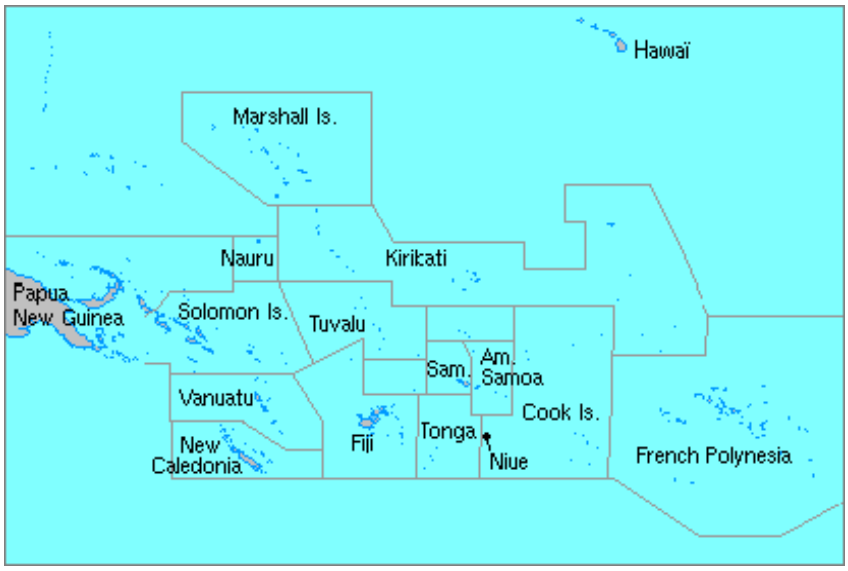
WORLD METEOROLOGICAL ORGANIZATION

HYDROLOGICAL CYCLE OBSERVING SYSTEM FOR THE PACIFIC ISLAND COUNTRIES

PACIFIC-HYCOS



PROJECT DOCUMENT

DRAFT

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EXECUTIVE SUMMARY

Recent analyses carried out by South Pacific Island hydrologists in the framework of WMO's Southwest Pacific Regional Association have indicated that improvements in the availability of water-related information are needed to support sustainable water resources management. The WHYCOS (World Hydrological Cycle Observing System) concept might provide a vehicle, with modification, to build regional capacity in this area, and WMO has commissioned a thorough needs analysis as a basis for a Pacific-HYCOS project design. The project design considers the group of Pacific Island developing states that stretches from Papua New Guinea to French Polynesia, and that has Melanesian or Polynesian indigenous populations. As in many developing countries, their governments tend to focus attention on health, education, and basic infrastructure (telecommunications, transport, energy), and water is of significance principally in the context of public health (that is, water supply and sanitation) and energy supply.

In summary, the main requirements for water-related information that are indicated by the needs analysis are:

- Real-time rainfall and streamflow information for flood forecasting: six countries.
- A drought forecasting capability: all countries.
- Baseline information on the water resource in waterways having hydropower potential, most of which would be at the micro- or mini-hydro scale: five countries.
- Baseline information on surface waters likely to be affected by mining or forestry development, and subsequent monitoring: four countries.
- Water resource information, including streams, springs, and aquifers, at a reconnaissance scale, in support of rural water supply projects: all countries.
- Baseline and ongoing monitoring information on the quality of groundwater, particularly in the low islands and atolls where aquifers are subject to contamination by human and animal wastes: about ten countries.

Each of these is a requirement only in a subset of the Pacific Island countries. The needs analysis also assessed capacity building requirements in the region. In some countries there is effectively no national hydrological service, and water-related information is collected, if at all, by the water using agencies – usually the water supply authority. In the others, there is some form of national hydrological service, normally located in a ministry for the environment, public works, or natural resources. However, in most cases it is under-resourced, sometimes with demoralized staff who have little vision for the future, and in several cases it has all but ceased to function. Only in Fiji and the French territories could the national ability to collect and archive water-related information be regarded as meeting national needs.

On the basis of the analysis of needs, a Project concept is proposed that takes the WMO's WHYCOS concept and reshapes it for Pacific Island circumstances. The project will involve a number of elements, in different combinations in each participating country, that together build national capacities to obtain and manage information about their water resources. The principal direct beneficiaries of the Project's outputs are envisaged to be officials of Pacific Island government agencies and NGOs, who have some responsibility for water resources planning and management, environmental monitoring and management, education, hazard mitigation, and/or national development. The ultimate beneficiaries, with whom the officials have direct contact, include elected representatives and leaders, and the general public.

The overall Project goal is that the participating Pacific Island countries will:

- attain a common level of ability (capacity) to assess and monitor the status and trend of their water resources, and to provide the water-related information and hazard warnings needed to support national social and economic development and environmental management.
- have established databases and information archives, maintained to acceptable standards, that form the basis for sustained future data capture and information processing and dissemination.

The Project has three main purposes that contribute to achieving the above goal:

1. To assist the participating countries to establish the human and institutional capacity to assess the status and trend of national water resources and to provide adequate warnings of water-related hazards.
2. To establish basic hydrological monitoring and data capture systems, using technology that balances modernity, economy, robustness, and suitability for Pacific Island circumstances.
3. To establish hydrological databases and information systems that provide users with the information they require, to the standards (including accuracy, timeliness, usability, etc.) they need, and that provide a secure repository of information for the indefinite future.

It has six 'output delivery" components, and one "management" component:

Component 1: Flood forecasting capability. *Objective:* To develop a methodology for flood forecasting and implement it in 15 selected critical catchments in the participating countries.

Component 2: Water resources assessment in major rivers. *Objective:* That participating countries with significant surface water resources have in place a basic network of near-real time hydrological observing stations and the capability to securely archive incoming data.

Component 3: Water resources databases. *Objective:* That participating countries will have national hydrological databases that are secure and meet agreed data quality standards, and the capability to maintain them and generate information products that meet users' needs.

Component 4: Drought forecasting. *Objective:* To develop and implement a common approach to drought forecasting in participating countries.

Component 5: Groundwater monitoring and assessment. *Objective:* To establish in participating countries a basic capability in monitoring and assessment of groundwater resources.

Component 6: Water quality monitoring and assessment. *Objective:* To establish in participating countries a basic capability in monitoring and assessment of water quality and chemistry.

Component 7: Project management. *Objective*: To have Project management systems in place and implemented that (1) ensure that contracted outputs are delivered on time, to standard, and within budget; (2) enable the Project to respond promptly to changing requirements; (3) facilitate the participation of stakeholders in Project affairs; (4) provide timely and accurate reporting.

The responsibilities of the Supervising Agency, Executing Agency and the participating countries are outlined in the document; a Regional Centre will be required, and a Regional Steering Committee will play a key role in Project oversight and monitoring. The Project is costed at almost A$2.2 million; it is recommended to have a duration of five years, with the several components being implemented in a staged manner to spread the cost and to avoid overloading the very limited capacity of the participating countries to absorb Project activities.

The Project will need to place emphasis on monitoring performance against a set of indicators, which are proposed in the logical framework. Because this is a development project that assists small island developing states, it is inherently a high risk project. The proposed design aims to minimise risk of Project failure and to maximize the likelihood of post-Project sustainability. The Executing Agency will need, during implementation, to:

1. demonstrate to participating country governments, NHSs and other stakeholders the benefits of the Project (which is best done as early as possible);
2. maintain very effective relationships and communication channels with the Project Steering Committee, participating country governments, and stakeholders, especially those involved in public sector institutional strengthening;
3. Update the analysis of NHS needs annually, as a basis for including capacity building in the annual plans;
4. incorporate into the annual plans a regularly updated risk management strategy;
5. carefully monitor during years 1 to 4 the progress of each NHS in establishing and sustaining the desired capabilities, and identify any under-achievement;
6. target capacity building at the areas and participating countries where there is greatest need.

An impact assessment indicates that the Project will have positive impacts in economic, environmental, and social areas, principally by improving the quality of information on which resource management, hazard mitigation, and economic development planning is based.

1. INTRODUCTION

1.1 The need for water resources information and the WHYCOS concept

Since 1990, effective water resources management has come to be recognized as an essential element of sustainable economic and social development, particularly in the Small Island Developing States. In turn, the provision and use of accurate water-related information is an essential component of effective resource management.

The World Meteorological Organization (WMO), a United Nations specialized agency, aims to assist its Member states to establish and operate the water information systems they require for water resources management and the management of water-related hazards and disasters. This is done through its Hydrology and Water Resources Programme, and increasingly through regional components of the World Hydrological Cycle Observing System (WHYCOS), implemented in cooperation with other development assistance agencies. The aim of the WHYCOS concept is to build the capacity of the WMO's Member states to acquire, archive, and use information on their water resources (WMO, 1998). It facilitates collaboration among regional groupings of Members, and uses the data transmission capabilities of the WMO's World Weather Watch system to provide near real-time information on the status of the water resource at selected key locations.

1.2 Project preparation and design: identifying hydrological needs in the Southwest Pacific region

The Hydrological Working Group of WMO's Southwest Pacific Regional Association, at its meeting in 1996, identified a range of water-related information needs in the region. Its work led to the convening by WMO of a meeting of expert representatives of ten Pacific Island countries, in Nadi, Fiji (4-6 October 1999), to further define *The hydrological needs of small islands.* Participants in the meeting resolved to request the WMO to investigate whether and how the WHYCOS concept could be applied in the Southwest Pacific region. They considered that a regional cooperative project might be contemplated that would encompass hardware for hydrological data collection, promotion of regional cooperation, training, exchange of expertise, development of data archiving capabilities, and public information. Not all countries would require similar types or levels of involvement.

In response, the WMO requested Mr P. Mosley (New Zealand) and Mr R. Raj (Fiji) to visit a cross-section of the Pacific countries, carry out a more detailed needs assessment, and prepare a draft project design document. The present document is that draft design.

A needs analysis was prepared on the basis of interviews conducted with a wide range of officials in eight countries. Interviews were semi-structured in form, with completion of a questionnaire sheet providing the framework to ensure that each interview was objective and targeted on issues that had already been defined by the Hydrological Working Group of WMO's Southwest Pacific Regional Association. The interview notes and reports are held separately, at the WMO Secretariat. They were supplemented by country reports presented to the Nadi meeting on *The hydrological needs of small islands*, and to the UNESCO/SOPAC/UNDDSMS workshop *Pacific water sector planning, research and training* (UNESCO, 1995).

During the country visits, we were advised on many occasions that the Pacific countries are favorably disposed to regional approaches to development assistance, because of the small size of several countries and the common issues that they often face. However, it was noted that

regional projects sometimes are too general to address the needs of each individual country in a wholly satisfactory manner. Several interviewees emphasized, therefore, that any regional project proposal addressing water information requirements would have to offer clear and specific national benefits, as well as more general and prospective regional benefits. Project sustainability – continuance after the start-up phase has been completed – can in any case be expected only if there are clear benefits whose value persuades countries to maintain commitment once external funding has ceased.

2. ANALYSIS OF THE PROJECT CONTEXT, SOUTHWEST PACIFIC REGION

2.1 Socio-economic and institutional background

The project design considers the group of Pacific Island developing states that stretches from Papua New Guinea to French Polynesia, and that has Melanesian or Polynesian indigenous populations (Table 1). Populations number from only 2,100 in the case of Niue, to over 4.4 million in Papua New Guinea. The per capita GDPs of four countries (Fiji, French Polynesia, Nauru, New Caledonia) place them outside the usual definition of developing countries. However, several of the Pacific Island states are among the poorest in the world, with values of the UNDP Human Development Index below the average for developing countries, and stagnant or shrinking economies. As in many developing countries, their governments tend to focus their attention on health, education, and basic infrastructure (telecommunications, transport, energy), and water is of significance principally in the context of public health (that is, water supply and sanitation) and energy supply.

A substantial amount of development assistance is directed to the region. Several countries (notably Papua New Guinea, Cook Islands, Niue, Samoa) receive considerable assistance from former colonial “powers”, and/or have formal political linkages such as free association. The three French territories of New Caledonia, French Polynesia and Wallis & Futuna have close economic and cultural links with France, even though the first two are moving towards a greater level of self-determination. Bilateral development assistance agencies such as AusAID, NZODA, JICA and many others have been much in evidence in several water-related sectors (notably power development and water supply and sanitation), while multilateral agencies such as UNDP and Asian Development Bank provide much grant aid, technical assistance, and access to capital at concessionary rates.

The countries of the South Pacific region are strongly committed to a regional approach to diplomacy and development. The South Pacific Forum and its Secretariat are the primary political vehicle for collaboration, and there are a number of more technical agencies that work to meet the interests of member nations. These include, of particular relevance to the water sector,

- the University of the South Pacific (USP, whose water-related courses include environmental sciences and geography);
- the South Pacific Applied Geoscience Commission (SOPAC, with a particular interest in groundwater and water supply);
- the South Pacific Regional Environment Programme (SPREP, whose interests in environmental management include any related to water); and
- the Secretariat of the Pacific Community (formerly South Pacific Commission, with wide ranging interests in regional and community development, principally in natural resource development).

TABLE 1. Basic statistics, Pacific Island countries

Country	Area (km^2)	Population	Human Developt Index*	GDP (US$)	GDP growth	Origin of GDP	Major exports
Cook Islands	237	19,000		106 m			
Fiji	18,350	840,000	0.763	1,575 m	-4.0	Agric/forestry/fish 19%; Services 32%; Trade/hospitality 17%; Manufacturing 15%	Sugar, garments, gold
Kiribati	81	85,000		44 m			
Marshall Is	181	61,000		111 m			
Nauru	21	11,500		164 m			
New Caledonia	19,100	204,000		3,179 m	-3.5	Commerce, 44%; Services 27%	Nickel
Niue	259	2,100		7.01 m			
Papua New Guinea	462,000	4.41 m	0.570	3,544 m	2.1	Agriculture 25%; Mining 26%; Services 32%	Gold, oil, coffee, copper
Polynesie Francaise	3,521	226,000		4,091 m			
Samoa	2,935	170,000	0.747	188 m	1.5	Agriculture 40%; Services 23%; Manufacturing 18%	
Solomon Islands	28,370	400,000	0.623	377 m	-1.0	Agriculture 48%; Public administration 23%; Trade 10%	Timber, fish, palm oil
Tonga	747	98,000		279 m	-3.4	Agriculture 30%; Services 44%	Squash, fish, vanilla
Tuvalu	26	11,000		12.5 m			
Vanuatu	12,190	180,000	0.627	250 m	3.5	Agriculture 23%; Trade 28%	Copra, beef, timber

Source of data: Economic Intelligence Unit, 1999; UNDP, 1999
Data for population and GDP are variously for the years between 1995 and 1998
*Human Development Index from UNDP World Development Report 1999. Other figures are: average for the world 0.706; average for developing countries in SE Asia/Pacific 0.695; and for Australia 0.922.

UNESCO has a regional office in Apia, which tends to focus on cultural matters, and the WMO has recently established a sub-regional office in association with SPREP, which already is bearing fruit in facilitating regional cooperation among the region's meteorological services. A major initiative is the development of a strategic plan for the region's national meteorological services (NMSs), and an associated needs analysis which is due to be completed in mid-2000. It is anticipated that this will lead to development assistance to strengthen the NMSs; while no direct effect on national hydrological services (NHSs) is expected, this initiative can be regarded as providing a favorable environment for NHS strengthening.

Only Papua New Guinea has (with Indonesia) any internationally shared river basins, and these are in remote areas, so that arrangements for international cooperation in shared river basins are not required in the region.

2.2 Physiographic background

The Pacific Island states in most cases are composed of several, and in some cases several hundred, islands that range in size from barely emergent coral reefs and sand cays up to the large main island of Papua New Guinea. In the east, many islands are low-lying coral atolls, such as those in the Tuamotu archipelago. They have no surface water, and groundwater is found as a shallow freshwater lens floating on seawater. In the west, most islands – such as Guadalcanal in the Solomon Islands – are mountainous and composed of volcanic rock, with deeply incised valleys in which perennial streams or rivers may flow. A third type of island is the upraised coral reef, typified by Niue. Here, freshwater again is restricted largely to a lens floating above the underlying seawater, except where it is revealed as lakelets or wetlands in the bottom of karstic features. It should be noted that the westernmost countries, which are often perceived as "high islands", also have atolls, while the easternmost countries, which in many peoples' minds are associated with atolls, also have high islands.

All these islands states have a sub-tropical climate, although the precise nature of their climates – and in particular their rainfall regime – depends on their physiography. The low-lying atolls have a rainfall regime characteristic of the open ocean, with annual totals on the order of 1,500 mm and strong seasonality, with a rainy season in Fiji, for example, during November-April and a dry season during May-October. The high islands also have strong seasonality, while their topography gives rise to considerable spatial variability. There is heavy rainfall (up to 7,000 mm per year in total) over their windward and highest parts, and a rainshadow over their leeward parts. There has been growing recognition of the significance of extreme events – heavy rainstorms that are associated with thunderstorm cells or tropical cyclones, and periodic droughts – in the Pacific Islands (Mosley, 1996; Raj, 1998). Year to year variations in their frequency and/or severity now are commonly ascribed, rightly or wrongly, to the influence of the El Niño-Southern Oscillation (ENSO) phenomenon. ENSO certainly has a significant impact on sea surface temperatures and atmospheric circulation in this part of the Pacific, and there is growing evidence that cyclone and drought frequencies do vary with its status.

2.3 Water resources and water demand/use

The region's water resources range from abundant in the rain-drenched Highlands of Papua New Guinea, to limited in the atolls located in the Doldrums (Table 2). Figures for water resources availability or use are available for few Pacific Island states. In any case, national figures do not adequately reflect seasonal and spatial variations, and those associated with long-term (possibly ENSO-related) climatic variability. As populations and per capita demand increase, many countries are experiencing periodic and even permanent water shortages,

TABLE 2. Water resources, Pacific Island countries

Country	Popul-ation	Water resource (m^3/cap/y)	Water withdrawal (m^3/cap/y)	Comments	Significance of hydrological extremes
Cook Islands	19,000		320	Principal current demand is for domestic/ industrial/ hotel use. Surface water is used on Rarotonga (main island), and groundwater anad roof catchments on the other islands. Wastage and losses put a heavy strain on existing sources, and there is insufficient storage during the dry season and droughts. Poor quality water is a key issue.	Dry seasons and droughts present supply difficulties, exacerbated by poor infrastructure.
Fiji	840,000	36,000	40	Principal water use is for hydroelectricity generation (Monasavu scheme supplies 95% of Viti Levu's needs), irrigation, and domestic/ industrial/ tourism. Major centres have piped water fed by rivers, and nearly 100% of the urban population is supplied; rural areas rely on streams, roof catchments and groundwater. There are water shortages during the dry season and droughts, although abstraction is a very small part of the total resource.	Both droughts and floods are major causes for public concern.
French Polynesia	226,000			The high islands have perennial streams and abundant water; the atolls are dependent on groundwater and harvested rainwater; consumption accordingly varies from 2,000 l/person/day in Tahiti to <100 l/person/day in the atolls. There is limited potential for or development of hydro-power, and most water use is domestic or commercial (tourism). Water quality is a serious problem in many places, for public health and environmental reasons.	Flash flooding and associated landslides occur on the high islands, especially during tropical storms. Dry period supplies are limited on the atolls.

