling	❒	❒
	Water use efficiencies	❒	❒
	The impact of climate change on water availability	❒	❒
	Monitoring water quality	❒	❒
Regional information	Historical water use in the region	❒	❒
	Current water use in the region	❒	❒
	Requirements of existing water users	❒	❒
	Population and economic trends in the region	❒	❒
	Future water demands of the region	❒	❒
	Water use and future requirements of Indigenous communities	❒	❒

Annex C: Participatory mapping exercises

Participatory Mapping Exercise with Bore Drillers

Name	
Company	
Length of time drilling bores:	
Length of time drilling in the modelled area:	

Mapping exercise

For this exercise, updated topographical maps of scale 1:25 000 are required. Show the driller the map and ask the following questions.

1. Mark the areas you have drilled previously

2. Using another colour, mark the areas that have potential for production in (a) in L/sec, (b) depth **for the dolomite (deeper) aquifer**.

3. If possible, using another colour, mark the areas that have potential for production in (a) in L/sec, (b) depth **for the cretaceous (shallow) aquifer**.

4. If possible, please indicate if there are 2 aquifers in the cretaceous layer? If so, where are they? Is there a shallow lateritic one (that is the red weathered material) and a deeper one (20-30 m??) that may be semi-confined?

Questions for drillers

A. Cretaceous formation (i.e. the upper sediments)

1. Are there one or two aquifers? (detail in what material)

2. Do the Cretaceous aquifer/s water levels drop by the end of the dry season?

3. What is the usual length of screens used?

4. In your opinion, is there leakage down bore casings from Cretaceous aquifer to dolomite aquifer?

5. What are typical yields from Cretaceous aquifer bores (L/sec)

6. Which lakes/lagoons are connected to Cretaceous aquifer, and which are not?

7. What is the condition of the Cretaceous aquifer (very good, good, fair, poor, stressed), at the end of the dry season?

B. Dolomite aquifer (the deeper confined one)

1. Where is the most productive zone in the aquifer?

2. What features produce the zones of high porosity (e.g. fractures, solution cavities, bedding, coarse grained material)?

3. Are there continuous zones of good porosity? Where are they?

4. What is the usual length of screens used?

5. Are all the bores under some pressure head (i.e. water rises up pipe)?

6. Does the pressure (potientiometric surface) decrease at the end of the dry season?

7. Where is the source of the dolomite aquifer recharge?

8. Which directions does the groundwater flow OR what is the direction of the gradient?

9. Where are springs that show dolomite discharge?

Finally, in your opinion, do you think the cretaceous aquifer is showing signs of stress or can have more bores drilled into it?