EXECUTIVE SUMMARY

1. BACKGROUND

This project developed a Generic Integrated Conceptual Framework (GICF) to assess the numerous and complex trade-offs between and within water resources and water uses management options. The project was initially intended to integrate water resources and water services management tools. However, because water services is one of the water use sectors and is itself affected by and affects other water use sectors, it was realised that integration cannot be sustainable nor meaningful without the inclusion of the other water use sectors. This is in line with the concept of integrated water management which is seen as a way to contribute to sustainability as envisaged in Agenda 21 (Inforesources, 2003). Integrated Water Resource Management (IWRM) has been accepted as a vehicle to achieve integrated water management, and has been framed around the principles of equity, economic efficiency and environmental sustainability.

In a South African context, the National Water Act (NWA) commits to the ideal of IWRM (Pollard and Du Toit, 2005). However, IWRM cannot be seen as an end in itself, but rather a means to an end. In the case of South Africa, that end is defined in the policy and legislation as being the equitable, efficient and sustainable use of water and the beneficial use of water in the public interest. The realisation of this end requires management tools appropriate to the demands of the NWA, and which utilises state-of-the-art integrated systems capable of taking into consideration social, economic and environmental needs which have to be considered (Clark and Smithers, 2006).

The South African water sector has developed a range of tools for managing water and for resolving water related problems, and has also improved these tools significantly over time. However, in-light of IWRM, the usefulness of these tools depends on the logical structure of valuation procedures, and on the common system required for defining and discussing complex water problems. If these tools are properly integrated, they can enhance decision making and communication between those who have to make the decisions, and those who are affected by them.

The project began by reviewing the various, often unrelated tools that have been developed over the years for the evaluation of water management options from both the water resources and water uses perspectives. This review took off from the notion that water management tools need to embrace IWRM principles, and that there must exist a common platform for integration.

Based on this review the GICF has been developed that can be applied in a coherent manner to a wide range of water management issues. It allows the users to link their tools to the mandate and objectives, to the reporting requirements, to the information value chain, and to the required resources in assessing trade-offs. More importantly, the GICF allows for decision making and reporting in a single platform linking the water managers, users and other stakeholders to the national government objectives.

2. OBJECTIVES AND AIMS

In an endeavour to avert the impact of fragmentation in the South African water sector, the Water Research Commission (WRC) has initiated this project, with the aim of adding value

to the process of looking into requirements for a multidisciplinary approach to IWRM. The objectives of the project were:
1. To assess and review existing knowledge and literature on integration and the scope and benefits of further integration.
2. To develop a conceptual framework for the integration of water resources and water uses (initially services) management tools.
3. To investigate and identify new concepts, technology and data sources that can improve the processes involved on an integrated platform.
4. To develop a case study solution.

Therefore, the primary objective of this project was to review tools with an aim to develop a GICF which can incorporate relevant and appropriate water management tools. The framework should be able to link the water resources and water uses management tools by a common flexible and extensible database, for use in strategic, tactical and operational planning and management. In light of this objective, it was imperative to provide a broad definition of a tool, and a base management performance measure which would be common to all actors, and which could be used to measure the success of the water sector as a whole.

3. METHODOLOGY

3.1 Overview

The team saw it necessary to unpack the scope by defining a tool, and defining integration from both the enterprise integration and in the context of IWRM. This was aimed at building a common understanding of the meanings of the words "tool" and "integration". Hence a tool was defined as something (either tangible or intangible) used to support operational and strategic actions in performing water management. Therefore, a tool can be a guideline, a procedure or protocol, a method or technique, a device, an apparatus and a software program dealing with all levels in relation to transition to IWRM (Barlebo, 2006)**.** From the Enterprise point of view, integration is seen as the natural continuing evolution, amalgamation and assimilation of many advanced enterprise-wide management, computing science, and networking concepts. The Global Water Partnership (GWP) perceives integration as a new governance and management paradigm which if effective, could give long-term solutions to water problems (Mcdonnella, 2008).

