IDRC INTERNSHIP PROGRAM

URBAN WATER MANAGEMENT RESEARCH AT THE IDRC:

IMPACTS, LESSONS LEARNED AND RECOMMENDATIONS FOR FUTURE RESEARCH

FINAL REPORT

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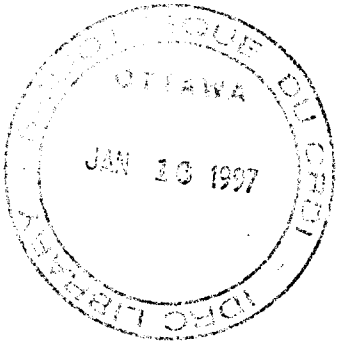

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i. Executive summary

This report is the final output of a six month study undertaken within the IDRC's internship program. This study was defined by three objectives:

- To assess the impact of IDRC urban water management research;
- To refine the IDRC's existing urban water management research agenda; and,
- To promote the IDRC's revenue generation capacity.

In order to achieve these objectives, the study undertook a review of historical urban water management program documentation, a survey of urban water management project leaders in Latin America, Southeast Asia and West Africa, and face-to-face interviews with a range of Southeast Asian project stakeholders.

The study's premise is that the IDRC's mandate is consistent with the support of a clearly defined urban water management research agenda. As a starting point, the effective management of urban water has become critical to promoting sustainable urban development. In this respect, urban water is closely linked to the urban environment, the urban poor and the urban economy. Another dimension of the urban water management problematic is its inherent complexity. Consequently, the successful management of urban water resources and services will demand an inter-disciplinary, inter-sectoral and multi-stakeholder approach. The IDRC is well positioned to contribute to this challenge.

In fact, the IDRC has played a significant role in supporting urban water management research. The study identified a total of 75 projects supported since 1973 which have addressed various aspects of the urban water sector. Each of the IDRC's former divisions contributed to these projects, which were implemented in all regions of the developing world. The most significant contribitions were made in the health sciences, social sciences and earth & engineering sciences.

Unfortunately, urban water research has been characterized by cyclical support, with the 1990s experiencing a relatively weak level of activity. Urban water research has also been marked by a lack of strategic direction, reflected in the failure to integrate the disparate research taking place within separate disciplines. While urban water projects continue to be supported at the IDRC, these do not form part of an integrated research agenda.

At the core of the study was an assessment of the impacts of nine projects, all of which took place between 1989 and 1995. Eight of these projects focused on groundwater management issues in five Latin American cities, two Southeast Asian cities, and one

West African city. These projects were executed over an average of three years, and received an average of CDN$280,000 in funding. The ninth project addressed wastewater management research in Dakar, Senegal. This last project took place over a four month period with less than $14,000 in funding.

The assessment addressed six areas of impact. The projects' greatest impact was on **scientific & technical innovation**. Substantial contributions were made in the areas of aquifer mapping and modelling, groundwater-surface water interactions, land subsidence, saline intrusion, wastewater treatment, groundwater contamination, artificial recharge, and optimal groundwater exploitation strategies.

The projects also had a relatively strong impact on individual and institutional **capacity building**. The strongest impact was in developing interdisciplinary research capacity. However, respondents also indicated that the projects contributed to the development of university and government research centres, PhD and Graduate students from developing countries and Canada, and municipal and national water companies. More limited benefits went to non-governmental organizations and Canadian university research centres.

The third impact considered was in the development of **partnerships**. While the projects contributed to a limited diversity of partnerships, very strong partnerships were developed between Canadian and developing country researchers, and between developing country university and government agencies.

The projects had a surprisingly strong impact on **resource generation**. In particular, this included funding for additional research and development projects, increased investment in infrastructure and development projects, revenue generation, and future cost savings. While the benefits of resource generation went primarily to developing countries, Canadian research partners also benefited to some extent. The IDRC itself was not considered a direct beneficiary of resource generation.

There was a relatively weak impact on **policy & decision making**. In large part, this was due to the long term nature of this impact. However, respondents indicated that the projects resulted in a greater awareness of urban water management issues amongst local and national politicians and bureaucrats, at the international level, and amongst the general public. In several instances, IDRC projects led to the application of project designed management tools, groundwater protection measures, and artificial recharge technology. Respondents also indicated a limited impact on water policies.

The weakest impact was in the area of **community development**. This was due largely

to the projects' emphasis on addressing large scale hydrogeological and geotechnical problems. However, respondents indicated that the projects contributed to limited improvements in quality of life, strengthening of community-based organizational capacity, and some community participation in project activities.

The study also included an analysis of the lessons learned from these impacts, and presented recommendations for the future direction of urban water management research. Some highlights of the key lessons and recommendations are as follows:

In the two areas of **project and program design**, the study recommended that project activities and objectives be clarified and explicitly integrated at the proposal stage. This was considered an absolutely necessary pre-requisite to successful research. A related recommendation was the importance of defining research programs in terms of specific and quantifiable goals, objectives and benchmarks.

Several recommendations were made in the area of **project and program delivery**. The most critical of these is the need to strengthen the project monitoring function. The two basic options available to the IDRC include contracting monitoring officers on a project-by-project basis, or strengthening the existing role of program officers. The study also recommended the continuation of support for Canadian research partners. However, in light of financial constraints, this recommendation was qualified by the need to develop specific strategies for supporting Canadian universities, government agencies and private sector firms interested in pursuing research activities in developing countries.

In response to the challenges involved in undertaking a proper assessment of the impact of IDRC projects, the study also addressed several **methodological constraints to assessing impacts**. The recommendations included the need to include impact assessment methodologies in project design, the need to improve documentation, and the importance of maintaing accurate contact information on project stakeholders. The value of a project is greatly diminished if there is no feasible mechanism in place for assessing its impact on development.

A final area addressed by the study was **revenue generation**. While the IDRC did not benefit directly from this impact, the fact that considerable resources were generated by the projects suggests the need for the IDRC to monitor the level and type of revenue generation. This would permit the IDRC to promote its successes in this area. Another area where more effort could be placed is in self-promotion. Despite its substantial and important contribution to both developing countries and Canadian researchers, the IDRC's name remains undervalued.

In light of the study's findings it is apparent that the IDRC would benefit significantly from focused and clearly directed support of urban water management research. In addition to the growing importance of addressing the impact of urbanization on water resources, and the importance of water management to sustainable development, the IDRC has built-up extensive expertise in this area over the past three decades. In the long term, the IDRC should work towards developing and supporting a wider program of integrated water resources management research.

ii. Purpose, objectives and outputs of the internship

Purpose and objectives

The objectives of the internship are as follows:

(1) to refine the existing International Development Research Centre (IDRC) agenda for urban water research, with a focus on the management of urban residential, agricultural and industrial water supply, and urban wastewater treatment, reuse and recycling;

(2) to assess the impacts of IDRC-supported urban water management research projects undertaken between 1985 and 1995; and,

(3) to enhance the revenue generation capacity of future IDRC-supported urban water management projects.

The timing of this internship coincided with fundamental and extensive changes at the IDRC. As a result, the internship's original purpose and objectives were continuously revisited and re-evaluated over the past six months. While the core of the internship's original mandate was largely maintained, there was a substantial change in emphasis.

From its inception, the scope of the internship was extended beyond that of an evaluation and towards a strategic approach for refining the IDRC's urban water management research agenda. This change had two important implications. First, rather than identifying four case study projects to be evaluated, seventeen projects were short-listed. This revised approached permitted a more comprehensive assessment of urban water management research. Of these seventeen projects, a total of nine are included in this final report. Second, the use of the term *evaluation* was dropped in favour of *assessment*. This change in terminology reflected the decision not to focus on the success of individual projects, but rather to identify and analyze their collective impact.

Outputs

In addition to this Final Report, the internship produced a considerable number of outputs related to its objectives. These are listed below:

- The internship contributed to the preparation of an IDRC water and wastewater project management marketing brochure.

- A proposal to study the feasibility of developing an urban water management research program was submitted in the form of an Exploratory Program Initiative Memorandum.
- Five progress reports providing a detailed summary of the progress of the internship were submitted over the course of the internship.
- A report providing a detailed description and analysis of the activities carried out during a two week trip to Indonesia and Thailand was prepared. This Trip Report provides an assessment of the impacts of six IDRC-supported urban water management projects undertaken in these two countries, and presents a series of urban water management research priorities in Southeast Asia.
- A summarized version of the Final Report will be prepared for distribution to the survey respondents.
- In compliance with the requirements of the internship program, a Technical Report was prepared and submitted to the Corporate Affairs Branch. This report summarizes the objectives and related activities of the internship.

In addition to these outputs, the internship originally intended to prepare and submit the urban water component of the Urban Environment Management SED Progress Report. While the formal submission of SED/Theme Progress Reports is no longer required, a summary version of this Final Report could be submitted as a Progress Report.

ii. Purpose and structure of the Final Report

The purpose of the internship's final report is as follows:

- To present the methodology and approach used as part of the internship;
- To present the findings of the assessment of the impacts of nine urban water management projects undertaken in nine cities in Latin America, Southeast Asia and West Africa; and,
- To present lessons learned from these projects and to recommend a future direction for urban water management research at the IDRC.

The report begins with a presentation of the approach and methodology used during the internship. Section 2 provides an overview of the scope of urban water management research. Sections 3 and 4 discuss the role played by the IDRC in urban water management research. This includes an overview of the IDRC's role since 1973, as

well as a description of the nine IDRC-supported urban water management projects selected for closer analysis. Eight of these projects address groundwater management issues, while one focuses on wastewater treatment. Sections 5 and 6 present the major findings of the assessment, including a detailed description of the impacts of the nine case study projects, an analysis of the lessons learned from these impacts, and recommendations in support of future research. The concluding section presents some thoughts on the specific to be played by urban water management research within the IDRC.

A series of appendices have also been attached to this report. These include bibliographical references, contact information for each of the survey respondents, a copy of the survey questionnaire, and the methodology used to analyse the survey data. A final appendix provides the names of IDRC Program Officers with a current or historical stake in urban water management research.

In addition to this final report and its appendices, the remaining internship outputs listed above have been compiled and are available for additional reference.

1.0 Approach and methodology

The internship was based on identifying the lessons to be learned from earlier projects. This was to be achieved by focusing on the impacts of these projects. The methods employed to identify and assess the impacts and lessons learned include the following:

1.1 Interaction with stakeholders

The project was based on the direct involvement of project stakeholders in the development of the methodology, and the collection of data. Stakeholders included relevant program officers in Ottawa and the regional offices, as well as Canadian and developing country researchers, public, private sector and non-governmental agencies with a stake in the project, and communities and community-based organizations affected by the projects.

1.2 Literature review

The literature reviewed considered documentation on the evolution of the IDRC's water research agenda since 1973. The review also included previously completed reports on the analysis and evaluation of project impacts. Relevant academic papers and reports on urban water management were also considered. Finally, a constant review of the documentation explaining the IDRC's transition was conducted in order to ensure the continued relevance of the internship effort.

1.3 Selection of projects to be assessed

The process of selecting projects involved an exhaustive review of completed and on-going projects, and the identification of programs and sub-programs with a substantial urban water research content. The selection process culminated with identification of seventeen case study projects to be considered for closer analysis. Of these, six were to be analyzed through site visits and eleven through mail out questionnaires. Nine of these projects were included in the final analysis.

1.4 Development of assessment plan

The assessment plan involved identifying existing sources of project documentation, identifying relevant project stakeholders, and determining the possibility of including these in the analysis. However, relying on written project documentation proved inadequate due to the paucity of information corresponding to project impacts contained in project files. Identifying relevant stakeholders was complicated by inaccurate or inadequate contact information for project leaders, and the absence of any explicit written documentation identifying other relevant stakeholders.

