Business as Usual (BAU) Scenario Information and Analysis Covering the Pra and Kakum River Basins

Prepared for Nature Conservation Research Centre

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Abbreviations

%	Per cent
µg/l	Microgram Per Litre
bn	Billion
BOD	Biological Oxygen Demand
CBO	Community Based Organisation
CCEMA	Cape Coast-Elmina Metropolitan Area
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organization
CWSA	Community Water and Sanitation Agency
DA	District Assembly
DANIDA	Danish International Development Agency
DBB	Densu Basin Board
DO	Dissolved Oxygen
ECHAM4	European Centre Hamburg Model, 4th Generation
EPA	Environmental Protection Agency
FSD	Forest Services Division
GHAPOHA	Ghana Ports and Harbours Authority
GHc	Ghana Cedis
GIDA	Ghana Irrigation Development Authority
GMet	Ghana Meteorological Agency
GREDA	Ghana Real Estate Developers Association
GSA	Ghana Standards Authority
GSBA	Globally Significant Biodiversity Areas
GUWL	Ghana Urban Water Limited
GWCL	Ghana Water Company Limited
GWP	Global Water Partnership
HSD	Hydrological Services Department
HU	Hazen Unit
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
IWS	Investments in Watershed Services
Km^2	Kilometre Square
m	Metre
M^3	Cubic metre
m^3/d	Cubic Metres Per Day
MA	Millennium Ecosystem Assessment

mgd	Million Gallons Per Day
N	Nitrogen
NCRC	Nature Conservation Research Centre
NGO	Non-Governmental Organisation
NRMP	Natural Resources Management Project
NTFP	Non-Timber Forest Products
NTU	Nephelometric Turbidity Unit
P	Phosphate
ppm	Parts per million
PURC	Public Utilities Regulatory Commission
SIP	Strategic Investment Programme
SOx	Oxides of Sulphur
SSNIT	Social Security and National Insurance Trust
STMA	Sekondi-Takoradi metropolitan Area
SWAT	Soil and Water Assessment Tool
TEEB	The Economics of Ecosystems and Biodiversity
US$	United States Dollar
UVB	Ultraviolet Band
VRA	Volta River Authority
WD	Wildlife Division
WQI	Water Quality Index
WRC	Water Resources Commission
WRI	Water Research Institute
WRSDF	Western Region Spatial Development Framework
WSSD	World Summit on Sustainable Development
WTP	Water Treatment Plant
WUP	Water Use Permit

Executive Summary

Recent studies show that many watershed systems around the world are in crisis over the availability, quality and flow of freshwater putting stress on these intricate ecosystems at their upstream origins meanwhile having untold impact on the downstream water systems and users.

The Nature Conservation Research Centre and its international partner, Forest Trends, have secured donor funds to support exploratory work on Investment[1] in Watershed Services (IWS) in several countries. The global project is entitled "Scaling Up Investment for Ecosystem Services to Meet the Global Water Crisis" and Ghana is one of the countries included in the project. A prerequisite of the Ghana component of the project is to assemble the requisite information and undertake a Business As Usual (BAU) scenario analysis for the Pra and Kakum River Basins, on which Sekondi-Takoradi and Cape Coast-Elmina potable water systems are based.

This study provides an analysis of critical ecosystems and watershed services, threats that impair watershed services (and their underlying causes) within the Pra and Kakum river basins. It examines the barriers hindering effective delivery of roles and functions of governmental agencies/institutions engaged in upstream watershed management and downstream distribution and supply of water. A review of literature on several aspects of the river basins including water quality and flow, human activities and land uses was conducted. Institutions and experts with interest and a working knowledge of the basins or on relevant issues were consulted. Direct observations were made during field visits to selected localities within the sub-catchments.

About 2,329m^3/cap/year of freshwater is generated by the Pra-basin and is far above the current utilization. On an annual basis, utilisation of the surface water resources through abstractions for urban piped schemes presently amounts to just over 1% of the mean annual runoff[2] of the Pra Basin. Groundwater abstraction for the schemes amounts to less than 0.03% of the mean annual basin recharge. However, there is insufficient raw water quantity throughout the year at the Kakum and Anakwari River basins which provide water supply to the Brimsu and Inchaban Water Treatment Plants respectively. The Brimsu reservoir on the Kakum Basin sometimes dries up due to the late start of the rains and limited reservoir storage capacity forcing the plant to be shut down. A new water treatment plant on the Pra River at Sekyere-Hemang (30,000m^3/day) was constructed to augment the supply from Brimsu to meet the demands of the service area.

Water quality tests sampled along the Pra Basin falls within the class II category, which represents fairly clean water. There is however a steady deterioration of the raw water quality as turbidity, colour and pH values are gradually reaching unacceptable levels and

[1] This used to be termed payments. However, they are now referred to as Investments in Watershed Services because they don't always take the form of cash payments and in many countries the term 'payments' implies a transfer of certain water rights (which may not be intended).

[2] If the base flow figure was available, it would be revealing to know how this utilization compares with the base flow at its lowest point during the dry season. However, this information was not available.

the treatment cost for raw water is increasing[3]. High values of colour and turbidity bring about increase in coagulant chemical usage and the associated cost of water treatment. Operational loss hours also result when the poor quality levels are too high to be handled by the Treatment Plants. At the Barikese reservoir within the Pra-basin the water quality was within the Class III category which represents "poor" water quality. This was attributed partly to low dissolved oxygen content, a condition which discourages any form of aquatic life in the water body.

Pollution of the raw water through illegal artisanal gold mining was identified as the topmost threat to the basins. The government of Ghana has established an Inter-Ministerial Committee to address the problems of illegal artisanal gold mining. Other unsustainable land use practices that pollute raw water include farming, fishing, timber logging, bush burning and waste disposal among others. Riparian areas of the Pra basin which provide critical protection for surface water quality are perceived to contain gold deposits; these are preferred zones for cropping because of easy access to water for irrigation. The lack of enforcement of laws governing illegal activities, non-deterrent punitive measures, and inadequate coordination and collaboration among institutions are some of the underlying causes.

Though the Pra basin is extensively mapped, available maps are static and generated from isolated databases which make it practically impossible to overlay them and to make meaningful deductions. In comparison, maps on the Kakum basin are scanty.

The WRC works with and through allied government institutions for the fulfilment of its mandate, particularly at the grassroots, but the reality is that the WRC currently does not cover all the sub-basins of the Pra and Kakum rivers. Further, it only has skeletal staff manning its offices at the sub-basins levels where it has a presence. Funding is a constraint for all the government institutions involved in managing the basins even though some of them are allowed to raise additional funds. Social networking, political patronage, lack of environmental awareness among the Ghanaian public, and weak enforcement of environmental laws and regulations were identified as barriers to effective management and conservation of the Pra and Kakum basins by the institutions mandated to do so.

IWS is already being explored by the WRC as an option and is practised by its Water Management Account which is partially resourced from Water Use Permit levies. Internally generated funds by the WRC for managing the water resources of the country are given in Appendix 4 and totalled seven hundred and ninety four thousand (Gh₵ 794,000) Ghana Cedis in 2012 (approximately US$ 417,895). The operation of the account has resulted in the protection of the White Volta and Densu River basins, and in theory could be expanded to include the Pra and Kakum River basins.

The study concludes that the Business As Usual (BAU) scenario is not satisfactory. It is very clear that water quality in the two basins is deteriorating due to problematic and often times illegal land use practices. In particular, the study shows a significant reduction in water quality in 2011 and 2012, which can be attributed to the recent upsurge in illegal mining operations within the basin. The study also found that in the

[3] GWCL/GUWL keeps record of each treatment plant down time due to various reasons including power failure, poor raw water quality, insufficient raw water quantity and maintenance. Analysis of these will determine the cost for each cause and should be considered as a critical next step for the Technical Working Group.

Odaso sub-basin, water pollution during this same time period (and due to the same causes) has reduced treatment plant operations by 87.5% from 4 mgd to 0.5 mgd.

In the Kakum basin, water quantity appears to be insufficient, though it is not well understood why. Data collected for this report did not suggest that this was the case for the Pra, but a study conducted by the Water Research Institute (WRI) found that the Pra River basin is already water stressed, and modelling for 2020 and 2050 indicate that the situation will continue to worsen (to water scarcity and extreme scarcity) by these future dates. Climate change and population growth further exacerbate the baseline projections. Overall, it is clear that if nothing is done to address these issues and change the business as usual (BAU) scenario, then we can expect that:

1) the quality of water will continue to decline to even worse levels,

2) the cost of water production will continue to increase,

3) water scarcity may emerge and worsen, and

4) the ability to meet the growing urban water demand will diminish.

Ghana has the opportunity to describe a "desirable state" for these two watersheds. It will then be necessary to identify the key steps to achieving this desired state and following and all of the necessary steps to achieving it. If no action is taken to stop or reduce the current levels of pollution of the water bodies, then the resulting poor quality raw water may be very difficult or too expensive to treat to ensure a safe and sustainable water supply in the next 10 to 20 years. There is an immediate need to address unsustainable land use practices. Critical next steps include: 1) an assessment of riparian zones within the basins so as to ascertain current riparian uses and their implications; 2) identification and prioritization of critical areas that need restoration and protection; 3) inform sharing with "managers" about how to manage the conflicting motivations driving the degradation of these areas, and 4) community based watershed restoration partnerships should be considered for both basins. Furthermore, all Metropolitan, Municipal and District Assemblies and relevant institutions working in the watersheds should be adequately staffed and resourced to carry out their mandates. At present they are not.

Chapter 1 General Information

1.1 Introduction and Background

The Millennium Ecosystem Assessment and more recently The Economics of Ecosystems and Biodiversity (TEEB) studies has demonstrated that many freshwater systems, estuaries and coastal ecosystems around the world are in crisis caused mainly from the effects of human activities and primarily as a result of pollution as well as dramatic changes to the landscape. Crisis also looms over the availability and flow of freshwater in nearly every corner of the globe putting stress on these intricate ecosystems at their upstream origins meanwhile having untold impact on the downstream estuaries, coastal and marine ecosystems and the users that rely on those resources. The good news is that if addressed in time, these bodies of water can bounce back from their degraded and dewatered state. However, while there has been a tremendous effort to identify the causes of decline in water quality and quantity and the practices necessary for their restoration, only recently have public officials paid more significant attention to developing and establishing the scientific, financial and political tools necessary for achieving success.