Kiribati	85,000		25	The only surface freshwater is in ponds on the northernmost islands. Lens of fresh groundwater are recharged by rainfall; exploitable resources are very limited, sufficient for less than than 10 l/person/day during dry periods in Tarawa. Usage is principally for domestic consumption. Contamination of water supplies by human waste is a serious problem.	The water resource is barely able to supply domestic requirements, so that dry seasons and dtoughts present serious problems.
Marshall Is	61,000			There is no surface water, and groundwater lenses are fragile. The major source of water is airport runways, urban areas, and roof catchments, and the principal usage is domestic/commercial consumption.	The resource is largely dependent on rainwater harvesting, so extreme events present serious problems.
Nauru	11,500			There are no streams but one small lake; water supply is predominantly from roof catchments. Water is shipped into the island during droughts.	The resource is largely dependent on rainwater harvesting, so extreme events present serious problems.
New Caledonia	204,000			Surface water is abundant on the high islands, and reservoirs and pipelines serve to meet demand with no difficulty, despite large losses and wastage. Hydro-electricity potential is not fully developed, but meets 35% of demand. The resource is inadequate to meet demand on the raised atolls of the Loyalty Islands, where pollution of the groundwater is also an issue.	Floods and droughts do not in general present difficulties. One town is subject to flooding, and the groundwaters of the Loyalty Islands are under severe stress.

Niue	2,100		180	There is no surface water. Water use is predominantly for domestic consumption, and is met entirely from groundwater. There is ample water, given a declining population, but possible contamination of the aquifer from agriculture and septic tanks is a concern.	
Papua New Guinea	4.41 m	185,000	35	There is abundant surface water in many parts of the country, although many villages and four towns use groundwater wells/bores and/or rainwater harvesting. There is strong demand for improved water supply systems in rural areas. Groundwater is being increasingly developed, especially in the Port Moresby/ Boroka area, which is the only centre with water supplied from reservoir. The water resource provides a large hydroelectricity potential, which is being developed	Flash flooding is an issue in places, given the intense rainfalls that can occur, and a (now non-functional) flood warning system has been installed on the Sepik River. There is increasing pressure on the dry season water resource, especially in the atolls and NCD.
Samoa	170,000	48,000	125	The two largest islands have many rivers and streams but they often are small and unreliable as supply sources. Apia, the only large town, is supplied from river intakes; many villages and rural areas rely on springs, wells, and rainwater.	Water shortages are a fact of life in rural areas

Solomon Islands	400,000	118,000	25	There is abundant water but it is unevenly distributed, and water shortages are experienced after long dry spells. There is considerable hydropower potential, with several mini-hydro schemes operating, and irrigation is practiced, especially on the Guadalcanal Plains. Surface water is used to supply towns and many villages; groundwater and roof catchments are used in rural areas, especially on the small islands. Water pollution is a growing issue.	Water shortages during dry periods are expenenced. Flood hazard is an issue along a handful of rivers.
Tonga	98,000		55	There is little surface water, and groundwater is used for the bulk of domestic/ commercial supplies, supplemented by roof catchments in some places. Potable water supply is the main demand, with minor use of water for irrigation. Wastage and losses are high in rural areas, where there are no incentives for efficient use. Water pollution by human waste, salinisation and agrichemicals is a growing issue.	
Tuvalu	11,000		20	There is no surface water, and most domestic water is supplied by roof catchments, supplemented by shallow wells on some islands. There are no other demands on the water resource., although waste disposal presents a threat to the quality of groundwater lenses.	
Vanuatu	180,000			Despite abundant rainfall, catchments are small so surface water is unreliable. Urban supplies are from groundwater; rural supplies are mainly from wells, and in some localities by roof catchments, streams and springs. There is little irrigation demand; stock water is supplied from wells.	Flood hazard is an issue in a number of catchments, especially on Efate.

Source of data: Country reports to WMO *Meeting of experts on hydrological needs of small islands* (Nadi, October 1999), ESCAP (1995) *Guidebook to water resources, uses and management in Asia and the Pacific*, and in-country interview notes during the Pacific-HYCOS evaluation mission (December 1999)

especially in rural areas and small towns that rely on small streams, shallow aquifers, or artificial rainwater catchments for domestic water supply. Water shortages are commonly associated also with degraded water quality, and consequent increases in the incidence of water-related disease.

At the same time, flash flooding and storm surge events are of growing concern (Raj, 1998). This is not necessarily because they are more frequent or more extreme. Equally, it may be because people are moving into more flood-prone areas, losses to life and property are increasing, the phenomena are being monitored more closely by the news media, the public and decision makers, and explanations in terms of climate variability and change become common "knowledge".

Because of the generally low level of economic development in the Pacific Island countries, the demands placed on freshwater resources are relatively limited in scope and volume. In several countries, the majority of the population has a subsistence, rural style of life, and water use is close to the minimum requirement, especially where they rely on roof catchments or shallow wells. This has implications for the type and quantity of information required to manage the resource.

Domestic and industrial water supply. Major settlements generally have piped water supplies. Some meet WHO standards for water quality; many do not. In many cases, the supply is not meeting demand, not necessarily because the water resource itself is inadequate but because of a lack of investment in the system, or excessive losses (unaccounted for water) and wastage associated with deteriorating infrastructure and pricing/revenue collection practices that encourage carelessness or dishonesty. The "demand side" of the equation is receiving increasing attention, for instance by corporatisation of water supply in the National Capital District of Papua New Guinea, to avoid the need to develop additional sources. However, some towns, such as Tarawa (Kiribati) are facing a critical situation on the "supply side" also, and information on the availability and reliability of alternative sources will be required. Rural water supply and sanitation is inadequate in most Pacific Island countries, and has been receiving considerable attention from a number of multilateral and bilateral development aid agencies. In several countries, provision of rural water supply is the principal or only water-related issue on the government's agenda. Requirements are met largely by small streams and springs, which are often unreliable, roof catchments, or shallow wells. In practice, sources are tapped as close as possible to the point of demand, and limited effort is allocated to determining the nature and reliability of different options. Geophysical surveys may be used to identify optimal locations for boreholes, but as often as not wells are drilled without investigation in the most accessible place.

Industrial development is limited, but in some locations major water users – particularly tourist resorts and hotels – drill their own wells to ensure a controllable supply and to reduce water charges. This practice is presenting problems in some places, where the size of abstractions, and their effects on the resource, are unknown.

Hydroelectric power. A number of the high island countries have developed hydro-electric schemes, and the hydro resource has been or is being established, in at least an exploratory way, in all of them. Major requirements now are for rural electrification (for which mini or micro-hydro tend to be more appropriate than that based on supply dams, because of the distributed nature of the load), and for replacement of diesel-powered thermal generating plant (which is very costly in foreign exchange).

Hydrological information is available for a number of prospective large hydro resources, although the length and quality of record often is an inadequate base for design and additional data would be needed (and could be collected as part of a development project). However, information is not available for all large potential resources, and not for the more numerous mini and micro hydro options. Neither are data available to provide a reliable capability in regional estimation. At this stage, hydro developments seem to be “on hold”, perhaps because of regional effects of the recent Asian economic downturn and the high capital costs of hydro relative to thermal generation.

Agricultural irrigation. There is very limited use of irrigation in the region, and little scope for or interest in future development. This is because of climatic and physiographic factors, the lack of a major concern for food security in the region, and the low likelihood that irrigation of export crops would be economically advantageous.

Instream uses. Many people in the region depend on rivers and streams not only for domestic water supply but also for food and for amenities such as sanitation/hygiene and recreation. There is growing awareness of the negative effects of development, particularly mining and forestry, throughout the region, with the Ok Tedi River the most extreme example of an environmental disaster. Several countries have recently enacted environmental or water resources legislation, or are presently working on it, to achieve sustainable management of water and other natural resources. The present paucity of and need for baseline information for environmental impact assessment (EIA), and subsequent monitoring, is widely recognized. Frequently, developers are legally required to carry out EIAs and to monitor the environment if a project is licensed. The advisability of having an official data collection capacity, to verify the accuracy of developers’ information, is recognized, however.

Hazard mitigation. In almost every country, awareness of national vulnerability to water-related hazards has reached new heights, thanks (correctly or not) to climate change and El Niño. Severe and widespread droughts recently have been added to flash flooding and storm surge as causes of significant economic loss and social disruption, and few of the South Pacific Island countries are well equipped to forecast or manage responses to any of them. (Several technical interviewees commented that they had advised senior staff of the likelihood of ENSO-related droughts in recent years, but that no notice had been taken, and their countries had suffered the ensuing impacts of drought to an unnecessary extent).

In most cases, staff of National Meteorological Services and hydrological services see an opportunity to develop their capabilities in the area of extreme event forecasting and warning, and see this as an area in which they can make a real contribution. To do so will require enhanced data acquisition and database management systems, improved understanding of the relevant physical relationships or improved models, and effective mechanisms for communicating with disaster management authorities or the public.

3. PROBLEM ANALYSIS

3.1 The status of national hydrological capabilities in the region

Assessments of the hydrological capability of at least five individual countries have been carried out in the last ten years, in association with bilateral development assistance projects. A comprehensive assessment of the status of hydrological services in the South Pacific Islands had not been conducted, until that carried out for the present needs analysis. However, the

UNESCO/SOPAC/UNDDSMS *Workshop on Pacific water sector planning, research and training* (UNESCO, 1995) provided an excellent insight into the then-current status of water resources management (largely from a water supply perspective) in all the countries except Nauru. Since that Workshop, progress presumably has been achieved in many areas, so the country reports therein cannot wholly be relied on as indicators of needs today.

In some South Pacific Island countries there is effectively no national hydrological service, and water-related information is collected, if at all, by the water using agencies – usually the water supply authority. In the others, there is some form of national hydrological service, normally located in a ministry for the environment, public works, or natural resources. However, in most cases it is under-resourced, sometimes with demoralized staff who have little vision for the future, and in several cases it has all but ceased to function. Only in Fiji and the French territories could the national ability to collect and archive water-related information be regarded as meeting national needs.

A characteristic of most Pacific Island countries is that water and water information are managed by several government departments, which commonly have very little contact with each other. Frequently, surface water and groundwater are the responsibility of different departments; in some cases, hydrological extremes (floods or droughts) are dealt with by the Meteorological Service, Disaster Management Service, or some other agency. Their databases and information archives are completely separate and, even though there are no theoretical restrictions on information exchange, there is little communication in practice. A by-product of this is that the present analysis has had difficulty in establishing exactly what water-related information is available in most countries. In general, though, it appears that:

- Rainfall and other climate information is in the most satisfactory state, although it is not available for the vast majority of the hundreds of inhabitated islands in the region;
- River flow data are available, sometimes with records more than ten years in length, for small numbers of rivers that have been investigated for specific projects. Basic hydrological networks have never existed, except perhaps in Fiji and the French territories.
- Groundwater well logs and some water level data are held, commonly by Geological Surveys, in many places where groundwater has been exploited. Resource investigations have rarely been carried out, and the wells that do exist are not necessarily surveyed into benchmarks, so level data cannot be used for modeling purposes;
- Water quality data (surface and groundwater) are collected, if at all, primarily for public health purposes (water supply monitoring), and are not readily accessed;
- Archives of water-related data often are primitive and badly maintained; most are at high risk of being lost altogether as a result of government restructuring, staff losses, and technological change;
- There has been limited effort to analyze available data, and disseminate it in user-friendly forms like investigation reports, hydrological atlases and the like. (Surprisingly, many technical hydrologists feel that they are only called on to supply data, but they do not seem to take the initiative to develop products that exploit their analytical capabilities). However, some examples of such products are available, such as the recent report on the groundwater resources of Papua New Guinea.

In summary, the regional state of affairs with respect to water-related data and information is:

- A lack of resources for equipment and operational work;
- A general reduction in observation networks and addition of data to archives;
- Attrition and demoralization of technical staff, poor vision, and weak management;
- Separation of responsibilities for water management and water-related information among several departments which do not communicate well;
- Poorly accessible databases that are at high risk of being lost, and limited availability of user-friendly information products;
- Inability of hydrological services to supply data and information to clients.

Interviews indicate that, in general, water resources management has a low profile in most South Pacific Island countries, and that concern about water-related issues tends to be short-lived, during droughts and floods. Governments have other things to worry about, such as revenue generation, restructuring of public administration, provision of social services, and infrastructure development; only water supply and sanitation are generally on the list of top government priorities.

On the other hand, an increasing number of countries are enacting environmental and natural resources legislation, and the need to achieve sustainable resource use is recognized, at least in principle. Enforcement of legislation is another matter, but experience in other parts of the world suggests that water resources management will receive more attention in coming years, even if as a component of the environment as a whole, and the need for reliable information will be recognized and acted on.

The *WMO Workshop on reviewing national capabilities for Water Resources Assessment in the South Pacific countries* (Nadi, September/October 1999) summarized the problems and issues facing the region's specialists in water resources assessment and management (Table 3). Of these, eight could be classified as institutional in nature, one refers to the need for appropriate monitoring technology, and one to the need for adequate databases. The other four refer to specific information gaps – water quality, effects of climate variability on water, the size of the water resource relative to demand, and the nature of interaction between surface water and groundwater.

A wide range of problems and issues were identified by the participants, including:

- Insufficient funding for water resources assessment and management in most countries
- Absence of specific legislative power and policies for water resources assessment
- Significant water quality issues not yet addressed, including
  - Salt water intrusion into freshwater reserves
  - Pollution
  - Discharge of pollutants into groundwater and surface waters
- Management decisions addressing immediate/short term issues rather than setting a long term strategic programme, and sometimes based on inadequate information Lack of and difficulty in retaining trained staff, exacerbated by the need to go overseas for training, and the rapid pace of technological development
- Fragmentation of roles and responsibilities in the water sector, and a lack of communication and information sharing among the various agencies
- Lack of coordination among donors, international organizations, and recipients

TABLE 3. Problems and issues identified by the WMO *Workshop on reviewing national capabilities for Water Resources Assessment in the South Pacific countries*.

The workshop discussed the main problems and issues facing water resources assessment in the region. A wide range of problems and issues were identified by the participants, including:

- Insufficient funding is provided for water resources assessment in most countries;
- Absence of specific legislative power for water resources assessment, hence WRA is difficult to apply;
- Significant water quality issues (important to WRA) not yet addressed include:
  - Salt water intrusion into freshwater reserves;
  - Pollution;
  - Discharge of pollutants into groundwater and surface water;
- Management decisions tend to address immediate/short-term issues, rather than setting a long-term strategic programme and are sometimes based on inadequate local information;
- Lack of and difficulty in retaining trained staff. This is made worse by the need to go overseas for training, and the rapid pace of development of new technology and supporting hardware and software;
- Fragmentation of roles and responsibilities within the water industry, exacerbated by a lack of communication/linkages and information sharing amongst the various agencies.
- Lack of coordination amongst donors, international organizations and the receiving countries;
- Changing populations, including urbanization and population decline in some rural areas and on some islands (Nuie);
- Imported activities do not necessarily work in the tropics and there is a need for economically viable technologies for the tropics;
- Insufficient knowledge on the effects of climate variability and climate change (for example, increases in extremes; ENSO episodes);
- Lack of knowledge on whether demand for the resource can be met;
- Lack of knowledge on the interactions between surface water and groundwater;
- Inadequate public awareness of the importance of water and the role played by hydrologists. This can result in the wastage and sub-optimal use of water;
- Lack of an integrated-multi-disciplinary approach to water resources management; and
- An inadequate database, lacking in long records for most hydrological elements in most countries and a shortage of spatial information and interpolation techniques.

The future data needs with respect to data collection, processing and dissemination that the Workshop identified were related to future potential development identified earlier in the Workshop (for example, urbanization, hydro-power, tourism, mining, integrated management and climate variability) and included:

- Streamflow and river height data in many ungauged catchments
- Rainfall data in more remote high rainfall regions
- Continuation of climate and other rainfall stations at the same level was seen as necessary for future requirements
- Groundwater levels, and river and groundwater quality were targeted as data collection activities which will be required to increase beyond their current extent
- Water use data will be required in areas where there is significant demand for water
- Soil moisture monitoring

The participants of the Workshop also identified a range of education and training issues that have to be confronted, including:

- There is a lack of specialized training in hydrology in most countries;
- There is a lack on in-house training capabilities in most countries;
- There is a great need for locally based relevant training courses at the technical (in particular) and professional levels;
- Very limited funds are provided for training as it is given a low priority;
- Institutional reforms have resulted in the loss of key experienced staff, as has the development of the private sector (attracted to higher salaries);
- Attracting new staff is difficult because salary levels are low;
- Many agencies are becoming more driven by “profit” then providing community services;
- Good, well-qualified staff are often promoted into management or other areas and sometimes their expertise is lost to the organization without consideration of the consequences;
- The unclear role many agencies have in water resources assessment adds confusion to the situation;
- Because of the low salaries and lack of opportunities within WRA agencies, there has been a “brain drain” of qualified staff;
- The entry level requirements for some specialist courses can sometimes be difficult to meet and therefore valuable training opportunities are sometimes lost;
- There is possibly too much reliance on international organizations for support in training initiatives;
- However, it is essential to involve the regional and international organizations (SOPAC, SPREP, WMO, etc.) in training initiatives;
- Consideration should be given to multi-disciplinary training, for example, training meteorologists in hydrology and visa versa;
- It is essential that proposed development projects within the region include and financially support a training strategy to ensure capacity building within the countries; and
- A change in attitude is necessary from a situation where we only learn from our mistakes to one where we learn in order to reduce the risk of mistakes.