1.5 Development of Assessment Criteria

A set of six assessment criteria was developed, based on research priorities and strategic objectives included in the Corporate Program Framework, the Urban Environment Management Global Program Initiative, and the Evaluation Unit:

1. *Scientific & Technical Innovation*
2. *Individual & Institutional Capacity Building*
3. *Partnerships*
4. *Policy & Decision Making*
5. *Community Development*
6. *Resource Generation & Cost Savings*

These criteria were used to guide the assessment of impacts and provided the structure of the survey questionnaire.

1.6 Questionnaire design

A questionnaire combining open and closed-ended questions was designed. The questions sought to identify the extent of impacts, the beneficiaries of impacts, and the causal factors contributing to these impacts. Twelve of the twenty respondents contacted by mail, including seven of nine Latin American respondents, completed a total of fourteen questionnaires. In addition, two questionnaires were completed during face-to-face interviews during the field trip to Southeast Asia.

1.7 Analysis of project impacts

The assessment of project impacts was based almost entirely on the results of the sixteen completed questionnaires and a series of face-to-face interviews with project stakeholders in Ottawa, Jakarta and Bangkok. Project documentation, including annual and final reports, provided background information on individual projects.

2.0 The urban water management challenge

2.1 Water and sustainable urban development

Currently, over 80 countries, representing 40 percent of the global population are experiencing chronic water shortages (World Bank, 1995). Competition among

agricultural, industrial and domestic water consumers for increasingly scarce water supplies, both nationally and internationally, is expected to be the world's greatest source of conflict by the next decade. Within this context, the impact of rapid urbanization and industrialization presents a particularly unique set of challenges to the management of water resources and to the sustainable development of cities in developing countries. Managed in a sustainable manner, water provides a vital contribution to social improvement, economic growth and ecological stability. In contrast, inadequate urban water management has a profound impact on the environmental sustainability, economic efficiency and social equity of developing countries.

The underlying causes of inadequate urban water management are complex. At the macro level, rapid urbanization and industrialization in conjunction with unprecedented population growth and intense poverty are exceeding the capacity of existing urban water delivery systems, leading to the over-consumption of surface and groundwater resources, and compromising the quality of water resources.

At the micro level, the challenge to water management is defined by several factors. Inappropriate pricing and outdated legislation facilitate overconsumption of water resources and fail to influence unsustainable behaviour of individuals and corporations. At the same time, the public and private sector agencies responsible for managing water resources and delivering urban services are characterized by inadequate financial, technical, and organizational capacity. As a result, inadequate waste management results in the disposal of solid and hazardous wastes directly into rivers and canals, and the direct contamination of groundwater from pit latrines and poorly maintained septic systems. Similarly, poor or non-existent treatment systems permit increasingly contaminated stormwater to further erode the quality of water resources, while ineffective land use and development planning results in a growing gap between the demand and supply for basic infrastructure and municipal services.

Lowering groundwater tables, reduced water supplies and contamination of existing supplies are, in turn, resulting in even more complex challenges to the urban environment, the economy and the urban poor. For example, significant land subsidence in larger metropolitan centres is occurring as a result of the consistent overwithdrawal of groundwater. Heavily urbanized metropoli such as Mexico City, Bangkok and Jakarta have experienced land subsidence of up to 8 metres. In addition to the damage sustained by buildings and infrastructure, subsidence contributes to extensive flooding. In some cases, lowering groundwater levels are allowing seawater to gradually enter aquifer systems. Saline intrusion serves to further contaminate groundwater resources and reduce the availability of water supplies. Another

significant impact of reduced supplies of water near to urban centres is the increased dependence on longer distance supplies. This invariably involves the construction of environmentally damaging water supply mains, and extensive distribution networks which serve to increase the cost of supplying water to urban residents.

In addition to its negative impact on the urban economy and natural environment, inadequate water management also has a disproportionately negative impact on the health, productivity and general quality of life of the growing number of low income families moving into or already living in the cities. Water sold by private water vendors in low income communities can cost twenty to one hundred times more than what middle income residents pay for piped water (Karp, 1995). As a result, many families rely on contaminated groundwater for sanitation, washing and even drinking, while others, unable to afford basic housing, live in close proximity to, or directly above, heavily polluted rivers and canals. Finally, the removal of subsidies and the dependence on ever distant supplies of clean water are placing the price of water further beyond the reach of lower income families.

2.2 Responding to the challenge

The challenge to urban water management is by no means limited to inadequate water supplies. More significant is the pervasive inefficiency of the delivery and use of water, the inappropriate use of water resources, and the contamination of available water resources (Serageldin, 1995). In this regard, any response to this challenge can no longer be based largely on the further development of water resources. Instead, the effective management of urban water will have to influence unsustainable water consumption behaviour through demand management strategies, promote the conservation of existing resources, and increase the efficiency of service delivery.

An effective response will also have to contend with the complex and multi-dimensional nature of urban water management, which consists of a wide diversity of disciplines, sectors, and stakeholders. The range of scientific and technical disciplines includes engineering, the natural sciences, the physical sciences, the social sciences, management, law, and the information sciences (Table 1). Constant and significant levels of co-operation and communication must take place among the professionals representing these disciplines.

Urban water management is also grounded in the inter-play of an extensive range of service delivery and urban management sectors. These include water distribution, wastewater management, stormwater management, surface and groundwater management, solid and hazardous waste management, and the management and

maintenance of other physical infrastructure, such as roads and sewers. Other sectors with an impact on urban water management include housing, commercial and industrial development, land administration, and social and human services delivery. The integrated nature of these sectors demands a range of perspectives from which to effectively address the management of urban water.

Table 1 Interdisciplinary dimensions of urban water management research

1. **Hydrogeological and hydrological research:** Modelling aquifer storage, flow direction, geological characteristics, artificial recharge, assessing runoff volumes and river flows.
2. **Biological and chemical analyses:** Assessing water quality, raw water treatment requirements, health implications of contaminated water, water treatment methods.
3. **Civil and environmental engineering:** environmental impact assessments, water supply, treatment, distribution and sewerage disposal systems.
4. **Urban development planning:** Integrated planning for housing, industrial development, transportation, water management.
5. **Institutional strengthening and capacity building:** strategic planning, human resource development; information technology development.
6. **Natural resource economics:** pricing, economic impact assessments.
7. **Community development:** mobilizing residents, strengthening community organizations, involving communities in resource management and conservation.
8. **Regulatory, legislative and policy reform:** related to pricing, access, health, social equity, pollution prevention and mitigation measures.

A final factor to consider is the role played by different levels of decision making in influencing the effectiveness of urban water management within any one city. At the micro level, these include individual households, industries and communities. At the macro level, these include regional, national and international governments, government agencies and development agencies, as well as large national and multinational corporations. Between these levels lie a range of decision makers with significant impacts on urban water management. These include municipal and metropolitan governments, and provincial/state authorities. In addition to these bodies, there are also a myriad of non-governmental, community-based and private sector interests with a stake in the urban water sector. There is thus a critical need to facilitate

the seamless integration of decision-making across these levels.

3.0 IDRC's role in urban water management research

3.1 The historical evolution of urban water management research

A 1991 report prepared by Jim Chauvin serves as a useful indicator of the past direction of water-related research within the IDRC. The report's findings suggest that since its inception in 1973, the attention paid to the water research agenda has been cyclical. Resources allocated to water projects rose steadily through the 1970s, peaking in 1979/80. Following a downturn in activity in the early 1980s, attention to water increased again, peaking in 1988/89, only to fall again into the 1990s. In the context of this cyclical history, the conditions for an upturn in water research at the IDRC are now in place as a result of the hiring of a Water Supply and Sanitation Engineer as a Senior Program Officer in the former Environment & Natural Resources Division (ENR) in 1995.

There have been well over 250 water projects undertaken in the IDRC since 1973, when the Rural Water Supply and Sanitation Program was established. While no single research program has uniquely addressed the issue of urban water, an IDRIS search revealed eight programs and sub-programs with a significant concentration of urban water projects. It is important to note that none of these programs and sub-programs are currently active. The same IDRIS search also identified a total of seventy-five completed and on-going projects which address various aspects of urban water management. These included twenty-seven Latin American projects, twenty-four in Africa, nineteen in Asia, and five global initiatives.

Table 2 IDRC Programs with significant urban water research content

	PROGRAM/SUB-PROGRAM NAME	LIFE SPAN
Cooperative Programs Division(CP)/Earth & Engineering Sciences Division(EES)/ Environment & Natural Resources Division(ENR)		
(1)	*Hydrology and Hydrogeology sub-Program*	1983-1989
(2)	*Water in the Environment sub-Program*	1989-1992
(3)	*Urban Environmental Management Program*	1993-1995
Health Sciences Division		
(4)	*Health and the Community Program*	1987-1992
(5)	*Health and the Environment Program*	1987-1992
Information Sciences Division		
(6)	*Human Environment, Health & Population Info. sub-Program*	1984-1992
Social Sciences Division		
(7)	*Urban Policy Program*	1984-1989
(8)	*Urban Development Program*	1989-1992

An analysis of the seventy-five IDRC-supported urban water projects suggests that urban water projects have traditionally fallen into one of four categories. These categories are presented below roughly in the chronological order in which they have occurred:

(1) Water, sanitation and health (Health Sciences focus)
(2) Management of municipal service delivery (Social Sciences focus)
(3) Hydrogeology/groundwater (ENR focus)
(4) Regional information and research networks (ENR focus)

This report focuses on the third of these categories, with eight of the nine projects included in the assessment addressing hydrogeological and groundwater management issues.

3.2 The current context of urban water management research

Despite extensive experience in supporting urban water management research at the IDRC, this area has been defined by a lack of a coherent purpose, poorly defined objectives, and an absence of any strategic direction. In fact, the IDRC has at no point in its history supported a research program with an exclusive focus on urban water management. However, urban water management was included in the recent Urban Environment Management program (URB), with specific objectives for urban water management research defined in a 1993 document entitled *Urban Environment*

Management Global Research Agenda. In addition to water management, the URB program was designed to address research in disaster prevention & mitigation, solid waste management and urban agriculture. However, URB's water-related objectives were never fully implemented, while the program ceased to exist in 1995.

The current vehicle for implementing the original URB agenda is the Cities Feeding People Global Program Initiative (CFP). CFP, as described in the Program Identification Memorandum "encourages and improves policy and technology developments in support of urban agriculture and the related protection and reuse of groundwater resources." This program initiative builds on the work undertaken through the Latin American Urban Hydrogeology Network and the Latin American Urban Water Management Network, and currently represents the program initiative with the closest links to urban water management research.

As evidenced by the role of CFP, urban water management research and development activities continue to be supported within the IDRC. In fact, the 1995-96 program includes a wide diversity of programs which address various strands of urban water management. In addition to Cities Feeding People, other notable initiatives include the Economy and Environment Program in Southeast Asia (EEPSEA) secretariat, the Water Management in Drylands PI, the Municipal Development Program, the Sustainable Cities Network, the Development of a Decision Support System for Land and Water Management, and a global exploration of Integrated Approaches to Safe Drinking Water. There are also proposed initiatives which address urban water management issues, including an exploration on Municipal Governance, and a proposed project on Local Water Supply and Conservation Strategies to Cope with Water Scarcity in India and Nepal. However, the entirety of this urban water management research is being conducted without any overall strategic direction.