The use of markets and market-like mechanisms to conserve, pay and create appreciable value for ecosystem services is a rapidly growing global trend practiced and promoted by environmentalists, community and business leaders, regulators, government practitioners and financiers alike. As documented in the 2010 report on the *State of Watershed Payments* some $9.3 billion was transacted through 288 payments for watershed services (PWS) programs worldwide. The PWS marketplace is the second largest ecosystem market after carbon and before biodiversity as researched by Forest Trends Ecosystem Marketplace.

The Nature Conservation Research Centre (NCRC) and its international partner, Forest Trends, have secured international funds to support exploratory work on Investment in Watershed Services (IWS) in several countries. The global project is entitled "Scaling Up Investment for Ecosystem Services to Meet the Global Water Crisis" and Ghana is one of the countries included in the project. A prerequisite of the Ghana component of the project is to assemble the requisite information and undertake the Business As Usual (BAU) scenario analysis for the Pra and Kakum River Basins, on which Sekondi-Takoradi and Cape Coast-Elmina potable water systems are based.

These water systems are located in an accelerated development zone in Ghana due to the rapidly evolving off-shore oil and gas industry and are already facing significant environmental, investment and water demand challenges. This offers a huge opportunity to develop an Investment in Watershed Services (IWS) initiative which would address some of these challenges. To date the project has carried out several steps including the following:

- Selection of the Pra and Kakum River basins as key target watersheds to focus the project.
- Consultant Report entitled "Independent Assessment of the Potential to Design Payments for Watershed Services under the Sekondi-Takoradi Metropolitan Area and Cape Coast-Elmina Metropolitan Area Water Systems."

- Consensus Report of the Technical Working Group entitled "Outlining the case to support Payments for Watershed Services in the Pra & Kakum River basins: improving Water Quality and Water Supply to the Sekondi-Takoradi and Cape Coast-Elmina Metropolitan Areas."

- On-going Remote Sensing Study by Oxford University Centre for Tropical Forestry entitled "An Exploration of the Relationship between Forest Cover and Rainfall Generation in the Forests of Southwest Ghana as Part of the Potential to Design Payments for Watershed Services for Kakum and Pra Watersheds in Ghana."

- Establishment of a Technical Working Group, chaired by the WRC, to provide the requisite oversight to the project.

1.2 Watersheds Services

A watershed is a drainage basin or a catchment area that is capable of delivering a wide range of services that contribute to human well-being. These include provisioning services (such as food, fish, fibre, water supply and water purification), regulating services (such as regulation of floods, drought, land degradation, disease, and coastal protection), and supporting services (such as soil formation and nutrient cycling). Watersheds also provide cultural services as a result of their recreational, spiritual, and religious as well as tourism and other nonmaterial benefits to the society.

Population growth and increasing economic development indirectly degrade watersheds and impair the services they provide. The primary direct drivers of watershed degradation and the resulting impairment or loss of the services they provide include infrastructure development, land conversion, water withdrawal, eutrophication and pollution, overharvesting and overexploitation, and the introduction of invasive alien species (MA, 2005). Physical and economic water scarcity and limited or reduced access to water are major challenges facing society and are key factors limiting economic development in Africa in general and Ghana in particular. However, many water resource developments undertaken to increase access to water need to give adequate consideration to harmful trade-offs with other services provided by watersheds.

Watersheds may be made up of sub-watersheds and within a sub-watershed are the stream segment management units. This is the basic watershed unit. The increasing stress on the water resources in Ghana as a result of increased exploitation of watersheds means that extensive and sustained management efforts (such as tree planting, stream channel clearance, clean-up exercises and other catchment rehabilitation interventions) are necessary to maintain or improve critical watershed services. IWS provides a unique opportunity for users and stakeholders alike to appreciate the economic value of watersheds, and be a source of funding for the necessary management interventions. It is important to note that the foregoing management efforts could be effective only when a good deal of awareness creation, education and training is established to warrant understanding, ownership and attitudinal change towards effective watershed management.

Table 1 elaborates on examples of watershed services that pertain within the Kakum and Pra watersheds:

Table 1: Watershed Services and Example

Watershed Service	Description	Examples
Gas regulation	Regulation of atmospheric chemical composition	CO_2/O_2 balance, O_3 for UVB protection, SOx levels.
Climate regulation	Regulation of global/watershed temperature, precipitation and other climatic processes	Greenhouse gas regulation.
Disturbance regulation	Storage, damping and other responses to environmental fluctuations	Storm protection, flood control, drought recovery and other habitat responses, mainly controlled by vegetation structure and landforms
Water regulation	Regulation of hydrological flows, flood mitigation	Water for agriculture, industry, transportation or power generation
Water supply	Storage and retention of water, groundwater recharge/discharge, water cleansing	Storage of water in watersheds, reservoirs and aquifers
Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of soil loss by wind, runoff or other processes, storage of silt in lakes, wetlands, shoreline stabilization
Soil formation	Soil formation processes	Weathering of rock and the accumulation of organic material
Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen Fixation, N, P and other elemental or nutrient cycles
Waste treatment	Recovery of nutrients and removal or breakdown of excess nutrients and compounds	Waste treatment, pollution control, and detoxification.
Pollination	Fertilization of flowers	Providing pollinators for the reproduction of plant populations
Biological control	Population regulation	Predator control; reduction of herbivores
Refugia	Habitat for resident and transient populations of animals.	Nurseries, migration habitat, over wintering grounds.
Food production	Production useable as food	Fish, game, crops, nuts and fruits
Raw materials	Production useable as raw materials	Lumber, fuel, fodder, minerals, etc.
Genetic resources	Sources of unique biological materials and products	Medicine, products for materials science, resistant genes/strains, ornamental species
Recreation	Opportunities for recreational activities	Eco-tourism, sport fishing, hunting, hiking, and camping

Cultural	Non-commercial uses	Aesthetic, artistic, educational, spiritual, scientific

Source: Costanza *et al.* (1997) with modifications

The citations in Table 1, points to the fact that a great deal of economic goods and services are derived from watersheds and therefore their conservation or protection is inevitable the world over. These ecosystem services are often overlooked or assumed to be available as development decisions are made thus jeopardising the attainment of development goals. On a global scale, the Millennium Ecosystem Assessment (MA, 2005) lays out four main findings (see Box 1).

Box 1: Main Findings of the Millennium Ecosystem Assessment

Humans have radically altered ecosystems in just 50 years

In the last half of the 20th century, humans changed ecosystems more rapidly and extensively than in any comparable period of history, primarily to meet growing needs for food, freshwater, timber, fiber, and fuel. Almost one third of global land is now under cultivation (MA 2005a:32). One result is that more than half of the synthetic nitrogen fertilizer ever used on the planet has been applied to crops in the past two decades (Green et al. 2004). As much as 50 percent of this is lost, contributing to rapidly rising nitrate concentrations in rivers, lakes, and coastal areas and creating dead zones where no living organisms are found (Welch and Graham 1999). An increase in atmospheric carbon dioxide concentration by one third since 1750, two thirds of which occurred since 1959, has great potential to alter natural systems through climate change (MA 2005a:13–14).

Ecosystem change has brought gains in human well-being, but at high costs to natural capital

Ecosystem changes have resulted in significant benefits to humans, including improvements in health and a reduction in the proportion of malnourished people. However, these gains have come at an increasing cost. The Assessment's findings indicate that increases in provisioning services that have a market price have inadvertently degraded other ecosystem services. These degraded services are often regulating services, such as water filtration, coastal protection, and erosion control, that have no value in the marketplace until they are lost.

Further unsustainable practices will threaten development goals

Ecosystem degradation, greater risk of ecosystem collapse, and exacerbation of poverty, particularly among the resource-dependent poor, are all affected by the choice of development strategies. If these problems continue unchecked, they will undermine the gains in human well-being. The Assessment concluded that degradation of ecosystems presents a significant barrier to achieving development goals worldwide. Rural poverty and ecosystem degradation, for example, often go hand in hand.

Workable solutions exist, but require major policy changes

It will be a significant challenge to reverse ecosystem degradation while meeting the demands of a growing population and economy, but options do exist. The Assessment found that major changes in policies, institutions, and practices, although on a scale well beyond anything under way at present, can reduce some of the negative effects of rising consumption of ecosystem services as well as provide improvements in human well-being.

1.3 Objectives of the Study

The purpose of this study is to determine the BAU scenario of the Pra and Kakum River basins and provides an analysis of the state of critical ecosystems and watershed services, the threats that impair watershed services and their underlying causes as well as the barriers hindering effective delivery of roles and functions of governmental agencies engaged in upstream watershed management and downstream distribution and supply of water. The report outlines the extent of investment in watershed services schemes that are currently being tested among some key stakeholders and further establishes the pre-conditions for successful implementation of river basin management practices within Ghana.

The specific objectives of the assignment are:

1. To determine the current status (BAU scenario) of the watershed systems of the Pra and Kakum Rivers taking account of the roles and responsibilities of governmental agencies/institutions at district, regional and national levels engaged in upstream watershed management and downstream distribution and supply of water;

2. To determine the ecosystem values critical for the sustainable watershed services of the Pra and Kakum River Basins.

3. To determine the human activities/land uses that are critically impacting on the Pra and Kakum watersheds and impairing their services;

4. To determine the pre-conditions for successful implementation of river basin management practices within Ghana using the Pra and Kakum River Basins as pilot;

1.4 Scope of Works

The study involved a BAU scenario information gathering mission, analysis of conditions in the main sub-basin of the Pra and Kakum River basins, and consultations with stakeholder institutions within the two river basins.

