# PAPUA NEW GUINEA

Ramu River below Yonki dam Spillway

# **1. COUNTRY INTRODUCTION**

#### **Description:**

Located directly north of Australia and east of Indonesia, in between the Coral Sea and the South Pacific Ocean, Papua New Guinea (PNG) comprises several large high volcanic islands and numerous volcanic and coral atolls. PNG has the largest land area found within the Pacific Island Countries with an area of over 462,840kms<sup>2</sup>. The highest point is Mount Wilhelm at 4,509m. The land is characterised by densely forested steep catchments, where less than 0.5% of the land area is considered arable with an estimated 1.4% of total the land used for permanent crops.

The 2000 census data identifies a population of 5,190,786 (PNG, National Statistics Office), with an estimated 87% of the population living in rural areas (Demography and Housing survey, 2006). The 2011 population is estimated at 6,187,591 and growth rate of 2.0 % (CIA WorldFacts, 2011). PNG is made up of some 20 provinces and 87 districts, reflecting the diverse nature of the population. The capital of PNG is Port Moresby with an estimated population of 314,000 (CIA WorldFacts, 2009)

#### Economy:

Papua New Guinea (PNG) has vast reserves of natural resources, but exploitation has been hampered by rugged terrain, land tenure issues, and the high cost of developing infrastructure. The economy is focused mainly on the extraction and export of the abundant natural resources. Mineral deposits, including copper, gold, and oil, account for nearly two-thirds of the export earnings. Agriculture provides a subsistence livelihood for 85% of the people. Natural gas reserves amount to an estimated 227 billion cubic meters. A consortium led by a major American oil company is constructing a liquefied natural gas (LNG) production facility that could begin exporting in 2014. As the largest investment project in the country's history, it has the potential to double GDP in the near-term and triple Papua New Guinea's export revenue. (CIA WorldFacts, 2011)

#### Water Availability:

Water resources include surface fresh water from streams, rivers, numerous lakes, ponds, reservoirs, estuaries and swamps; groundwater from confined and unconfined aquifers; and freshwater collected from rainwater harvesting. A few commercial establishments in the drier areas of the country operate small desalination plants to supplement their water supply during the dry seasons. In 2008, in rural PNG, it was estimated (WHO/UNICEF JMP, 2010) that 33% of the rural population have access to improved water supplies which include public standpipes, boreholes, protected wells or springs. In the urban areas, which PNG Waterboard services, up to 87% (WHO/UNICEF JMP, 2010) have access to treated and reticulated water but only 57% of the households get piped water directly into their homes. In its nationwide urban water supply network, the PNG Water board has succeeded in reducing unaccounted for water from the 1987 level of 50% to the present level of 31%. It is estimated that, in total, only 40% of the PNG population has access to improved water supply (WHO/UNICEF JMP, 2010).

#### **Island Vulnerability:**

Due to its location on the intersection of the Australian plate and the Pacific plate - being situated along the Pacific "Ring of Fire" - many parts of PNG are vulnerable to the effects of natural disasters associated with active volcanism. These include tsunamis, earthquakes, volcanic eruptions and landslides. Flooding, droughts and saline intrusion are also common. Wastewater discharge from large urban centres, mining, logging and major agricultural activities, increased sediment, bacterial and chemical pollution from untreated waste streams and improper solid waste management severely effect natural water sources. As a consequence, aquatic flora and fauna will continue to be impacted on and the health of people downstream of these developments affected.

#### **Power generation:**

Papua New Guinea has large hydropower stations supplying approximately 85% of consumption. They are located at Yonki on the Ramu River (75 MW) in the Eastern Highlands and close to Port Moresby on the Laloki River with the Rouna hydro electric scheme (62.2 MW). The Moitaka diesel plant generates 30 MW and up to 30 MW is purchased from the private sector plants. Smaller scale and micro-scale plants also generate electricity for resource development, commercial and private sector. The countries oil and gas supplies are also used in generating power to meet needs but on a limited basis. Renewables play a small role and account for around 1% production. Some geothermal energy is produced on islands such as Lihir for mineral processing.

#### Health:

It has been estimated that 55% (WHO/UNICEF JMP, 2010) of the population do not have access to safe sanitation services. Diarrhoea is the number one cause of mortality and morbidity in the country. The current low access to unimproved water sources and sanitation facilities increased the risk of infectious water borne diseases including cholera and typhoid. Adverse impacts on water resources in catchments arise from road construction, agriculture, logging, mining waste and improper disposal of solid and human waste. This is major cause for concern where 67% (WHO/UNICEF JMP, 2010) of the rural population obtain drinking water directly from an unimproved source. The Department of Health has been promoting better hygiene, improved sanitation and proper solid waste disposal throughout the country but it needs the support of other government agencies, provincial and local level governments as well as NGOs and the resource development sector.