The demand for research into a range of issues which focus directly on management of resources, supply, and service delivery related to water and wastewater in the cities of developing countries remains stronger than ever. This is true both at the level of development agencies and developing countries themselves. For example, in a move that reflects a strong indicator of the direction of similar institutions, the World Bank recently announced an increase in lending to the water sector (Water crisis, 1995). The Bank will contribute loans equal to $40 billion over the next ten years, as part of global investments towards clean water supplies amounting to an estimated $600 billion. In Canada, CIDA is currently preparing a strategy document which will address that agency's increased emphasis on water supply and sanitation. Similarly, Care Canada is currently in the process of embarking on the support of projects in the urban water sector in Africa. The rationale for Care Canada's decision is based, in part, on their

perception of increased support for the urban water sector by the international lending and development agencies. Accordingly, there remains a strong need to actively develop and promote a coherent research agenda in this sector.

4.0 The case study projects

4.1 Overview

The following sections provide brief overviews of the background and objectives of each of the nine projects included in the analysis. It is important to note that these overviews are based on the original proposals, rather than the actual outcomes of the projects. Consequently, there are several inconsistencies between the proposed objectives and the actual activities and outcomes of each project.

Five of these projects took place in Latin America, two in Southeast Asia and two in West Africa. Eight of the projects addressed groundwater management issues, while one focused on wastewater treatment. Consequently, the assessment of project impacts and lessons learned contained in the following sections is based almost exclusively on issues related to groundwater management research.

Table 3 The case study projects

Project Title (Project Number)	City	Dates	Budget	Project Objectives
1. Artificial Recharge Subsidence Control (90-1020)	Bangkok, Thailand	05/1991-06/1994	$298,530	2 3
2. Groundwater Cochabamba Valley (88-1059)	Cochabamba, Bolivia	08/1989-10/1991	$207,590	2 4 7
3. Quaternary Hydrogeology Phase II (89-1017)	Cotonou, Bénin	12/1990-12/1993	$375,105	2 4 5 6 7
4. Urban Domestic Wastewater Treatment (90-0153)	Dakar, Sénégal	02/1991-06/1991	$13,703	8 9
5. Groundwater Management in Coastal Region (91-1007)	Jakarta, Indonesia	11/1991-12/1995	$351,570	1 2 4 5 7
6. Groundwater Management (88-1056)	La Plata, Argentina	07/1989-07/1993	$306,567	1 4 6 7
7. Aquifer Managua (88-1054)	Managua, Nicaragua	09/1989-09/1991	$151,300	1 2 4 6 7
8. Aquifer Development Phase II (89-1029)	Mexico City, Mexico	04/1990-05/1993	$261,000	2 4 6 7
9. Artificial Recharge (91-1009)	Santa Marta, Colombia	10/1991-12/1994	$312,610	2 3 4 5 6 7

1. Groundwater management strategies
2. Groundwater modelling
3. Artificial recharge
4. Characterizing aquifer systems
5. Measuring land subsidence/salt water intrusion
6. Assessment of groundwater contamination risks
7. Institutional capacity building
8. Wastewater treatment
9. Community-based management

The urban areas which form the focus of all nine projects include a combination of medium, large and mega-populations, ranging in size from 300,000 in Santa Marta, Colombia, to 22 million in the Valley of Mexico. All nine of these cities are experiencing significant population growth, as well as a range of water-related development problems. The tables included in the following sections provide summary profiles of the water-related problems facing each of these cities.

Table 3 provides several summary indicators related to the nine projects. IDRC's financial contribution to the projects ranged from under $15,000 for a four month project in Dakar, Sénégal to more than $375,000 for a three year project in Cotonou, Bénin. The mean average project budget was slightly more than $250,000 for an average duration of slightly less than three years. Since it was not considered feasible to assess projects completed more than five years ago, all nine projects were either completed within the past five years, or are near completion. However, the Mexico City, Cotonou and Bangkok projects were each preceded by related projects initiated in the mid-1980s. While these earlier projects were not explicitly included in the analysis, reference to the impacts of these three projects often implies contributions made by the earlier projects.

4.2 Artificial Recharge Subsidence Control/Bangkok, Thailand

The Artificial Recharge Subsidence Control project was administered by the EES and ENR Divisions through the South Asia Regional Office (SARO). IDRC's contribution to the project was $298,530 for the period May 1991 to June 1994. The project's research leaders included the Asian Institute of Technology and the Geotechnical Research Centre of McGill University. Bangkok's Metropolitan Waterworks Authority was also identified as a project collaborator, to be responsible for implementing the artificial recharge system. The National Environment Board was also to be consulted during the system design.

This project was a follow-up to an earlier project, entitled Urban Geology (84-1044). Urban Geology produced a detailed geologic map of the Bangkok aquifer system and its characteristics, as well as a mathematical model. Based on the results of this earlier project, the Artificial Recharge project was designed to test the hypothesis that land subsidence caused by groundwater depletion can be controlled by artificially recharging the underlying aquifers. The city of Bangkok's land surface had been subsiding by up

City Profile 1	**Bangkok, Thailand**

Metropolitan Bangkok, situated in a valley along the southern coast of Thailand, has a rapidly growing population of over 10 million. Pumping of Bangkok's major aquifer has been taking place since 1954. In 1982, groundwater pumpage exceeded 1.35 million m^3/day from more than 11,000 wells. amounting to more than 30 percent of total water supply. Continued overwithdrawal and declining groundwater levels have resulted in significant land subsidence in the urban area, varying between 0.01 m/year and greater than 0.04 m/year. Given that ground elevations of Bangkok are 1 to 1.5 m above sea level,. the accumulated subsidence has increased the risk of flooding, to the point where annual flooding is widespread. Arresting land subsidence has become essential to Bangkok's survival as a city.

to 7 cm. each year due to extremely high groundwater withdrawal rates.

The project was defined by three objectives:
1. to develop appropriate technology and methodology for recharging the aquifers in order to stop the land subsidence in Bangkok;
2. to conduct a field recharge experiment for calibrating and verifying the design approach developed; and,
3. to prepare a manual for recharge well design, recharge requirements and land subsidence prediction-suitable for full scale implementation.

The project was also defined by several other aspects relevant to the internship's work. Several government agencies at the national and municipal levels were to be directly involved in the project in order to facilitate application of the study's findings. Workshops were to provide relevant agencies with information on recharge technology specific to Bangkok, control of land subsidence, and recharge/subsidence management. The project was also to provide training to four local trainees through hands-on experience.

4.3 Groundwater Cochabamba Valley/Bolivia

The Groundwater Cochabamba Valley project was administered by the EES Division between July 1989 and November 1991. IDRC's contribution to the project was $207,590. The project was to be carried out by the University of Waterloo's Groundwater Research Centre (WGRC), the Universidad Nacional Autonoma de Mexico Instituto de Geofisica (UNAM-IG), the Universidad de Sao Paulo Centro de Estudos e Pesquisas de Aguas Subterraneas (CEPAS), in conjunction with the Corporacion Regional de Desarollo de Cochabamba (CORDECO). This project was proposed as part of the IDRC-supported Latin American Urban Hydrogeology Network (LAUHN), involving university research centres across Latin America.

The project originated as a result of the concern expressed by Cochabamba water authorities regarding the abstraction potential of the local aquifer system and the vulnerability of that system to contamination. These authorities envisaged the need for new water management policies based on a relevant groundwater model.

The project's originally proposed objectives were as follows:
1. to achieve a better understanding of the groundwater system in the Valley of Cochabamba;
2. to develop an improved model of groundwater flow and quality in order to maximize water use; and,
3. to strengthen the groundwater research capabilities at CORDECO and in Bolivia generally.

City Profile 2	Cochabamba, Bolivia

The Valley of Cochabamba is located in the Eastern Range region of Bolivia. It has a high density population, with a total of 300,000 inhabitants, about half of which reside in the City of Cochabamba itself. Water needs of the Valley are supplied by surface and groundwater resources. However, about 60 percent of the population, mostly in suburban areas, are not served by the municipal water supply network. Most of those not supplied rely on groundwater from 200-250 domestic wells. The non-urban population of the Valley relies on groundwater for irrigation, household and some industrial uses.

Neither the withdrawal nor recharge rates are known for the aquifer system, though it is evident that current recharge rates are considerably higher than rates of withdrawal. However, land use practices on the slopes of adjacent mountains have increased run-off and surface erosion. Furthermore, since the sewerage system reaches only 100,000 people, domestic and industrial waste disposal threatens contamination of the groundwater.

The project was designed in to facilitate the eventual implementation of project findings. This was to be achieved, in part, by an end-of-project workshop attended by relevant authorities in the Valley of Cochabamba. In addition, SEMAPA, the institution directly involved with the Valley's water supply was to receive relevant groundwater model software and basic training on using the computer model. Results of the study were also to be made available to CORDECO and the Cochabamba Geological Survey (GEOBOL). Finally, several other local and national institutions involved in water management in Bolivia were to be kept informed of the results of the project.

Another important aspect of the project was the proposed contribution to the suburban and rural population of the valley of Cochabamba. These were seen as benefiting directly from the project through the improvement of their water supply. In addition, local scientists were to benefit from on-the-job training, while institutional training was to be provided to Bolivian researchers.

4.4 Quaternary Hydrogeology Phase II/Cotonou, Benin

The second phase of the Quaternary Hydrogeology project was carried out between December 1990 and December 1993. The EES Division contributed $375,105 over this

time. Co-funding was also provided by the Société Béninoise d'éléctricité et d'eau (SBEE) and the Direction de l'hydraulique. The beneficiaries of this funding included the Département des sciences de la terre of the Université Nationale du Bénin, the Département de géologie of the Université Cheikh Anta Diop, and the Département de géologie of the Université Laval.

The first phase of this project was initiated in 1985 in response to water shortages and the contamination of the local aquifer system. This earlier project was linked to other water

supply improvement projects in West Africa, including a 1986 project in Dakar, Sénégal entitled Saltwater Intrusion in Aquifers. Modelling from the Sénégal project was adapted to Bénin's conditions in order to predict saltwater intrusion and simulate groundwater exploitation strategies. The second phase of the Bénin project was devoted to providing a better understanding of the hydrodynamic and hydrochemical conditions of the aquifer system along the southern coast of the country in order to permit the SBEE to develop rational groundwater exploitation strategies, to permit the Direction de l'hydraulique to plan for future water demand, and to provide the ministry of health with information necessary to intervene in rural areas affected by groundwater contamination.

City Profile 3	**Cotonou, Bénin**

Metropolitan Cotonou, population of 700,000, is situated along the coast between the Atlantic Ocean and Lac Nokoué. The region includes a two aquifer system of prime importance to the country: a deep aquifer that recharges the Godomey rivershed with Metropolitan Cotonou's water supply; and a shallow aquifer, vulnerable to salt water intrusion and human contamination due to intense domestic exploitation through hand dug wells. Cotonou is the most heavily populated area of Bénin and has been growing at a rate in excess of 8 percent per annum. While exploitation of groundwater in the city began in 1956, rapid urbanization is resulting in far more intense exploitation. Saltwater intrusion and contamination from industrial and domestic pollutants is placing the region's groundwater supply at risk. Furthermore, inadequate sanitary conditions are causing water-borne bacteria to create health problems, including diarrhoea and cholera. The National Government has already invested considerably in the region's water supply, and cannot afford to further increase water supply.

The specific objectives of the second phase project included the following:
1. to continue contributing to an improved understanding of the geology of the study area;
2. to characterize the saltwater-freshwater interface;
3. to develop a model of the aquifer system for use in optimal exploitation strategies;
4. to identify the potential vulnerability of the shallow aquifer to contamination; and,
5. to transfer results to relevant water authorities.