The consulting team undertook the following activities:

- Assessment of water quality and flow at the sub-basin level, including threats to the basins at the sub levels;
- Identification and analysis of human activities impacting on the two river basins;
- A review of existing body of maps covering the targeted watersheds in the possession of the Water Resources Commission (WRC) and other relevant agencies so as to determine adequacy and currency of existing mapping;
- Analysis of current operations of the WRC Water Management Account and determined their appropriateness for IWS purposes;
- Documentation of complimentary and/or overlapping initiatives in the target watersheds;
- Determination of the barriers hindering effective delivery of roles and functions of governmental agencies/institutions at district, regional and national levels engaged in upstream watershed management and downstream distribution and supply of water;
- Analysis of the pre-conditions for successful implementation of river basin management practices within Ghana drawing from the IWRM experiences of River Densu and the White Volta;

1.5 Methodology

The assessment was conducted in three steps. A set of activities were completed in each step. Rather than collecting primary data on the different issues examined, this work relied on secondary data, and on in-depth consultations with experts and managers of relevant institutions working in the two basins.

1.5.1 Desk Study

A review of literature on several aspects of the river basins including water quality and flow, human activities and land uses impacting negatively on the target watersheds, roles and functions of governmental agencies/institutions;, critical ecosystems and services, etc. at the sub-basin level of the two basins was completed.

The Protected Areas database of the Resource Management Support Centre (RMSC) of the Forestry Commission (FC) was consulted for a list of protected areas in the basins. This together with information obtained from published sources (journal, expert communications) and non-published sources (management plans, and several technical reports) were consulted.

1.5.2 Consultations

Institutions and experts (with an interest in and working knowledge of the assessment areas or of other relevant issues) were consulted (Appendix 1). Consultations were held with officials of key stakeholders within the two river basins in Ashanti, Eastern, Western and Central Regions. These stakeholders included, but were not limited to: Ghana Water Company Ltd (GWCL), Ghana Urban Water Ltd (GUWL), Water Resources Commission and Environmental Protection Agency[4]. Officials of NGOs, the Wildlife Division (WD), and the Forestry Services Division (FSD) were also consulted. They provided insight on the various issues examined, and enabled the team to identify the various complementary interventions in the basins (Appendix 7).

1.5.3 Direct Assessment

The consultants made direct observations (at the sub-basin level) during field visits to areas within the catchment (upstream, middle and downstream) to evaluate the current land use practices, interact with key informants, grassroots stakeholders and identify their potential needs under any river basin management scheme.

Figure 1: Stakeholder Consultation at Owabi Wildlife Sanctuary

[4] Water Research Institute (WRI) of the CSIR should have been consulted as it has come to our notice that they conducted a Soil and Water Assessment Tool (SWAT) analysis of the Pra River Basin. It would be appropriate to involve them in future related studies.

1.6 Challenges Encountered During the Study

Consultations were held with officials of key stakeholders within the two river basins in Ashanti, Eastern, Western and Central Regions. Meetings were held with those the consultants opined had a major role to play in the management of the river basins and therefore the implementation of an IWS scheme in the selected areas. The team spent twelve (12) days in total for the field visits, which took it to the upper, middle and lower parts of the basins for consultations and direct observations. However, due to the vast nature of the basins, only sample sites were visited including Kumasi, Owabi, Barikese, Dunkwa-on-Offin, Twifo Praso, Kakum and Daboase (as shown in Figure 2).

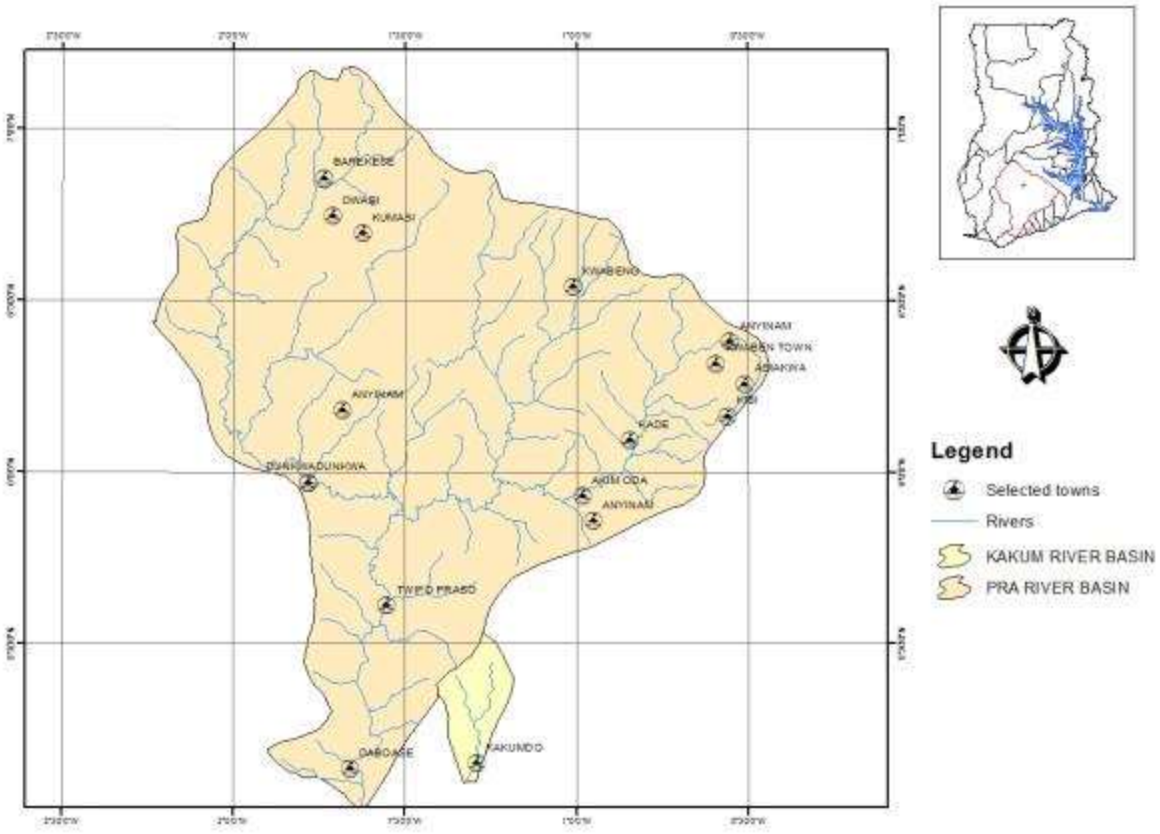


Figure 2: Sites Visited in the Pra and Kakum River Basins

With respect to sub-basin level data, the team was unable to get adequate raw water data covering a reasonable period of time. Even where data was available, there were many gaps and sometimes conflicting figures in what was provided.

1.7 Acknowledgements

The consulting team wishes to acknowledge the immense contributions of the Western and Central regional offices of the Ghana Urban Water Ltd towards the success of the field visits. Many thanks also go to WRC, FSD and WD for their valuable inputs.

Chapter 2 Water Quality and Quantity (Flow)

2.1 Water Resources of the Pra and Kakum River Basins

This section of the report provides a brief description of the two river basins and discusses some of the watershed services of the basins and the critical ecosystems of the basin.

2.1.1 The Pra River Basin

The Pra River Basin is located between Latitudes 5^0 N and 7^0 30' N, and Longitudes 2^0 30' W, and 0^0 30' W, in south-central Ghana. The Pra River, together with its tributaries, forms the largest river basin of the three principal south-western basins systems of Ghana (i.e. Ankobra, Tano and Pra). Its total basin area of approximately 23,188 km² extends through almost 55% of Ashanti, 23% of Eastern, 15% of Central and 7% Western Regions (see Fig. 3).

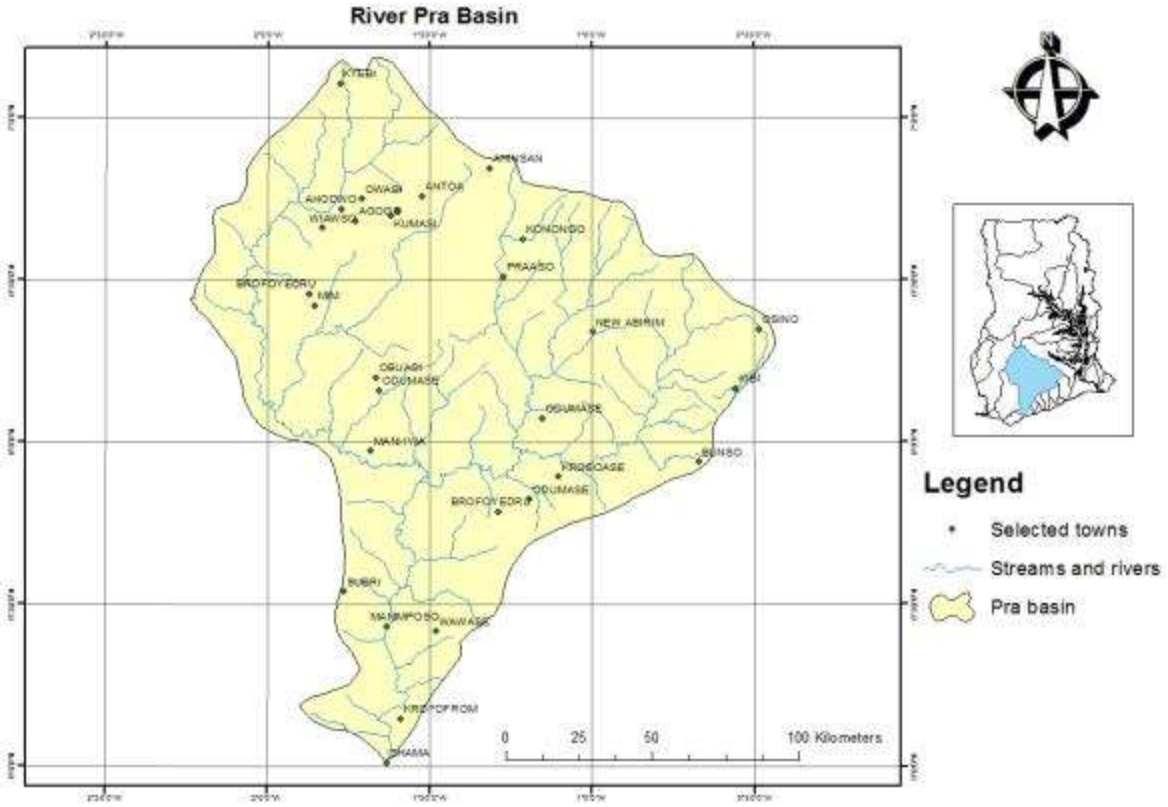


Figure 3: Pra River Basin

The topography of the Pra basin ranges between sea level and an elevation of 800m above mean sea level. The highest elevations in the area are located in the northern sections and the fringes of the eastern parts of the basin where elevations of up to 800m above sea level are common (Fig. 4). The southern sections are relatively flat to slightly undulating, although there are a few peaks in the central regions. The nature and orientation of the "highlands" determine the direction of the general drainage network in the entire basin.