#### **Environment and Tourism:**

PNG has a variety of terrestrial, coastal and marine ecosystems ranging from very high mountain peaks (Mount Wilhelm at 4,509 meters), through to humid tropical forests and swampy lowlands to pristine coral reefs. Forest cover is the dominant vegetation in Papua New Guinea covering 360,000 km<sup>2</sup> (78%) of the total land area. These forests, the extensive mangrove forests that characterise the major river deltas along the southern coast of Papua New Guinea and the coral reefs, are all of global biodiversity significance. The main threats to these interconnected ecosystems are activities such





as commercial logging, commercial agriculture, subsistence agriculture, road clearance, mining and petroleum developments, industrial and sewage effluents as well, as indiscriminate disposal of solid wastes. The impact on watersheds by tourism is minimal mainly because the concentration of rural based eco-tourism facilities and the annual volume of incoming tourists are relatively low.

## 2. GEOGRAPHIC

Papua New Guinea is an island country that consists of the eastern half of the very large island of New Guinea and adjacent islands, the Bismarck Archipelago, and the northern Solomon Islands. Papua New Guinea lays 6° south of the Equator, wholly within the tropics and is one of the most primitive areas on earth still having many remote groups living a traditional tribal lifestyle. The greater part is mountainous, with peaks reaching a maximum height of 4,509 m. Lowlands are most extensive in the Fly River basin in the southwest and along the Sepik River in the northwest. Except in the highlands and high mountains, the climate is hot, humid, and extremely wet with much of the country consisting of tropical forests and grasslands. Animal life is diverse and abundant. Primitive subsistence farming, hunting, and fishing support most of the country's people; some tribes in the interior still have a Stone Age culture and some practiced cannibalism and headhunting well into the 21st century. Western culture and modern commercial activities are found mainly in coastal cities and towns. In scattered locations there are modern plantations producing coconuts, cocoa, rubber, palm oil, tea, and coffee. Timber production and mining of gold, copper, nickel, petroleum and natural gas, make up the

Lalola Island Resort, Port Moresby

bulk of the export industry. Manufacturing, transportation and communication facilities are poorly developed. Due to the mountainous topography, air transportation services are the primary means of inter provincial transport for many.

The country's population is Melanesian, divided into more than 500 tribes speaking hundreds of languages and dialects. The three official languages are Tok Pisin (most widely spoken), English (used by 1-2% of population) and Hiri Moto. Nominally 93 per cent of the population are Christians, but belief in magic, sorcery, and traditional deities is widespread. Papua New Guinea is a constitutional parliamentary democracy with the Prime Minister as the head of the government. The Prime Minister is elected by the country's national legislature, which is elected by the people. Papua New Guinea is a member of the Commonwealth, with the chief of state the monarchy of England. Great Britain and Germany divided the eastern half of New Guinea in 1884 (the Dutch ruled the western half). Britain took the southern part, which became the Territory of Papua, and held it until 1906, when control was transferred to Australia. After World War I the German portion was mandated to Australia by the League of Nations. The mandate became the Trust Territory of New Guinea after World War II. After 1949 the two territories were administered as one by Australia, although they retained their separate identities. Internal selfgovernment was granted in 1973, and the two territories merged to become independent Papua New Guinea in 1975.



Map of Papua New Guinea showing Ramu Catchment

Source: SOPAC 2010

Soil Map of Papua New Guinea (Bleeker 2003, CSIRO)



Source: http://eusoils.jrc.ec.europa.eu/esdb\_archive/eudasm/asia/lists/cpg.htm





## **3. CLIMATIC**

Papua New Guinea's climate is tropical, experiencing monsoonal climate characterized by high temperatures and humidity throughout the year in the coastal regions and cooler to cold temperatures at altitude. The country can be characterised into three main climatic zones, the low lands, the highlands and the high mountains which bring more extremes. The North west Monsoon season is from December to March while the Southeast monsoon season, bringing dry trade wind, extends from May to October. Rainfall is at its heaviest in the highlands with mean annual precipitation varying from less than 1,000mm in Port Moresby up to 9,000 mm in the higher west. The average daily temperature in Port Moresby ranges from 26°C to 28°C all year. The highlands regions being generally over 1,000 meters, and cooler, have a temperature range of 12-28°C with less humidity. Frosts can be experienced in the highlands and snow falls periodically on the highest peaks. Relative humidity is uniformly high in the lowlands and coastal areas at about 80% and averages between 65 and 80% in the highlands. In both areas, the days are generally fine, but often there is a build up of cloud in the mountains in the