This project was consistent with the drinking water supply master plan for the City of Cotonou, and was meant to provide the National government with a management system that would assist in reducing and stabilizing national investments in this sector.

4.5 Urban Domestic Wastewater Treatment/Dakar, Senegal

City Profile 4 **Dakar, Sénégal**

The City of Dakar and its surrounding region are located in a coastal area of highly variable climate. The region's irregular precipitation is unable to consistently meet the water needs of household, industrial, and agricultural users. As a result, the 1.5 million residents of the region, representing one-third of Sénégal's population, rely heavily on groundwater. An estimated 83 percent of water demand in the region is met by means of pits and wells dug into the aquifer system underlying the city. The remainder is transported from Lac de Guiers, situated 250 km. from Dakar. The volume of groundwater pumped in the region is currently exceeding the aquifer's capacity to replenish itself. Consequently, the groundwater table has been lowering consistently, while the level of salinity has been rising due to seawater intrusion. While plans exist to increase the region's reliance on surface water resources, the lake's water supplies are at risk due to long periods of drought.

The smallest of the case study projects, the Urban Domestic Wastewater Treatment project took place over a four month period between February and June 1991. The IDRC contributed $13,703 to the project which was supported by the Health Sciences Division of the West Africa Regional Office (WARO). The sole recipient of IDRC funding was the Institut des sciences of the Université Cheikh Anta Diop in Dakar.

This project focused on the potential for community-based purification of domestic wastewater for aquaculture using aquatic plantlife. The study also sought to address the health implications of the disposal of untreated urban domestic wastewater in middle-sized peri-urban centres. The project's study area was Pikine, a peri-urban community outside Dakar with a population of 700,000.

The project objectives included the following:
(1) an analysis of existing wastewater treatment process, and quality of effluent;
(2) a sociological study of the attitude of the population towards the treatment of

wastewater; and,
(3) an inventory of the ecology and plant biology of the area in conjunction with an analysis of the value and potential use of these plants as part of the purification and aquaculture development process.

At the time of its proposal, Senegal's Ministry of Rural Development and Hydraulics had expressed a deep interest in using the results of the project. The outcome of the project was seen as being particularly useful to the residents of low income, peri-urban communities by allowing them to acquire simple, affordable technology for recycling water as well as in public health terms. The project was also considered to have strong potential to allow communities to generate revenue.

4.6 Groundwater Management in Coastal Region/Jakarta, Indonesia

The Groundwater Management in Coastal Region project was supported by the EES and ENR divisions through the East and Southeast Asian Regional Office (ASRO), and was provided with funding of $351,570. The project was scheduled to take place between November 1991 and December 1994, though its completion was delayed by a full year. The project was carried out by two agencies. The Agency for the Assessment and Application of Technology (BPPT) served as Indonesian project leader. Its Canadian counterpart was the Saskatchewan Research Council. A grassroots community

organization was also to be directly involved in the research. Finally, several government agencies were to be involved in the research by means of a consultative committee.

City Profile 5 **Jakarta, Indonesia**

Metropolitan Jabotabek had a 1990 population of 17 million people, including 8.2 million residents living in Jakarta. At present, 97 percent of Jakarta's population is without access to adequate sanitary facilities, while 60 to 70 percent are without piped water. As a result of unreliable and inadequate piped water, more than 2 million residents of Jakarta rely on informal supplies of groundwater. However, the absence of basic sanitation, wastewater treatment and solid waste management facilities has resulted in the extensive pollution of the shallow aquifers from which groundwater is drawn. The city's rivers and canals have also been contaminated by untreated industrial and domestic waste. This situation is most acute in the northern, coastal portion of the city, which is characterized by contaminated groundwater, polluted river water, a near total absence of piped water, severe land subsidence and regular flooding. Compounding this situation is the fact that the majority of Jakarta's residents have extremely low incomes, with Rp200,000 (US$90) considered a typical monthly household income.

The project was designed in response to the need for the development of a groundwater management strategy for the coastal region of Jakarta. This region was characterized by saltwater intrusion in the coastal aquifers, land subsidence, and shortages of clean drinking water. This project was linked to several other urban water resource management projects supported by the IDRC in Southeast Asia, including Urban Geology/Bangkok (84-1044), Water Resources Management Model for Metro Manila (89-1025) and Artificial Recharge Subsidence Control/Bangkok (90-1020).

As proposed, the project was defined by four objectives:
1. to develop guidelines for management of groundwater resources in the coastal region of Jakarta, with the participation of the communities, for and secure water usage.
2. to determine groundwater basin yield and its geological and hydrogeological characteristics and inflow-outflow characteristics
3. to measure and evaluate the extent of salt water intrusion and land subsidence
4. to propose preventive and corrective measures and develop groundwater resources

City Profile 6	**La Plata, Argentina**

Metropolitan La Plata, in the province of Buenos Aires, has a population of about 600,000. One of the major factors which influenced the location of the city is the presence of high quality groundwater underlying the area in the Puelche aquifer. The city was supplied entirely by groundwater until 1957. At present about 50 percent of water supply comes from groundwater. Salt water intrusion from saline water underlying the coastal plain has been experienced since the 1940s due to overpumping. Relocation of the wells from the coastal plain have provided a temporary solution, though very little is known about the geochemistry or hydrodynamics of the groundwater of the coastal plain.

management system/model with community participation

The project was also designed to provide training to Indonesian researchers in the areas of groundwater modelling and applications. In particular, the proposal indicated that forty to fifty junior researchers from BPPT would receive on-the-job training, while a smaller number of senior researchers were to participate in the computer modelling. Dissemination and application of the research results were to take place by means of a consultative committee. The relevance of the project's results were strengthened by the adherence of the project to national government priorities set out in Indonesia's Fourth Five Year Development Plan.

4.7 Groundwater Management/La Plata, Argentina

The Groundwater Management project in La Plata took place between July 1989 and July 1992. This project was supported by the EES division and received funding of $306,567. As a result of its place within the Latin American Urban Hydrogeology Network, several university research centres were involved in executing the project. These included the WCGR, CEPAS, Universidad de la Plata's Centro de Investigaciones del Medio Ambiente (CIMA) and the Facultad de Ciencas Exactas y Naturales of the Universidad de Buenos Aires (UBA).

The project was proposed in response to serious challenges to the management of the water supply and coastal wetlands in the La Plata area, and the lack of information on the subject. In particular, the project was motivated by a need to investigate the characteristics of the local Puelche aquifer, develop management strategies required to avoid further damaging the groundwater reservoir, and assess the vulnerability of this system to various forms of contamination. La Plata authorities recognized the need to address these issues following closure of several municipal wells due to high salinity levels.

Reflecting these issues, the project originally included the following objectives:
1. to determine water quality of both the surface and underground water;
2. to identify areas with high vulnerability to contamination;
3. to study the groundwater characteristics;
4. to define and interpret mechanisms of artificial and natural contamination of groundwater;
5. to define management criteria and potential alternatives to maximize groundwater exploitation;
6. to identify areas suitable for future urban/suburban and/or industrial development from the point of view of water availability and quality; and.
7. to strengthen research capabilities of participating universities.

The project was originally sponsored by the municipality of La Plata, which was to apply the project's results for planning future urban development strategies. In addition, the groundwater models were to be supplied to the Ministerio de Obras y Servicios Publicos, of the Province of Buenos Aires, responsible for operation and management of the city's water supply system. This would place the Ministry in a strong position to apply the research results.

City Profile 7	**Managua, Nicaragua**

The City of Managua, population 1 million, has grown considerably in recent years due to in-migration from the rest of the country. Managua's 1988 water needs were estimated at about 200,000 m^3/day, and are expected to rise to 420,000 m^3/day by the end of the decade. By comparison, total supply by the end of the 1980s was 130,000 m^3/day. Strict rationing is now taking place, and there are water shortages 90 percent of the time. The city's main sources of water are Lake Asososca and a well field drawing its water from the largely unknown Las Sierras aquifer. The lake has been used for urban water supply since 1930. Strong drawdown of water levels related to heavy pumping has reduced volumes supplied to the city well below their actual needs, and has increased the risk of contamination from downstream industrial areas near the large and polluted Lake Managua. Despite the gravity of this situation, very little is known about the potential of the Las Sierras Aquifer.

4.8 Aquifer Managua/Nicaragua

The Aquifer Managua project took place between September 1989 and September 1991. The IDRC contribution amounted to $151,300 for the project, which was administered by the EES division. In addition to the WCGR and UNAM-IG, two Nicaraguan government agencies were to participate directly in the project's activities. These agencies were the Instituto Nicaraguense de Estudios Territoriales (INETER)-a government groundwater research agency- and the Instituto Nicaraguense de Acueductos y Alcantarillados (INAA), a government urban water supply agency. This project was also proposed as part of the Latin American Urban Hydrogeology Network.

The project was a response to significantly reduced supplies of drinking water to the city of Managua as a result of overpumping. The water supply was also threatened with contamination. The project was intended to characterize the local aquifer and develop a mathematical model to test various management options. This model was to be adapted

City Profile 8	**Mexico City, Mexico**

Some 22 million people live in the drainage basin of the Valley of Mexico, including 16 million in the City of Mexico. Urbanization in the valley is prone to many unusual conditions, including air pollution due to thermal inversions, severe earthquake hazard caused by poor foundation conditions, limited sources of water supply, and poor drainage of flood waters and sewage. Total demand for water supply is 58m/s out of which 42 is supplied by wells in the Valley. About 80 percent of Mexico City's water supply comes from groundwater. Overpumping since 1930s has caused land subsidence of up to 8 metres in parts of Mexico City, and there is strong evidence of groundwater contamination. Water levels have dropped significantly in some well fields. At the same time, the population of the city and the valley continues to grow at a rapid rate.

from the IDRC's Valley of Mexico project.

The five objectives of the project were as follows:
1. to characterize local hydrogeological and hydrological conditions;
2. to define the risk of contamination of the lake Asososca;

3. to develop a mathematical model of the Las Sierras aquifer to use as a management model;
4. to define basic criteria for proper management of the aquifer; and,
5. to provide training in hydrogeology to INETER researchers.

4.9 Aquifer Development Phase II/Mexico City, Mexico

The IDRC contributed $261,000 to the second phase of the Aquifer Development project, which was carried out between April 1990 and May 1993. The project was

administered by the EES division and was executed by the WCGR and UNAM-IG as part of the Latin American Urban Hydrogeology network. In addition to these research centres, public sector participation in the project was to be achieved through the Comision de Aguas del Valle de Mexico (CAVM), the Departamento del Distrito Federal (DDF), and the Secretaria de Agricultura y Recursos Hidraulicos (SARH).

Rational utilization of the country's scarce water resources was declared a national priority by the National Government during the 1980s. In response to this priority, phase one of the project was initiated in 1985, and was devoted to investigating a range of groundwater and hydrogeological issues. The second phase was designed to continue the investigation of the hydrogeology of the valley and to develop a sound groundwater management program for the water authorities using a mathematical model developed during phase one.

The specific objectives proposed under phase two were as follows:
1. to quantify groundwater recharge in the mountain areas surrounding the Valley;
2. to assess the role of surficial water in the hydrologic regime;
3. to map the extent of zones of contaminated groundwater; and,
4. to further develop the computer model of the hydrogeologic system, and to make it user friendly and more useful as a management tool.

4.10 Artificial Recharge/Santa Marta, Colombia

Urban water supply has been a constant preoccupation of successive national governments in Colombia and of the Santa Marta government, mainly due to the difficulties of providing water services to a rapidly growing urban population. The Caribbean Coastal town of Santa Marta, population 300,000, obtains about 40 percent of its water supply from groundwater sources. Overpumping of wells both near and inland from the coast has caused intrusion of salt water and excessive drawdown of water levels in the aquifer. This has forced the abandonment of many wells and shortages of water. The impact has been most severe on lower income families, who depend almost entirely on well water.