- Changing populations, including urbanization and rural depopulation
- Difficulty of transferring hydrological techniques to the tropics, and the need for technology appropriate for tropical conditions
- Insufficient knowledge of the effects of climate variability and change
- Lack of knowledge of the size of water resources relative to demand
- Lack of knowledge of groundwater-surface water interactions
- Inadequate public awareness of the importance of water and the role of hydrologists
- Lack of an integrated, multi-disciplinary approach to water resources management
- An inadequate database, shortage of long records, and shortage of spatial information and interpolation techniques

3.2 Assessment of hydrological needs

An assessment of "hydrological needs" in the region was conducted by the *Meeting of experts on hydrological needs of small islands* (Nadi, 4-6 October 1999) and the *WMO Workshop on reviewing national capabilities for WRA in the South Pacific countries* (Nadi, 29 September-2 October 1999). The reports of these two meetings provide a wealth of ideas on issues facing hydrologists, and their suggested solutions; it should be noted that most participants were technical staff, and their assessments can be expected to reflect that background. The UNESCO/SOPAC/UNDDSSMS Workshop on *Pacific water sector planning, research and training*, as well as the UNESCO publication *Small tropical islands: water resources of Paradise Lost* (Falkland, 1992), also provide assessments of hydrological needs. All are largely consistent – which might be taken to imply that insufficient progress has been made since the very informative UNESCO/SOPAC/ UNDDSMS workshop in 1994.

3.2.1 Hydrological information needs

Since the mooted Pacific-HYCOS project is related to the provision of hydrological information, the needs analysis has considered the future *needs* for water-related information, in the context of anticipated or reasonably foreseeable water resources development and management. The basic philosophy is that information is of value only if it is likely to be used in decision-making (i.e. design or operation of water-related infrastructure, and sustainable management of the resource). Table 4A-D summarizes the assessments of the country reports and in-country interviews.

Because of the small size and restricted nature of the economies of most of the Pacific Island countries, reasonably foreseeable water-related developments in most cases are limited in scope and scale, and so too are the associated information needs. Informants, all water professionals, from several countries referred to their desire to assemble hydrological information representative of national conditions – i.e. to operate a "basic network". This seems an unrealistic goal, given the universal shortage of funding for hydrology at present. Nevertheless, it is essential to affirm that there is a need in <u>all</u> countries for long-term water resources information that is not earmarked for a specific project, to support future, unanticipated design and management requirements. Because of climatic variations, analysis based on observations during a short period (which may, for example, have experienced unusually wet conditions during a period of El Niño events) may lead to incorrect decisions and infrastructure that cannot deliver services as expected. Individual governments with limited financial resources may take a short-term view, but external support agencies like WMO must adopt and promote a longer term perspective.

In most countries, there already has been a considerable input of external assistance in water resources *assessment*, and in at least four there is substantial ongoing assistance at present. In particular, SOPAC has provided and still provides extensive assistance throughout the region, especially in the area of groundwater assessment. Virtually all of the Pacific Island countries also have received extensive assistance in water resources *development*, especially for water supply, sanitation and hydropower development; again, several are at present receiving such assistance. In many cases, however, the benefits from past assistance have been lost, due to a lack of ongoing commitment and funding by the governments concerned, and by losses of key staff.

Table 4 lists information needs for particular areas of water management, on the basis that governments are likely to be particularly receptive to a project designed to build capacity in the area of water resources information, if they have current unmet needs.

Domestic and commercial/industrial water supply. In the majority of countries, further development of water supply, particularly in rural areas, is necessary, or even a government priority. Information on reliable sources – surface water or groundwater, depending on the characteristics of the islands – is required in these countries. Commonly, large numbers of small village supplies will be required, so that resource assessment will need to be on an extensive, near-reconnaissance scale rather than using long-term continuous monitoring.

Hydropower development. Five countries have unexploited hydropower potential, and development would require improved hydrological records in all of them. It was unclear how many countries actually anticipate development of resources, because of the relatively high initial cost of hydropower (other than micro-hydro, which requires minimal in-channel construction).

Irrigation. Only in New Caledonia does it appear that prospective irrigation on a significant scale might require information on the water resource.

Environmental flows. Protection of water quality in both surface waters and aquifers is a growing concern in many of the Pacific countries, and monitoring presently is inadequate virtually everywhere. A particular area of concern is the potential impact of mining, and also forestry, mentioned in four countries. Baseline information is required, as well as ongoing surveillance monitoring. Developers could be required under law to obtain information for EIA and subsequent surveillance, but governments would need their own capability for confirmatory data collection.

Flood forecasting. Six countries have requirements, or desires, for flood forecasting, commonly related to one or a few rivers or settlements in which losses have recently been experienced. Generally, the rivers involved are short and steep, so that real-time information on rainfall and possibly streamflow at the head of the catchment would be needed, and would need to be input almost instantaneously into a forecasting model.

Drought forecasting. Climate prediction services, in general related specifically to droughts associated with ENSO episodes, were specified as an area requiring development in seven countries, although in fact the need probably exists in all of them. High correlations between rainfall and SOI have already been demonstrated in the region, but more extensive data and the development of reliable relationships is needed to make operational use of them. Where streamflow or aquifer levels are of concern, direct relationships need development, rather than relying simply on forecasting of rainfall. The *ENSO impacts on water resources in the*

TABLE 4A. Water-related information needs in the Pacific Islands

Water use	**Cook Islands**	**Fiji**	**French Polynesia**	**Kiribati***
Domestic and commercial/ industrial water supply	Demand, including wastage and losses, exceeds existing sources and storage capacity is insufficient during dry periods. Water quality is not adequate. Information is needed on groundwater quality and recharge, and streamflow to assist design of additional supplies, especially on outer islands. Info needs differ between the high islands and atolls.	There is a growing emphasis on managing demand, and provision of adequate water to main centres is an investment issue. Full supply coverage of rural areas is a government objective, and data on water resources (streams, springs, aquifers), especially on their reliability, are needed throughout the settled rural areas and islands.	Demand management plus abundant water limit quantity-related problems on the high islands, and therefore information needs. Provision of adequate supply on the low islands/ atolls is a major need, requiring data on sustainable groundwater yields and monitoring of abstraction.	Water supply and management of aquifer contamination by waste disposal are essentially technological matters, given the very limited resource known to be available. Development of design techniques e.g. for extraction galleries is a major requirement.
Power generation				
Irrigation				
Environmental flows	Maintenance of water quality, especially in the low island aquifers and in coastal/lagoonal waters, requires surveillance.	The Sustainable Development Act will bring a need for enhanced monitoring, especially of surface water quality.	Poor water quality in many places requires improved monitoring to support remediation measures.	Monitoring of the aquifers to avoid over- abstraction is the principal information requirement.
Flood forecasting	Quantitatve flood warning would be desirable on Rarotonga, but would be very difficult to implement.	The need for flood forecasts in several major rivers is becoming urgent; flow data are needed to supplement rainfall data/forecasts.	Flood forecasting is needed but difficult because of short, steep rivers; flood hazard mapping is required.	
Drought forecasting		A drought forecasting capability is increasingly regarded as essential for water management.		A drought forecasting capability would assist in water supply/storage management.
Notes	A NZODA-funded project to provide information on surface water on Rarotonga has just commenced.	A major need is for improved communication of data among agencies, and more coordinated database management.	Commercial water supply and electricity companies have adequate data for their own purposes, but either do not archive them or/and do not release them.	

* Not represented at the meeting on *The hydrological needs of small islands*, and not visited for in-country interviews.

TABLE 4B. Water-related information needs in the Pacific Islands

Water use	**Marshall Islands***	**Nauru***	**New Caledonia**	**Niue****
Domestic and commercial/ industrial water supply			Management of aquifers, especially of their water quality, in the Loyalty Islands requires improved information and monitoring.	The principal information need is for enhanced understanding/modelling of the aquifer characteristics, with respect to sustainable yield and preventing contamination by agri-chemicals and septic tanks.
Power generation			Feasibility studies of several prospective hydro schemes have been done; Enercal would carry out additional resource assessment if any were to proceed.	
Irrigation			Further irrigation development along the western coast of Grande Terre requires improved knowledge of groundwater resources in particular.	
Environmental flows			Baseline stream monitoring for EIA and design of mining proposals, and monitoring of the impacts of mining for regulation, are a major information requirement. Mine companies are required to obtain such data and the government will need a review capability.	

Flood forecasting			One town is subject to flood hazard, and a forecasting capability is sought.	
Drought forecasting	A drought forecasting capability would assist in water supply/storage management.		A drought forecasting capability would assist in water supply/storage management, especially in the Loyalty Islands.	
Notes	The Marshall Islands are largely dependent on rainwater catchments and some groundwater abstraction, although groundwater lenses are in most cases to small and thin to be safely exploitable. Hydrological information in its usual sense, other than relating to rainfall statistics, is not required.	Nauru is largely dependent on rainwater catchments, supplemented by water shipped in during prolonged droughts. Information on Nauru's groundwater resources could not be located, but presumably the island has a freshwater lens which could be exploited.	Prospective water-related information needs in New Caledonia relate principally to the mining industry; service providers (eg Enercal) meet their own information needs or employ consultants.	An AusAID-funded project on Water and Waste Management has (1997-9) assisted Niue in water management, demand management, public education etc to address water demand/use and potential contamination issues.

*Not represented at the meeting on *The hydrological needs of small islands*, and not visited for in-country interviews.
**Not visited for in-country interviews.

TABLE 4C. Water-related information needs in the Pacific Islands

Water use	**Papua New Guinea**	**Samoa**	**Solomon Islands**	**Tonga***
Domestic and commercial/ industrial water supply	Information on groundwater resources in the NCD (which are subject to unknown levels of abstraction) and atolls is needed to establish sustainable yields. Information on reliable sources of supply in rural areas is needed to support efforts to extend rural water supply.		Efforts to extend water supply schemes to all provincial capitals and rural areas will require information on reliable sources of supply in each locality.	Assessment of groundwater resources, aquifer characteristics (for modelling), the probability of saltwater intrusion and groundwater quality is required for settled localities, to support improved water management (especially demand management).
Power generation	Long record water resource information for hydropower design is a major need.	Longer hydrological records for hydropower assessment and design are a principal need. (A Hydropower Master Plan was prepared in 1979.)	Longer hydrological records for hydropower assessment and design are a continuing need, despite earlier work in this area. A Power Development Master Plan is being prepared.	
Irrigation				
Environmental flows	Mining impacts on water quality and riverbeds are a major issue, requiring monitoring by developers and confirmatory observations by the OEC. Baseline info on quantity and quality is needed with respect to future developments.		A new Environment Act will bring new monitoring and EIA requirements, when implemented. Baseline information on quantity and quality of waters likely to be impacted by mining and forestry developments, and subsequent monitoring, is a major need.	Contamination of aquifers and saline water intrusion are recognised as major concerns, but insufficient data are available to specify the scale of the problem, its cause or appropriate remedies.

Flood forecasting	Flash flooding and flooding on major rivers requires real time data; a satellite telemetry system for the Sepik River was installed but is non-functional now.		Several rivers present flood hazards, and flood forecasting capability is sought.	
Drought forecasting	Mitigation of drought impact is a major issue, and improvement of drought forecasting techniques, including communication to decision makers, is needed.		Climate prediction services are perceived as a major need, especially regarding the effect of ENSO-related droughts on smaller islands and stressed water supply systems. A much enhanced database will be needed.	Climate prediction services are perceived as a major need, especially regarding the effect of ENSO-related droughts. A much enhanced database will be needed.
Notes	Hydrometric networks established in the last 10 years with external assistance are defunct, for lack of funds.		Hydrometric networks established with external assistance in the last 15 years are in a poor state of repair.	Unchecked demand and wastage rather than insufficient supply appears to be the greatest threat to the water resource.

* Not represented at the meeting on *The hydrological needs of small islands*.

TABLE 4D. Water-related information needs in the Pacific Islands

Water use	Tuvalu*	Vanuatu
Domestic and commercial/ industrial water supply	A Ten Year Water Plan (1192-2002) has been prepared and largely implemented, based on rainwater harvesting.	Extension of Rural Water Supply is a national objective, and the 5-Year Strategic Plan will require information on reliable sources.
Power generation		Hydropower design will require water resources data in any catchments selected for development (at present unlikely, because of capital costs).
Irrigation		
Environmental flows	Contamination of aquifers by waste disposal is the most serious water-related issue requiring monitoring.	Baseline hydrological information is required in rivers likely to be impacted by mining developments presently being explored. Aquifer contamination is a growing concern, which needs monitoring.
Flood forecasting		A flood forecasting capability is sought for several rivers, most importantly the largest river on Efate Island.
Drought forecasting		
Notes		Baseline hydrological studies for mining development are being funded by AusAID. NZODA is providing assistance in hydrological database management and for a Five Year Strategic Plan for Water.

* Not represented at the meeting on *The hydrological needs of small islands*, and not visited for in-country interviews.

Pacific workshop convened in October, 1999 in Nadi by SOPAC, made a number of recommendations in this regard, which must be taken into account when developing proposals for future hydrological work in the Pacific.

In summary, the main requirements for water-related information that are indicated by the needs analysis are:

- Real-time rainfall and streamflow information for flood forecasting: six countries.
- A drought forecasting capability: all countries.
- Baseline information on the water resource in waterways identified as having hydropower potential, most of which would be at the micro- or mini-hydro scale: five countries.
- Baseline information on surface waters (particularly water quality) likely to be affected by mining or forestry development, and subsequent monitoring: four countries.
- Water resource information, including streams, springs, and aquifers, at a reconnaissance scale, in support of potentially numerous rural water supply projects: all countries.
- Baseline and ongoing monitoring information on the quality of groundwater, particularly in the low islands and atolls where aquifers are subject to contamination by human and animal wastes: about ten countries.

Each of these is a requirement only in a subset of the Pacific Island countries.

3.2.2 Capacity building needs

An essential element of the WHYCOS concept is capacity building, focused on the staff training needed to make full use of state-of-the-art instrumentation and its data and information products. The Nadi *Meeting of experts on hydrological needs of small islands* identified capacity building requirements in the Pacific, summarizing them under the headings:

- Training of hydrologists and water resources specialists.
- Immediate needs for specific training events.
- Knowledge and information exchange and information transfer.
- Guidance on legislation, policy and institutional development.
- Data capture, archiving and dissemination (monitoring).

A separate exercise has developed proposals for specific training events in 2000/2001. More specific needs for capacity building in the Pacific Island countries have been synthesized from the country reports and in-country interviews (Table 5A-D).

Institutional arrangements. Unsatisfactory institutional arrangements – legislation, policies, organizational relationships, administrative arrangements such as planning and budgetting – are an impediment to water resources management and assessment in a majority of countries. Several have already addressed these issues, or are presently working through them, although organizational restructuring often brings its own problems. One of the areas specifically identified by the Nadi meeting was the need for guidance on institutional development.

TABLE 5A. Institutional issues in Pacific Islands operational hydrology

Issue	Cook Islands	Fiji	French Polynesia	Kiribati*
Institutional arrangements	Institutional arrangements are fragmented and uncoordinated, with several agencies having different, sometimes overlapping functions in water management and data collection. Legislation, policy and regulations need updating, clarifying, and to be more specific. Management of demand for water is essential.	Institutional arrangements are fragmented and uncoordinated, with several agencies having different, sometimes overlapping functions in water management and data collection. Institutional capacity building and coordination is needed, especially in the context of the new Sustainable Development Bill.	Institutional arrangements are fragmented, uncoord-inated and sometimes uncooperative, with several agencies having different, sometimes overlapping functions in water management and data collection. Some organizations are reluctant to transfer their data to others.	
Human resources	There are limited numbers of skilled technical staff, and a lack of appropriate training opportunities. Staff training in management and supervision, water quality monitoring and analysis, field hydrology, database management, hydrological analysis, and watershed management in particular is required.	A shortage of skilled staff limits ability to process data, until they are actually needed. Training in all areas – field hydrology, equipment use and maintenance, data processing and analysis, extreme event forecasting and analysis – is needed, as well as appropriate incentives to attract and retain qualified staff.	Staff numbers at inter-mediate and low levels are insufficient for the workload, and enhanced skills in database management an hydrological analysis are required. There are limited local training opportunities, and reliance on France for training presents problems. Training of local staff is a priority.	

Instrumentation and infrastructure	Resources for maintenance of infrastructure are limited, and additional reliable, suitable equipment is needed, especially if presently unmet data needs are to be addressed.	Some equipment is obsolete and needs replacing; instrument failure results in high data loss rates. Real-time data transmission is required.	There are difficulties with operation and maintenance of equipment.	
Databases	Quality control of data and processing procedures is required. Databases for both groundwater and surface water are required.	Quality standards for all steps in data acquisition and archiving are needed. Improved provision, coordination, and transfer of information (interpreted data) is needed, and will be more necessary when the Sustainable Development Bill is enacted.		
Public information	Improved community awareness of water issues is desirable.	Improved community awareness of water issues is desirable.		
Notes	A new NZODA project will assist the Water Department to establish a surface water monitoring system on Rarotonga, and will provide necessary capacity building and staff training.			Extensive changes in the water sector have been implemented during the last decade, with AIDAB, UNDP, UNCDF, WHO and other external assistance, under the 10 Year National Water Master Plan and National Development Plans.

* Not represented at the meeting on *The hydrological needs of small islands*, and not visited for in-country interviews.

TABLE 5B. Institutional issues in Pacific Islands operational hydrology

Issue	Marshall Islands*	Nauru*	New Caledonia	Niue**
Institutional arrangements			Institutional arrangements are in a state of change at present, with increasing autonomy from France, and there are risks that water-related matters receive partial attention. Effective arrangements for collaboration and data transfer among different types of organization (NC government, French government, private sector, state-owned corporates) are required.	
Human resources			Hydrological staff need broader skills, especially in data-base management and hydrological analysis. There are limited technical training opportunities in NC, with training being undertaken in France.	There is a shortage of technically qualified staff. Further training in database management, water chemistry/quality and in groundwater resource assessment and management is sought.
Instrumentation and infrastructure			The hydrometric network was developed by ORSTOM and its sustainability under NC administration, with greater competition for resources, is uncertain.	Further development of water chemistry/quality monitoring capacity is required.

Databases			There is a need for improved coordination and data transfer among hydrological database owners, and quality assurance, data analysis and summary need to be further developed. There appears to be a risk of data loss. Migration from HYDROM to THALIE is encountering problems.	Groundwater modelling and associated data requirements needs further development.
Public information				
Notes	A Sector Strategy and Action Plan for water and sanitation, National Envir-onmental Management Strategy, and Five Year Development Plans, in the context of capital development grants under the Compact of Free Association with the USA, have addressed many issues in the water sector during the last decade.	No informataion is available to the project team.	Several commercial and quasi-commercial organizations such aas Enercal operate in the water sector and collect data as they require. A2EP is a consultancy which provides hydrometric services (especially related to groundwater) on contract and the Meteo-France office in NC is very well resourced.	The Water and Waste Management Project (1997-9) provided comprehensive capacity building, in institutions, infrastructure, public information, and staffing.