Bootless Bay sunset, Port Moresby

afternoon resulting in rain in the late afternoon and evening. Weather in PNG is generally very localised and PNG does not experience frontal weather as in common in more temperate areas. Port Moresby and its immediate area can be considered as having a very distinct dry season as evidenced by the mean monthly rainfall plots, as compared with Purari in the south central highlands where significant rain can be experienced on most days of the year, commonly rain days exceed 320 days. Winds in PNG are normally light, variable, increase at altitude and dependant on the seasonal climate variation. Periods of cyclonic activity occur and bring damaging winds and storm surges, especially in the coastal areas. The Solomon and Coral Seas are the tropical cyclone prone areas within tropical region of Papua New Guinea. Weather systems originating in the Solomon and Coral Seas are considered climatically important impacting on the country and its neighbors, Australia and Solomon Islands. This role of maintaining a weather watch over Papua New Guinea is undertaken by the National Weather Service (NWS) who ensure forecasts and warnings are consistent and always available for dissemination to maritime or Island communities within the cyclone prone areas.

Observation Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature Mean max (°C)	32.1	31.6	31.4	31.3	31.0	30.3	29.9	30.3	31.0	32.0	32.5	32.4	31.3
Precipitation (mm)	192	140	190	105	56	22	14	12	14	15	40	98	898

Monthly Climate Data for Port Moresby Source PNG National Weather Service (1973-2007)

Source: PNG National Weather Service (1973-2007)

The following plots of monthly mean rainfall demonstrate the rainfall pattern from two distinctly different areas in PNG, the Capital of Port Moresby, which experiences a definite dry season and low annual rainfall of less than one metre, and a site on the Purari River in the southern highlands where the mean annual rainfall from 1962 - 1986 was 6,120m with a maximum rainfall of 9,355 being measured in 1962. The Star Mountains close to the Irian Jaya (Indonesian) border in the western province is reputed to be the wettest place in PNG with in excess of 10,000 mm per annum being measured at the Ok Tedi mine site.

Monthly mean rainfalls Port Moresby (1973 – 2007)



Monthly rainfall at Purari River above Wabo Creek, (1962 - 1986)



Source: BWR

CATALOGUE OF RIVERS FOR PACIFIC ISLANDS



Lake Sirinumu, Rona Hydroelectric Power Plant intake



Papua New Guinea Isohyetal map

Source: SMEC 1973 - PNG Flood Estimation Manual

Prior to the implementation of Pacific HYCOS, the PNG NHS had ceased to operate a regular field program and there were no manual or automatic raingauges in operation. To address this shortfall, 8 automatic raingauges were purchased for installation; two of these were installed in the Eastern Highlands and have collected some useful short term datasets. The NHS has been unable to install any of the gauges in the Port Moresby or study catchment area. There is considerable data from tabulations and chart data that could be rescued, however it has been difficult to progress data rescue activities due to a lack of funding. The following table identifies the HYCOS supported rainfall stations. Data collected from these gauges to date is very limited, additional gauges are to be installed by the NHS at more strategic sites indicated where there were old gauges installed. Apart from the long term daily data, available from the National Weather Service (NWS) synoptic climate stations, there is little current and ongoing available data for short or long term rainfall analysis. The many mineral and petroleum resource development companies operating throughout PNG recognise the shortfall in nationally available data and collect hydro meteorological data themselves; however this has not been routinely made available to the NHS.

No.	Station and number	Elevation (m)	Location and coordinates	Period of observations	Average rainfall (mm)
NA	Port Moresby	58	Jackson's Strip (Airport) 09° 26' 27" S 147° 12' 37" E	NA	898*
705470	Goroka	1605	DEC Office 06° 04' 24" S 145° 23' 45" E	1985 - 1987	2168 limited data
201600	Aiyura	1620	Coffee Research Station 06° 19' 59" S 145° 53' 59" E	1984 - 1991	1500 limited data
202350	Ramu	1350	Below Yonki Dam 15° 17' 12" S, 166° 55' 08" E	1986 – 1990	NA
605710	Laloki GS1	463	Gauging station (Weir) 15° 17' 12" S, 166° 55' 08" E	1989	NA
605230	Eilogo	476	Ruruluba 15° 17' 12" S, 166° 55' 08" E	1963 - 1977	3435
606350	Bomona	150	Pumping station 17° 41' 31" S, 168° 19' 31" E	1989 – 1990	NA
NA	Lake Sirinumu	540	Sirinumu Dam 17° 42' 37" S, 168° 19' 26" E	NA	NA

Rainfall stations installed by Pacific HYCOS.