The Artificial Recharge project took place between October 1991 and December 1994. This project received $312,610 in IDRC funding and was administered by the EES/ENR divisions and the Finance & Administration Division. Recipients of project funding included Jacques Whitford Environmental Ltd., a Canadian engineering firm, and the Facultad de Ingenieria of the Universidad de los Andes in Bogota. Other primary project collaborators included the Universidad Nacional in Bogota, and METROAGUA, the municipal agency responsible for urban water supply. This project formed part of the Latin American Urban Hydrogeology Network.

The project was proposed as a response to saltwater intrusion in the local aquifer system and the resulting shortages in available drinking water supplies. The project sought to address these problems by developing artificial recharge methods.

The specific objectives of the project were as follows:
1. to determine hydrogeological characteristics of the Santa Marta coastal basins;
2. to develop a conceptual and mathematical model for the aquifers;
3. to evaluate the unused flows of local waterways that could be used to recharge aquifers;
4. to identify the aquifers' vulnerability to contamination;
5. to identify the position and behaviour of brackish/freshwater interface; and,
6. to design, test and model artificial recharge methods using low cost techniques.

In addition to these objectives, the project was also designed to strengthen the research capabilities of the Universidad de los Andes in the field of hydrogeology. This training was to be extended to other universities. Training was also to be provided to METROAGUA in the areas of research and management of water resources. The dissemination of project results was to take place by means of an end-of-project workshop. The project was also designed to consider the needs of the poorer sectors of the city population affected by lack of water. In particular, the project was to address the impact of lack of water on lost income to low income beneficiaries.

5.0 Project impacts

The following section presents the assessment of the collective impacts of the nine projects on scientific & technical innovation, individual & institutional capacity building, partnerships, resource generation & cost savings, policy & decision making, and community development. This assessment is based primarily on the survey responses and interviews with project stakeholders. Project documentation, in the form of progress and final reports, served as a secondary source. The tables included in this section were derived from the survey data (The data analysis methodology is discussed in Appendix B).

This section illustrates the extent of IDRC's contribution in the area of urban water management. While this section presents a positive assessment of the impact of IDRC-supported urban water research, this assessment is qualified by two important points. First, without exception, the nine projects were not designed to address all six of the impacts considered as part of this study. As a result, none of the projects assessed had a significant impact in all of these areas. A second point is that many of the impacts described in this section occurred either inadvertently, or despite the limitations of a particular project. These limitations will be presented in terms of the lessons learned.

5.1 Impact on scientific & technical Innovation

The starting point for carrying out a research program capable of having a significant and meaningful impact on the water management sector in the cities of developing countries is to develop a detailed understanding of the relevant issues. Well-focused research provides an excellent base for carrying out relevant development projects capable of having direct impacts on the residents and communities of individual cities.

The projects included in this analysis were designed primarily to answer scientific and technical questions regarding the management of water resources. This included the collection of base line data, and the development of management models capable of analyzing and predicting complex hydrogeological phenomena. *In fact, the single greatest contribution made by IDRC-supported urban water management research was in their impact on scientific and technical innovation.* Research institutions and government agencies were the primary beneficiaries of this research.

Within this category, the most valuable contribution made by the projects was in

greatly improving the understanding of complex aquifer systems. The significance of this achievement rests with the dependence of urban populations on largely undefined aquifer systems. The projects contributed comprehensive descriptions and analyses of aquifer systems in Latin American, Southeast Asia, and West Africa which often represented the first initiatives of their

Table 4 Scientific & technical innovation

Contribution to water management knowledge	Strong
Impact on government agencies	Strong
Impact on research Institutions	Strong
Impact on communities	Moderate

kind. Furthermore, many of these findings are applicable to other cities and regions. The findings have also contributed to other non-IDRC studies being supported by international lending agencies.

- *Aquifer Mapping and Modelling*

In the case of Mexico City, an entire project study area was classified in terms of a series of seven hydrogeological units. The hydrogeologic map of the study area that was developed provides a tool for undertaking preliminary risk assessments as land developers begin to consider expansion in these areas. Another innovation was the design of user friendly computer modelling systems in Cochabamba, Cotonou, and Mexico City. These computational models permits realistic simulations of the behaviour of aquifer systems.

- *Groundwater-Surface Water Interactions*

IDRC-supported research contributed to a deeper understanding of various aspects of the natural recharge and discharge behaviour of aquifer systems. This included the study of both vertical and horizontal infiltration of surface water, as well as determining the behaviour of aquifers in response to rainfall events. As a result of the La Plata project, researchers are now better able to determine whether large bodies of water act as recharge or discharge areas. This knowledge is particularly critical in assessing the potential for industrial contamination of groundwater. Another outcome of the research on natural recharge was the coining of the term "depression-focused recharge," which refers to recharge occurring primarily in topographically lower areas. This was the first documentation of the phenomenon in a coastal plain. Another innovation was the use of Radon-222 as a groundwater tracer in the Mexico City project to determine flowpath and water-rock interaction.

- *Land subsidence*

The Bangkok, Jakarta, and Mexico City studies documented the incidence of land subsidence. In addition, a computer model was developed which permits the analysis and prediction of land subsidence through the use of depressions in benchmark elevations, as well as the level of groundwater withdrawal through observations of the decline of the hydraulic head.

- *Saline intrusion*

The most significant contribution to understanding the dynamics of saline intrusion was the challenge to the popular hypothesis regarding the dramatic intrusion of a large wedge of seawater into coastal aquifers. In contrast, the Jakarta and La Plata studies concluded that brackish groundwater pumped from deeper aquifers was the result of deposits of saltwater left by bodies of saltwater that had long ago receded. The research also found that where a wedge of seawater was intruding, this was taking place at a far slower rate than was previously believed.

- *Wastewater treatment*

The Dakar study provided a greater understanding of affordable methods available for treating urban domestic wastewater. The city's wastewater was characterized in terms of average outflow per hour, suspended solids, settled solids, and chemical and bacterial composition. The city's treatment facilities were also assessed. Finally, the study contributed a sociological study of the attitudes of the population towards domestic wastewater disposal and treatment.

- *Groundwater Contamination*

IDRC-supported research resulted in the compilation and detailed evaluation of potential sources of groundwater contamination. The Managua study was described as one of the most comprehensive programs of analysis for industrial organic contaminants in Central America. The Mexico City study found that lacustrine sediments perform extremely well in protecting underlying aquifers by significantly slowing down the infiltration rate of most groundwater contaminants.

- *Artificial Recharge*

As a result of the Bangkok and Santa Marta projects, IDRC-supported research provided some of the most rigorous experiments of artificial recharge into shallow aquifers. This included the first use of artificial recharge in groundwater research for a

coastal area of Latin America, as well as the most thorough study of artificial recharge in Southeast Asia. In particular, the studies produced a guideline for the design of a recharge well into a shallow aquifer, as well as two separate computerized models to assist in defining artificial recharge alternatives. The Bangkok study provided in-depth analysis of the tendency of recharge wells to clog, while the Santa Marta project contributed a full scale model weir that is still operational.

- *Optimal groundwater exploitation strategies*

Several computerized prediction models capable of identifying alternatives for aquifer exploitation were developed through the projects. These models are capable of generating management strategies that minimize overwithdrawal and contamination of groundwater, as well as minimizing land subsidence.

5.2 Impact on capacity building

Seven of the nine projects included in the analysis explicitly addressed the strengthening of the capacity of local organizations with a stake in water management. Capacity building efforts were directed mainly at research institutions and government agencies. However, private sector interests, and to a lesser extent, non-governmental organizations, also benefited from capacity building activities. By promoting the development of leadership, management and research skills as well as human and financial resources, IDRC-supported projects have helped to ensure the long term ability of developing countries to manage their own high quality, self-sustaining research in priority areas of urban water management.

- *Interdisciplinary research capacity*

Survey respondents reported that the IDRC-supported projects were particularly successful in developing institutional capacity to undertake research that responds to complex development problems by cutting across formal disciplines. One specific outcome of the research was the development of a Groundwater Program at the Geophysics Institute of the National University of Mexico (UNAM-IG). The primary objective of the program, which was formed in 1988, is to bring together a range of disciplines to study alternatives for handling and exploiting the aquifer system, and to propose possible solutions to the contamination problem.

In large part, respondents acknowledged that interdisciplinary research flowed naturally from undertaking groundwater research. The disciplines which collaborated during the various experiments included water quality chemists, hydrogeologists, hydraulic

engineers, geotechnicians, geologists, environmental hydrologists, hydrologists, geophysicists, environmental engineers, and civil engineers. At the same time, there was limited interaction with professionals involved in such disciplines as the social sciences, law, the information sciences and management sciences.

- *Development of local university and government research centres*

The primary source of capacity building took place as a result of the collaboration between Canadian and local researchers, both within universities and government research centres. In particular, this took the form of on-the-job training, short courses and seminars, provided to local research teams both in Canada and locally. Researchers acquired skills in Canadian groundwater field and analysis research methods, various aspects of report preparation, and also received access to information on new software and scientific developments in the field. Another important and significant area of capacity building was in the acquisition of a range of project management skills. There was also a marked increase in the leadership capacity of university and government research centres on groundwater-related issues.

Table 5 Capacity Building

Impact on interdisciplinary research	Strong
Impact on research institutions	Strong
Impact on government agencies	Strong
Impact on the private sector	Moderate
Impact on NGOs	Weak

The projects also contributed significantly to the development of capacity in the area of computer modelling. Researchers were trained in the interpretation of groundwater models, and organization of data for input into groundwater models. Where such skills already existed, researchers were provided the opportunity to diversify their modelling expertise. Perhaps the most significant contribution in this regard was the provision of real world data which provided researchers with the opportunity to apply theoretically strong, but otherwise untested, groundwater models.

Another importance source of capacity building was in the form of scientific equipment acquired by the local researchers as a result of the IDRC-funded projects. This included geophysics equipment, computer infrastructure, and, in the case of Dakar, an experimental wastewater treatment station. Respondents commented that the acquisition of these technologies was made more effective as a result of development of the

capacity of technicians and support staff at many of the research centres.

The most tangible outcome of the capacity building component of the projects was the establishment and expansion of graduate research programs. For example, the program in Groundwater at UNAM-IG is one of the only programs of its kind in Latin America. This program has become one of the major training centres for groundwater professionals and scientists in Mexico and throughout Latin America, in large part as a result of the IDRC-supported groundwater projects in Mexico.

- *PhD and Graduate students from developing countries and Canada*

An important contribution was in improving the skills and knowledge of students. In addition to providing both local and Canadian students with highly relevant research material for the preparation of graduate theses and doctoral dissertations, the majority of the projects provided students with hands-on training in their field of study. Several students have enrolled in Canadian and American groundwater programs, often with the support of Canadian researchers involved in the projects. Other students trained during the projects were subsequently employed by public and private sector water companies and research agencies. In one case, a Mexican graduate of the Waterloo program became a member of the faculty of UNAM's Geology Department. In another case, two Canadian Waterloo graduates who were involved in the groundwater projects are now running an IDRC-funded project in Costa Rica.

- *Municipal and National water companies*

The decision-making capacity of municipal and national water companies was strengthened largely through the application of modelling and management strategies developed through the IDRC projects. Most notable in this regard were the Managua, Mexico City and Santa Marta projects. Water companies were also strengthened by the ability to hire professionals who received training as a result of IDRC projects. In one case, an employee from a local water company who was brought into the Santa Marta project, is now enrolled in a University of Nevada graduate program in hydrogeology.