*Not represented at the meeting on *The hydrological needs of small islands*, and not visited for in-country interviews.
** Not visited for in-country interviews.

TABLE 5C. Institutional issues in Pacific Islands operational hydrology

Issue	**Papua New Guinea**	**Samoa****	**Solomon Islands**	**Tonga***
Institutional arrangements	A chronic lack of funding for hydrology and water resources management, as well as the effects of frequent reorganization, has prevented the former Bureau of Water Resources from providing a credible service. There has been a consequent loss of confidence by the public, and collaboration by other agencies. Policy and regulations for resource management need developing, in order to implement existing water legislation.	There is overlap of responsibilities among agencies involved in the water sector, and various institutional impediemtns such as a lack of annual planning and a lack of community support for the Samoa Water Authority.	Inadequate water legislation and policy, and uncoordinated plans and objectives, present difficulties for collaboration and communication among the several governmental and non-governmental institutions with water-related functions.	Institutional arrangements are fragmented, legislation and policy need development, and responsibilities for water resources management are unclear.
Human resources	Changing organizational responsibilities require that existing trained and frequently very capable staff often need retraining to do other tasks, but relevant in-country training opportunities (water resources management, database management, general hydrology) are limited. Management and leadership training appears to be an area of need.	There is a shortage of skilled staff, and appropriate training is required in many areas.	Further specialised training in hydrological practice (water resources assessment through to hydrological analysis, as well as environmental monitoring and water resource management) is required for the existing skilled staff. Management and supervisory skills also need upgrading. A Staff Development Programme has been prepared but needs to be implemented.	There is a severe shortage of trained staff in the water sector. Particular areas of need for training include groundwater database management, groundwater modelling, water quality monitoring, and water quality database management. There is very limited scope for in-country training.

Instrumentation and infrastructure	Field hydrology has almost ceased because of financial constraints, and it is expected that the hydrological network will need extensive renewal.	There is a shortage of the basic equipment and instrumentation needed to carry out hydrological functions, due to insufficient runding.	Instrumentation is obsolete and mostly unserviceable. There is a lack of funding to maintain and service field installations.	Groundwater monitoring infrastructure is very limited, as is the capacity to collect baseline information on water quality. Financial resources are insufficient.
Databases	Arrangements for transfer of data among government departments and private companies are ineffective. Databases are not all well managed, coordinated or easily accessed.	Improved software for database management and data processing. analysis is needed.	Arrangements for data management and exchange require improvement, and an integrated information base on water resources matters is needed. More analysis to provide information and products rather than simply data is needed.	Databases are limited and of poor quality, so that future data analysis and modelling will be difficult. Implementation of the National Environment Management Strategy will require improved monitoring and data archiving.
Public information		Lack of communiity understanding of water issues and support for water agencies needs to be countered by improved public information.		

Notes	A Strengthening of Water Resources Assessment and Management programme was carried out about ten years ago, but as a result of subsequent restructuring and financial constraints its impact has been limited. ToR for a review of water legislation and policy are being prepared, with the aim of developing a National Water Resources Management and Planning Strategy.	Samoa has received extensive assistance from SOPAC. A NZODA project to assist in surface water assessment has just commenced.	There has been extensive assistance from NZ Ministry of Works & Development in establishing a hydrological capability, but lack of subsequent funding has meant that many of the benefits have been lost.	Past external assistance in the area of water resources management has not had sustained benefits because of a lack of committed funds and staff resources. However, further assistance to develop a national water policy is being sought, and this may provide an environment for progress in water resources assessment and management.

*Not represented at the meeting on *The hydrological needs of small islands*.
** Not visited for in-country interviews.

TABLE 5D. Institutional issues in Pacific Islands operational hydrology

Issue	Tuvalu*	Vanuatu
Institutional arrangements		The Vanuatu government presently is restructuring, and new water resources and environmental legislation is being drafted. A 5-Year Strategic Plan for Rural Water Supply is being finalised. A National Water Committee will be established to focus on the country's water issues. Improved links between organizations (government and private sector) with water-related functions are required.
Human resources		A Training Needs Analysis has just been completed as part of the Strategic Plan for Water, which will form the basis for a comprehensive training programme in all areas, technical and managerial. Particular areas are management and supervision, database management, hydrological analysis, water quality monitoring and analysis, field hydrology, water resources management. There is a lack of trained people to implement legislation and policies, although staffing of the Water Resources Unit is sufficient.
Instrumentation and infrastructure		Hydrological monitoring has been allowed to deteriorate due to lack of resourcing
Databases		The Water Resources unit presently is receiving assistance from SOPAC and NZ in hydrological data and database management, using Tideda. Policies and legislation are needed to establish arrangements for data transfer. There is a need also for preparation of hydrological analyses and products (although a substantial report on water resources was produced by Kowaco in 1997)
Public information		
Notes		It appears that the training programme envisaged for Vanuatu would be relevant to many other Pacific countries.

* Not represented at the meeting on *The hydrological needs of small islands*, and not visited for in-country interviews.

Human resources. A shortage of suitably trained staff, and difficulty in retaining them, is a serious problem in several countries. Despite a great deal of past assistance in staff training, there is an ongoing need for training in most countries, because of continuing losses of staff (to other departments, overseas or to the private sector) or evolving responsibilities. Training in virtually all areas of water resources assessment and management is mentioned by at least one country, but several countries refer to each of the following:

- groundwater investigations, assessment and modelling,
- water quality/chemistry monitoring and analysis,
- database management,
- hydrological analysis (e.g. water balance computations; extreme event analysis),
- design, operation and maintenance of water supply infrastructure,
- water resources and watershed management practice.

In countries where potable water supply is essentially the only use of water, training needs focus on water supply technology. Although rarely mentioned, training in management, supervision and leadership appears to be a critical need in virtually all organizations with responsibilities in the water sector – at the very least, the unsatisfactory nature of institutional arrangements would indicate this.

There has already been significant external assistance in training of hydrological staff in the region. Capacity building, including training, is presently being provided in several countries through bilateral cooperation, and SOPAC provides ongoing assistance and training, particularly in groundwater. Some of the current efforts in fact offer scope for regional-scale training. For instance, the training programme proposed for Vanuatu on the basis of a thorough Training Needs Analysis appears to be very relevant to the needs of several countries. Similarly, new projects to build the capacity of the Cook Islands and Samoa in surface water resources assessment is relevant to other countries where there are equivalent needs. On the other hand, it has to be said that several such past projects have not had lasting effect, due to staff movements, institutional restructuring, or a simple lack of funding. Measures to assure the sustainability of benefits will be required.

*Instrumentation and infrastructur*e. A majority of the countries have unsatisfactory inventories of instrumentation and other field equipment, commonly because of a lack of financial allocations to maintain existing assets or to purchase new ones. In several countries, field hydrology has all but ceased, because resources are not made available for instrument repairs, or even for vehicle running costs. In circumstances where equipment required to meet past and present information needs cannot be maintained or replaced, purchasing equipment to meet future needs – water quality monitoring, groundwater assessment, and real-time rainfall and water level data for flood forecasting, in particular – is unlikely.

The lack of resourcing for hydrological instrumentation is, of course, associated with the low priority that Pacific Island governments tend to place on water-related expenditures, and which results in staff shortages and other forms of under-investment.

Databases. A majority of the countries identify specific needs in the area of hydrological database provision. These include, in particular:

- Improved methods for data quality management.

- Improved database management systems and software, and additional capabilities for data analysis and presentation.
- Improved arrangements for coordination and transfer of data among different organizations with interests in the water sector, particularly private and state-owned companies and government departments.
- Databases in new areas of activity, particularly water chemistry/quality and groundwater resources.

A further need is for modelling that utilizes the databases, for instance to understand contaminant transport in groundwater, or groundwater flow and aquifer behaviour. The information needs summarized in Table 4 imply, in fact, the need for additional databases to be established; these should be coordinated and if possible integrated.

Some interest was expressed in the provision of regional databases, principally as backup for national databases (as presently is provided for some countries by NIWA in New Zealand or SOPAC in Fiji).

Public information. Limited interest was expressed in the need for enhanced information to the public, decision-makers, and elected representatives. However, it seems that water resources assessment and management have such a generally low level of support in Pacific countries that water professionals cannot be doing an effective job in demonstrating their contribution to national welfare. The summary statement for Samoa (Table 5C) that "lack of community understanding of water issues and support for water agencies needs to be countered by improved public information" probably has general applicability.

3.3 Past and current efforts to address needs

As already mentioned, bilateral and multi-lateral agencies have provided the Pacific Island countries with a considerable amount of assistance in the water sector, particularly in the area of water supply and sanitation. For example, Solomon Islands, Papua New Guinea, Fiji, Cook Islands, Samoa all have received or are now receiving assistance in strengthening national capabilities for water resources assessment, oriented towards hydropower or water supply provision. New Caledonia and French Polynesia have received substantial investment in hydrological investigations over the years by ORSTOM/IRD, but these two countries increasingly must look after their own needs, and hydrological effort appears to be weakening.

Bilateral arrangements have the advantage that they can be targeted precisely on a country's needs, and they have made a significant contribution to life in the Pacific countries. However, they can be inefficient, because most Pacific countries are too small to make full use of some particular forms of assistance. For instance, a training programme that could benefit eight people may have only two candidates in a given country. At the present time, there are at least three bilateral cooperation projects underway (in Cook Islands, Samoa, Vanuatu) that could very beneficially be extended to other countries which are facing similar issues. A common complaint in the island countries (and, indeed, throughout the world) is that assistance from different sources commonly is uncoordinated at country level and regionally, so that the potential benefits and efficiencies of a coordinated, strategic approach are not realized.

In line with the Pacific countries' cooperative approach to many matters, a regional approach to capacity building in the water sector has been developed to a degree. SOPAC and SPREP are the principal instruments at present; during the needs analysis, several interviewees mentioned the key role that SOPAC has played in building their capacity, particularly in

groundwater assessment and management, as related to water supply and sanitation. SOPAC's work often addresses specific needs, so that the full potential benefits may not be obtained at the regional level. In the past, of course, the UNDP/World Bank Water Supply and Sanitation Programme made a major contribution to human welfare in the region.

In addition to increasing the efficiency with which limited resources are used, a regional approach has several other advantages:

- Individuals from each country have more opportunities to interact with and learn from their peers in other island countries – a benefit repeatedly mentioned during this analysis.
- The people administering the project build up substantial and diverse local knowledge, which facilitates transfer of appropriate or even "home-grown" technology.
- It is possible progressively to build up an island capability for self-help (e.g. by training trainers), and therefore to reduce the need for inputs from outside.
- Personnel from the island countries build up networks of contacts from whom they can seek assistance, particularly where common technology has been adopted.
- Ongoing support is more likely than with a bilateral project, particularly one with a country or agency from outside the region.

3.4 Lessons learned

The consultations provided a rich source of lessons about potential weaknesses in the Project design. Perhaps the most important lessons to be learned are:

1. It is essential to generate "ownership" of the Project by the participating countries, and this requires their active participation. Without this, sustainability beyond the life-span of the Project is very unlikely.
2. Provision to the several audiences, in appropriate formats, of information about and from the Project, is essential to maximize immediate benefits, raise the profile of the Project, and achieve partner country acceptance.
3. The urgent issues relating to water resources in the partner countries are not simply the quantity of water *per se*, but the practical implications of variability in the resource, related to climatic and other influences.
4. Partner country people have many ideas about how they can most benefit from the Project, particularly in terms of public information and capacity building, and the Project manager should listen carefully to their views throughout the Project.
5. There is a strong preference for in-country, hands-on training that specifically relates to the job responsibilities of the trainees.
6. In technical organizations such as NHSs, few employees are female. The impediment appears commonly to be that girls tend not to study science subjects at school, so are unable to compete for technical jobs, even if they wished to do so. The females that were encountered during the consultation process were, however, invariably of high calibre. The Project has little scope for influencing appointments to NHSs, but can encourage the selection of female employees for training in Project-related duties.

Earlier experience with capacity building in the region's NHSs indicates that:

7. Pacific Island technical staff are well able to learn, use and retain the technical skills required by this Project, particularly in a supportive and enabling institutional environment.
8. There is a tendency for well-trained and capable technical people to move up in the organization, or move to other departments or the private sector, often because of a sense of frustration at lack of opportunity to use their skills, or because monetary rewards are better elsewhere.
9. Many institutional deficiencies (legislation, government mandate, lack of resources, inexperienced senior management, etc.) seriously limit the ability of partner countries themselves to obtain information on their environment and natural resources.
10. An effective and sustained national programme to obtain environmental and natural resource information seems to require the presence of a “champion” – a senior technical officer or professional staff member, perhaps – who will make the programme his/her own.
11. An effective programme is difficult to maintain without sustained government support and stable institutional arrangements.

The AusAID “lessons database” also contains a variety of lessons that have relevance to design of this Project.

12. Recipient counterpart organizations must be involved in project design and in management decisions if a project is to have any chance of being sustained after the project period. (lesson ID 8)
13. Education and training strategies also need to be consistent with the Education and Training Policy which identifies five areas as priorities for assistance - basic education, vocational and technical education, higher education, institutional strengthening and distance education. Cutting across these areas are the five underlying principles - access, equity, quality, relevance, and effective and efficient use of resources. (lesson ID 60)
14. The use of an external Project contractor can provide an opportunity to support and develop local contracting skills both technically and as regards management. Contractors should be seen as an additional development input into the project. (lesson ID 68)
15. Sustainability of infrastructure activities is a problem when responsibilities and 'ownership' for recurrent budgetary commitments are not clearly established prior to commencement of the project. One post-project evaluation noted that successful implementation depended on firm recipient government commitments as being critical to project sustainability. Further that more attention should be paid to this area in project design. (lesson ID 6)
16. The Pacific Regional Hydrographic Survey Project was implemented over a period of seven years without any significant consultations with the recipient governments concerned because it was funded through the multi-country programme. As a result of this lack of consultation, the project's emphasis on deep-water survey was completely at odds with the developmental priorities of the countries concerned. (lesson ID 58)
17. The Fiji Meteorological project demonstrated the value of international networking in the provision of development assistance. Through its linkages with, and use of international contacts, the value of the aid supplied has been enhanced. While a specialized field, it is an example for other projects. (lesson ID 68)
18. Out-of-country training is not necessarily the most appropriate form of training. Consideration should be given to other options including in-country training, distance mode studies, use of regional institutions. It is necessary to ensure that in-country training is adequately resourced, particularly where partner governments are required to

allocate budgetary funds. The CAISTC project was clearly sustainable since the delivery procedures used for the courses were flexible, adjusting training to needs and with a training team residing long-term at the site. (lesson ID 61)

4. PROBLEM RESPONSE: PROPOSAL FOR A PACIFIC-HYCOS

On the basis of the analysis of needs and lessons presented in section 3, a Project concept is proposed that takes the WMO's WHYCOS concept and reshapes it for Pacific Island circumstances. The project will involve a number of elements, in different combinations in each participating country, that together build national capacities to obtain and manage information about their water resources.

4.1 Principles and strategy

The proposed Project applies the WHYCOS concept to the distinctive circumstances in the Southwest Pacific region, taking particular account of the diverse needs for water-related information that have been identified. This diversity points to the advisability of adopting a modular, sub-project approach that can provide specific benefits that are targetted to each country. Several principles underlie the proposed strategy:

- The capabilities that already exist in the region should be recognized, and the assistance and support that already has been or is being provided should be capitalized on.
- As far as possible, a common, regional approach to common problems should be used.
- Technology that is appropriate to and sustainable under Pacific Island circumstances should be adopted, but also should extend existing capabilities.
- Benefits must be provided that are sufficiently tangible that post-Project sustainability is probable.
- Immediate and specific needs must be addressed, while provision is being made for medium and long term requirements.
- Implementation as far as possible should be by Pacific Island nationals, with guidance and support from contractors where necessary.

4.2 Intended Project beneficiaries and partners

The principal direct beneficiaries of the Project's outputs are envisaged to be officials of Pacific Island government agencies and NGOs, who have some responsibility for water resources planning and management, environmental monitoring and management, education, hazard mitigation, and/or national development. The ultimate beneficiaries, with whom the officials have direct contact, include elected representatives and leaders, and the general public.

The same group of officials also are potential partners in the Project. The Project could play a significant role in aiding participating countries and regional organizations to develop their abilities to acquire and use environmental data. To do this, national and/or regional partners should be involved to the fullest possible extent in Project implementation. This will entail careful focusing of the training carried out during the Project, particularly to build the capability of the NHSs in the area of providing water-related information. By encouraging the selection of female participants in Project implementation and associated training, the Project potentially could help to redress the present gender imbalance in technical and scientific areas in the partner countries.

In the context of international affairs, important partners and beneficiaries of the Project's data and information outputs are members of the scientific community, who are attempting to reduce our uncertainty regarding trends and variability in climate and water resources, and to provide policy makers with usable assessments and advice. Particularly significant in this group are "the modellers" – those who are developing and refining models of the atmosphere-ocean-land system, and of projecting conditions into the future. Models require data to set them up and verify their accuracy. Presently available models are not capable of accurately simulating or projecting climate and water resources variability and trend in the region, but rapid progress can be anticipated. Project data will provide a valuable source of data for model calibration and verification in the region, so that projections of water resources status can be provided to analysts.

An additional beneficiary is the biophysical environment. The Project should enable significant positive environmental outcomes, through reduced uncertainty in development of policy and response strategies in the area of global environmental change, more informed management of water resources in participating countries, and enhanced response to water-related hazards. The extent to which partner countries apply the Project's information products to water resources management and hazard mitigation is, however, beyond the scope of the Project.

The negative environmental impacts of the Project should be limited, since Project infrastructure, principally water level recorders, is small scale, and frequently will be installed at locations that already have been used for similar purposes. It will be essential to make provision for ultimate removal of all Project installations when their useful life has expired.

4.3 Location of Project activities

The Project will be implemented in the island countries of the Southwest Pacific, within the grouping of the Pacific Forum. Participating countries have not been finalized; this will be a task for the preliminary phase of the Project, through invitations to participate in establishment of the Regional Steering Committee.

Installation of Project hardware – monitoring and communications equipment, computer databases etc – will of course focus on participating countries, with support capabilities established at the Regional Centre. Hardware will be purchased from the most economical source, irrespective of geographical location. As far as possible, all other Project functions, such as training, will be carried out in the participating countries. Those functions that are the same for all countries, or are most economically done only once (e.g. maintenance of a regional database or a spares inventory), will be carried out at the Regional Centre.