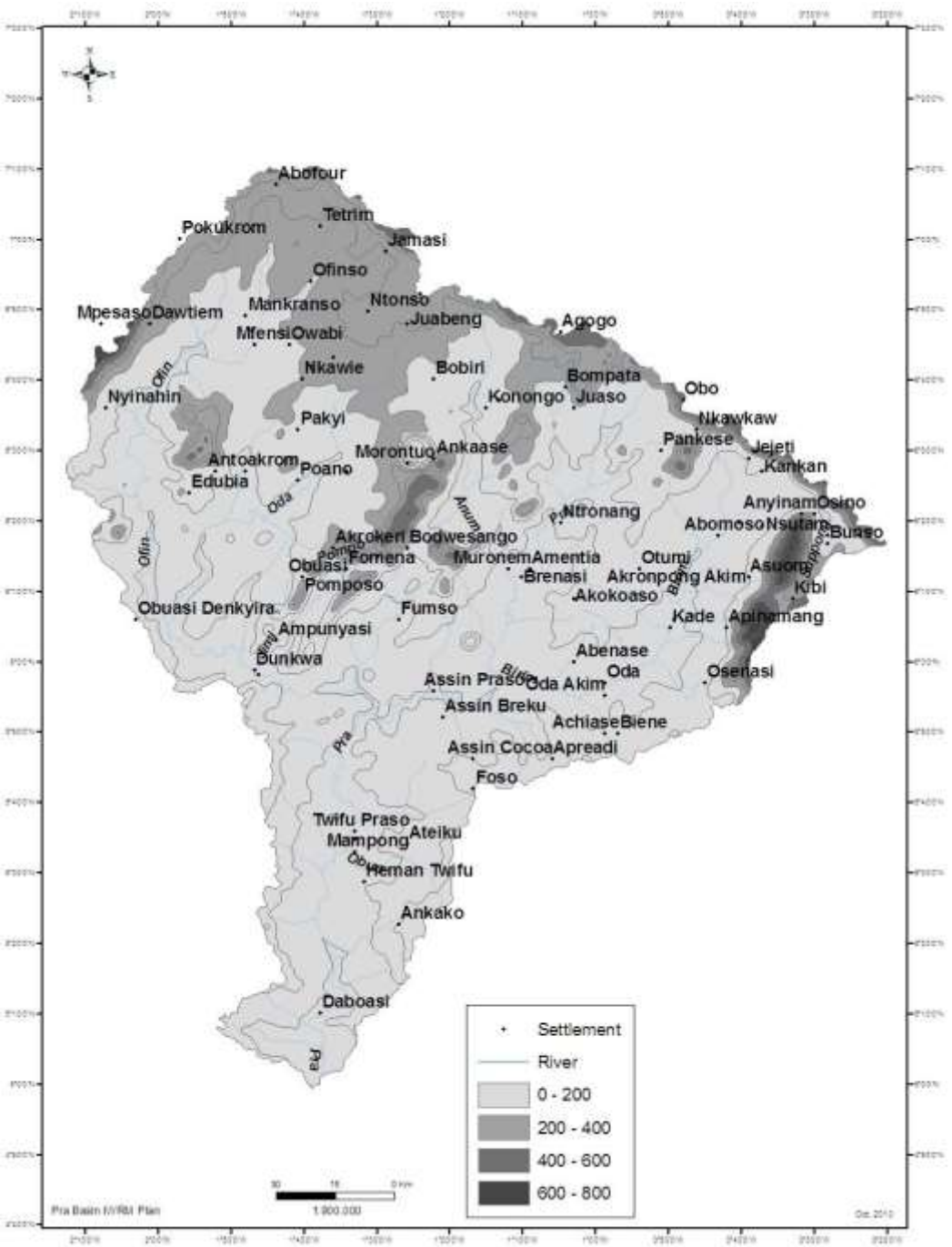


Figure 4: The Topographical Map of the Pra Basin

The Pra River and its major tributaries (Rivers Anum, Birim, Offin and Oda), originate from the eastern and north-western fringes and flows southwards. The Pra River takes its source from the hills of the Kwahu Plateau in the Eastern Region and flows for some 240km before entering the Gulf of Guinea near Shama in the Western Region. Additionally, the river network includes Lake Bosumtwi, the only significant natural freshwater lake in Ghana which is a large crater lake with a maximum depth of nearly 80m and a rim diameter of about 8km across. The catchment area of the lake is about 106 km^2, of which the lake occupies 52km^2. It is situated about 30 km south-east of Kumasi and is a popular tourist facility.

Approximately 70 per cent of the original forest area of the Pra basin has either been converted to agricultural land or to human settlements over the last 50 years. Currently, the main land cover types are estimated as follows; agriculture (60%), forest (30%), grassland and human settlement cover 10% (WRC, 2012)[5]. An assemblage of forest reserves (e.g. Atewa Forest Reserve) and large established commercial tree plantations contribute to the share of the remaining forest (see Fig. 26), which ultimately has implications for watershed services offered by the basin**.**

The available surface water resources originate from rainfall. The basin as a whole receives an average annual rainfall of about 1,500 mm or 34,786 million m^3, and the Pra River carries an average annual runoff of about 4,174 Mm^3. About 12% of the mean annual rainfall in the basin contributes to the flow of the Pra (see Table 2). The main consumptive uses of water in the basin are for domestic, industrial/mining and agricultural (irrigation) purposes.

Table 2: Water Resources Utilization of Pra Basin

Category	**Mm^3/year**	**%**
Available Runoff	4,174	
Recharge to groundwater (volume)	5,566	
Water Resources Use		
-Urban Water Supply	42.3	1
-Rural Water Supply	31.7	0.8
-Irrigation	17.4	0.4
Livestock	3.0	0.07
-Industry (not served by urban piped schemes	49.2	1.2
Total water use for Pra basin	**143.6**	**3.4**

Source*: Pra River Basin IWRM Plan (WRC 2012a)*

In the Pra River Basin Integrated Water Resources Management (IWRM) Plan, the water (hydrological) balance representing a full year of the Pra Basin as a whole as given in Table 3 has been calculated based on the following criteria:

- Monthly data series used;
- Average basin rainfall based on rainfall distribution (Fig. 4) weighted according to areas between isohyets;
- Actual evapo-transpiration estimated as the unknown water balance element;
- Average groundwater recharge rate estimated at 16% of rainfall;
- Basin runoff computed as 12% of rainfall (relating the mean annual flow at the Twifo Praso gauging station from available flow records for the periods 1991-1995 and 2001 - 2007 with the mean annual basin rainfall); and
- Contribution from groundwater to river flow (base-flow) and vice-versa not known and, therefore, ignored.

The Daboase WTP has an abstraction rate of 9,960,120m^3/yr for domestic purposes. It is estimated that on the average 45% and 47% of households in the Central and Western Regions respectively have access to potable water (wells not included).

The Water Resources Commission (WRC) grants water use permits in Ghana and charges administrative and processing fees as shown in Tables 10 and 11. It has granted water

[5] Were data available, it would be useful to chart water quality and/or base flows over this same period of time and shown graphically.

use permits to GWCL/GUWL and Ghana Irrigation Development Authority (GIDA) to abstract various amounts of surface water for their purposes. For the GIDA, the combined annual water abstraction permitted for these schemes in 2010 is 17.4 million m^3 or a daily abstraction of 47,671 m^3. Records of water use permits granted by the WRC for mining and other industrial uses in the basin show a total 49.2 million m^3/year for both surface water and groundwater. The existing utilisation (abstraction) of the water resources of the Pra Basin is given in Table 2.