- *Non-governmental organizations (NGOs)*

The projects had a limited, but significant, impact on the capacity of NGOs. On the whole, the IDRC enhanced NGO capacity in two ways. The first was in enhancing the capacity of NGOs to undertake effective research and lobbying. In general, the level of NGO awareness of and participation in water management issues has risen significantly as a result of the projects, due in large part to improved access to accurate information. This, in turn, has strengthened the cause of the grassroots movements, and limited the ability of governments to maintain a veil of secrecy surrounding groundwater

problems. The IDRC research project in Cochabamba permitted the creation of a non-profit water research agency. CREAMOS has become an outspoken advocate for well thought-out water management strategies in Bolivia.

The capacity of NGOs was also enhanced in the area of water management. While limited in scope, some local NGOs were involved in decision making related to managing various aspects of municipal water management.

- *Canadian university research centres*

An important, and perhaps underestimated, contribution made by the IDRC has been the development of what can be termed "collaboration capacity." In effect, Canadian research agencies involved in IDRC-supported projects have been provided with the skills and experience necessary to conduct research in developing countries which results in the effective transfer of soft and hard technologies. For example, the project changed the direction of research undertaken by Waterloo's Centre for Groundwater Research, which now places a much greater emphasis on entering into collaboration with researchers in developing countries. As a result, Waterloo is now closely involved with at least six Mexican universities.

5.3 Impact on partnerships

Research projects supported by the IDRC will have a significant impact on society only if the researchers establish strong ties with representatives of government agencies, NGOs, community organizations and private sector interests with an interest in applying the research results. In effect, researchers must translate research findings into the language of policy makers, decision makers and practitioners with a stake in the urban water management sector. In this regard, an important contribution made by the IDRC-supported projects was to expose local stakeholders in urban water management to extensive networks of local, Canadian and international universities, government agencies, private sector companies, and NGOs.

Table 6 Impact on partnerships

Between local researchers & Canadian researchers	Very Strong
Research institutions & government agencies	Strong
Between different government agencies	Moderate

Research institutions & private sector companies	Moderate
Government agencies & private sector companies	Weak
Research institutions & NGOs	Weak
Government agencies & NGOs	Weak
Government agencies & community organizations	Weak

- *Local universities and Canadian researchers*

Eight of the nine projects included a partnership between Canadian and local researchers. Canadian partners included university and government research centres as well as private sector firms. In fact, survey respondents clearly indicated that the most significant impact of IDRC-supported research was in the development of partnerships between them and Canadian researchers. Of particular benefit to both the local and Canadian partners was the increased access to extensive networks in the North and the South. In addition, many of these partnerships continue to result in additional research collaboration and on-going communication in terms of current publications, information on software and conferences.

- *Local universities and government agencies*

The most critical type of partnership, in terms of ensuring the practical application of research findings, took place between local researchers and local water management decision makers. The IDRC-supported projects rated well in terms of their impact on promoting collaboration between university research centres, government research agencies, municipal water authorities, and national ministries responsible for water management. In Mexico, UNAM-IG is collaborating with government officials to formulate regulations regarding waste disposal. In Bénin, the National University of Bénin is now collaborating with the National Water and Electricity Authority in formulating a national water resources management policy through a World Bank-funded project. IDRC-supported research in Bangkok contributed to the establishment of a government committee with a mandate to address land subsidence. This committee includes representation by the Asian Institute of Technology.

- *Other partnerships*

Respondents identified a variety of other partnerships that have been formed as a result of the IDRC projects. These included partnerships between different local universities, between local and foreign universities, between different government agencies, and between local university research centres and private sector companies. In Mexico City, a partnership was formed with a private company called Sosa Texcoco. This company operated a large well field, developed since 1955, and responsible for

producing 70 percent of the sodium bicarbonate consumed annually in Mexico by industries. As a result of declining water levels and salinity in some of its wells, Sosa Texcoco made use of the groundwater management model developed through the IDRC project. Notwithstanding this example, respondents indicated that while collaboration between the private sector and government agencies had most likely increased as a result of the IDRC projects, these relationships were difficult to identify.

The partnerships also involved various Canadian interests. For example, respondents indicated an increase in collaboration between Canadian university research centres and developing country government agencies, as well as between Canadian and local private sector companies.

5.4 Impact on resource generation

The assessment of the impact of IDRC-supported research projects on resource generation included the generation of income, project funding and capital investments. Resource generation was also treated as encompassing any significant future cost savings occurring as a result of IDRC project activities. Despite not having included this impact as an objective, the projects made a surprisingly strong contribution to the generation of resources in developing countries. However, the projects made no direct contribution to the generation of resources of benefit to the IDRC itself. Instead, respondents suggested that benefits went primarily to university research centres, government agencies and the private sector. Based on the analysis, it is also apparent that the community at large has been an important beneficiary of resource generation and future cost savings.

- *Funding for research and development projects*

The projects were particularly successful in facilitating the generation of funding for additional research. In some instances, international development agencies and foreign universities have contributed project funding for non-IDRC projects after having been attracted by the increased interest and activity in groundwater research generated, at least in part, by the IDRC. For example, in Mexico, the Institute of Geophysics at UNAM has become enthusiastically supported by CONACYT, the main national scientific funding agency. In other cases, the IDRC-supported projects themselves have been able to attract additional funding, allowing these projects to either expand their scope or carry out additional phases.

Table 7 Resource Generation

Generation of project funding	Strong
Investment in community or region	Moderate
Realization of cost savings	Moderate
Generation of revenue	Moderate
Generation of other resources	Moderate
Impact on research institutions	Moderate
Impact on government agencies	Weak
Impact on small (private) enterprises	Weak
Impact on community-based organizations	Weak
Impact on non-governmental organizations	Weak

Government agencies have been able to secure additional funding to carry out groundwater management projects as a result of the increased exposure of groundwater issues. In Thailand, the national Department of Mineral Resources has been able to study land subsidence and groundwater management strategies as part of a multi-year project funded by the Japanese International Cooperation Agency. While in Bénin, the National Government has secured World Bank funding to carry out a project on a National Water Resources Development and Management Strategy.

- *Increased investment in infrastructure and development projects*

IDRC-funded projects also contributed to the increased investment in infrastructure which took place in some of the countries as a result of increased awareness of groundwater issues. For example, Santa Marta's water authority was able to procure a US$3.5 million USAID loan towards increased exploitation of groundwater resources, conducting artificial recharge, and upgrading and maintaining the existing water distribution system. In Cochabamba, the local government attracted a US$2.5 million loan for local well development in the wake of the IDRC project. In addition to international loans, government agencies are also in a stronger position to claim a larger portion of the public sector purse in order to carry out groundwater projects.

- *Revenue generation*

The general increase in the level of activity in the groundwater sector is resulting in greater opportunities for companies which are in the business of providing groundwater management-related goods and services. In general, hydrogeology consultants and suppliers of drilling equipment have benefited as a result of increased attention being

paid to implementing groundwater management strategies. University research centres in Mexico and Bénin have also reported having increased their generation of revenue through research contracts.

- *Future cost savings*

While the full impact of the IDRC-projects on providing cost savings to the groundwater management sector will not be apparent for a number of years, there were several instances provided by the survey respondents. In the case of the Santa Marta project, the cost of supplying drinking water to communities was reduced, made possible by research into optimal groundwater exploitation strategies and the application of artificial recharge techniques. In Managua, the prevention of future contamination of Managua's water supply has averted potential health and water treatment costs. This situation arose when recommendations to reduce the amount of water pumped from a lake threatened by contamination were implemented by the local authority.

- *Impact on Canadian interests*

Canadian interests also benefited from the impact of IDRC research on resource generation. On the whole, Canadian researchers involved in IDRC projects established a good reputation for themselves, and for Canadian research agencies in general. Canadian engineering firms and university research centres involved in overseas research were able to establish linkages with overseas networks and were also provided with the skills necessary for doing business overseas. For example, the Waterloo Centre for Groundwater Research has been involved with several smaller research projects in at least four other Mexican states. Jacques Whitford Ltd. was able to establish an office in Buenos Aires, largely as a result of their involvement in IDRC-funded research in Santa Marta.

5.5 Impact on policy & decision making

A highly effective means of applying research findings is to influence the development and implementation of government policies. However, the ability of a project to have an impact on the development of relevant policies, or to influence the opinions of key decision makers is not an end in itself. Rather, it is a highly effective means for a project to have an impact on a much wider population than would be possible under normal project circumstances.

The impact of the nine projects on policy & decision making must be understood in the context of the length of time required for such an impact to take place. In fact, the strongest impact on policy was observable as a result of those projects which built on earlier phases. At the same time, several of the projects did have an immediate impact on the general public, as well as on key decision makers at the local, national and even international levels.

- *Greater awareness among local and national politicians and bureaucrats*

Nearly all the projects included either workshops, conferences, or meetings with relevant municipal and national government stakeholders. As a result, politicians, national government agencies and municipal authorities no longer consider groundwater resources to be inexhaustible. Instead, groundwater resources are considered limited, severely overexploited and susceptible to contamination from a variety of sources. There has also been a considerable improvement in the understanding of how to manage groundwater resources. Similarly, awareness of the impact of wastewater and the challenge in treating it are now increased. In Mexico, environmental awareness, including debates on groundwater issues, played a significant part of the 1994 Presidential campaign. In Bénin, parliamentarians challenged the national government to address the threat of contamination to the aquifer in the country's largest city. In Bangkok, two national government departments established a National Committee to investigate the viability of recharge as a means of mitigating flooding and subsidence.

Table 8 Policy & Decision Making

Impact on attitudes of decision makers	Moderate
Impact on attitudes of general public	Weak
Impact on local policies	Strong
Impact on international policies	Moderate
Impact on state/national level policies	Moderate

- *Awareness at the international level*

IDRC-supported research studies have also been promoted at the international level. A recent publication on the *Future of Water Resource Management in the Valley of Mexico* was prepared by the Institute of Geophysics with the support of the US-based National Science Foundation. This publication includes detailed policy recommendations, and represents a comprehensive publication devoted to the subject of groundwater in the Valley of Mexico.

- *Greater awareness among the general public*

As a result of media coverage, the public living in many of the cities and countries where IDRC research has taken place are now far more aware of groundwater-related problems and the need to organize to protect water resources. In addition to the role played by newspaper coverage, some of the workshops and conferences organized through the projects were promoted on television. Finally, increased attention to groundwater management issues at the political level is serving to raise consciousness among the general public. At the same time, the attitudes of the general public will have a long term impact on government policy.

- *Application of management tools*

Several of the projects provided useful groundwater management tools that have been applied by government agencies. Perhaps the best example of the application of project-developed management tools is in Mexico City. There, computerized management models based on the one developed through the project are being adapted for use in all critical groundwater basins in the country. Using management tools, wells are now being dug in order to increase water supplies without endangering groundwater supplies. Whereas only one deep well was active prior to the project, twelve deep wells were drilled in the wake of the project.

- *Groundwater protection measures*

The Managua project influenced the City's water supply institute (INAA) to implement specific recommendations to reduce the risk of industrial contamination of Laguna Asososca. The recommendations involved a fifty percent reduction in the amount of water pumped from the Laguna. Similar studies on contamination have since been initiated by government research agencies.

- *Application of artificial recharge technology*

The Bangkok and Santa Marta studies have shown artificial recharge to be a cost effective mechanism for increasing groundwater supply. As a result of successful experiments in Santa Marta, the local council decided to support and increase the use of groundwater rather than increase pipeline capacity. Similarly, the Bangkok Metropolitan Waterworks Authority plans to implement the recharge methods developed through the IDRC project. However, they await funding to implement this initiative.