Project tasks that involve research and development (R&D) could be implemented anywhere in the world, but might preferably be carried out within the countries of WMO RA V, including the University of the South Pacific, which is the regional university. Several R&D outputs, especially the development of software tools, are likely to require the capabilities of a large research institute, likely based in one of the metropolitan members of RA V.

4.4 Key assumptions

The Project design is based on a number of assumptions, in addition to those implicit in the preceding sub-sections:

1. The WMO Geostationary Meteorological Satellite and Global Telecommunication System continue to be accessible to the Project.
2. The Project's infrastructure suffers no accidental or deliberate loss or damage beyond that for which prudent provision has been made.
3. The Executing Agency is able to maintain awareness of events and changing circumstances that have an impact on the Project.
4. The Executing Agency will be able to establish effective working relations with the participating country governments, NHSs, and other stakeholders.
5. It will be possible to arrange payment of NHSs for disbursements and services that they provide under the Project.
6. NHS Directors will be willing to take responsibility for the Project's routine tasks, and will be able to make available the staff-time required.
7. Participating country governments and their departments/ministries will agree to their NHSs taking responsibility for the routine Project components.
8. NHS staff who are trained by the Project will be retained by their Service, or it will be possible to train replacements in time for them to take responsibility for Project tasks.

A risk analysis is presented in Section 6.6, based partly on the assumptions listed above.

5. PROJECT DESCRIPTION

5.1 Project goal

The overall goal is that the participating Pacific Island countries will:

- attain a common level of ability (capacity) to assess and monitor the status and trend of their water resources, and to provide the water-related information and hazard warnings needed to support national social and economic development and environmental management.
- have established databases and information archives, maintained to acceptable standards, that form the basis for sustained future data capture and information processing and dissemination.

5.2 Project purposes

The Project has three main purposes that contribute to achieving the above goal:

1. To assist the participating countries to establish the human and institutional capacity to assess the status and trend of national water resources and to provide adequate warnings of water-related hazards.
2. To establish basic hydrological monitoring and data capture systems, using technology that balances modernity, economy, robustness, and suitability for Pacific Island circumstances.
3. To establish hydrological databases and information systems that provide users with the information they require, to the standards (including accuracy, timeliness, usability, etc.) they need, and that provide a secure repository of information for the indefinite future.

5.3 Project components

The “standard” core of WHYCOS, acquisition of river flow and related information via satellite, does not wholly meet the needs of the Pacific countries, because of their diversity and distinctiveness. What is needed is a “portfolio” of components or sub-projects, some of which relate to some countries, some to others, but all of which in some way develop their capacity to operate and maintain a “HYdrological Cycle Observing System”.

The Project is seen as having six distinct “output delivery” components, (Figure 1, expressed also in the form of a logframe in Annex 2). There is a seventh component for Project management. The components are identified principally in terms of the distinct contributions that they make to the Project, and the capabilities required to implement them. In many respects, some of the components are somewhat independent of the others, except that they relate to the normal functions of a national hydrological service. They could therefore be implemented by separate contractors, within the context of an overall strategy for each country and for the region as a whole. An additional advantage of an approach based on sub-projects is that they can be implemented in stages, so that the capacity of the NHSs to absorb assistance, new technology, and new tasks is not overloaded.

For each component, the component objective is stated, some background explanation is provided. and indicative tasks are listed.

Component 1: Flood forecasting capability. *Objective:* To develop a methodology for flood forecasting and implement it in 15 selected critical catchments in the participating countries.

Explanation

Six countries (Cook Islands, Fiji, French Polynesia, New Caledonia, Papua New Guinea, Solomon Islands) have expressed a need for a flood forecasting capability in at least one river basin. In total, 15 river basins, requiring a total of 30 field observing stations and six base stations, is a realistic target for the sub-project. Once a flood forecasting capability is established in a given country, it can be replicated in other river basins by installing more observing stations, in a modular fashion. Each country could, if it required further coverage, obtain or make available the resources needed to acquire additional stations.

Many reliable flood forecasting systems already are operational in Australasia and Southeast Asia. Assessment of the specific circumstances in each candidate river basin will be required to evaluate the suitability of these systems, and select the one or two approaches that are most appropriate, for general application. The essential need will be for real-time transmission of data and input into a forecasting model, because rivers are so short that forecasting lead times cannot be more than 2-4 hours. This requirement seems to preclude the use of meteorological satellites for data transmission (because they either do not support random access or are too expensive), and points towards the use of radio telemetry.

Many of the stations installed for this sub-project would provide data that could be utilized for water resources assessment (see following sub-project).

Indicative tasks

1. Design a real-time data acquisition and transmission system for rainfall and river level data, that is appropriate for application to small Pacific Island catchments.
2. Identify national needs for flood forecasting, and select up to 15 catchments regionally.
3. Select up to 30 suitable field observing sites and design installations.
4. Procure and install the necessary field observing stations, data transmission equipment, and base stations.
5. Develop and implement forecasting models for each river basin application.
6. Train staff in the operation and maintenance of the system.
7. Establish arrangements for conveying forecasts to the civil defense authorities and the public.
8. Investigate complementary approaches to flood mitigation for application in each river basin.

Component 2: Water resources assessment in major rivers. *Objective:* That participating countries with significant surface water resources have in place a basic network of near-real time hydrological observing stations and the capability to securely archive incoming data.

Explanation

Five countries (New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Vanuatu) require improved information on the water resources in river basins considered to have hydropower potential. Those same countries, and others (Cook Islands, Fiji) whose surface water resources have potential for other uses, would benefit also from a programme for general assessment of water resources. This would provide the basis for estimating hydrological statistics in catchments for which no data are available, and would be the principal vehicle for capacity building in the hydrological service(s). These seven countries currently are monitoring some surface water resources, although instruments have only just been installed in Samoa, Cook Islands, and Vanuatu, and the monitoring programme is in poor health in Papua New Guinea and Solomon Islands.

This sub-project is equivalent to the basic concept of a WHYCOS regional component. It will provide near-real time data retrieval and archiving using electronic data collection platforms (DCPs) and meteorological satellites. It will complement existing activity, providing new stations or upgrading existing stations where additional data are needed or servicing costs are prohibitive at present. Specific locations have not yet been selected; this task will be an important one in the start-up phase of the Project. They should be on major watercourses, and be intended as long-term, benchmark or baseline stations that represent the hydrologic regime of significant parts of each country. A total of 25 stations is considered to be an appropriate number to allocate among the seven countries, allowing each to meet at least part of its basic needs for surface water resources assessment, and providing a vehicle for staff training.

Use of DCPs and satellite telemetry has some advantages over a “lower tech” approach:

- DCPs are able simultaneously to monitor up to 16 variables describing water quantity, water quality, weather conditions, and the status of the DCP itself.
- Data retrieval via satellite provides near-real time reporting on the status of the data collection station, minimizing missing record due to equipment failure, vandalism etc.

- Satellite data transmission reduces the frequency of field visits, the cost of which is a major hindrance in most countries.
- Automatic daily data retrieval enables the data to be subject to quality checks, and to be added virtually immediately to the archive, for immediate use.
- The sub-project provides a vehicle for building the capabilities of staff in modern hydrological practice, and does so efficiently by enabling training that is common to several countries.
- DCP and satellite technology is more reliable than conventional methods, and can draw on the support available through the WMO's World Weather Watch. (Data transmission is free for projects operating under the auspices of WMO).
- The sub-project can draw on the experience developed by the other regional HYCOS projects, and should strengthen links among meteorological and hydrological services, both nationally and regionally.

This sub-project "follows in the footsteps" of several regional components of WHYCOS, and can draw on the expertise that has been developed in their design, implementation and trouble-shooting. Their experience indicates the need for a regional centre or focal point, that oversees implementation, makes arrangements for joint activities such as training events, maintains a regional database (for back-up and training purposes), provides advice and assistance, and facilitates inter-communication among participants and stakeholders. The need for a regional centre in the water resources area has been mooted several times in the past, but has never come to fruition. Existing agencies, SOPAC and SPREP, to an extent carry out the necessary functions. In the Pacific context, a regional centre could also provide a focal point that would interact with the other regional bodies through which Pacific Island countries habitually work. (It might *be* one of those bodies). An initial step therefore will be to agree to and designate a Regional Centre, most likely at an existing institution that has significant resources. The need for a regional centre has been recognized in the project design for an AusAID-funded project to monitor sea level variations in the region. The similarity between the sea level project and the proposed Pacific-HYCOS Project suggests the advisability of collaboration in respect of arrangements for a regional centre.

Indicative tasks

1. Select locations at which to install DCPs, and carry out site-specific feasibility assessment and design.
2. Negotiate with WMO (i.e. Permanent Representatives in each country, World Weather Watch secretariat, satellite operator) on the arrangements for data transmission via the GMS satellite to national meteorological and/or hydrological services. (Note: all meteorological services consulted have supported the sub-project concept and see no operational difficulties)
3. Install sensors (Table 6), DCPs, solar power supply and battery backup, transmission equipment, and any necessary ancilliary installations (e.g. gauging cableway, weir, staff gauge).
4. Install base station facilities at national meteorological and/or hydrological services.
5. Establish communication networks (using the WMO's Global Telecommunication System and Internet) to transmit the data from the satellite receiving station to each service.
6. Develop and implement procedures for quality control of data capture system function, and for data transmission to national databases (see component 3).
7. Establish a regional communication network among all participating services, to provide email, file/document transfer, database access and electronic fora. (Note: Easy and prompt communication is essential, to facilitate trouble-shooting, exchange of

knowledge/experience, etc. Several services have email capability, but full Internet capability is uncommon. SOPAC has recently initiated the Hydro-PAC email forum. Tasks 5 and 7 are closely linked).

8. Train staff in maintenance, quality control, and operation of all system components listed above. A two-week training course (Table 7), supported by follow-up on-the-job training, assistance and advice, will be required.
9. Establish an inventory of spare parts, administered by the Regional Centre, and an ordering/control system.

TABLE 6. Data collected at DCPs

Variable	**Measurements per day***	**Comment**
Water level	1-6	Pressure sensor
Water conductivity	1-6	
Water temperature	1-6	
Dissolved oxygen	1-6	
Turbidity	1-6	
Rainfall	24	Tipping bucket sensor
Air temperature**	8	At “Synoptic hours”
Relative humidity**	8	At “Synoptic hours”
Wind speed**	8	At “Synoptic hours”
Wind direction	8	At “Synoptic hours”
Net radiation**	8	At “Synoptic hours”
Battery voltage	1	“Housekeeping variable”
Solar panel voltage	1	“Housekeeping variable”
Memory status	1	“Housekeeping variable”
Housing internal temperature	1	“Housekeeping variable”

* Measurement frequency can vary depending on local requirements

** Potential evapotranspiration can be calculated from these variables in combination

TABLE 7. Coverage of training course, water resources assessment component

Principles and purposes of water resources assessment
Installation, operation and maintenance of DCPs
Basic field hydrometric practice
Installation, operation and maintenance of base station facilities
Quality control of data and system function
Data input to archives
Effective use of electronic communications

Component 3: Water resources databases. *Objective:* That participating countries will have national hydrological databases that are secure and meet agreed data quality standards, and the capability to maintain them and generate information products that meet users’ needs.

Explanation

All but one of the countries consulted for the needs analysis expressed needs for substantial improvements in the area of database management. It is probable that the other four have similar needs. The areas in which improvements are sought include quality assurance,

computing hardware, exchange of data among databases operated by different agencies, database integration, the provision of new or much improved databases for groundwater and water quality data, long-term data security and avoiding the loss of existing data, and facilities for data retrieval/access, analysis, summary, and presentation. Several countries presently use or will soon be using Hydsys (Australia) or Tideda (New Zealand), while New Caledonia and French Polynesia use Hydrom and Pluviom (France, which is no longer supported). However, the needs are so widespread that a common, regional approach to database development appears to be justified.

A water resources database component meshes closely with the preceding water resources assessment component, and has been included in other regional WHYCOS projects. Some interest was expressed in a Pacific regional database, as a backup to national databases, and this option will need to be further investigated during the needs analysis and design phase. (Growing use of the Internet and file transfer protocols may enable a virtual regional database to be provided by linking national databases.)

Indicative tasks

1. Comprehensively analyze the needs of the participants, leading to design (or selection) of a data structure, database, database management system, and software that meet those needs. (Widespread adoption of Hydsys and Tideda indicates that these should in some way be accommodated).
2. Provide or upgrade computer hardware at each service, and install the database management system software thereon.
3. Establish a regional database at the regional centre, and develop protocols for data exchange with national databases. (The second step may provide a virtual regional database, avoiding the need to establish a separate database).
4. Develop and introduce procedures for quality assurance and archiving of incoming data (in conjunction with the water resources assessment component, but noting that many data streams will not be related to that component).
5. Migrate existing data onto the new national databases.
6. Develop procedures for basic analysis, summary and presentation of hydrological data and statistics, and prepare basic products such as water resources assessments for particular river basins.
7. Train staff in the use and maintenance of all components of the database management system and associated procedures. Training will be primarily on-the-job instruction in each service, with an introductory two weeks regional training course (Table 8), supported by follow-up on-the-job assistance and advice.

TABLE 8. Coverage of training course, water resources database component*

Data preparation, quality control, correction, and input
Data rescue techniques
Database management procedures
Data analysis – basic summaries
Data analysis – statistical parameters
Data analysis –analysis of trends and relationships
Data presentation
Development of hydrological products
Customer relations and marketing

* No distinction is made between different types of data – surface water, groundwater etc – because data management, analysis and presentation procedures are generally applicable.

Component 4: Drought forecasting. *Objective:* To develop and implement a common approach to drought forecasting in participating countries.

Explanation

Given the susceptibility of all countries in the region to periodic droughts apparently associated with ENSO, an ability to forecast drought would be of tremendous benefit in helping countries to make appropriate preparations for impending droughts. For instance, it would enable the introduction of water use restrictions in advance of drought onset, so that the need to import water by ship is reduced. There has already been considerable investigation of the effects of ENSO on drought incidence in the Pacific Islands, so that (while not neglecting the possibility of other causal mechanisms for drought) a good basis for the component already exists.

For drought forecasting, hydrometeorological observing stations do not need to provide real-time data, since the onset of drought is a rather slow process. Standard synoptic or climate stations, with at least daily reporting, can provide the necessary meteorological information, if they are located where the forecasts are required. On the other hand, hydrological stations tend to be visited infrequently (monthly or even quarterly), and this frequency is insufficient for drought forecasting purposes. Real time or near-real time data retrieval using radio (as for component 1) or satellite (as for component 2) is therefore desirable. The number of additional stations that will be required in each country should be small, since existing stations and other components should provide adequate coverage in most localities of interest.

Indicative tasks

1. Analyze meteorological and hydrological drought statistics, using available rainfall, river flow, groundwater level, and other available data, in relation to long-term variations in climatic indices (Southern Oscillation Index, Sea Surface Temperature, etc).
2. Analyze the impacts of recent droughts on water resources and water users, and develop appropriate approaches to mitigation and management of impacts that take account of climatic variability.
3. Develop a simple procedure to generate timely and accessible forecasts of monthly rainfall and streamflow, drought onset and severity, based on the results of the preceding steps and drawing, if appropriate, on existing models such as the Australian RAINMAN.
4. Install any additional observing stations that are required to provide data inputs into the forecasting procedure developed in the previous step.
5. Develop and introduce a consistent approach to and format for delivery of drought forecasts, and for interactions among meteorological services, disaster managers and water managers.
6. Train staff in relevant agencies and community organizations, in drought forecasting, response and mitigation.
7. Prepare public education and awareness programme materials on climate variability and droughts, in appropriate languages and formats.

Component 5: Groundwater monitoring and assessment. *Objective:* To establish in participating countries a basic capability in monitoring and assessment of groundwater resources.

Explanation

Ten countries specified this area as one in which information availability and technical capability need to be enhanced. There has been considerable assistance in the past, via

bilateral cooperation and, in particular, SOPAC projects, but no overall strategy has been used to ensure that national needs are comprehensively met. Knowledge of the extent and sustainable yield of the resource, particularly for rural water supply, is a major need, requiring reconnaissance/exploration techniques rather than monitoring over a period of time. Nevertheless, monitoring of trends, for instance to identify excessive abstraction rates, is desirable in many places, but extremely uncommon. Aquifer quality and contamination are of increasing concern.

For trend monitoring, a total of 30 monitoring stations is a realistic target for the project, although far short of what probably is required. Once a groundwater monitoring capability is established in a given country, it can be replicated in other locations by installing additional monitoring stations, in a modular fashion. Each country could, if it required further coverage, obtain or make available the resources needed to establish additional stations.

Indicative tasks

1. Identify national needs for continuous monitoring of groundwater level and quality (especially salinity), selecting up to 30 locations regionally.
2. Procure and install instrumentation (water level and salinity sensor, datalogger, power supply).
3. Provide a groundwater data module in the national water resources database system (as part of the Water Resources Database component; all steps listed therein will be followed. Note that for some countries a Groundwater Database is all that is required. The Groundwater Database will be designed for continuous monitoring data, periodic observations, reconnaissance/exploration data).
4. Develop and implement procedures for quality control of incoming data, and developing procedures for data input into national Databases (see component 3).
5. Train staff in groundwater assessment and monitoring. Training courses for non-technical staff and technical staff (Table 9) will be required, with follow-up on-the-job training, advice and assistance for technical staff. (Note that training carried out under component 3 will cover groundwater data).

TABLE 9. Coverage of advanced training course for technical staff, groundwater resources assessment component*

Principles of geohydrology
Aquifer properties
Well drilling and management
Flow in and from aquifers
Groundwater exploration techniques
Rapid (reconnaissance) groundwater exploration techniques
Groundwater contamination
Effects of human activity on groundwater bodies
Groundwater modelling
Groundwater management: case studies

* Training related to data processing and analysis (Table 8) is also relevant to this component. This course is envisaged as a two-week course. A cut-down version of 3 days would be required for non-technical staff who require a non-detailed knowledge of groundwater.

Component 6: Water quality monitoring and assessment. *Objective:* To establish in participating countries a basic capability in monitoring and assessment of water quality and chemistry.

Explanation

Eleven countries indicated that water quality degradation, particularly in groundwater aquifers, is a major concern, and an area in which information availability and technical capability need to be enhanced. Baseline information, impact assessment, and trend monitoring are all required. Network design is a critical element of the component, to ensure that the precise needs of each country are economically met.