NA records too short for analysis or not available \* other sources indicate mean annual rainfalls up to 1169 mm pa

## 4. WATER RESOURCES

#### 4.1 General Description

Papua New Guinea has substantial and reliable freshwater resources including springs, creeks, very large rivers, lakes, wetlands and groundwater. The main water uses are for domestic consumption (56%), industrial use (43%), including hydropower generation, resource development companies, and small industry, with limited agricultural use (1%). There are two significant hydroelectric storage reservoirs, the Yonki Dam on the Ramu River in the Highlands and Sirinumu Dam on the Laloki River close to Port Moresby. In the rural areas the main sources of potable water are rainwater tanks, shallow hand-dug wells, springs, creeks and rivers with only 33% of the population having access to improved water supply systems. In the urban areas 87% of the population have access to improved water supply.

Water resources in urban areas, both for quantity and quality, are coming under increasing

threat from the pressure induced by rapid population growth. Additionally, point source pollutant laden discharges from mining, logging, agriculture, infrastructure development and industrial processing, are impacting on both surface water and groundwater sources. While existing regulatory controls are in place to minimise these impacts, better monitoring, compliance and enforcement arrangements are required to regulate these activities. In order to overcome the constraints imposed by limited regulatory funding from the government, monitoring networks involving partnerships with private sector, NGOs and local landowners need to be considered and working models developed. In addition, with one of the wetter climates in the world, floods occur annually with magnitudes differing from one year to another. Even whilst there is overall a very wet climate, the topography of the country is such that there are areas which experience distinct dry seasons and where droughts can develop during extended dry seasons.



Climate variation and change is expected to intensify the impacts of the ENSO phenomenon in both extremes resulting in more frequent and severe floods and droughts. Inadequate preparedness, adaptation and contingency planning will result in the increased potential for damage and loss of life due to floods and amplified difficulties associated with droughts. Investment in improved flood and drought forecasting, hazard assessment and risk management will minimise impacts associated with climate extremes providing greater understanding of the frequency, and magnitude of the event.

In recent years integrated water resources management has commenced through the GEF funded IWRM project which is a process to engage stakeholders in meaningful dialogue to address and develop mitigation measures addressing the issues associated with sustainable development and management of water resources.

#### 4.2 Major Floods and Droughts

Flooding is common on low-lying flood plains near rivers such as those close to Port Moresby (Laloki River) and Lae (Bhumbu River) especially during tropical cyclones and during La Niña years. Prolonged rainfall during the wetter season often causes severe impacts to low lying villages, crops, road crossings, culverts, bridges and urban drainage infrastructure. The most recent devastating flooding was experienced in the Oro province in November 2007 which led to at least 200 deaths with 2,000 people being evacuated as a result of the flooding. Roads, bridges and 40 houses were washed away, as tides and surges in the area reached two metres high. In the provincial capital, Popondetta, the water supply and electrical infrastructure was damaged and all road access was blocked. Papua New Guinea's national airline, Air Niugini, suspended flights to Popondetta's main airport. The Rabaraba district in Milne Bay Province was also hit by flooding, with 30 houses and food gardens washed away, and forcing the evacuation of about 100 people. The government in Papua New Guinea reported that an estimated 145,000 people were affected

from the flooding in Oro Province. Six days of torrential rain led to a damage total of 200 million kina (\$71.4 million USD). The torrential rain was the worst seen in the region in 30 years, according to the local people. Many lesser flood events go unreported due to the remote nature of many clan groups and villages and their capacity and need to naturally adapt to these events due to poor levels of provincial support. These floods are not uncommon and as indicated can have devastating impacts on the communities.

The PNG Flood Estimation Manuals (SMEC 1973 & 1990) were developed as a valuable document for deriving flood estimates on PNG's major rivers for engineering infrastructure related to Government utilities, infrastructure and for resource developers. Given climate variation and apparent increases in flood flows and the need for current design estimates, this manual again needs updating. For PNG this is not possible as no substantial hydrological (flow and rainfall) data has been collected to improve on the 1990 publication, apart from that collected by the resource development companies themselves which is currently unavailable to the NHS and has not been consolidated into one document or database.