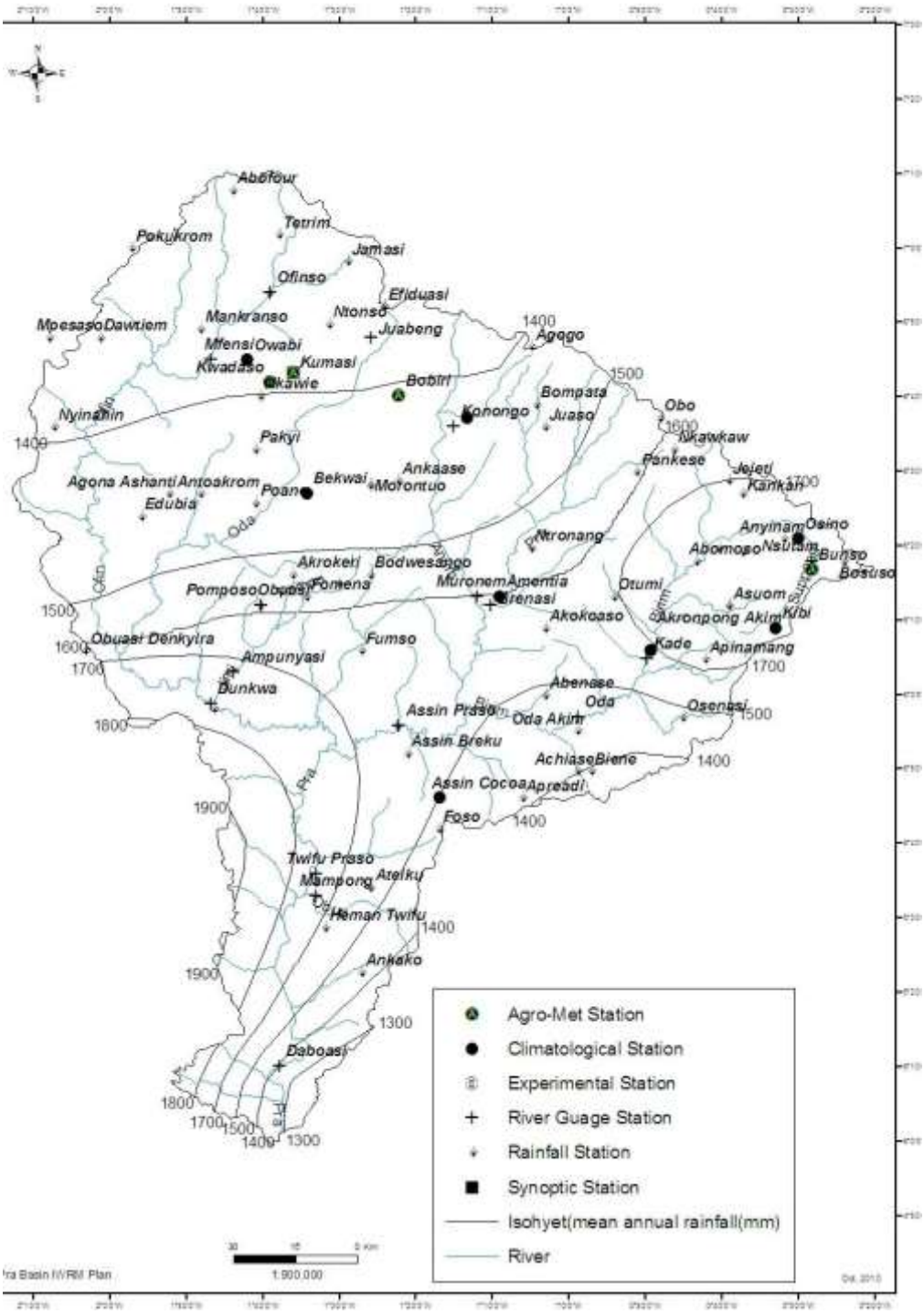


Figure 5: A Hydrometric Map of the Pra Basin

Source: *Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report*

Table 3: Annual Water Balance for Pra Basin

Water balance component	Annual amount	In percent of rainfall
Rainfall	1,504mm	
Actual evapo-transpiration	1,083 mm	
Pra Basin area	23,129 km2	
Rainfall over basin (volume)	34,786 million m3	100 %
Actual evapo-transpiration (volume)	25,046 million m3	72%
Recharge to groundwater (volume)	5,566 million m3	16 %
Surface water runoff (total for basin)	4,174 million m3	12%

Source: Pra River Basin IWRM Plan (WRC 2012a)

Table 4: Mean Annual Flow Volume of Pra River System

River/locality	Area of sub-basin (km2)6	Mean annual runoff (million m3)
Offinso	674	122
Mfensi	1,638	295
Bekwai sub-basin	958	173
Anwia Nkwanta sub-basin	1,303	235
Adiembra sub-basin	3,124	564
Dunkwa/Adwumaim sub-basin	8,345	1,505
Konongo sub-basin	681	123
Muronem sub-basin	2,189	395
Pra at Brenase	2,069	373
Bunso sub-basin	150	27
Kade sub-basin	2,209	399
Akim Oda sub-basin	3,248	586
Pra at Assin Praso	9,793	1,767
Pra at Twifo Praso	20,761	3,745
Twifo Mampong sub-basin	378	68
Total Pra basin	23,129	4,174

Source: *Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report*

Information from the WRC show that for 2010 permits have been granted to GWCL for a total water abstraction of 115,847 m3/day from the Pra Basin for Urban water supply. The GWCL water supply schemes are listed in Table 5, including information about source, intake and granted abstraction rates. The water supplied is used for domestic, industrial, commercial and institutional purposes.

Comparing the figures in Table 2 and Table 5, it can be concluded that on an annual basis, utilisation of the surface water resources through abstractions for urban piped schemes presently amounts to just over 1% of the mean annual runoff of the Pra Basin. The groundwater abstraction for the schemes amounts to less than 0.03% of the mean annual basin recharge. If all the available surface and groundwater water resources

(9,740Mm^3) are mobilised, then 2,329m^3/cap/year is available for use. Based on this data, the basin is presently not water stressed.

Research conducted by WRI (Obuobie et al 2012) comes to a different conclusion, finding that water flow is expected to reduce by 46% in the Pra River Basin through 2050[6]. Using the Falkenmark indicator of water vulnerability, with ECHAM4 and CSIRO climate models and the "Soil and Water Assessment Tool" (SWAT) model and They argue that considering the most optimistic conditions with 90% of the available freshwater in the basin mobilized (leaving 10& to environmental flow), the Pra Basin is already experiencing conditions of water stress (1,160 m³ per capita per year) and expected to worsen to water scarcity (681 m³ per capita per year) by 2020 and to hit absolute scarcity by 2050 (306 m³ per capita per year) without climate change or population growth considerations. When climate change is added to the analysis, the condition is expected to amplify to 529 m³ by 2020 and 165 m³ by 2050 (Obuobie et al 2012). However, when compared to the effect of population growth, the results indicate that an increasing population is by far the bigger threat to water availabitlity in both 2020 and 2050.

Table 5: Piped Urban Water Supply within Pra Basin

No.	District water supply scheme	Source	Intake	Abstraction					
				Surface water		Groundwater		Total	
				m3/day	million m3/yr	m3/day	million m3/yr	m3/day	million m3/yr
1	Amansie West	G"water + River	pump	136.99	0.050	569.86	0.208	706.85	0.258
2	Asante Akim North	River	Dam Dam	Dam Dam	1,324.24	0.483	1,324.24	0.483	
3	Atiwa	River			408.45	0.149	408.45	0.149 29.164	0.003
4	Atwima Nwabiagya	River			79,901.46	29.164	79,901.46		
5	Birim North	River			8.18	0.003	8.18		
6	Birim South	G"water + River	Pump+Dam	44.43	0.016	139.22	0.051	183.66	0.067
7	East Akim municipal*	River	Dam	Dam	1,493.01	0.545	1,493.01	0.545	0.142
8	Fanteakwa	River			389.42	0.142	389.42		
9	Kwaebibirem	G"water + River	Pump+Dam	216.00	0.079	321.97	0.118	537.97	0.196
10	Kwahu West Municipal	G"water	Pump	-	630.40	0.230	630.40	0.230	7.724
11	Mpohor Wassa East	River	Dam	21,160.57	7.724	-	21,160.57		
12	Obuasi Municipal	G"water + River	Pump+Dam	5,360.57	1.957	1,344.00	0.491	6,704.57	2.447
13	Sekyere East	G"water	Pump	-	312.62	0.114	312.62	0.114 0.561	0.003 0.074
14	Sekyere West	River	Dam	1,537.74	0.561	-	1,537.74		
15	Shama Ahanta East	River	Dam	7.96	0.003	-	7.96		
16	Suhum/Kraboa /Coaltar	G"water	Pump	-	201.41	0.074	201.41		
17	West Akim	G"water	Pump+Da	261.49	0.095	76.66	0.028	338.15	0.123

[6] In view of this contradiction, further studies on water security of the Pra Basin and collaboration between WRC and WRI needs to be done.

		+ River	m						
	Total for the basin			112,250.52	**40.971**	3,596.15	**1.313**	115,846.67	**42.284**

** 8,679 m3/yr abstraction from River Densu*

Adapted from Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report, December 2010

However, observers to the Daboase Intake site especially in the dry season may note de-silting works and insufficient raw water being abstracted making it appear that the raw water is inadequate. The reality is that in the dry season illegal miners also create coffer dams/dykes within the river bed which restrict the water flow to the intake point, otherwise the assertion that the Pra Basin is not water stressed is true (see Table 4). The dykes not only restrict water flow, but also diverted the water flow away from the intake points. Consequently, this results in an inadequate quantity of water being available for abstraction since the system is a run-off river scheme.

As mentioned earlier, it was estimated that the installed capacity of the Cape Coast-Elmina water supply system of Brimsu (29,500m^3/day from the old and new plants) and new water treatment plant at Sekyere-Hemang (30,000m^3/day) will be sufficient to meet the demands of the service area of projected population of 532,945 up to the year 2025. The total production capacity from the combined sources is 59,500m^3/day (29,500m^3/day+30,000m^3/day).

2.1.2 The Kakum River Basin

The Kakum Basin lies within the Kakum National Park and Assin Attandanso Resource Reserve which lie between longitudes 1°51' and 1°30’ W and latitudes 5°20' and 5°40'N. Kakum National Park and Assin Attandanso Resource Reserve each cover about 210 km^2 and 150 km^2 respectively. The Kakum National Park is generally flat with only a few undulating hills ranging between 150-250m above sea level. Most of the hills occur in the south-western portion rising up to 250m. The Assin Attandanso Resource Reserve on the other hand is generally flat with hills ranging from 120-150 m above sea level.

The Kakum River feeds the Brimsu Water supply system with raw water by a dam to store the water. The major drainage of the Kakum Conservation Area consists of the Kakum, Nemini, and Nchemna Rivers which flow out to the south-east towards the sea and Obuo, Sukuma, Panim Bosumfuo and Afia rivers flowing to the west into the Pra River. Other rivers include Ajuesu and Aduasu to the East and Benebe, Aboabo, Ongwa and Abogbo to the North (see Fig. 6). The Pra Basin and the Kakum River Basin lie adjacent to one another (Fig. 39).

Figure 6: Location Map of the Kakum River Basin

The basin consists of typically moist evergreen forest and has a characteristic rainfall pattern. The area experiences a two-peak rainy season. The major peak is between May to July and the minor falling between September to December, separated by a short dry period in August. The wet season is followed by a long dry season from January to April during which most streams dry up and rivers break into pools. The mean annual rainfall is between 1,500mm and 1,750mm. The prevailing winds are south-westerly and are generally light. The average relative humidity is about 85% with temperatures fluctuating between 10.2°c and 31.6°c (Kakum Management Plan-1996).

2.2 Water Availability and Treatment

Water is available on this earth in various forms or states. The path of the changes of water from one state to another is known as the ***hydrologic cycle***. The movement of water from the sea to the atmosphere *(**evaporation**),* and by ***precipitation*** to the land, where it flows back to the sea *(**run-off**)* is influenced by many factors, such as weather, land forms or land surface, nature of the ground surface, inclination of the surface, the rainfall and climate, the vegetation and the quantity of water already in the ground. Water in its natural state is called ***raw water***. Water is essential for the sustenance of

life and the use to which water can be put depends on the type of water, its quality and quantity and its spatial and temporal distribution.