Indicative tasks

1. Specify national needs for assessment and monitoring of water quality.
2. Design appropriate national sampling networks (locations, frequencies, determinands).
3. Procure sampling equipment, and arrange for laboratory analyses.
4. Develop a water quality data module for inclusion in the national Databases (as part of the Water Resources Database component; all steps listed in that component will be followed.).
5. Develop and implement procedures for quality control of incoming data, and develop procedures for data input into national Databases (see component 3).
6. Train staff in water quality/chemistry assessment and monitoring. A training course for technical staff (Table 10) will be required, with follow-up on-the-job training, advice and assistance. (Note that training carried out under component 3 will cover water quality/chemistry data).

TABLE 10. Coverage of training course for technical staff, water quality assessment component*.

Principles of water chemistry and water quality management
Sampling network design
Management of a sampling programme
Field collection of samples
Field observations
Laboratory practice and observations
Quality control of procedures and data
Data input procedures

* Training related to data processing and analysis (Table 8) is also relevant to this component.

Component 7: Project management. *Objective*: To have Project management systems in place and implemented that (1) ensure that contracted outputs are delivered on time, to standard, and within budget; (2) enable the Project to respond promptly to changing requirements; (3) facilitate the participation of stakeholders in Project affairs; (4) provide timely and accurate reporting.

Explanation

All aspects of contract management and administration will be carried out to WMO and donor standards. The most important specific results are deemed to be that Project resources are applied effectively and economically; participants in the Project are well-informed and well coordinated; donors and (where appropriate) other stakeholders are promptly and fully informed

of Project progress, use of inputs, and production of outputs; exceptions are reported to donors in a timely manner; and alternative strategies are devised where necessary to cater for changing circumstances. In summary, the strategic plan detailed in the Project Design Document will be implemented and milestones achieved.

Indicative tasks

1. Administrative, contract management, and financial management/control procedures and information systems will be established and maintained that meet donor requirements.
2. Capital expenditure on necessary instruments and equipment will be carried out in a timely and economical manner.
3. The Project will be implemented and milestones achieved, with exceptions reported to donors in a timely manner, and alternative strategies devised where necessary to cater for changing circumstances.
4. An annual plan will be supplied to donors by 31 October of the preceding financial year, that incorporates the views and requests of stakeholders, comprehensively describes intended Project outputs and relevant milestones for the year, and presents a timeline of work and budget.
5. Quarterly (within one week of the end of the quarter), Annual (by 31 January of the following financial year), and draft Project Completion (by 30 September of year 5) Reports will be provided to donors and the Project Steering Committee, and made available to other stakeholders via Internet and other appropriate means.
6. The Project Steering Committee will be fully informed of and have satisfactory input into Project affairs, and the results of its meetings will be accurately recorded.

6. IMPLEMENTATION

6.1 Organization and management

Component 7 of the logframe lists indicative tasks/results required to ensure that the Project is managed well. The six “results delivery” components make up a seemingly complex Project, but there are many interlinkages and complementarities, and normal project management practice will be quite sufficient to manage them. Several approaches to Project management are possible that would achieve the component results outlined in section 5.3. It is therefore unwise to prescribe, or even describe, appropriate project management and contractual arrangements. They will depend on the tenders that are received by WMO, and subsequent contractual negotiations.

It is expected that an Executing Agency will be appointed by WMO to take responsibility for Project management (component 7). The Executing Agency should designate a Project Director to be responsible for ensuring that the Project objectives and outputs are achieved, and for all communication with WMO and Project stakeholders. Project management will be guided by an annual Project plan, against which the Executing Agency will report to WMO and the Project Steering Committee quarterly and annually.

The wide range of capabilities needed for the Project is likely to demand several providers, working under sub-contracting arrangements. Subject to successful capacity building, Project activities progressively will be transferred to participating countries, principally their National Hydrological Services (NHSs). At the same time, a regional technical support capability for instrumentation, data transmission, and database management will be established at a

Regional Centre, likely based at an existing regional organization. Given the participating countries' preference for in-country, hands-on training, Project staff will need to spend considerable time (around 2 weeks per year) in each country.

Project implementation and institutional arrangements must achieve strong national and regional co-ordination and open lines of communication among participating NHSs, the Executing Agency, and other stakeholders at national and regional level. If the anticipated program of strengthening of the region's NMSs proceeds, particular attention will need to be paid to WMO, SPREP, and donors supporting this initiative.

6.2 Responsibilities of implementers

The responsibilities of participants in the Project are outlined in the following sections. WMO, as the instigator of this Project proposal and the Supervising Agency, will – in cooperation with the South Pacific Forum – appoint an Executing Agency to implement the Project.

6.2.1 Supervising Agency

The WMO will, as Supervising Agency, supervise and facilitate Project implementation by the Executing Agency and provide, as necessary, technical and scientific backstopping (Table 11). WMO will ensure that the Project takes maximum benefit from lessons learned in implementing previous HYCOS projects, and is implemented in concert with the global WHYCOS concept, ensuring its linkage with other ongoing and planned regional HYCOS components.

Table 11. Responsibilities of the Supervising Agency

• Take a lead role in seeking Project funding
• Supervise and facilitate Project implementation
• Support the Executing Agency
• Evaluate tenders for equipment
• Link with the meteorological community (NMSs and EUMETSAT) to facilitate the use of GMS satellite and exchange of data through the GTS and Internet
• Monitor, supervise and support the Project, through regular missions and participation in the Project Steering Committee meetings.

6.2.2 Executing Agency

The *Executing Agency* will be responsible for implementation, management and administrative/financial control of the Project (Table 12). In the Pacific, with its strong commitment to regional bodies, the possibility should be considered that a regional (Forum) body could carry out the tasks of the Executing Agency. The essential characteristics of the Executing Agency are demonstrated project management capabilities, and wide acceptability to Project participating countries, donors and stakeholders.

Table 12. Responsibilities of the Executing Agency

• Obtain, coordinate and administer Project funding
• Prepare a draft Project implementation plan
• Coordinate the Project with other water-related projects in the region
• Manage the tender process for the provision of services and procurement of equipment under the individual sub-projects, in consultation with the Supervising Agency
• Manage contracts for the providers of services
• Manage procurement of materials and equipment
• Provide administrative control of the Project
• Monitor and report to all stakeholders on Project progress
• Monitor and report to funding agencies on Project financial matters

6.2.3 Regional organizations

The Pacific region countries are strongly committed to a regional approach to technical and development assistance, and several regional organizations have been established. It is appropriate that this Project proposal reflect this commitment. The Nadi *Meeting of experts on the hydrological needs of small islands* requested that WMO consult with the South Pacific Forum secretariat in the development of a proposal, and the subsequent *ENSO impacts on water resources in the Pacific* workshop expressed the desire for WMO, SOPAC and other regional agencies to collaborate in the area of water resources. Collaboration between the WMO, as the instigator of this project proposal, and regional bodies is regarded as essential. WMO has the experience with the WHYCOS programme to draw on, a sub-regional office in Apia, and the worldwide network of meteorological services – and the data transmission infrastructure – to provide essential support and facilities. Regional bodies within the Forum "family" have local knowledge and experience, including a substantial track record in the water sector, and a regional network of contact with the countries themselves, external support agencies, and potential participants (contractors, suppliers) in the project.

For this regional Project, there are three essential regional components:

1. the participating countries
2. a Regional Steering Committee
3. a Regional Centre

6.2.4 Participating countries

The *participating countries* will have a number of responsibilities for Project implementation (Table 13). To assure Project success and to help assure post-Project sustainability, it will be essential to have the agreement of participating countries to act on these responsibilities, in the form of a Memorandum of Understanding (MoU). The likelihood of Project success will be increased if funds can be provided to participating country NHSs to cover their Project-related costs; administration should be the responsibility of the Executing Agency.

Table 13. Responsibilities of the participating countries

• Provide support to missions by staff from the Regional Centre and contractors
• Provide appropriately qualified staff to participate in Project activities, as required
• Manage any impediments to successful Project implementation (e.g. land access)
• Carry out installation and other work required to establish the sub-projects, with the assistance where needed of the Regional Centre and contractors
• Perform ongoing, routine activities related to operational water resources assessment and monitoring, and to the operation and maintenance of Project installations
• Disseminate data and information to users, and to the Regional Centre
• Provide information about the Project to national interests and the public

6.2.5 Regional Steering Committee

The role of the Regional Steering Committee will be to ensure project coherence and to oversee project policy, strategy, and implementation (Table 14). The Committee should consist of a representative from each participating country and external support agency, and should be serviced by the Regional Centre. To ensure that the Committee is fully effective, it will be desirable to obtain the commitment of the participating countries (through the MoU) to make available representatives who are able to make the necessary time available.

Table 14. Responsibilities of the Regional Steering Committee

• Determine Project policies and strategies
• Manage conflicts or disagreements among participating countries and organizations
• Select the location of the Regional Centre
• Revise and approve the Project implementation plan
• Oversee and monitor Project implementation
• Assess Project progress and success
• Provide a communication channel with regional bodies and other interests

6.2.6 Regional Centre

The Regional Centre in general will act as a focal point to co-ordinate the Project activities implemented in and by the participating countries, foster regional co-operation in the fields of water resources assessment, monitoring and management, and provide a forum for exchange of expertise. Table 15 summarises responsibilities, and Annex 1 provides a fuller statement, as well as criteria for selection of the Regional Centre. There are obvious complemenarities between the Executing Agency and the Regional Centre, and it may be that the Executing Agency could host the Regional Centre.

Following on from the experience in other regional HYCOS's, it is envisaged that a Regional Centre for the Pacific would be located at an existing institution. It would comprise 3-5 staff, who would come from the parent institution and from other participating countries. Core Project staff at the Regional Centre, would likely include a Project Manager, a database expert, a field hydrologist, a computer expert (part-time), and a secretary. The Project budget will include the remuneration of the Project staff, according to the Pacific Forum salary scale.

Following the successful practice in other regional HYCOSs, proposals to host the Regional Centre would be invited, and the choice would be made by the Regional Steering Committee.

Table 15. Summary responsibilities of the Regional Centre

• Act as a focal point to co-ordinate the project activities implemented in and by the participating countries
• Provide all services (training, ongoing assistance and advice etc) that are not provided under other contracts
• foster regional technical and scientific co-operation in the fields of water resources assessment, monitoring and management
• provide a forum for exchange of expertise and knowledge
• Monitor DCPs and forward data to NMSs that do not have direct access to satellite data
• Manage a regional database and associated functions (data dissemination etc)

6.2.7 Institutional change

A significant thrust of the Project is to enable NHSs to provide a number of new activities and outputs, with regional and broader WMO support. At present, few are able to do so, principally because of a lack of resources and qualified staff, and an unsupportive institutional environment. It is expected that many of the institutional issues will be dealt with during the Project, both by the Project itself and by institutional strengthening that is being carried out on an extensive scale in the region, through AusAID, NZODA, ADB and other interventions.

6.3 Project duration and phasing of activities

The six proposed technical components vary in their relevance to the several countries. Component 3, water resources databases, is perhaps the most general. It would be desirable to implement components in such a way as to:

(a) involve all participating countries as early as possible, to build and maintain interest and distribute benefits widely, and
(b) distribute the workload over as long a period as possible, so that participating countries are not overwhelmed.

The sequence of the components proposed in the implementation schedule (Annex 4) reflects:

(a) the general relevance of component 3
(b) the scale of component 2, and the time that will be required to implement it
(c) the immediacy of need (in terms of reducing threats to human life and property) of component 1

Components 4, 5, and 6 implicitly are assigned a lower priority than 1, 2, and 3, but participating countries may wish to amend this. They may also wish to alter the order in which 4, 5, and 6 are implemented. It will be necessary to obtain the agreement of the participating countries to the implementation schedule - revised as required - as soon as possible during the preliminary phase of the project.

A number of the participating country NHSs are starting from a rather weak baseline, and/or have limited capacity to absorb assistance. It is therefore considered that the Project should be implemented over an extended period – 4 or 5 years – at low intensity. Project duration will, of course, need to be negotiated with donors, who commonly prefer shorter Project durations. With results of a Mid-Term Review being used if necessary to retarget the Project, a 4-5 year duration is not unrealistic, however. An indicative schedule of implementation for the Project components is presented in Annex 4, but details of implementation will inevitably be determined as the annual Project plans are prepared and the participating countries define their needs and capacities to take on Project components.

A number of specific tasks will be necessary during the Project, that are not specified in the logframe but need highlighting. They are presented here in very abbreviated form. The Executing Agency must have the competence in project management to develop, under the oversight of the Supervising Agency and Regional Steering Committee, an appropriate and comprehensive Project implementation plan. However, a number of regional HYCOS Project Documents have now been prepared, and these provide a substantial amount of guidance with respect to the various activities that are likely to be required in the Pacific region (WMO 1996, 1997, 1999).

6.3.1 Preliminary phase

Several tasks must be completed before the project can proceed (responsibility in parentheses):

- Revise and obtain the agreement of participating countries to the project proposal (WMO)
- Appoint members of the Regional Steering Committee (participating countries)
- Agree on and appoint an Executing Agency (Regional Steering Committee, WMO)
- Seek and obtain commitments to funding from external support agencies (WMO and Executing Agency, assisted by Regional Steering Committee)
- Invite proposals for and select a Regional Centre (Regional Steering Committee assisted by the Supervising Agency)
- Arrange staffing of and establish the Regional Centre (host country, other participating countries, and Regional Steering Committee)
- Obtain agreement of participating countries to exchange of data and information obtained under the Project's auspices (Regional Steering Committee)
- Develop terms of reference for Project Mid-Term Review (Executing Agency)

6.3.2 Project start-up

During this phase, the Executing Agency and the Regional Centre will take on the major role in commencing implementation of components as laid out in the logframe, under the oversight of the Supervising Agency and the Regional Steering Committee. It should be noted that, because it is proposed that the components be implemented in a staged fashion, start-up of particular components will occur over an extended period. "Background" tasks include also:

- Formulate a detailed Project implementation plan, budget and schedule (Executing Agency)

- Define project management and reporting procedures, including performance indicators (Executing Agency)
- Develop proposed terms of reference/contracts for services (Executing Agency)
- Carry out negotiations with WMO Permanent representatives and satellite operators on access to satellite transmission facilities and the GTS (WMO)
- Carry out negotiations with information users, especially in the flood forecasting and drought forecasting sub-project areas, regarding mechanisms for information transfer (Regional Centre, participating countries)

6.3.3 Project implementation

This phase will see the provision of services by the contracted providers, to implement the details of the Project components as laid out in the logframe. The specific steps and their order will depend very much on the final form of the Project implementation plan and schedule, and on the contracts that are let. It is anticipated that the sub-projects will be implemented in a staged manner, to avoid overloading national implementing agencies, the NHSs.

6.3.4 Project stabilization

During this phase of the Project, the basic groundwork will have been completed, in that equipment and computer systems will have been installed and staff training will be well advanced. The main activities would be:

- Trouble-shooting, advice and assistance
- Provide ongoing training, as required
- Progressively transfer full operational responsibility to national services

6.4 Input requirements

The resources required for the Project have been estimated using a set of interlinked spreadsheets (Annex 5) that present cost assumptions (estimated unit costs of the inputs), resource requirements (estimated requirements of each type of input), and cost computations (the product of resource requirements and cost assumptions). Values are presented in Australian dollars. The gross estimated costs are:

Personnel	784,140
Procurement	993,000
Training	122,500
Travel	237,750
Other	60,600
TOTAL A$	2,197,990

Year 1	273,440
Year 2	1,097,470
Year 3	447,680
Year 4	270,800
Year 5	108,600
TOTAL A$	2,197,990

No allowance has been made for the Regional Centre *per se*; it is assumed that the cost of the work of the Regional Centre will be covered by the budget defined for the individual components, including in particular component 7. The input for a particular item might, therefore, be provided in part by a staff member of the Regional Centre and in part by an external consultant. Personnel costs, which are the largest of the major groupings, assume a multiplier of 2.1 to cover administrative and other support. Training appears to be a small component, but it is expected that a great deal of training will be carried out during missions to each country, so that in practice a significant proportion of personnel costs might be better ascribed to training.

A large part of the expenditure is incurred during the first three years of the Project, as hardware is installed. However, the Project is budgetted to extend out for five years, to address the expressed preference of Pacific Island people for an approach to capacity building that allows continued, low intensity inputs to ensure reinforcement and absorption of new skills and technologies.

Project management (component 7) appears to be an unduly large proportion of the total budget. As noted above, it is anticipated that a significant part of project management will be provided by the Regional Centre. It is also expected that project management activities will add value to the Project (e.g. through consultation with and advice to NHS Directors and other officials in each country), rather than being merely an administrative chore. The Project Steering Committee will have an important role to play in ensuring that all Project inputs do indeed add value to the participating countries' activities.

6.5 Project monitoring and assessment

The Project will be monitored principally by the Executing Agency, drawing on monthly reports provided by the Regional Centre and sub-contractors. Annual reports will be prepared by the Executing Agency, for transmittal to the Regional Steering Committee (which includes representation from funding agencies). All reports (monthly and annual) will cover technical, financial, and administrative matters, using performance indicators to be developed during the preliminary phase.

Project progress and success will be evaluated by the Regional Steering Committee, during annual meetings. A mid-term review and completion review should be carried out by an independent expert, on the basis of visits to the Regional Centre and a selection of participating countries. Terms of reference will be developed by the Executing Agency during the preliminary phase.

6.6 Project reporting and monitoring

6.6.1 Performance indicators

The Project logframe (Annex 2) includes a comprehensive list of verifiable indicators of achievement, and the associated means of verification. As far as possible, acceptable levels of the indicators will need to be quantified, so that achievement can be compared against predefined standards. Some indicators (e.g. the acceptability of a QA programme) will require judgement by WMO, donors and the Regional Steering Committee. Normally, achievement of results will be verified by reports to the Regional Steering Committee or files maintained for QA purposes by output providers. In some cases, a less formal approach to verification will be necessary, via interviews with NHS Directors or stakeholders.

6.6.2 Reporting

The Executing Agency will be required to report quarterly to the Regional Steering Committee on progress with all component objectives/results of the Project (result 7.5)[1]. This reporting also should include particular reference to exceptions (i.e. failures to achieve planned results), changing circumstances that present threats or risks to the Project, and measures taken or proposed in response. The quarterly reports should be suitable for distribution to partners and key stakeholders, and therefore should be of more than simply administrative interest. Confidential material can be supplied separately to WMO as Supervising Agency. The Executing Agency should maintain a distribution list for hard-copy reports, as well as maintain quarterly reports on an up-to-date web-site. The Executing Agency also should assemble information products disseminated under Project auspices, and provide copies to WMO and the Regional Steering Committee quarterly.