Droughts in PNG are related to ENSO (the El Niño Southern Oscillation phenomenon). The latest ENSO episode of greatest affect was in 1997/98 which resulted in dry conditions throughout PNG with food production being severely effected for 80% of the population who depend on a subsistence lifestyle. On the other hand in the Port Moresby urban area, water availability in the Sirinumu reservoir fell to critically low levels for electricity production and water supply. During a normal year, drought affects can be experienced in rain-shadow areas such as the Laloki Catchment which is of extreme importance to Port Moresby for water and energy. The absence of an operational hydrology program and water resources data precludes the development of any flood warning and quantifiable assessment of floods or droughts being undertaken, since the data collection program was compromised and ceased in the mid 1990's.



#### 4.3 Socio-economic characteristics

Most Papua New Guineans live in rural communities, 87%, many extremely remote and extremely far from road access, based on traditional village and clan social structures and are dependent on subsistence agriculture supplemented by cash cropping (where town markets are close by and accessible), fishing and forest products. Use of water is based on traditional cultural use for fishing, food preparation, washing and recreation. Limited use is made of water for village based irrigation. Most use can be considered in-stream where any degradation of the resource from uses such as cattle farming, cropping, logging or mining can have a detrimental effect. For example in the case of the Ok Tedi mine in the Western Province, the very large Fly River has been highly contaminated by mine tailings especially over the past 30 years and significant compensation claims have been made. Groundwater use and rainwater harvesting are the only options on the outer small islands and in some of the contaminated areas on the main Islands.

There has been increasing levels of urban migration for employment from the provinces to cities and towns in the past decade or so which has contributed to urban unemployment and accompanying social problems, sometimes being quite severe with very high levels of crime and violence. Associated with this is poor infrastructure including degrading reticulated water supply systems and poor sanitation in the rural towns. Port Moresby relies on surface water from the Laloki River which, with rapidly

Asaro River hydrological station, Eastern Highlands

increasing population from urban migration, and industrial and mining developments, this river is coming under extreme stress. Papua New Guinea still has limited primary health care facilities and infectious diseases, including water borne disease, still claim many lives. Poverty and economic hardships remain significant concerns. There is significant opportunity with the rivers on all larger islands for hydro electric power production for local and industrial use. Diesel based energy is extremely expensive where it is used and hydroelectric power is a sustainable option for local supply and resource development. There is a difficulty in sustaining hydrological monitoring systems in PNG and implementing site investigation works due to cultural issues pertaining to land ownership and compensation. This impacts on the sustainability of any ongoing field data collection. By far one of the greatest issues facing data collection programs are land owner based, where damages can be effected to any public or remote monitoring equipment deployed or large compensation claims made. These can amount to some 10's of thousands of kina for the installation of even basic sites, and then with no guarantee of security or sustainability, with the sustainability of ongoing field investigations being jeopardised.

Water related tourism sector opportunities, especially on the larger rivers, abound in PNG. However the socio economic issues largely preclude such eco tourism ventures such as trekking, bush walks, river rafting, fishing and water fall experiences progressing beyond initial planning due to the extremely high risk factor to economics and personal security issues.



# 5. HYDROLOGICAL INFORMATION

Hydrological monitoring and assessment commenced in Papua New Guinea during the Australian Administration and the first station was installed on the Laloki River at Sogeri in the 1950's out of need for data for hydroelectric and water supply development. Following independence in 1975 the Hydrological monitoring was undertaken by the Bureau of Water Resources, BWR, it as has since migrated between several Government Departments and the function currently resides with the Department of Environment and Conservation. There are two centres of operation, one at Port Moresby and one located in the Eastern Highlands in the town of Goroka. Up until the early 1990's the BWR was extremely well resourced and supported and collected perhaps the best data in the South Pacific. With representative regional sites being remote and many very distant from road access, significant use was made of fixed wing aircraft and helicopters to access sites for servicing and gaugings at some considerable cost. Subsequent political decisions reduced the support to the BWR to the point where little data was being collected from the mid 90's, being unable to mobilise due to limited financial support, no motor vehicles, and where significant and expensive field equipment had been lost due to various causes. By the time Pacific HYCOS

Mini Hydroelectric Power Plant, Lake Sirinumu

implemented in PNG in 2007, no sites were operating, there had been significant staff retrenchments, and the BWR activities had been transferred to the Environmental Audit and Risk Division within DEC. The situation has not significantly improved, and currently the NHS have great difficulty in implementing and sustaining even the HYCOS supported initiatives for the two pilot river basins. Limited international assistance has been advanced to the NHS over the years apart from that provided through UNDP (1990-92), AusAID (1997) and the Pacific HYCOS assistance (2007-2010). During this period only limited datasets were collected and sustainability of the field programs is still an ongoing problem, despite an increasing requirement for hydrological data from a growing natural resource development sector. A small core of skilled hydrology staff is retained by the department.