Water from the Pra and Kakum River basins is used as a public water supply. The requirements of a public water supply demand that the water shall:

1. Contain no disease causing organisms.
2. Be sparkling clear and colourless.
3. Be good tasting, free from odours and preferably cool.
4. Be reasonably soft.
5. Neither be scale forming nor corrosive.
6. Be free from objectionable gas, such as hydrogen sulphide and objectionable minerals, such as iron and manganese.
7. Be plentiful and produced at a low cost. (Adombire, 2007)

Therefore raw water from Pra and Kakum has to be treated to meet the above requirements. Deteriorating vegetative cover and artisanal mining activities upstream increase the need (and cost) of water treatment, or that improvements in land management practices can reduce water treatment needs/costs. Therefore, "green infrastructure" can complement "gray infrastructure" (engineered civil works) to meet water quality and flow criteria. If this relationship can be quantified, a baseline status or trend in the BAU regarding costs for GWCL, GUWL, and other stakeholders in the absence of improvements upstream can be established.

A number of the water treatment plants owned by Ghana Water Company Limited are located within the two river basins (see Table 6). These include Barikese, Owabi, Konongo, and Obuasi water treatment plants (Upper Pra-basin in Ashanti Region), the Dunkwa-on-Offin, Anyinam, Bunso, Kibi, Kwabeng, Akim Oda, Akim Ofoase, Osenase and Osino water treatment plans (Mid Pra basin in the Central and Eastern Regions), and the Inchaban and Daboase (Lower Pra basin in Western Region) and Brimsu (the Kakum basin in the Central Region).

Table 6: Water Treatment Plants on the Pra and Kakum Basins

No	River Basin	Basin Section	Region	Treatment Plant
1	Pra	Upper-Pra	Ashanti	Barikese
2				Owabi
3				Konongo
4				Obuasi
5	Pra	Mid-Pra	Eastern	Anyinam
6				Bunso
7				Kibi
8				Kwabeng
9				Akim Oda
10				Akim Ofoase
11				Osenase
12				Osino
13			Central	Dunkwa-on-Offin
14	Pra	Lower-Pra	Central	Twifo Hemang
15			Western	Daboase
16	Anakwari	Anakwari	Western	Inchaban

17	Kakum	Kakum	Central	Brimsu

These treatment plants were situated and designed based on the raw water quality at their time of construction and projected quantity. For example, Brimsu was built in 1927. However, over the years, the raw water quality has deteriorated making it difficult to achieve the desired quality of treated water (in terms of treatment costs and each plant's capability to meet quality requirements). In some instances, raw water quantity has reduced to the extent that treatment plants were forced to shut down, or production quantities were reduced below demand or plant capacity. The periods of plant shut downs, the resulting lost production and costs can be obtained from the records of GWCL at the various plants. The following sections analyse the available raw water quality and flow data over the period. No data was available on actual water production costs in time for this report; however an effort should be made to assess the potential savings from green infrastructure and IWS activities, as compared to BAU grey infrastructure or additional treatment solutions.

2.3 Water Quality Data for Pra River Basin

2.3.1 Water Supply Facilities

The Sekondi-Takoradi Metropolitan Area water supply is served by two Water Treatment Plants (WTPs) namely the Inchaban WTP and Daboase WTP. The Inchaban WTP has installed capacity of 4mgd (18,181 m3/day), and its dry season production is 4,888 m3/day due to limited river yield. Measures are being taken to increase the abstraction capacity to 13,000m^3/day.

The Daboase WTP is also a conventional WTP with the Pra River as its source of raw water. There is no impounding structure, and raw water abstraction is from the river. Its installed capacity is 6mgd (27,273m^3/day) but the current production is much less as a result of reduction of the flow of the river and sea water intrusion reaching the point of abstraction during high sea tides resulting in high concentration of chlorides in the raw water. The sea water intrusion has necessitated construction of another intake at Bosomase, upstream of the original point of abstraction. Of late, the Daboase intake gets silted up as a result of illegal mining in the river bed upstream of the abstraction point. For the past few years, the abstraction intakes have been dredged annually as a result of siltation mainly resulting from illegal gold mining in and around the river Pra. About Three Hundred and Sixty-Five Thousand Cedis (GH¢365,000.00) was spent in 2012 on the dredging.

Figure 7: Dredging Operations at Daboase Intake (February 2013)

2.3.2 Water Quality

The quality of the raw water is one criterion used in determining the right type of water treatment plant to design and build so as to produce the desired quality of potable water. However, during the life of the reservoir, the raw water quality may deteriorate considerably. Weeds such as algae and water hyacinth bloom as a result of propagation and availability of nutrients in the water. Nutrients can come from sewage discharges into the reservoir or fertilizers applied on farms within the catchment area, which get washed into the reservoir after rains. Weeds also promote the growth of snails, which transmit bilharzias. The quality of the water can also be affected by the use of pesticides in fishing or the discharge of toxic chemicals into the water body. It is also possible that the impounded reservoir can dissolve minerals and deteriorate in quality. Some of the relevant water quality parameters for this study include colour, turbidity, suspended solids and metals.

The Pra River and its tributaries constitute the surface water system in the basin. Water pollution has been identified as the number one water management problem in the basin (WRC, 2003). This is due to mining activities in the basin (Fig. 8) but also to inadequate sanitation and improper waste disposal in the basin (Fig. 9). In the Pra River a large single source of Arsenic is the Obuasi mining area in the Jimi catchment (WRC 2012). In addition, large sources of arsenic also exist in the lower Offin and Pra rivers. The report indicates that total discharge of arsenic in 2006 in the Pra River, at Daboase, was 67,000 kg/year. High levels of faecal coliform counts in the rivers of the basin were reported (WRC, 2000).

Turbidity is the measure of relative clarity of a liquid. Excessive turbidity, or cloudiness, in drinking water is aesthetically unappealing, and may also represent a health concern since it can provide food and shelter for pathogens. If not removed, turbidity can promote re-growth of pathogens in the distribution system, leading to waterborne disease outbreaks. Drinking water should be colourless. This means that the colour in raw water has to be removed to make it colourless. Colour is caused by material in solution as well as the presence of very fine particles suspended in water such as leaves, peat, logs and other organic matter. Iron and manganese combined with other organic matter also cause colour in water.

Figure 8:Deteriorating Raw Water Quality of Odaso near Obuasi (Illegal Mining)

Figure 9: Deteriorating Raw Water Quality of Owabi (City waste discharges)

2.3.3 Water Quality Data

Raw water quality data was collected from the Ghana Water Company Limited for various water treatment sites within the river basins. The available data was over a short period with gaps and sometimes conflicting values or wrong entries. The quality measurements taken did not initially include certain parameters such as heavy metals and pesticides because they were not a concern until recently. In other situations, there was no suitable laboratory equipment to measure those parameters. As a recent concern on presence of heavy metals and pesticides in the raw water, samples are being sent periodically to the Ghana Standards Authority for analysis for such parameters. For example, samples analysed by GSA in October 2012 for heavy metals and pesticides for the raw waters of Daboase showed cadmium levels of 0.004ppm. (Acceptable limit is 0.003ppm according to Ghana Standards Authority-2009). There were no pesticides detected in that water. Figure 10 shows that there was no presence of lead in raw water at Daboase until 2009. Significantly higher values of this metal were recorded in 2009 and 2012 (Fig. 10). The maximum allowable limit of lead according to the Ghana Standards Authority is 0.01mg/L.

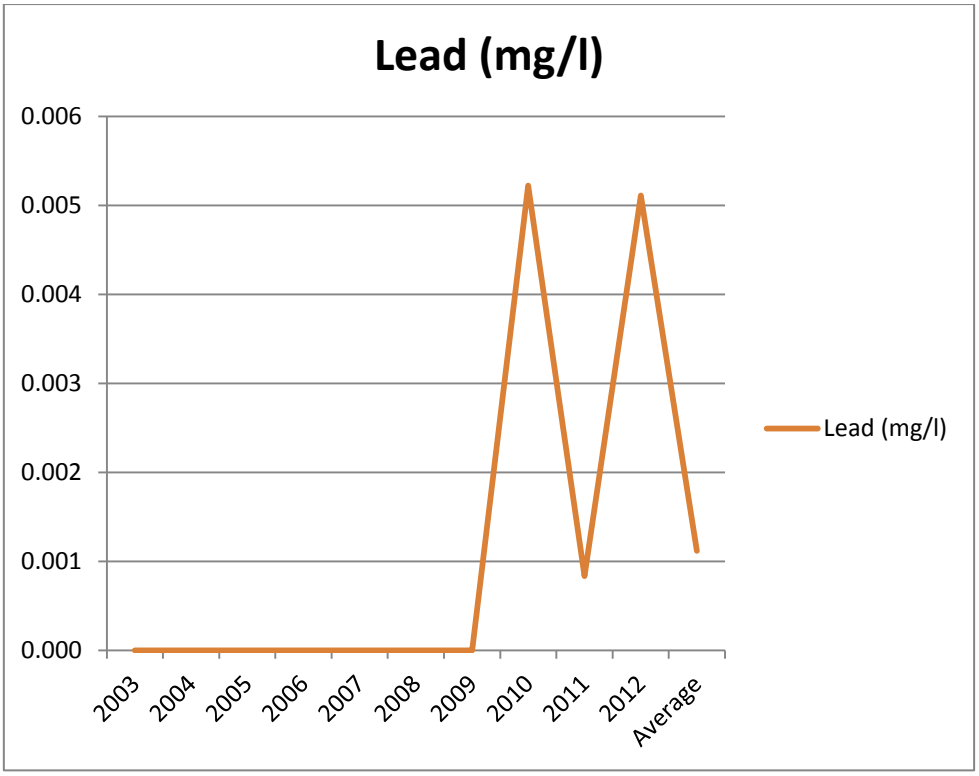


Figure 10: Concentration of Lead in Daboase Raw Water

The common parameters measured include pH, turbidity, colour and suspended solids. However, some of them clearly show a deteriorating raw water quality within the basins. Figures 10-17 show quality of Daboase raw water with respect to these parameters. The data is contained in Appendix 3