- *Impact on groundwater policies*

While this impact will be felt in the long term, several of the projects have already

made an impact in this area. In Thailand, the Asian Institute of Technology's work in the area of applied geotechnical research has come to be considered the main source of ideas for government policy on groundwater management. As a result of AIT's activities in the study of land subsidence, the government of Thailand has implemented measures to reduce or eliminate groundwater pumping in Bangkok. Most recently, in July 1995, the government of Thailand announced a policy to stop groundwater pumping outside the City of Bangkok, where the majority of pumping is now taking place. IDRC support of AIT research since 1985 has contributed to this successful impact. In Bénin, the findings of an IDRC-supported project have been used in the development of a project on national water resources development and management strategy, financed by the World Bank. This strategy will address the protection and management of water resources in the IDRC project study area. In Mexico, the increased attention paid to groundwater issues has resulted in the creation of a super ministry responsible for water management, named the Comision Nacional de Agua.

5.6 Impact on community development

In terms of water management, community development can include increased community awareness of water problems, increased capacity of the community to identify and address water problems, improvements in the quality and reliability of the community's water supply, or improvements in the general health and socio-economic well-being of the community.

There are two fundamental ways in which a project can have an impact on community development; Directly, through involvement of the community in project activities, or indirectly through the impact of government policies. The advantages of the direct approach are that it has a greater likelihood of providing a definite and immediate benefit to people. Its main disadvantage is that it affects only a small number of people. The indirect approach has the potential for a much wider, and possibly more significant, impact over the long term. However, this approach has a greater likelihood of resulting in only negligible impacts. Furthermore, there is always the possibility that the impact will be broad in scope, but negative. The Dakar project was the only one of the nine projects which chose to pursue a direct path to promoting community development. While the groundwater management projects generally did not integrate the participation of communities, their impact on community development is being felt

in the long term. As a result, the overall impact on community development to date has been moderate to weak.

Table 9 Impact on Community Development

Quality of water management in communities	Moderate
Strengthening of community-based capacity	Weak
Community involvement in project design	Weak
Community involvement in project implementation	Weak
Community involvement in project monitoring/evaluation	Weak

- *Improvements in quality of life*

The projects had a limited, but positive impact on the quality of water management. In Santa Marta, there are noticeably fewer hand dug wells used to gain access to groundwater situated two to three metres below the surface. There are also fewer donkey carts used to transport water collected from well heads and sold to water vendors who use hand carts. Similarly, rates of subsidence have been reduced within Bangkok and the intensity of flooding has noticeably declined.

- *Strengthening of community-based organizational capacity*

While only a limited number of projects had a significant impact on community-based organizations, the impact was positive. In Managua, an organization of Water Committees was promoted, with their own regulations and statutes. In Dakar, local residents were trained to assume responsibility for wastewater treatment.

- *Community participation in project activities*

Only the Dakar project had any significant level of involvement of community residents. In this case, community members participated in the development of a pilot wastewater treatment station and a proposed wastewater treatment and reuse program.

6.0 Lessons and recommendations

This section presents key lessons learned from the impact assessment of the nine IDRC-supported urban water management projects and recommends various actions to be taken by the IDRC in order to enhance the impact of future projects. In particular, these lessons and recommendations address revenue generation, project and program

design and delivery, and methodological constraints to assessing impacts.

In addition to the nine projects included in the survey of project impacts, two other IDRC-projects implemented in Southeast Asia, as well as two non-IDRC projects being carried out in Indonesia were analyzed in order to contribute to the understanding of project impacts. All four of these projects addressed urban water management issues from a variety of perspectives, including groundwater management, attitudes toward surface water pollution, community-based conflict resolution, and community-based waste management.[1]

6.1 Project design

- *Competing project objectives*

Put simply, many of the IDRC projects intended to do too much with too few resources. The attempt to implement a project which combines scientific research with capacity building represents a tremendous challenge. However, several of the project proposals made reference to a multiplicity of objectives. Unfortunately, the successful implementation of all these disparate and often competing objectives was generally not feasible. The tendency to place what amounted to competing objectives into a single proposal probably reflected the ambiguity within the IDRC regarding expectations for researchers. In fact, the projects included in this analysis were essentially scientific exercises onto which objectives of capacity building, community participation and policy uptake were awkwardly superimposed. In contrast, those projects with the most focused objectives were the most successful in having meaningful and far-reaching impacts.

Recommendation: Projects should generally be limited to one or two clearly defined, balanced and compatible objectives. Multiple objectives should be included in a single project only when these are all equally substantiated and clearly defined.

- *Strategic project activities*

Those projects defined by competing objectives tended to lack the necessary activities needed to fulfil these objectives. For example, projects which included capacity building or community development as an objective were not adequately designed to

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1 The projects: Urban Geology/Bangkok; Community Problem Solving/Jakarta; Community and the Environment/Jakarta; Community-based Composting/Jakarta.

provide the activities and outputs necessary to achieve an impact on capacity building or policy. Instead, project activities focused almost entirely on ensuring a rigorous and meaningful scientific output. In other cases, project activities that were included in a proposal were not accounted for in the proposal's budget.

Recommendation: In reviewing and developing project proposals, importance should be placed on ensuring that each project objective is fully supported by a range of activities, including budgetary support.

- *Developing inclusive partnerships*

Project activities should involve actively promoting and cultivating partnerships. In this regard, it is important to extend beyond the traditional partnerships of universities and government agencies, and embrace the full range of stakeholders. Where possible and feasible this means including private sector interests, NGOs, and community-based organizations.

The projects included in the analysis tended to exclude non-governmental and community-based organizations, as well as private sector interests as partners. In the case of the former, there is a widely held perception amongst the researchers that NGOs are unreliable and lack the capacity necessary to serve as useful partners in a serious study of water management issues. In addition, there are relatively few NGOs involved in the water management sector. At the same time, there is recognition that these organizations would play a valuable role as a partner responsible for the dissemination of information, and for providing a liaison function with communities and the public. The failure to include the private sector was due in large part to the low level of private sector development in groundwater. There also exists an extensive, but difficult to define, informal private sector.

Recommendation: Beyond the importance of including strategic partnerships in each IDRC project, particular attention should be paid to including private sector, non-governmental and community-based organizations.

- *Planning for capacity building*

Capacity building activities were limited largely to informal, hands-on training and short courses and seminars. For example, the Jakarta project proposed a training component without providing any budgetary allocation for training activities. None of

the projects assessed included a long term vision for the development of an institution's capacity. To be effective, institutional capacity building requires the identification of organizational strengths and weaknesses, a well thought-out development of a training and capacity building program that seeks to strengthen these weaknesses, and the careful selection of individuals who will receive training.

In fact, the best example of an effective capacity building project came from one of the non-IDRC projects. The Community Problem Solving project carried out in Jakarta, Indonesia by a local environmental NGO was designed specifically to provide a low income community with negotiating and problem-solving skills. As a result, a full range of project activities were devoted to this objective.

Recommendation: Ensure that each project comprises a sub-committee on capacity building, responsible for defining the institutional vision and the steps necessary to achieve this vision.

- *Planning for policy & decision making*

This impact is very much related to effective capacity building and the development of strategic partnerships. However, the type of capacity required to have an impact on policy is very distinct from the capacity required for the development of scientific research. Having an impact in this area also demands a longer term commitment on the part of the IDRC and the project stakeholders.

Recommendations: The IDRC should develop a framework by which proposals can be designed to have a strategic impact on policy and decision making. The example of the Indonesian Community-based composting project offers a strong example of how to achieve a successful impact on policy. The strategy used included these elements:
1. A lead institution that is strategically positioned and capable of policy advising/development;
2. Flexible models for implementation of the project;
3. Careful identification of a government agency willing to implement policy; and,
4. Including a wide spectrum of stakeholders.

- *Project impact assessment methodology*

Without exception, the projects included in the analysis were not designed to facilitate the eventual assessment of their impact. The absence of performance indicators renders the evaluation of project impacts extremely difficult, inhibits any attempt to monitor the progress of impacts, or even to anticipate the likelihood of impacts. In addition to an

absence of performance indicators, there was considerable confusion expressed by respondents regarding the expectations of IDRC. This included confusion surrounding the precise meaning of individual impacts, as well as the priorities of the IDRC in the area of impacts.

Recommendation: Projects should comprise a built-in evaluation methodology to permit monitoring of project progress towards achieving intended objectives, and to facilitate the assessment of long term impacts. Projects should include generic indicators, with the expectation that project leaders would develop more project-specific indicators. In addition to the use of indicators, project leaders should be provided with an up-front understanding of IDRC's expectations regarding the assessment of long term impacts. This includes providing clear definitions of each area of impact, and the relationships between each impact.

- *Selecting the right lead organization*

The type of organization that will play a lead role in the research project must reflect the strategic orientation of that project. For a capacity building exercise, the type of organization to be selected will be weak in capacity, but should have a legitimate role to play in the area of research. For a policy-oriented project, a politically well-connected agency, and one which has strong policy advising capacity should be selected. In this regard, the success in Bangkok can be attributed to the dominant role that the project leader has played in this field for the past fifteen years. In the case of a community development project, an NGO or community-based organization should be selected.

Recommendation: Standardized, but flexible, selection criteria should be defined to assist in the process of selecting organizations and individuals to play the lead role in IDRC research projects. The relevance of these criteria is predicated on the existence of clearly defined and reasonably stable program objectives.

6.2 Program design

- *Program objectives*

Despite the fact that eight of the nine projects formed part of an IDRC program, these projects were not explicitly oriented towards achieving a collective goal.

Recommendation: Individual projects should play an explicitly defined role in supporting wider program objectives. In this regard, program objectives, and the inter-

relationship between these objectives must be clearly defined.

- *Program time frame*

The design and objectives of the projects gave no indication that they were part of a program defined by a time horizon with specific deadlines and milestones.
Recommendation: IDRC programs must be defined by specific a beginning and an end. More importantly, individual projects must be shown to contribute to pre-defined program milestones and end results. In this regard, it is critical that program evaluation criteria are incorporated into the program in order to permit the assessment of progress towards temporally-defined goals and objectives.

6.3 Project and program delivery

- *Project monitoring*

Respondents suggested that project monitoring was largely irrelevant to informing and influencing the direction of the projects. In part, this can be attributed to the instability over the past few years which has resulted in the steady turnover of monitoring officers. However, the under-reliance on project monitoring represents a lost opportunity of having the IDRC play a direct role in improving the impact potential of IDRC-supported projects.

Effective project monitoring can address many, though not all, of the factors cited by survey respondents which influenced the impact of projects. These factors are listed as follows:

- Lack of accountability regarding adherence to project objectives and delivery of project outputs: Canadian researchers often made up for the lack of delivery of local researchers by preparing final and technical reports on their own.
- Poor communication between stakeholders
- Bureaucratic resistance to project implementation: In Mexico, permission to access contaminated sites was extremely difficult. In Thailand, a 1982 law forbids any injection of foreign substances into the shallow aquifer.
- National and organizational culture
- Unclear expectations regarding the objectives of the IDRC

At present, there is a tendency for Program Officers to lose interest in a project, for a variety of factors, beyond its formal approval. Program Officers are more likely to focus their efforts on developing further projects than to closely monitor the progress of an approved project.

Recommendation: There is a need for a far more active role to be played by project monitoring officers. A monitoring officer should be actively engaged in providing clear guidance, responsive leadership, and impartial enforcement. Monitoring officers should also be prepared to undertake mediation, negotiation, and the promotion of the IDRC.