Pacific HYCOS was implemented in 2007 and has supplied considerable assistance and capital equipment to the NHS and made the best effort to renew the interest in hydrological data collection. Some effort was invested by HYCOS in data rescue of the national database from an unsupported database system to the TIDEDA database and for digitising of paper chart records. A brief review of the data on the TIDEDA database installed initially by NIWA in 1990 shows the data to be of limited use with the longer term datasets having many gaps in the record. Quality issues are obvious, with few discharge measurements done in recent times and where rating curves have been poorly maintained. Floods, even small ones, are not measured where measurement of small floods is necessary to understand large floods. The NHS continues to struggle to maintain a field program and collect very basic datasets.

#### 5.1 Hydrological Stations

As indicated at the commencement of Pacific HYCOS implementation, no hydrological stations were operating in PNG despite having good road access and some of them being located relatively close to Port Moresby and Goroka. These reasons for the deterioration extended to institutional issues, lack of resources and a poor understanding on why hydrological data is needed, rather than reduced staff capacity or technology. A scan of the PNG hydrological archive supplied by the NHS indicates a total of 357 sites (water level and or gauging stations) that have operated for varying periods, some of which are mining company sites. This data amounts to perhaps some many hundreds of station years of data.

#### 5.2 Study Catchment Introduction

Pacific HYCOS in discussion with the NHS elected to support hydrological stations in the National Capital District (NCD) of Port Moresby and in the Eastern Highlands. The Laloki catchment in the NCD was selected as the primary demonstration catchment as it is also the demonstration catchment for the Pacific IWRM GEF Project and all stations are accessible on good roads close to Port Moresby. The Ramu catchment in the Highlands was selected as the secondary study catchment as it was supported by the SOPAC EDF8 funded community risk program for flood mitigation studies and again has good road access.

#### 5.2.1 General Description

The primary study catchment of the Laloki rises east of Port Moresby and is Port Moresby's source of water with the supply, treatment plant and reticulation operated by Eda Ranu. Energy production through four hydro electric power stations is operated by PNG Power Limited. The headwaters of the catchment have a significant dam, the Sirinumu reservoir, commissioned in 1963 which provides storage for both water supply and hydroelectric power generation. The catchment is diverse and is generally forested with lower catchment clearings of pasture land for cattle grazing and food production. This terrain is interspersed with some incised rugged gorges. Access to the hydrological stations is relatively good on sealed and unsealed roads.

The secondary catchment of the Ramu in the Eastern Highlands is a very large river system which was previously monitored by the NHS. The Ramu River flows from the Highlands through the much lower Morobe province to the ocean. The EDF8 project purchased monitoring equipment in 2007 for the measurement of Ramu stream flows and floods at three sites, only limited data has been collected to date. The catchment is diverse having significant remote villages with traditional land use as well as resource development in the form of logging and mining of gold and nickel deposits.

#### 5.2.2 Measured Hydrological data

There is little recent hydrological information collected by the NHS available for Papua New Guinea. The following table identifies the sites and their locations which were supported by Pacific HYCOS, however their ongoing operation is uncertain.



No.	Station and number	Location	Catchment Area (km²)	Observation Period	Observation Items (frequency)
1	Laloki 605710	Sogeri 15° 17' 12" S, 166° 55' 08" E	310	1967–1995	WL, Q <u>,</u> RF
2	Eilogo* 604960	Arubada 15° 17' 12" S, 166° 55' 08" E	31	1979-1995	WL, Q, RF
3	Eworogo 605580	Sogeri 15° 17' 12" S, 166° 55' 08" E	77	1958-1998	WL, Q, RF
4	Laloki* 606350	Bomona Pump Station 17° 41' 31" S, 168° 19' 31" E	385	1987-1996	WL, Q
5	Lake Sirinumu* 604710	Sirinumu Dam 17° 42' 37" S, 168° 19' 26" E	172	1967-1995	WL, Q
6	Ramu 201300	Kainantu 15° 17' 12" S, 166° 55' 08" E	212	1962-1995	WL, Q
7	Ramu 202350	Damsite 15° 17' 12" S, 166° 55' 08" E	854	1966-1992	WL, Q
8	Ramu* 203800	Aiome 15° 17' 12" S, 166° 55' 08" E	8751	1966-1994	WL, Q, RF
9	Asaro* 705150	Highway Bridge 15° 17' 12" S, 166° 55' 08" E	244	1981-1994	WL, Q, RF

#### Hydrological stations in Papua New Guinea supported by Pacific HYCOS

WL = Waterlevel, Q = discharge flow, RF = Rainfall NA not available

\* HYCOS/EDF8 instrumentation/equipment supplied, installation by the NHS is uncertain