The Executing Agency will report annually to WMO and the Regional Steering Committee against achievement of the strategic plan and annual plan for that year. Its representatives should visit partner countries annually, in order to carry out site inspections, speak to NHS Directors and staff, and report accordingly. Again, annual reports should be suitable for distribution to partners and key stakeholders, and be maintained on a Project web-site.

Technical reporting will be within the context of the QA processes established for the regional archive, NHS national databases, and NHS instrument maintenance programmes. It is not considered necessary to provide the Regional database records and Monthly Data Reports to WMO and the Project Steering Committee, but they should be available for inspection if required.

6.6.3 Monitoring

The Executing Agency will be contractually responsible for all monitoring and reporting to WMO. The Project Steering Committee will have a significant role in Project monitoring, using the Executing Agency's regular reports and its members' own networks of contacts with stakeholders. Its monitoring and advisory role will be discharged formally through the minutes of its meetings, but it is hoped that Committee members will be willing to provide a more ongoing overview of the Project. It is important that members of the Committee are selected for their interest and likely active participation in the Project and their contacts with stakeholders.

A Mid-Term Review should be carried out, with the review team reporting directly to WMO and the Project Steering Committee.

6.7 Risk assessment

6.7.1 Key assumptions and risks

Key assumptions were presented in Section 4.4, with additional assumptions indicated in the Project logframe (Annex 2). The risks of events or circumstances that are outside the ability of the Executing Agency to control are outlined in the risk management matrix (Annex 3).

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[1] All component objectives and results should be addresses in the quarterly reports and Project completion report, even though these are not specifically mentioned as a means of verification in the logframe.

6.7.2 Feasibility of managing risks

The technical and financial risks (Annex 3) are generally ranked as of low to medium importance, and there should be no difficulty in managing them.

Most high to extreme risks relate to the feasibility of building capacity and ownership in NMSs, to the point that they are able and willing to assume responsibility for Project activities by the end of the Project. The present capabilities of NHSs are variable, and it may not be possible to build sufficient capacity in *all* of them, by the end of the Project. The capacity building purposes of this (or any other) development project are inherently risky, and past experience in similar efforts often has been discouraging. On the other hand, this *is* a development project, and the capabilities to be provided consistently have been requested by the partner countries during consultations. The lessons learned in this and other projects provide a basis for successfully managing the risk (section 3.4).

The key issues arising from the risks related to NHS capacity are that:

1. the Project's principal technical results may not be achieved, and the Project accordingly would be judged a failure;
2. there is no point investing in capacity building if there is a high probability that the new capacity will not be used or sustained.

Consultations indicate that NHSs are keen to participate effectively in the Project, and to become recognized – and well supported – national providers of water-related information. National demand for such information can be expected to increase, so that the NHSs should have a growing market for their products and services. They recognize the opportunity to enhance their service to their communities, and as a result the level of recognition and support that they receive. A number of donors presently are focussing effort on public sector institutional strengthening in the Pacific Island countries. This should provide an enhanced institutional environment in which NHSs will be able to maintain a capability in and commitment to generating and disseminating water-related information.

The most feasible approach to these issues is for the Executing Agency to:

3. demonstrate to participating country governments, NHSs and other stakeholders the benefits of the Project (which is best done as early as possible);
4. maintain very effective relationships and communication channels with the Project Steering Committee, participating country governments, and stakeholders, especially those involved in public sector institutional strengthening;
5. Update the analysis of NHS needs annually, as a basis for including capacity building in the annual plans;
6. incorporate into the annual plans a regularly updated risk management strategy;
7. carefully monitor during years 1 to 4 the progress of each NHS in establishing and sustaining the desired capabilities, and identify any under-achievement;
8. target capacity building at the areas and participating countries where there is greatest need.

Poor working relations and communication could compromise the success of the Project. The Executing Agency must pay particular attention to the quality of its working relations and communication with others involved in the Project as contractors, collaborators or stakeholders.

6.8 Impact assessment

6.8.1 Poverty and sustainable development

The Project's goal focuses on the provision of information about the physical environment of the participating countries, and does not directly address poverty alleviation and sustainable development. Therefore, it is not possible to quantify the Project's contribution to national economies. However, by enabling partner countries to make more informed decisions regarding the management of their freshwater resources, the Project should enhance their ability to address poverty and development issues. Information on variability in water resources, together with the tools that are to be developed for mitigating the effects of natural hazards, should enable the risks to be reduced in a number of human activities – agriculture, occupation of floodplains, construction of transport systems, etc. It therefore should reduce economic losses, and increase national wealth above that which otherwise would be enjoyed.

6.8.2 Environment

As noted in the preceding section, the Project's information outputs should enable partner countries to make more informed environmental management decisions, so that the Project should have positive – although indirect – environmental effects. Project activities in general have minimal environmental impacts. The principal impact relates to construction of the Project's observing stations, but many of these will be at existing monitoring sites, where the environmental impacts of human activity already have occurred. Environmental impacts can and should be eliminated by removing the stations when they are no longer required, but it is expected that they will be handed over to participating countries for indefinite continued operation.

6.8.3 Social and cultural impact; gender implications

The Project will have limited *direct* social and cultural effects, principally through its influence on the thinking and work methods of the national staff who are involved in it. In conjunction with other public sector institutional strengthening, the Project should introduce more structured work methods in this area of government, and should promote an approach to decision making and environmental (including hazard) management that is more reliant on verifiable information.

The Project should have substantial *indirect* impacts, as it provides improved information to decision-makers. For example, through shedding light on the real risk of drought in a given country, it should influence thinking regarding the viability of that nation's agricultural industry and assist decisions on the need for government assistance to rural communities to adopt new crops or more drought-resistant varieties. However, the impacts of the Project will depend on how decision makers choose to use its information products.

The Project has only limited ability to influence gender issues in the Pacific. The principal means would be through providing enhanced opportunity for training of female staff in NHSs, and NHS Directors should be encouraged by the Executing Agency and Regional Steering Committee to select females for Project-related activities and training. Database management and quality assurance tasks seem to be well suited to the aptitudes of many female technical staff employed in Pacific Island organizations. However, female staff are few in numbers, apparently because female school students rarely choose to study science subjects, and so are not well qualified to apply for technical positions.

6.9 Sustainability

Experience in the Pacific Island countries indicates that it is impossible to assure the long-term sustainability of a development project. In the water resources sector, many projects have been implemented but have had little or no lasting effect. A range of reasons can be identified, including the frequent loss of key staff, the higher priority placed by governments on other areas of expenditure, government restructuring, inadequate provision for ongoing operation and maintenance, and so forth. The risk assessment (section 6.6) attempts to identify and address these reasons for lack of sustainability. Several NHSs are likely to benefit from current public sector institutional strengthening initiatives, and the Project will need itself to complement these.

Fundamentally, projects are more likely to be maintained if they clearly meet a need of which the government is (preferably, acutely) aware, and the benefits of post-project expenditure clearly exceed the costs and the benefits of other possible expenditures. The needs analysis has been used to design a project that targets clearly identifiable needs, and needs that have significant financial implications. A benefit-cost analysis has not been carried out because the data simply are not available, but numerous such analyses of hydrological information indicate benefit-cost ratios commonly in the order of 6:1 or better. Such figures carry little weight with decision makers in developing countries, however, who are much more concerned about immediate social and economic problems that are so obvious that benefit:cost ratios are not needed to demonstrate them.

Several similar or related projects recently have been initiated in the region. This indicates that governments are increasingly aware of the importance of water-related issues, particularly in the context of contamination of water resources and the impacts of extreme events. It also suggests that an integrative project like this one has a place, by bringing greater efficiency through adopting a regional rather than national approach.

A key thrust of the Project is to maximize participation and technical capacity in the participating country NMSs and supporting regional organizations, so that they are willing and able to continue water data collection and archiving after Project funding terminates. Without this, data collection is likely to cease in most partner countries at the end of the Project, and the available data series will still be too short for hydrological analysis. The likelihood of post-project sustainability varies from high in Fiji to low in the poorest of the island countries. Realistically, some of the island countries have no chance of being self-supporting in any respect, and a project such as this one will require ongoing international assistance. Implicitly, that is perhaps why the Pacific Island countries have recognized the value of regional bodies, to provide support for independent countries that cannot really stand alone economically. The Project is conceived and designed to maximize the likelihood of sustainability in all participating countries, but it cannot realistically be guaranteed. Some countries will be able to stand alone; others will require ongoing assistance. The regional bodies will have a crucial role to play, in either case.

To assure sustainability beyond the end of the Project, the equipment (including observing stations, analytical procedures, and computer systems) must be handed over to partner countries as a “going concern”. It is important that the technology that is selected is appropriate to Pacific Island circumstances, including the likely skills of NHS staff during the design life of the equipment.

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ANNEX 1

DRAFT TERMS OF REFERENCE FOR THE REGIONAL CENTRE

The Regional Centre for Pacific-HYCOS in general shall act as a focal point to co-ordinate the project activities implemented in and by the participating countries, foster regional technical and scientific co-operation in the fields of water resources assessment, monitoring and management, and provide a forum for exchange of expertise.
In particular it will:

1. Assist participating countries to prepare the final list of stations to be included in the Pacific-HYCOS sub-project networks;
2. Prepare a draft implementation plan for Pacific-HYCOS ;
   (The list of the stations and the implementation plan shall be prepared in close co-operation with the national bodies responsible for hydrological networks. The Regional Steering Committee shall approve the final list and the implementation plan before Project implementation starts)
3. Make, in co-operation with WMO, the necessary arrangements for the inclusion of Pacific-HYCOS DCPs in the WMO World Weather Watch/GTS system;
4. Organize, in co-operation with the suppliers of the hardware and software for each sub-project, training courses on installation, operation, and maintenance;
5. Support participating countries in the installation, operation, and maintenance of hardware and software;
6. Maintain daily monitoring of the DCP functioning and notify NHSs of any problems;
7. Develop and implement regional databases for the data (raw and validated) collected through the Pacific-HYCOS networks. NHSs shall validate raw data and enter them in the regional database according to procedures and timing to be agreed upon by the participating countries;
8. Distribute, in (near) real-time time, the raw data received from DCPs to participating countries without direct access to satellite data (through DRS, GTS or Internet)
9. Co-ordinate the development and implementation of a regional system for disseminating data and information (through GTS, Internet, etc) between the participating NHSs;
10. Organize, in agreement with participating countries, the dissemination at international level of data and information originating from the Pacific-HYCOS networks;
11. Develop and implement, in agreement with countries and WMO, a training programme on subjects relevant to Pacific-HYCOS implementation, such as:
    - Use of Internet and World Wide Web
    - Data quality and consistency checking
    - Data processing (primary and secondary)
    - Preparation of products of national and regional interest

Criteria for the evaluation of the candidatures submitted by the countries to host the PRC:

Premises

Offices for project staff;
Room for data reception and archiving;
Meeting room;
Training room equipped with PCs, printers, etc;
Storehouse.

Support services
Direct telephone/fax line for the project;
Internet access (e-mail, ftp, and WWW);
Availability of peripherals (plotter, digitizer, streamer, etc).
Specialized services
Access to real-time satellite data;
Access to other non-hydrological databases (meteorological, climatological, environmental, socio-economical, etc.);
Personnel experienced in the field of telecommunication networks and databases management;
Institutional framework
Institutional and administrative arrangements proposed (running cost, secondment of personnel, etc),
Official commitment to host the Centre.

ANNEX 2

PROJECT LOGFRAME

Narrative Summary	Verifiable Indicator	Means of Verification	Assumptions about external conditions
Goal That participating Pacific island countries will (1) attain a common level of ability (capacity) to assess and monitor the status and trend of their water resources, and to provide the water-related information and hazard warnings needed to support national social and economic development and environmental management; and (2) have established databases and information archives, maintained to acceptable standards, that form the basis for sustained future data capture and information processing and dissemination..	No. of partner countries that have operational Water Resources databases, effective mechanisms for generating and distributing information related to water resources status and trend and water-related hazards, and staff able to implement them.	Mid-term Review and Project Completion Report.	
Purpose 1. To assist the participating countries to establish the human and institutional capacity to assess the status and trend of national water resources and to provide adequate warnings of water-related hazards. 2. To establish basic hydrological monitoring and data capture systems, using technology that balances modernity, economy, robustness, and suitability for			

	Pacific Island circumstances. 3. To establish Water Resources databases and information systems that provide users with the information they require, to the standards (including accuracy, timeliness, usability, etc.) they need, and that provide a secure repository of information for the indefinite future.			
1.	Component Objective To develop a methodology for flood forecasting and implement it in 15 selected critical catchments in the participating countries.	Number of catchments for which a flood forecasting system is operational. Percentage of flood events for which a useful warning is provided.	Statistics provided by NHSs and presented in annual Project reports.	Participating countries are able to identify catchments for which flood warning is warranted. Participating countries are able to make available the basic requirements (radio channels, reliable power supplies etc) for the system.
1.1	Results A real-time data acquisition and transmission system for rainfall and river level data is designed and installed, that is appropriate for application to small Pacific Island catchments.	Reliability, accuracy, and ease of use of the system. Warning period provided. Percentage of flood events during which the system functions correctly.	Statistics provided by NHSs and presented in annual Project reports. Interviews with NHS staff, presented in Mid-Term Review Report and Project completion report.	Suitable data transmission capabilities are available and functional during storms.
1.2	National needs are identified for flood forecasting, and up to 15 catchments regionally are selected.	Number of catchments included in the Project.	Annual Project reports.	Participating countries are able to identify catchments for which flood warning is warranted.

1.3	Up to 30 suitable field observing sites are selected and installations are designed.	Number of field observing stations established.	Statistics provided by NHSs and presented in annual Project reports.	It is possible to identify and obtain access to suitable sites.
1.4	The necessary field observing stations, data transmission equipment, and base stations are procured and installed.	Number of field observing stations, data transmission systems, and base stations that are functional	Statistics provided by NHSs and presented in annual Project reports.	It is possible to identify and obtain access to suitable sites. Suitable technology is available on the market at affordable cost.
1.5	Forecasting models for each river basin application are developed and implemented.	Number of catchments for which a flood forecasting system is operational. Percentage of flood events for which a useful warning is provided.	Statistics provided by NHSs and presented in annual Project reports.	Data can be obtained for a sufficient number of storms in each catchment to calibrate the model.
1.6	Staff are trained in the operation and maintenance of the system.	Number of staff, recorded by gender, capable of operating and maintaining the system.	Interviews with NHS directors.	Trained staff are retained or can be replaced by new staff who can be trained.
1.7	Arrangements are established for conveying forecasts to the civil defence authorities and the public.	The existence of functional arrangements in each catchment.	Interviews with NHS directors and directors of national disaster management offices.	Effective working relationships exist among the relevant national organizations.
1.8	Complementary approaches to flood mitigation are investigated for application in each river basin.	Extent of investigations in each country to explore complementary approaches to flood mitigation.	Interviews with NHS directors and directors of national disaster management offices.	Effective working relationships exist among the relevant national organizations.

2.	Component Objective That participating countries with significant surface water resources have in place a basic network of near-real time hydrological observing stations and the capability to securely archive incoming data.	Number of functioning near-real time hydrological observing stations. Percentage of the total possible hydrological record that is securely archived.	Statistics provided by NHSs and presented in annual Project reports.	Participating countries are able to identify catchments for which water resources assessment is warranted. Participating countries are able to make available the basic requirements (security, access, etc) for the system.
2.1	Results Locations are selected at which to install DCPs, and site-specific feasibility assessment and design are carried out.	Number of suitable locations for which designs are prepared.	Annual Project reports.	It is possible to identify and obtain access to suitable sites.
2.2	Negotiations are completed with WMO (i.e. Permanent Representatives in each country, World Weather Watch secretariat, satellite operator) on the arrangements for data transmission via the GMS satellite to national meteorological and/or hydrological services.	Existence of agreements for access to WMO communications infrastructure for Project purposes.	Annual Project reports.	Present WMO policy continues to provide free access to GMS/GTS for WHYCOS projects.
2.3	Sensors, DCPs, solar power supply and battery backup, transmission equipment, and any necessary ancilliary installations (e.g. gauging cableway, weir, staff gauge) are installed.	Number of stations at which all equipment has been successfully installed and is operational.	Annual Project reports. Regional Water Resources Database records.	It is possible to identify and obtain access to suitable sites. No difficulties are experienced with logistical matters such as customs clearances. NHSs are able to provide the necessary staff and other facilities.
2.4	Base station facilities at national meteorological and/or hydrological services are installed.	Number of participating countries in which base station facilities have been successfully installed and are operational.	Annual Project reports. National Water Resources Database records.	No difficulties are experienced with logistical matters such as customs clearances. NHSs are able to provide the necessary staff and other facilities.

2.5	Communication networks (using the WMO's Global Telecommunication System and Internet) are established to transmit the data from the satellite receiving station to each service.	Number of stations from which data are successfully transmitted to the Regional Centre. Percentage of the total possible datastream that is captured by the Regional Centre.	Annual Project reports. Regional Water Resources Database records.	Present WMO policy continues to provide free access to GMS/GTS for WHYCOS projects. The Regional Centre is able to establish the necessary capability to disseminate data to NHSs.
2.6	Procedures are developed and implemented for quality control of data capture system function, and for data transmission to national databases (see component 3).	Existence of a documented Quality Management System for the Regional Centre's data capture and transmission functions. Conformance of regionally archived data to defined standards.	Quality Management System documentation. National and Regional Water Resources Database records Monthly Data Reports	None required
2.7	A regional communication network among all participating services is established, to provide email, file/document transfer, database access and electronic fora. (see task 2.5)	Number of NHSs connected to the regional communications network. Levels of use of the network for Project and other purposes.	Annual Project reports. Regional Centre records.	Availability of public communication systems. Ability of NHSs to purchase telecommunication services.
2.8	Staff are trained in maintenance, quality control, and operation of all system components.	Number of trained staff, recorded by gender, who are competent to carry out Project duties. Number of NHSs that are able unaided to operate and maintain their system.	Annual Project reports. Regional Centre records of assistance provided to NHSs. Interviews with NHS directors.	NHS directors are able to make available staff for training. Trained staff are retained or can be replaced by the NHSs
2.9	An inventory of spare parts is established, administered by the Regional Centre, and an ordering/control system.	Number of spare parts held in inventory.	Regional Centre's inventory system records.	None required.