There is also a need for a mechanism to ensure stability in monitoring functions, though this does not necessarily imply that the same officer must be responsible for the duration of a project. One option in this regard is for monitoring functions to be performed by qualified third party consultants impartial to the researchers, but with a strong understanding of the relevant development issues. A second option is to reinforce and strengthen the monitoring role played by existing program officers.

- *Delay between proposal, approval and implementation*

The relevance of a project that is approved several years after having been proposed can be seriously compromised. In Jakarta and Managua, respondents reported that large groundwater research projects supported by other agencies had been proposed and approved in the time between the proposal and approval of IDRC projects. In both cases, the IDRC project that was eventually implemented was overshadowed by these larger projects.

Recommendation: If delays in approving projects are inevitable, the IDRC should be prepared to revise the proposal based on changes in the research environment. This will require monitoring of a research environment even where a project has not yet been approved. Alternatively, emphasis should be placed on minimizing the lag-time between project proposals and approvals.

- *Funding-expectations balance*

There was a strong message concerning the imbalance between expectations for outputs and levels of funding. This was particularly the case with the groundwater projects, which were capital intensive. Despite the relatively large investment made by the IDRC in these projects, the consensus was that substantially more resources were required.

Recommendation: In these instances, the IDRC must either increase the level of funding, reduce the level of expectation, or focus on less capital intensive projects.

- *Multi-phase, longer term projects*

The most effective projects were those which were preceded by earlier phases or related projects. These earlier projects provided researchers a much clearer focus and

helped in the establishment of far more realistic goals. In addition, earlier projects provided a strong momentum to these projects, permitting a much more substantial return on the IDRC's investment.

Recommendation: The IDRC should promote longer term, multi-phase projects, especially where a program is oriented toward achieving an impact in time-intensive areas such as policy development.

- *Research in secondary cities*

Research in larger cities tends to require a far more substantial investment, and is faced with far more complex constraints. Conversely, research in medium-sized cities with populations of 250,000 to 1 million, is more likely to have substantial impacts. This type of a project will be even better received where a national government is promoting a policy of political decentralization and economic deconcentration in the face of development activities that tend to congregate in larger, primary cities.

Recommendation: The IDRC should focus greater resources on supporting research in smaller, secondary cities, and promote itself as a supporter of this kind of research.

- *The multiplier effect of collaborative research*

In addition to its immediate impact on developing country institutions and researchers, collaborative research also has an important long term impact on research capacity in developing countries. There is a capacity building multiplier effect in place as a result of Canadian interests continuing to undertake collaborative research in developing countries.

Recommendation: The IDRC should continue to support collaborative research involving both private sector, public sector and university interests. In general, far more emphasis should be placed on identifying and promoting the IDRC's contribution to the long term multiplier effect of supporting collaborative research.

- *Provide greater focus to the role of Canadian partners*

Based on the survey results, it is apparent that collaborative research projects benefit both Canadian and developing country partners. However, collaborative research projects required substantial budgetary allocations to accommodate Canadian partners. Much of this allocation provided for short term travel by Canadian researchers, leaving precious little opportunity for face-to-face contact. There is a need to better focus the activities of collaborative projects. However, while private sector firms may be more

willing to pursue shorter term assignments, university researchers generally require long term collaboration with close and continuous interaction. As a result, there is also a need to develop distinct strategies relating to each of these interests.

Recommendation: In light of limited funds available for pursuing collaborative research, the IDRC should develop different strategies that reflect the particular needs and interests of private sector firms, public sector research agencies and university research centres. In particular, the IDRC should capitalize on the willingness of private sector firms to trade-off financial losses related to IDRC support with potential gains from access to new markets. The ability and willingness of private sector interests to pursue shorter term partnerships should also be considered. Ideally, public sector and university researchers should be provided with as much time as possible to undertake collaborative research. To a more limited extent, it will be possible to capitalize on the willingness of these interests to accept a financial loss on IDRC projects in exchange for access to new research networks.

In general, there are two options in this regard. The IDRC can either move towards more focused, problem-oriented, consultancy-based partnerships; or it can support far more extensive partnerships permitting more face-to-face interaction. Some combination of these options will be required to attract Canadian research partners.

- *Follow-up communication*

Researchers commented on the surprising lack of any follow-up by the IDRC beyond the completion of their projects. Researchers also expressed an interest in finding out more about other related IDRC projects.

Recommendation: A workshop should be organized which brings together the researchers involved in the various IDRC groundwater projects. Similar workshops should be organized for future programs in order to develop strategic directions and strengthen partnerships.

6.4 Methodological constraints to assessing impacts

Many of the difficulties associated with assessing impacts can be addressed by improved project design and project administration. Most significant in this regard are inclusion of performance indicators in project design, greater enforcement of the requirement to submit useful deliverables, including annual and final reports that provide a clear indication of progress and impacts. However, there are several other

factors.

- *Contact information for project stakeholders*

It was difficult to identify individuals with a clear understanding of the impacts of a project. Project leaders were difficult to contact, and were not necessarily aware of the impacts that had taken place.

Recommendation: Project documentation should make clear reference to the relevant project stakeholders. These should not be limited to project leaders, and should include accurate contact information.

- *Project documentation*

There is a lack of final reports and technical reports available in project files. Furthermore, where these reports do exist, they are often of limited usefulness in terms of project evaluations. Final reports and progress reports are often not linked to a project's original objectives, but instead merely document activities that took place during the life of the project.

Recommendation: Stronger controls should be put in place to ensure that final reports are included in project files. Stronger controls should also ensure that project documentation is relevant to project objectives.

6.5 Revenue generation

While the nine projects included in the assessment did achieve a significant collective impact on revenue generation, this impact was of only limited direct benefit to the IDRC. The lesson in this case is that even where the IDRC cannot benefit directly from revenue generation, it can significantly add to its contribution to international development. An important finding of this internship was the relative ease with which projects contributed to the generation of various types of resources. This finding was made more significant by the fact that none of the projects included in the assessment were explicitly designed to generate revenue of any kind. This suggests a built-in incentive for project stakeholders to capitalize on the strengths of a project.

Recommendation: Projects designed to generate revenue for interests other than the IDRC itself should be openly and explicitly promoted.

- *Monitoring the level and type of revenue generation*

The fact that IDRC-supported projects are generating resources without being designed

for this purpose suggests a need for the IDRC to better monitor and anticipate this impact. Revenue generation which benefits stakeholders in developing countries represents a critical achievement of any development project. A prerequisite to promoting this objective is capacity to anticipate and clearly identify successes in this area.

Recommendation: The IDRC should improve its monitoring of the type and level of revenue generation taking place as a result of individual projects. This includes classifying various types of revenue generation, and anticipating potential beneficiaries. At a minimum, the IDRC should be aware of the level of revenue generation taking place as a result of its support, even where it does not benefit directly from this revenue generation.

- *Self-Promotion*

Generating revenue through projects represents an immense challenge. It is difficult to see how the projects included in this assessment could have been designed differently in order to benefit the IDRC without fundamentally altering their purpose and objectives. However, self-promotion represents an indirect, but no less critical, route to sucessful revenue generation. In fact, the IDRC's name was consistently under-promoted as part of the research projects analyzed. In many cases, the IDRC's name was either misspelled, or left out entirely. In one case, the IDRC was described as being an agency of the Government of Ontario.

Recommendation: The IDRC should compile a publication summarizing the activities of completed groundwater and urban water management projects. In addition, more attention should be paid to ensuring that the IDRC's name is accurately and widely promoted.

7.0 Concluding remarks

Based on the analysis of the historical role of the IDRC in supporting urban water management research, as well as the growing attention being paid to urban water management issues, the IDRC would benefit from supporting an urban water management research program. This research program would involve consolidating existing projects, and defining a specific direction for future initiatives.

A future urban water management research program should have as its priority objective the development of the quality of life and organizational capacity of

communities. This objective should include both a short term and long term approach to achieving community development. In the short term, the program's objective should be achieved through partnerships with grassroots organizations committed to community development. In the long term, community development should be achieved by way of promoting changes in policy, legislation and delivery of services. In both these cases, projects should focus on capacity building and strengthening of networks.

An urban water management research program should focus on the management of demand for water, the conservation of existing water resources, and increasing the efficiency of service delivery. The IDRC will be able to build on its existing experience in supporting and promoting research in these three areas.

Finally, an urban water management research program should form part of a wider integrated program of research devoted to water resources management. A broader water resources management program would build on the IDRC's extensive experience in water-related research. This includes research which links together national water resources policy, rural and urban drinking water quality, wastewater management, drylands management, water pricing, and rural and urban water conservation strategies.

In its recommendations, the Chauvin report outlined the principle elements of a program framework for the corporate water policy at the IDRC:

1. Water resources management
2. The planning and management of urban-based water services
3. Structural adjustment and water resources
4. Community-based planning, management, evaluation of water resources and supply systems
5. The impact of water on human health
6. Institutional capacity building/human resources development
7. The socio-cultural dimension of human interaction with water

These recommendations remain relevant today.

Appendix A Bibliographical References

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APPENDIX C Survey analysis methodology

Respondents were asked to rate various impacts on a scale of one to five, with one being the weakest and five the strongest. Where a respondent indicated that an impact was not applicable to the project, that score was considered a zero. It was on the basis of these scores that the impacts of the projects were summarized into the following tables. For the purposes or analysis, the scores were divided into the following categories:

0-1.49	**Weak impact**
1.5-2.49	**Moderate impact**
2.5-3.99	**Strong impact**
4.0-5.0	**Very Strong impact**

Scientific & technical innovation

Contribution to water management knowledge	Strong	(3.9)
Impact on Government Agencies	Strong	(2.9)
Impact on Research Institutions	Strong	(2.8)
Impact on Communities	Moderate	(1.8)

Capacity Building

Interdisciplinary Research	Strong	(3.0)
Research Institutions	Strong	(2.9)
Government Agencies	Strong	(2.6)
Private Sector	Moderate	(1.7)

Non-governmental organizations	Weak	(0.5)

Partnerships

Local researchers & Canadian researchers	Very Strong	(4.1)
Research institutions & government agencies	Strong	(3.3)
Between different government agencies	Moderate	(1.9)
Research institutions & private sector companies	Moderate	(1.8)
Government agencies & private sector companies	Weak	(1.3)
Research institutions & NGOs	Weak	(0.8)
Government agencies & NGOs	Weak	(0.8)
Government agencies & CBOs	Weak	(0.8)

Resource Generation

Generation of project funding	Strong	(2.5)
Investment in community or region	Moderate	(2.4)
Realization of cost savings	Moderate	(2.4)
Generation of revenue	Moderate	(1.8)
Generation of other resources	Moderate	(1.5)

Impact on research institutions	Moderate	(2.1)
Impact on government agencies	Weak	(1.4)
Impact on small (private) enterprises	Weak	(1.4)
Impact on community-based organizations	Weak	(0.9)
Impact on non-governmental organizations	Weak	(0.3)

Policy & Decision Making

Impact on attitudes of decision makers	Moderate	(2.4)
Impact on attitudes of general public	Weak	(1.3)
Impact on local policies	Strong	(2.5)
Impact on international policies	Moderate	(1.9)
Impact on state/national level policies	Moderate	(1.6)

Community Development

Quality of water management in communities	Moderate	(2.0)
Strengthening of community-based capacity	Weak	(1.0)
Community involvement in project design	Weak	(0.7)
Community involvement in project implementation	Weak	(0.6)
Community involvement in project monitoring/evaluation	Weak	(0.6)

Appendix D IDRC Urban Water Stakeholders

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