#### Study Catchment 1 – Laloki

The Laloki River flows from the eastern mountains close to Port Moresby. In PNG terms it is not considered a large river but it is highly significant to Port Moresby because of its importance to the National Capital District and of the catchment land and water use development issues. Water is used conjunctively and is balanced between the needs of the Rouna 1, 2, 3 and 4 hydro electric power stations (totalling 62.2 megawatts of energy) and the Port Moresby water supply operated by Eda Ranu, as well as local land owner and cultural needs. Additionally, in the upper catchment, the ecological and conservation needs of Variata National Park, as well as agricultural demands are present whilst in the lower catchment, there is a growing industrial demand for water such as abattoirs, piggeries as well as domestic needs through urban sprawl and squatter settlements.

Significant copper deposits exist in the mid to lower catchment, which were mined in the 1920's with options for future re-mining. The Laloki River experiences periodic flooding affecting squatter settlements and infrastructure located close to the river. The Sirinumu Dam in the headwaters was commissioned in 1963 and provides system storage and balancing of flows for PNG Power (PPL) and Eda Ranu. During the 1997/98 El Nino event, the dam was reduced to minimum operating level and energy and water supply was limited to supplies



Highland Warriors, Goroka Eastern Highlands

from natural stream flows, unfortunately limited, hydrological data was collected during this high stress period. Since the mid 90's, there has been insubstantial hydrological data collected. Pacific HYCOS supported re-commissioning of the stations in 2008 but with limited success. Data from this catchment is highly important for national hydrological assessments in general as well as specifically for water management for PPL, Eda Ranu and Integrated Water Resource Management, IWRM. It is hoped that the NHS can better engage with data collection when their institutional position improves. The NHS has to date been unable to supply any additional data for inclusion in this publication from the Laloki sites. Datasets on the TIDEDA database are very incomplete considering the Laloki at Sogeri (GS1 or Gauging Station No. 1) site was PNG's first hydrological station installed in the mid 1950's and is a site of national importance.



#### Map of Laloki and sub catchments

Source: Papua New Guinea Department of Environment and Conservation





Yonki Lake, Ramu Hydroelectric Power Plant, eastern Highlands

The following water level hydrograph presents available flow data from the Laloki River. The data from when the site was opened in the 1950's to 1967 is missing or is unprocessed plus there are other significant periods of missing record. This site has a concrete control weir which is very stable. Whilst discharge measurements above 100m<sup>3</sup>/s have not been undertaken, it is assumed that the rating curve is stable and discharge hydrographs have been presented.





Source: Papua New Guinea Department of Environment and Conservation

As the Laloki River is regulated by the Sirinumu dam, an annual hydrograph is very attenuated by this control and no high flows are released unless there are large floods with a full reservoir. Data is presented from a typical flow year of 1986. Gaps in the record are quite apparent.



Lalola Island Resort, Port Moresby

The Laloki at Sogeri discharge rating is considered stable and is presented below. It is a composite curve due to the type of weir design. The most recent discharge measurement listed on the hydrological archive was undertaken in 1992.



Laloki River at Sogeri annual discharge hydrograph 1986, Station No. 605710,

Source: Papua New Guinea Department of Environment and Conservation



Laloki River at Sogeri, discharge rating curve



Source: Papua New Guinea Department of Environment and Conservation

The following table lists the discharge measurement statistics on the Laloki River. Many discharge measurements have been undertaken and one might assume that the sites are well rated, however, these are invariably almost exclusively at low flows and ceased in the early 1990's.

Site and	Minimum gauged		Date	Maximum gauged		Data	Max level	Data	Total No of
Number	Level Flow m m <sup>3</sup> /s		Date	Level m	Flow m³/s	Date	recorded (m)	Date	measure- ments
Laloki Sogeri 605710	0.34	3.31	17/06/58	2.27	97	23/02/68	3.57	10/12/84	200
Laloki Bomona 606350	0.55	1.75	14/9/65	3.27	75	16/3/90	10.74	14/3/95	129
Eilogo 604960	0.26	0.45	13/02/92	1.06	15.1	15/02/67	2.04	2/06/80	314
Eworogo 605580	1.42	0.45	8/10/82	0.61	36.9	28/05/81	3.61	10/12/84	309

#### Discharge measurement statistics for the Laloki River stations

Source: Papua New Guinea Department of Environment and Conservation

#### Study Catchment 2 (Ramu)

#### **General Description**

The Ramu is the largest river in the Kainantu District of the Eastern Highlands Province. It flows through the western end of Madang Province before discharging into sea. The river which originates from Mount Otto (3,200 m) and flows out to the Bismark Sea in the Pacific Ocean has a catchment area of 17,114 km<sup>2</sup>. During the period 1966-1992, the catchment received an average annual rainfall of 1,070 mm and had a mean flow at the Yonki dam site of 40 m<sup>3</sup>/s.