Three levels of integration hierarchy were identified and adopted for use in the project. The three levels consist of frameworks as follows:
1. Level I Frameworks – these can be referred to as just "Frameworks" or "Integrated Tools".
2. Level II Frameworks – these can be referred to as "Integrated Frameworks".
3. Level III Frameworks – these can be referred to as "Generic Integrated Frameworks".

In essence, the objective of "Level I Frameworks" is usually to provide a new tool, the objective of "Level II Frameworks" is to provide a mechanism by which existing tools can be linked or organised in a consistent manner, and the objective of "Level III Frameworks" is to reduce duplication of effort between the different domains/silos, and to facilitate tool use and development by providing optimal direction. In fact "Level III Frameworks" are like a loose "wrapper", which ensures consistency both in the tools themselves and in their use, and delivers greater utility and value than the simple sum of the constituent parts (HarmonIT, 2002; Marston et al., 2002; Argent and Rizzoli, 2004).

3.2 Project Scope

The scope of the project covered the review of literature regarding integration, a review of a range of management tools as defined by GWP, the assessment of the requirements for integration, and the development of a GICF. A software product was envisaged for this project, however, it was recognised that full integration, and the development of a fully integrated software system, would require that all tools as well as institutional arrangements conform to the GICF requirements for integration. Such a change would require more effort, time and money, and therefore, only a prototype system was developed for the purposes of demonstrating how the GICF works.

3.3 Project Approach

The approach to undertake the study was split into five phases, and eight tasks. The phases were intended to guide the project in a measurable manner. Four of the five phases were structured so as to deliver a key deliverable in line with the objectives, and these deliverables were each tabled for discussion by the reference group. The eight tasks on the other hand related mainly to project management and sequencing of activities. The phases were structured as follows:

- Inception Phase – an Inception Report was the main deliverable
- Research Phase – a Literature Review Report was the main deliverable aimed at addressing the requirements of objective no. 1.
- Solution Formulation Phase – the GICF was the main deliverable aimed at addressing the requirements of objective no. 2.
- Tools Assessment Phase – a Tools Assessment Report with recommendations on available concepts, data sources, and technologies was the main deliverable. This addressed the requirements of objective no. 3.
- Application Phase – a Case Study Report and a Demonstration Workshop were the main deliverables aimed at addressing the requirements of objective no. 4.

The approach was structured so as to answer the following questions:

- Why integrate?
- What to integrate?
- How to integrate?

4. RESEARCH RESULTS

The project established that the South African water sector has made progress in the path of integration, starting with the development of legislature and policies premised on the ideal of IWRM. The project has also established that in the different domains or functional areas, the South African water sector has, on average, developed the components of the Level II Frameworks**.** The components of the Level II Frameworks were in most cases found to have reached maturity levels, making the whole water sector ready for the development of a Level III Framework.

In an effort to guide the transition to the level III of integration, the project has developed a GICF in line with the objectives by:

- Undertaking a literature review resulting in a literature report which has been incorporated in this report as chapter 2.
- Developing the GICF for integration, this is reported in detail in chapter 5.
- Reviewing the tools and Identifying trends in technology and data management in the water sector, and these has been detailed in chapter 3 and 4.

• Developing a case study solution, as detailed in chapter 6 and 7.

The GICF is a high level architecture process that frames major integration issues and is seen as a means to bring together the Level II frameworks for complete integration. The GICF has been framed as a two dimensional system as follows:

• Based on integrating water management frameworks – requiring the existence of structures to, assess water resources; set up communication and information systems; resolve conflicts in allocation of water; establish regulation, establish financing arrangements; establish self-regulation; research and development; undertake development works; ensure accountability; develop organisational capacity (GWP and INBO, 2009). See **Figure 39**.

• Based on integrating Information Technology (IT) and water business – requiring concurrent-interactive development built on a unified process; supported by information systems; embedded in management of the "system'; in line with business culture/knowledge; done by all; and consistently implemented. See **Figure 41**.