3.	Component Objective That participating countries will have national Water Resources databases that are secure and meet agreed data quality standards, and the capability to maintain them and generate information products that meet users' needs.	Number of participating countries with a secure national database in which the data meet agreed quality standards. Number of participating countries with NHSs able unaided to maintain national databases and generate information products.	National Water Resources Database records. Monthly Data Reports	NHS directors are able to make available staff for training. Trained staff are retained or can be replaced by the NHSs
3.1	Tasks The needs of the participating countries are comprehensively analysed, leading to design (or selection) of a data structure, database, database management system, and software that meet those needs.	Acceptability to the Project Steering Committee of the needs analysis.	Minutes of Project Steering Committee. Needs analysis report.	Participating countries are willing to take part in a needs analysis.
3.2	Computer hardware is provided or upgraded at each service, and the database management system software is installed thereon.	Number of NHSs with computer hardware and dbms that meet their requirements.	National Water Resources Database records.	Agreement can be reached with all countries regarding choice of suitable dbms.
3.3	A regional database is established at the Regional Centre, and protocols are developed for data exchange with national databases.	Existence of a functioning regional database. Number of NHSs to and from which data are exchanged.	National and Regional Water Resources Database records. Monthly Data Reports	Agreement can be reached with NHSs regarding choice of suitable data exchange protocols. Countries accept WMO Res. 25 or an equivalent data exchange agreement.

3.4	Procedures are developed and introduced for quality assurance and archiving of incoming data (in conjunction with the water resources assessment component, but noting that many data streams will not be related to that component).	Existence of a documented Quality Management System for the Regional Centre's and NHSs' data capture and archiving functions. Conformance of archived data to defined standards.	Quality Management System documentation. National and Regional Water Resources Database records. Monthly Data Reports	None required.
3.5	Existing data are migrated onto the new national databases.	Number of records that have been added to the national databases.	National Water Resources Database records. Monthly Data Reports	NHSs are able to recover existing data and make them ready for migration.
3.6	Procedures are developed for basic analysis, summary and presentation of hydrological data and statistics, and basic products are prepared, such as water resources assessments for particular river basins.	Availability of a Procedures Manual for hydrological analysis to NHSs. Number of countries in which basic hydrological information products have been published.	Procedures Manual. NHS files.	NHS agreement can be obtained for basic common procedures. NHS Directors are able to make available staff resources needed to do analyses.
3.7	Staff are trained in the use and maintenance of all components of the database management system and associated procedures.	Number of trained staff, recorded by gender, who are competent to carry out dbms duties. Number of NHSs that are able unaided to operate and maintain their system.	Annual Project reports. Regional Centre records of assistance provided to NHSs. Interviews with NHS directors.	NHS directors are able to make available staff for training. Trained staff are retained or can be replaced by the NHSs

	Component Objective 4. To develop and implement a common approach to drought forecasting in participating countries.	Availability of a Procedures Manual for drought forecasting to NHSs. Number of countries with an established national capability in drought forecasting.	Procedures Manual. Interviews with NHS Directors and directors of national disaster management agencies.	Participating country governments wish to proceed to establish a national drought forecasting capability.
	Tasks 4.1 Meteorological and hydrological drought statistics are analysed, using available rainfall, river flow, groundwater level, and other available data, in relation to long-term variations in climatic indices.	Geographical coverage, historical coverage, and data sources of drought statistic analyses.	Report on drought analysis.	Usable data can be obtained from participating countries.
4.2	The impacts are analysed of recent droughts on water resources and water users, and appropriate approaches to mitigation and management of impacts are developed that take account of climatic variability.	Geographical coverage, historical coverage, and data sources of drought impact analyses. Suitability of drought mitigation and management strategies.	Report on drought impact analysis. Report on recommended drought mitigation and management procedures.	Usable data can be obtained from participating countries.
4.3	A simple procedure is developed to generate timely and accessible forecasts of monthly rainfall and streamflow, drought onset and severity, based on the results of the preceding steps and drawing, if appropriate, on existing models such as the Australian RAINMAN.	Ease of application of the drought forecast procedure, and timeliness and accessibility of its results.	Report on recommended drought forecast procedure.	None required.

4.4	Any additional observing stations are installed that are required to provide data inputs into the forecasting procedure developed in the previous step.	Number of observing stations installed. Data availability from observing stations.	Annual Project reports. National Water Resources Database records. Monthly Data Reports	It is possible to identify and obtain access to suitable sites. No difficulties are experienced with logistical matters such as customs clearances. NHSs are able to provide the necessary staff and other facilities.
4.5	A consistent approach to and format for delivery of drought forecasts, and for interactions among meteorological services, disaster managers and water managers, are developed and introduced.	Acceptance by relevant agencies of the recommended approach and format for drought forecasts. Number of countries in which the approach is implemented.	1.3 Interviews with NHS directors and directors of national disaster management offices. Annual Project reports.	Effective working relationships exist among the relevant national organisations. Needs analysis is satisfactory.
4.6	Staff in relevant agencies and community organisations are trained in drought forecasting, response and mitigation.	Number of trained staff, recorded by gender, who are competent to carry out drought-related duties. Number of countries that are able unaided to operate and maintain their drought forecasting/mitigation system.	Annual Project reports. Regional Centre records of assistance provided to NHSs. Interviews with NHS directors and directors of disaster management agencies..	Directors of NHSs and other relevant agencies are able to make available staff for training. Trained staff are retained or can be replaced by the relevant agencies.
4.7	Public education and awareness programme materials are prepared on climate variability and droughts, in appropriate languages and formats.	Number of items of public information material that are produced.		
5.	Component Objective To establish in participating countries a basic capability in monitoring and assessment of groundwater resources.	Number of participating countries with an established capability in groundwater monitoring and assessment.	Interviews with NHS Directors and directors of national disaster management agencies. National Groundwater Database records	Participating countries are able to provide the basic requirements (access to and security of field sites, etc)

	Results			
5.1	National needs are identified for continuous monitoring of groundwater level and quality (especially salinity), selecting up to 30 locations regionally.	Acceptability to the Project Steering Committee of the needs analysis. Number of monitoring locations selected.	Minutes of Project Steering Committee. Needs analysis report.	Participating countries are willing to take part in a needs analysis.
5.2	Instrumentation (water level and salinity sensor, datalogger, power supply) is procured and installed.	Number of monitoring stations established and functioning.	Annual Project reports. National Groundwater Database records.	It is possible to identify and obtain access to suitable sites. No difficulties are experienced with logistical matters such as customs clearances. NHSs are able to provide the necessary staff and other facilities.
5.3	A groundwater data module in the National Water Resources Database system is provided (as part of the Water Resources Database component; all steps listed therein will be followed).	Number of participating countries with a secure National Groundwater Database in which the data meet agreed quality standards.	National Groundwater Database records.	The National Water Resources Database is successfully implemented.
5.4	Procedures are developed and implemented for quality control of incoming data, and for data input into National Groundwater Databases (see component 3).	Existence of a documented Quality Management System for the Regional Centre's and NHSs' groundwater data capture and archiving functions. Conformance of archived data to defined standards.	Quality Management System documentation. National Groundwater Database records. Monthly Data Reports	None required.
5.5	Staff are trained in groundwater assessment and monitoring.	Number of trained staff, recorded by gender, who are competent to carry out groundwater-related duties. Number of countries that are able unaided to operate and maintain their groundwater assessment system.	Annual Project reports. Regional Centre records of assistance provided to NHSs. Interviews with NHS directors and directors of disaster management agencies.	Directors of NHSs and other relevant agencies are able to make available staff for training. Trained staff are retained or can be replaced by the relevant agencies.

6	Component objective To establish in participating countries a basic capability in monitoring and assessment of water quality and chemistry.	Number of participating countries with an established capability in water quality and chemistry monitoring and assessment.	Interviews with NHS Directors and expected users. National Water Quality Database records	Participating countries are able to provide the basic requirements (access to and security of field sites, etc). Participating countries have effective institutional arrangements for water quality monitoring.
6.1	Tasks National needs are specified for assessment and monitoring of water quality.	Acceptability to the Project Steering Committee of the needs analysis. Number of monitoring locations selected.	Minutes of Project Steering Committee. Needs analysis report.	Participating countries are willing to take part in a needs analysis.
6.2	Appropriate national sampling networks (locations, frequencies, determinands) are designed.	Number of countries for which national sampling networks have been designed.	Annual Project reports. Interviews with NHS Directors and expected users.	It is possible to identify and obtain access to suitable sampling sites. Needs analysis is satisfactory.
6.3	Sampling equipment is prepared, and laboratory analyses are arranged	Number of sampling sites established and functioning. Number of laboratory analyses carried out.	Annual Project reports. National Water Quality Database records.	It is possible to identify and obtain access to suitable sampling sites. No difficulties are experienced with logistical matters such as customs clearances. NHSs are able to provide the necessary staff and other facilities.
6.4	A water quality data module is developed for inclusion in the national Databases (as part of the Water Resources Database component; all steps listed in that component will be followed.).	Number of participating countries with a secure National Water Quality Database in which the data meet agreed quality standards.	National Water Quality Database records.	The National Water Resources Database is successfully implemented.

6.5	Procedures are developed and implemented for quality control of incoming data, and for data input into national Databases (see component 3).	Existence of a documented Quality Management System for the Regional Centre's and NHSs' water quality data capture and archiving functions. Conformance of archived data to defined standards.	Quality Management System documentation. National Water Quality Database records. Monthly Data Reports	None required.
6.6	Staff are trained in water quality/chemistry assessment and monitoring.	Number of trained staff, recorded by gender, who are competent to carry out water quality-related duties. Number of countries that are able unaided to operate and maintain their water quality assessment system.	Annual Project reports. Regional Centre records of assistance provided to NHSs. Interviews with NHS directors and expected users.	Directors of NHSs and other relevant agencies are able to make available staff for training. Trained staff are retained or can be replaced by the relevant agencies.
7.	Component Objective To have Project management systems in place and implemented that (1) ensure that contracted outputs are delivered on time, to standard, and within budget; (2) enable the Project to respond promptly to changing requirements; (3) facilitate the participation of stakeholders in Project affairs; (4) provide timely and accurate reporting.	Timeliness of delivery, quality, and cost of outputs. Project flexibility in response to partner country and donor requirements. Extent of stakeholder participation in Project affairs. Timeliness and accuracy of Project reports.	Executing agency's Project files: quarterly and annual reports. Mid-term Review and Completion Report. Interviews with stakeholders.	Effective working relationships are established among the Executing agency, partner country NHSs and governments.

7.1	Administrative, contract management, and financial management/control procedures and information systems will be established and maintained that meet donor requirements.	Timeliness of delivery, quality, and cost of outputs. Acceptability to donors of their working relationship with and the responsiveness of the Executing agency.	Executing agency Project files: quarterly and annual reports. Mid-term Review and Completion Report.	None required.
7.2	Capital expenditure on necessary instruments and equipment will be carried out in a timely and economical manner.	Timeliness of delivery, quality, and cost of capital items - instruments and equipment.	Executing agency Project files: quarterly and annual reports.	Suppliers meet agreed schedules and prices.
7.3	The Project will be implemented and milestones achieved, with exceptions reported to donors in a timely manner, and alternative strategies devised where necessary to cater for changing circumstances.	Timeliness and completeness of achievement of Project goal, objectives, and milestones. Timeliness and completeness of exception reports. Quality of any necessary alternative strategies.	Executing agency Project files: quarterly and annual reports. Mid-term Review and Completion Report. Executing agency Project files: strategic and annual plans.	Effective working relationships are maintained among the Executing agency, partner country NHSs and governments. The Executing agency is made aware of events and changing circumstances that are outside its control.
7.4	An annual plan will be supplied to donors by 31 October of the preceding financial year, that incorporates the views and requests of stakeholders, comprehensively describes intended Project outputs and relevant milestones for the year, and presents a timeline of work and budget	Timeliness and completeness of annual plan.	Executing agency Project files: strategic and annual plans.	Effective working relationships are maintained among the Executing agency, partner country NHSs and governments.

7.5	Quarterly (within one week of the end of the quarter), Annual (by 31 January of the following financial year), and draft Project Completion (by 30 September of year 5) Reports will be provided to donors and the Regional Steering Committee, and made available to other stakeholders via Internet and other appropriate means. 1.4	Timeliness and information content of reports.	Executing agency Project files: quarterly and annual reports. Draft Project Completion Report.	NHSs and other stakeholders provide necessary information to the Executing agency. The Executing Agency is made aware of events and changing circumstances that are outside its control.
7.6	The Regional Steering Committee will be fully informed of and have satisfactory input into Project affairs, and the results of its meetings will be accurately recorded.	Satisfaction of RSC members with the information and opportunity for input that they receive. Accuracy of RSC meeting minutes.	Minutes of RSC meetings.	Partner country governments (and any other stakeholders included in the RSC) designate RSC members who choose to participate in Project affairs.

ANNEX 3

RISK MANAGEMENT MATRIX

Risk (event or circumstance beyond the control of the Executing Agency)[1]	Importance[2]	Required action	Responsibility
Partner country governments and their departments/ Ministries are not able to agree to their NHSs taking responsibility for the assigned Project activities.	High	Demonstrate the Project benefits to partner countries, as early as possible.	WMO, Executing Agency
The anticipated public sector strengthening in the region fails to materialize or does not establish necessary levels of management capability in NHS parent ministries.	High	Place greater emphasis on NHS strengthening in Project annual plans.	Executing Agency
NHS Directors are unwilling to take responsibility for the assigned Project activities, or are unable to make available the staff-time required, or NHS staff fail to carry out agreed activities to the standards required.	High	Persuade NHS Directors of benefits to their Services, as early as possible.	WMO, Executing Agency
NHS staff who are trained by the Project are not retained by their Service, or it is impossible to train replacements in time for hand-over of responsibility by Project completion.	Extreme	Design training programmes to provide sufficient repeat/refresher training, with training inputs based on worst-case assumptions.	Executing Agency
It is impossible to arrange payment to NHSs for services that they provide under the Project.	Medium	Persuade NHS Directors of benefits to their Services, as early as possible.	Executing Agency
The WMO Geostationary Meteorological Satellite or GTS links to the partner countries are unreliable.	Low	Alternative data retrieval methods will need to be maintained – manual downloading by NHS staff, transfer via commercial telephone system – as alternatives to GTS.	Executing Agency, NHSs
Project equipment (e.g. computer systems, field stations) incur accidental or deliberate damage (e.g. shipping collision, lightning strike, computer viruses, vandalism).	Low	Maintain an inventory of replacement parts, preferably at the Regional Centre. Maintain a “rapid response” capability to carry out major repairs promptly or arrange for the necessary servicing.	Executing Agency, Regional Centre

[1] Only events or circumstances that are beyond the Executing Agency’s reasonable ability to control are included. It is assumed that in general the Project Strategic Plan and Annual Plan will have been designed to address reasonably foreseeable eventualities.

[2] Importance is defined as the product of likelihood and consequence.

Participating country governments decline approval for installation of water level recorders, on environmental or other grounds.	Low	Respond to the objections of the participating country governments	WMO, Executing Agency
Stakeholders' information needs are not adequately defined.	Medium	Improve lines of communication with stakeholders.	Executing Agency, Project Steering Committee
Effective working relationships among the Executing Agency, NHSs and governments, and other stakeholders are not established.	High	Maintain excellent lines of communication with participating governments,NHSs, and other stakeholders, and improve them if they are found to be defective.	Executing Agency
Instrument and equipment suppliers are unable to meet agreed schedules and prices.	Low	Build flexibility into instrument maintenance and replacement strategies/budgets	Executing Agency
The Executing Agency is unaware of events and changing circumstances beyond its control that have an impact on the Project.	High	Maintain excellent lines of communication with participating governments, NHSs, and other stakeholders, and improve them if they are found to be defective.	Executing Agency
Regional Steering Committee members are unable or do not wish to participate fully in Project affairs.	High	Renegotiate nominations to RSC, and increase efforts to affirm and demonstrate the utility of the RSC.	WMO, Executing Agency

IMPLEMENTATION SCHEDULE

× signifies a specific deliverable such as a quality management system. ♦ signifies a regular report to WMO/RSC.
Grey tone signifies ongoing activities.

Code	Narrative Summary	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	COMPONENT 1 **Flood forecasting capability**																				
1.1	Design data acquisition and transmission system			×																	
1.2	Identify national needs for flood forecasting																				
1.3	Select field observing sites																				
1.4	Procure and install equipment																				
1.5	Develop and implement forecasting models																				
1.6	Train staff																				
1.7	Establish arrangements for conveying forecasts							×	×												
1.8	Investigate complementary approaches				×																
	COMPONENT 2 **Water resources assessment in major rivers**																				
2.1	Select DCP sites																				
2.2	Negotiate arrangements for GMS/GTS access				×																
2.3	Install field equipment																				
2.4	Install base stations																				
2.5	Establish communication networks																				
2.6	Develop and implement quality control procedures					×															
2.7	Establish regional communication network			×																	
2.8	Train staff																				
2.9	Establish spare parts inventory																				

Code	Narrative Summary	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	COMPONENT 3 **Water resources databases**																				
3.1	Analyse needs and design dbms				×																
3.2	Provide/upgrade computer hardware																				
3.3	Establish a regional database																				
3.4	Develop and implement quality control procedures				×																
3.5	Migrate existing databases																				
3.6	Develop procedures for analysis and presentation				×																
3.7	Train staff																				
	COMPONENT 4 **Drought forecasting**																				
4.1	Analyse drought statistics								×												
4.2	Analyse drought impacts								×												
4.3	Develop drought forecasting procedure									×											
4.4	Install necessary observing stations																				
4.5	Develop approach/format for delivery of forecasts									×											
4.6	Train staff																				
4.7	Prepare public education/awareness materials									×											
	COMPONENT 5 **Groundwater monitoring and assessment**																				
5.1	Identify needs and select monitoring locations																				
5.2	Procure and install instrumentation																				
5.3	Provide groundwater database module											×									
5.4	Develop and implement quality control procedures											×									
5.5	Train staff																				

		Year 1				Year 2				Year 3				Year 4				Year 5			
Code	**Narrative Summary**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	COMPONENT 6 **Water quality monitoring and assessment**																				
6.1	Specify national needs																				
6.2	Design national sampling networks																				
6.3	Procure sampling equipment																				
6.4	Develop a water quality database module																				
6.5	Develop and implement quality control procedures																				
6.6	Train staff																				
	COMPONENT 7 **Project management**																				
7.1	Establish/maintain all procedures and systems																				
7.2	Administer capital expenditure																				
7.3	Devise alternative strategies				a	s		r	e	q	u	i	r	e	d						
7.4	Prepare annual plans				✕				✕				✕				✕				✕
7.5	Prepare quarterly, annual, Completion reports	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
7.6	Service Project Steering Committee				♦				♦				♦				♦				

ANNEX 5

RESOURCE REQUIREMENTS