The population in the catchment according to 1990 census was about 8,000. The Yonki dam was commissioned in 1991 to store 332xl0<sup>6</sup> cubic metres of water. The river segment above Kainantu District is considered as the upper catchment, located in the mountains with small holdings of coffee plantations. The river segment below Kainantu District in the low lands is considered as the lower Ramu, commonly known as the Markham plains.

#### Map of Ramu Catchment.



Source: Papua New Guinea Department of Environment and Conservation



The Ramu river falls very steeply, over 1000 metres in less than 10 km, equivalent to a 10% gradient, from the eastern highlands and this is well demonstrated in the longitudinal profile. This is quite typical of rivers which rise in the highlands and fall rapidly through very active and highly erosive rock gorges.



#### Longitudinal Profile of the Ramu River

The following table lists the discharge measurement statistics on the Ramu River, where most of the flow ratings were undertaken during low flows and ceasing in the early 1990's.

Site and Station Number	Minii gau	mum ged	Date	Maximum gauged		Date	Max level	Date	Total No of discharge
	Level m	Flow m <sup>3</sup> /s	Dute	Level m	Flow m³/s	Dute	recorded (m)	Dute	measure- ments
Ramu at Kainantu 201300	2.1	2.92	28/10/1961	2.62	14.4	03/03/1961	4.87	23/07/1963	200
Ramu at Damsite 202350	0.56	5.94	15/09/1966	3.04	319	01/03/1971	3.83	13/05/1982	318
Ramu at Aiome 203800	0.936	121.8	28/09/1974	5.913	256	24/10/1969	6.865	07/03/1983	
Asaro at Bridge 705150	0.58	3.76	06/11/1969	2.08	42.7	11/04/1962	3.78	07/02/1982	262

#### Discharge measurement statistics for the Ramu River stations



Laloki River at GS1, surveying in gauge board, PNG's first hydrological station

# 6. COMMENT

In general there is limited recent usable hydrological data available for PNG due to poor and fragmented records, few discharge measurements have been undertaken and essentially no substantial data has been collected within the last decade or two especially on the larger rivers. There is great uncertainty in any rating curves which have been developed. This is despite PNG commencing hydrological monitoring over 40 years ago. There is concern that the data that is available is barely sufficient for the basic calibration of catchment models and identification of storm or drought sequences. A minimum of 10 years of consistent and continuous data is needed for hydrological statistics to be derived and a review of the data has shown this is lacking despite some sites being listed as open for close to 40 years. The NHS and their staff have shown a fair level of commitment during Pacific HYCOS to the collection of hydrological data. When they are better funded and valued by government at the national level there will be an improvement in the collection of robust datasets in the coming years.

Hydrological datasets will assist government and stakeholders alike to make a more informed assessment on the development and sustainability options of the nation's water resources. In particular the need for data for hydro electric energy production, the rapidly developing mineral resources sector, disaster risk management and mitigation in regard large floods and droughts, as well as increasing population pressures due to urbanisation and ageing infrastructure. It is unfortunate that the NHS staff have had little to no access, since the UNDP and AusAID Projects in the 1990's, to relevant training courses, capacity building or professional development either in PNG or offshore. As a result, their skills and capacity to undertake operational hydrology work remain much depleted despite there being great need. There are no professional hydrologists within the NHS who might be able to better advance the operational program, develop capacity and address the serious and ongoing issues recognised during the Pacific HYCOS implementation and the preparation of this publication. The hydrology program is driven from a largely technical base with only modest skill levels.

# 7. PHOTOGRAPHS



Ramu River in the Eastern Highlands below the Yonki dam and spillway



Hydrological station on the Asaro River, Eastern Highlands at the highway bridge, scheduled for upgrading by the NHS



Laloki River at Sogeri (GS1) undertaking site survey following re-commissioning of the station in 2009, note the left bank edge of the control weir



NHS Technicians installing a hydrologger in the Laloki River at GS1 in an established stilling well



Lake Sirinumu intake tower where the monitoring station is located



Rouna 1 (closest) and Rouna 3 hydro electric power stations, Laloki River



Ramu River at Kainantu, new security housing, even these security mesures have been compromised by vandalism



NHS staff servicing the Aiyura automatic raingauge in PNG's Eastern Highlands