The project has identified ten Level II Frameworks of grouped related components as key in a move towards integration. These building blocks were grouped into three pillarly and seven foundational main-blocks. The foundational block consists of those Level II frameworks that are a prerequisite to the existence of the GICF, while the pillarly block consists of those that do not need to be all in existence at once, but a sufficient number of them must be in place in order to realise integration. The ten identified Level II Frameworks are as follows (**Figure 39**):

• Foundational – this consists of:
- The coordination and conflict resolution integrated framework.
- The monitoring and compliance integrated framework.
- The data and information management integrated framework.

• Pillarly – this consists of :
- The water resources assessment and development integrated framework.
- The regulatory integrated framework.
- The financing integrated framework.
- The water allocation and use integrated framework.
- The capacity building integrated framework.
- The research and development integrated framework.
- The domain/field specific integrated frameworks.

The Level III Framework or the GICF was itself framed around the need to make decisions in an integrated platform, to store and manage the water sector knowledge, to store and manage the water sector tools, store and manage the water sector data and information, and to allow for user interface. Therefore the GICF was designed to contain five modules **(Figure 41)** as follows:

1. Integrated Decision Support System (IDSS) Module – the IDSS brings together the three levels of the decision process, i.e. it contains the:

• Strategic level DSS – this level of the IDSS is mainly concerned with high level policy/political decision making, and factors in all issues of policy and political nature to the water business

• Tactical Level DSS – this level of the IDSS in mainly concerned with technical/scientific decision making, and factors in the science (including social sciences) surrounding the water business.

• Operation Level DSS – this level of the IDSS is mainly concerned with

stakeholder involvement in decision making, and factors in the stakeholder preferences to the water business.

2. Integrated Database-Access (Data Mart) Module – data integration and standardisation is seen as core to integration, and the integrated data mart ensures that data requirements for planning purposes, and data produced by the tools are compatible, and that there is no duplication of efforts.
3. Knowledge Management System Module –This module ensures that as integration happens, the knowledge and purpose of the individual tools are also appropriately retained.
4. Tools Management Module – this module ensures that tools exist to support the business objectives, and consists of two sub-modules as follows:

- Integrated Surrogate Tools Module – this module allows managers to perform analysis using data from different complex/specialist tools in a simplified environment.
- Tools Inventory and Management Module – this module allows the users to put together all tools at their disposal with an ability to compare different tools, search for an appropriate tool for a particular assignment, classify and categorise tools, undertake gap analysis and assess maturity of tools.

5. User Interface Module – this module allows the user to interact with all the above mentioned modules, to choose the type of analysis to be performed and the tools to be used.

The application procedure to guide the use of the GICF consists of nine steps, grouped according to the GICF modules as shown in **Figure 42.** The nine steps are as follows:

- Step 1 – Identify the high-level mandate of an entity.
- Step 2 – Identify actors and their objectives.
- Step 3 – Identify the decision process and performance indicators.
- Step 4 – Identify required tools and assess their maturity, these tools are required to achieve the objectives as per the performance indicators.
- Step 5 – Identify the required data.
- Step 6 – Identify the data sources and point of contact on the value chain.
- Step 7 – Bring the actors with their objectives and data requirements to the unifying platform using the appropriate Level II Frameworks.
- Step 8 – Identify overlaps and gaps on objectives, tools and data.
- Step 9 – Streamline the processes accordingly.

The GICF was, for demonstration purposes, implemented into a prototype web-based software system called the WATERGRAL. The WATERGRAL demonstrated that the GICF provides a platform for defining, in a standardised simplified and logical manner, the interrelations between the different actors in the water sector as well as to provide a platform for trade-offs in the optimisation of the water balance equation. This is based on examining trade-offs among water quantity, water quality, efficiency, equity, and sustainability as well as to quantify the drivers, pressures, states, impacts and responses when analysing the design of water management programmes.