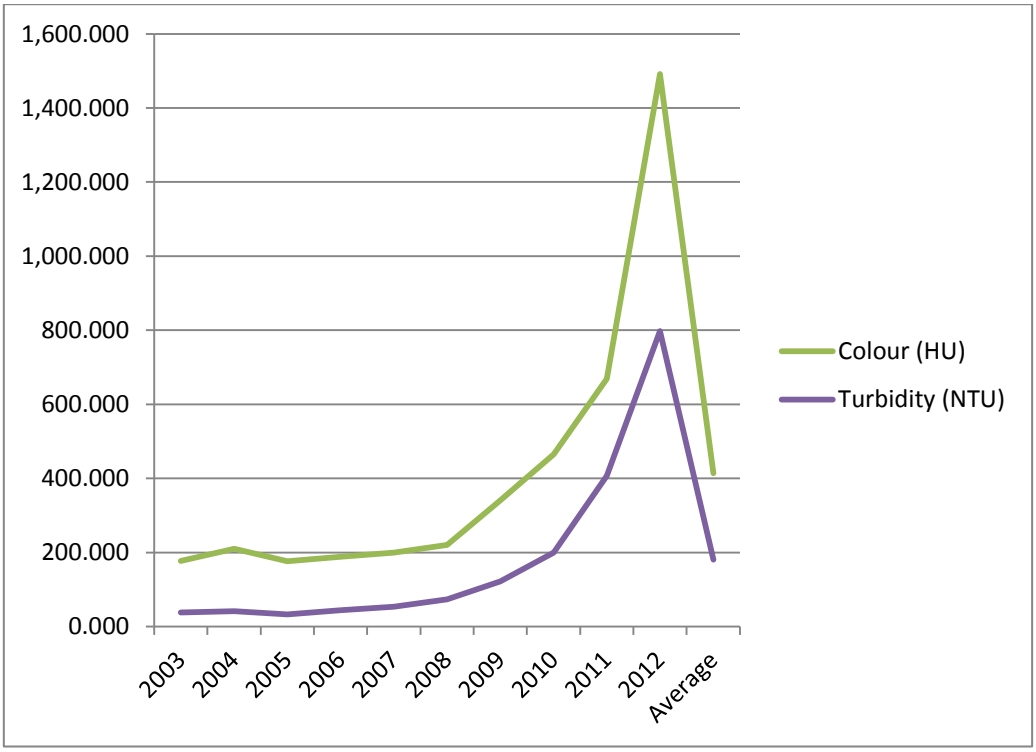


Figure 11: Colour and Turbidity Values for Daboase Raw Water

In Figure 11, both colour and turbidity show a rising trend from 2008 of 220.5HU and 73.73NTU with the highest of 1491.85 HU and 180.96NTU in 2012 respectively. These high values are to be reduced by treatment to the standard of 5HU and 5NTU respectively. This requires not only the use of more alum for settlement, but also frequent de-sludging and therefore less final water output from the treatment plant. Improper disposal of the resulting sludge can also pose an environmental pollution downstream.

An analysis of the raw colour values (on monthly basis), indicates a deteriorating trend in water quality (Figures 14 and 15) as the data shows a drastic increase in recent years. For example, the July values for 2003, 2004, 2006, and 2007 show an increasing trend of 150NTU, 200NTU, 250NTU and 375NTU respectively. Similar trend can be seen for the values from 2008 to 2012 in Figure 15. They are comparable with those of the Kakum basin for the same period. However, those of 2011 and 2012 are significantly higher than usual and depict the increased level of galamsey[7] operations.

With regards to solids in the water, those suspended need to be removed since they are foreign to the water. Suspended solids increase the turbidity of the water also. Whilst total dissolved solids virtually remains constant, suspended solids, from the available data since 2003, has been on the increase (Fig. 12). The increase indicates a continuous trend if the underlying causes are not addressed.

Even though the total hardness values are within the allowable maximum of 500 mg/l, the measured raw water values have been increasing since 2003 as can be seen in Figure 13.

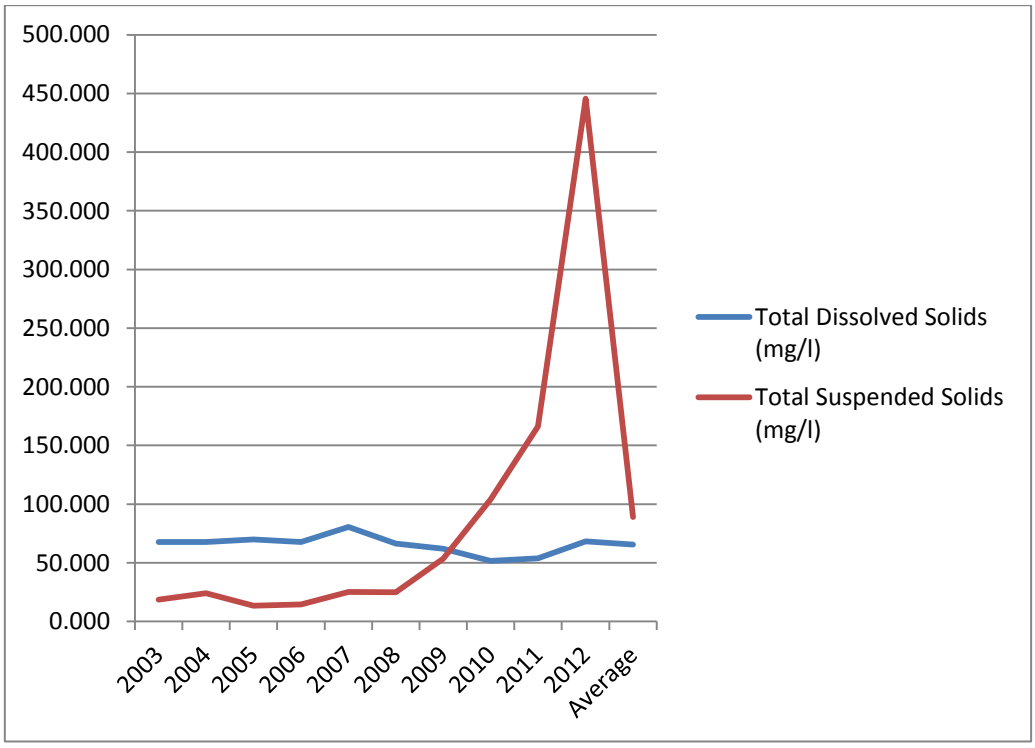


Figure 12: Dissolved and Suspended Solids in Daboase Raw Water

[7] "Galamsey" is a local parlance which means illegal small scale mining.