4. CONCLUSIONS

From the outcome of the project it is concluded that many of the water management tools in the South African water sector supports the principles of IWRM within their respective domains. However, it is also concluded that the tools, as a collective, do not embrace the principles of IWRM, and to enable a transition to IWRM, a unifying framework is required.

The project has also identified that many of the domain specific Level II Frameworks have reached their maturity level, and that efforts are being made to integrate with other Level II Frameworks on an ad-hoc basis, this could result in systems procured and developed to solve a specific problem, characterised by a limited focus and functionality, and containing data that cannot be easily shared with other systems.

The project has, therefore, developed a GICF, aimed at guiding the integration process in a holistic manner; and in order to illustrate its applicability, the GICF was implemented into a prototype software integrated system called the "WATERGRAL". The web-based WATERGRAL prototype aimed to demonstrate how the GICF can help to assess the tools with respect to their collective ability to evaluate the state of a water resource system holistically (i.e. in terms of sources, usage, water cycles (pathways) and environmental state). The WATERGRAL prototype was used to demonstrate the GICF as a unifying platform for defining, in a standardised, simplified and logical manner, the interrelations between the different actors and tools in the water sector.

The project has shown that there are efforts towards integration, internationally. Although most of the efforts are not guided by a framework like the GICF developed in this project, they are, however, based on the same principles, and build towards a complete system as envisaged with the WATERGRAL. For example, the Australian government through the Bureau of Meteorology is building the Australian Water Resources Information System (AWRIS) which is to be a powerful information system capable of receiving, standardising, organising and interpreting water data from across Australia (initial investment of $10 million and further $50 million over 5 years) (NWC, 2011); Europe is developing a Water Information System for Europe (WISE) which is to manage information on projects, tools, documents or any other information relevant for the Water Framework Directive (WFD) implementation; the American Consortium of Universities for the Advancement of Hydrologic Science Inc (WISE, 2011); (CUAHSI) is developing a Hydrologic Information System (HIS) which should provide web services, tools, standards and procedures that enhance access to more and better data for hydrologic analysis (initial research investment was $3 million, annual operating cost of $3 million and capital investment of $5 million) (CUAHSI, 2011). These developments and others presented in **chapter 4** have indicated the need for a long term perspective and a need for substantial investment in an effort to integrate water resources and water uses management.

It is hoped that the GICF, if implemented, will foster greater awareness of the issues affecting integration, and focus attempts and resources to address disintegration problems. The GICF represents a means to an end, rather than an end in itself, and what is ultimately required is for all the actors in the water sector to align with the GICF's optimal direction leading to complete integration. It is therefore not expected that the GICF will be implemented all at once, but that it will be used to guide prioritisation on programmes that should be undertaken.

6. RECOMMENDATIONS

The GICF as implemented in the WATERGRAL is currently a concept, and the case study results have emphasised that integration requires both a short term and long term view, and that the water sector, particularly the DWA as a sector leader will have to act accordingly to:

- Undertake a benchmarking and cost benefit analysis exercise of implementing the GICF.
- Identify appropriate institutional model for implementing the GICF.
- Develop a long term plan and a funding model for implementing the GICF.

- Develop the three prerequisite foundational Level II frameworks i.e. the coordination, monitoring and compliance, and the data and information management integrated frameworks.
- Streamline the sector in line with the GICF.

The implementation of the GICF and the development of the WATERGRAL system is proposed to be in three phases as follows:

1. Phase 1: undertake the above recommendations focused on streamlining the sector wide objectives on a strategic level – top management (Minister to Deputy Director Generals and/or Chief Directors), mapping the relationships with other sectors and other government institutions.
2. Phase 2: focused on streamlining the functional areas on a tactical and operational level (middle and lower management in the water sector).
3. Phase 3: development and deployment of the WATERGRAL system.

Detailed recommendations are presented in **chapter 9**.