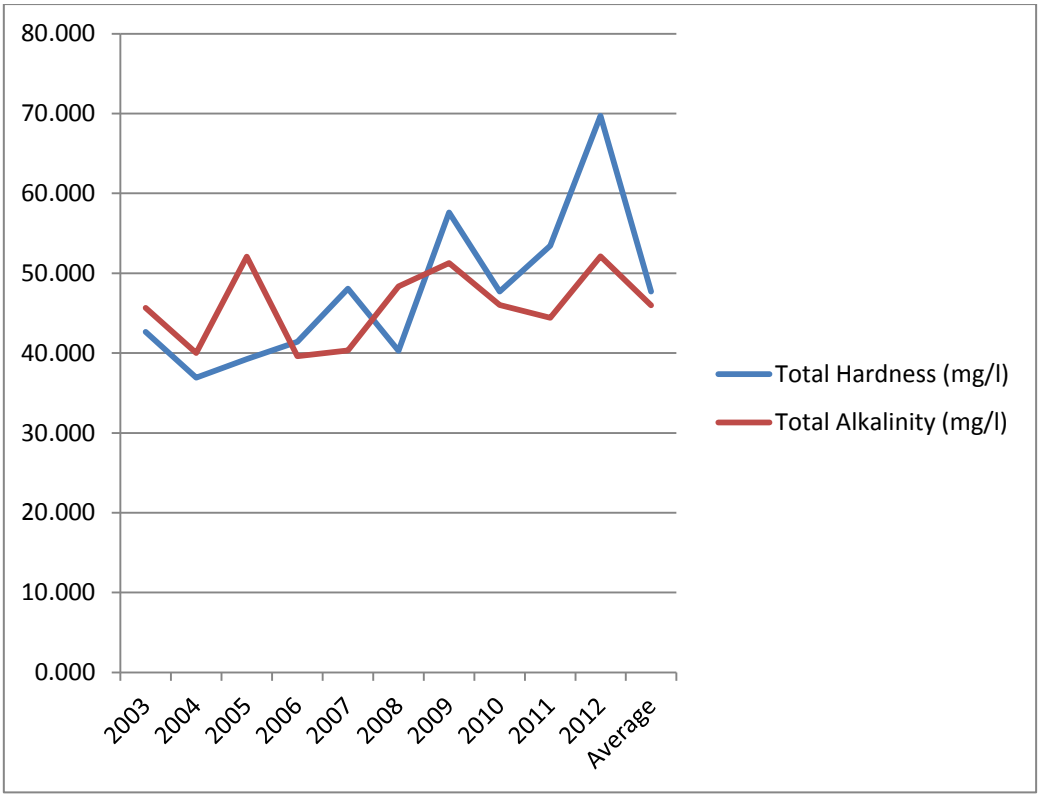


Figure 13: Total Hardness and Alkalinity of Daboase Raw Water

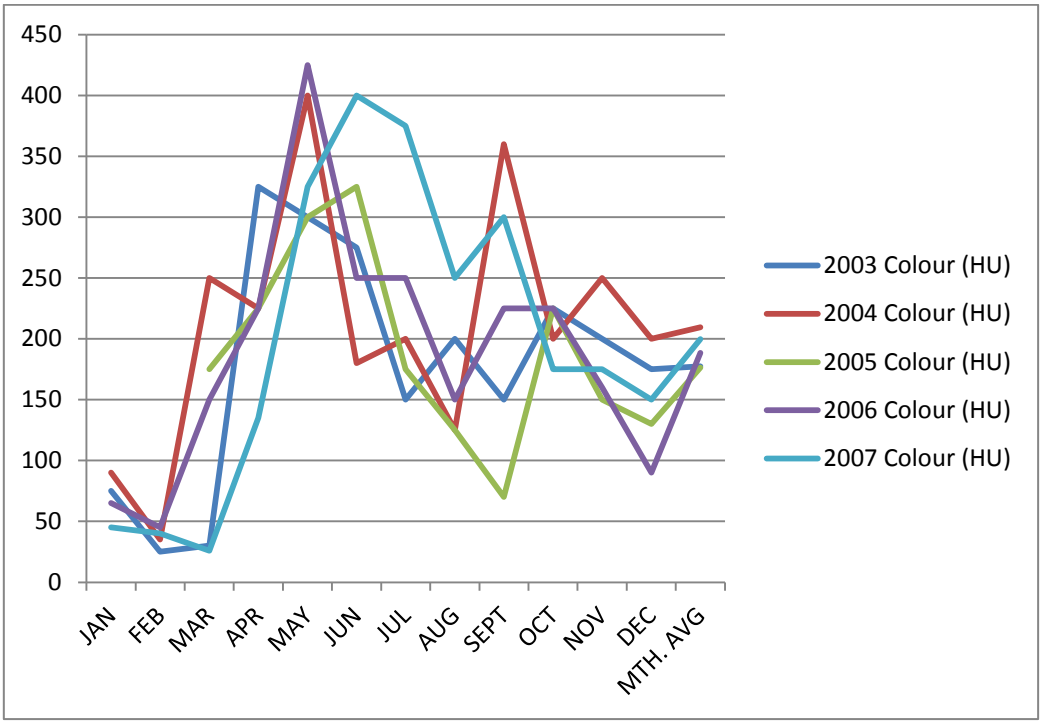


Figure 14: Monthly Colour Values for Daboase Raw Water from 2003-2007

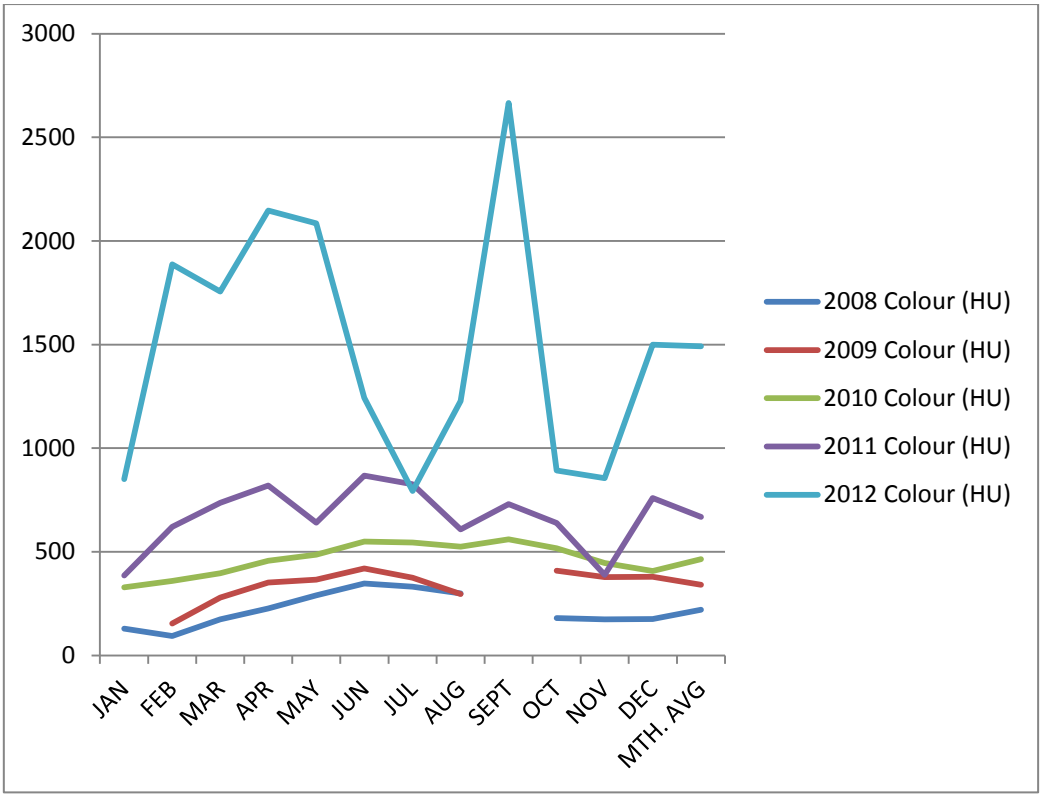


Figure 15: Monthly Colour Values for Daboase Raw Water from 2008-2012

Similarly the turbidity values for the Daboase raw water are of the same trend as shown in Figures 16 and 17. The issue of missing data is obvious in the figures.

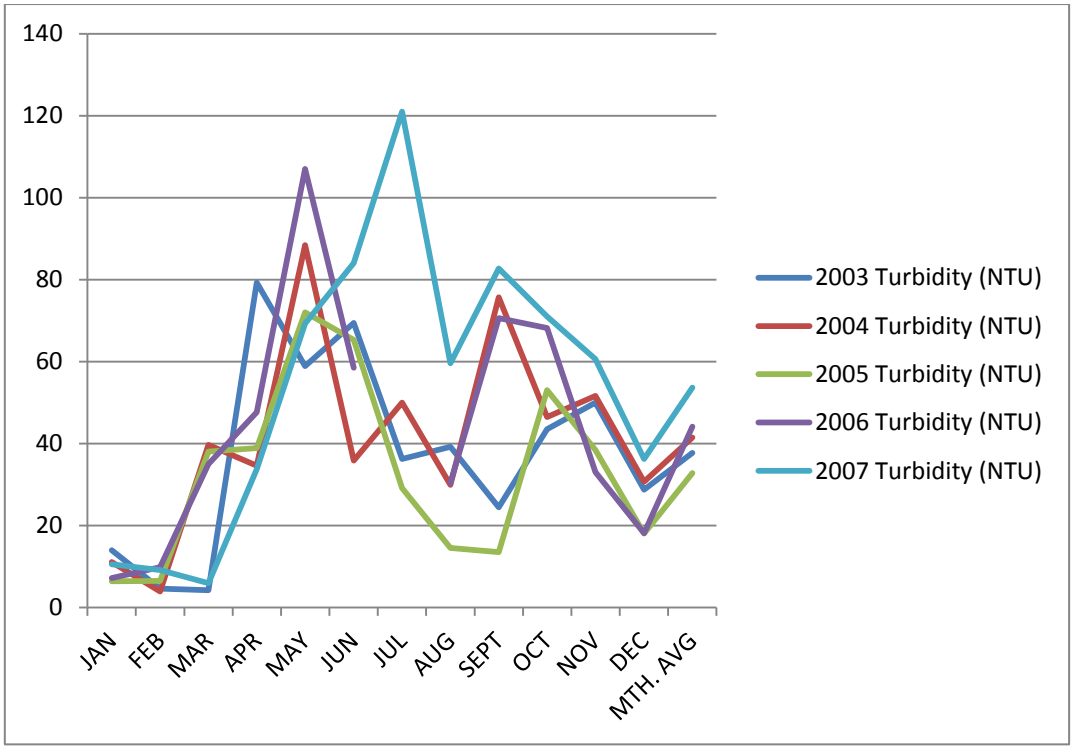


Figure 16: Monthly Turbidity Values for Daboase Raw Water from 2003-2007

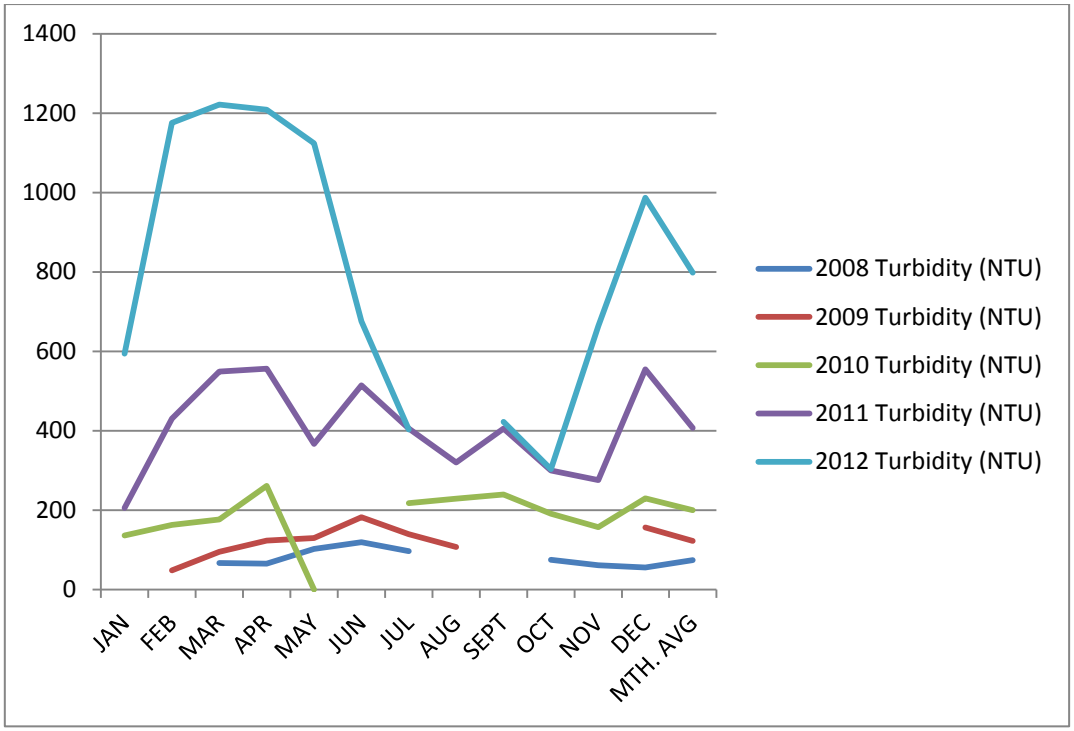


Figure 17: Monthly Turbidity Values for Daboase Raw Water from 2008-2012

2.3.4 Water Quality Data for Other Tributaries of the Pra River Basin

Raw water data was collected for water used at water treatment plants at Owabi, Odaso and Barikese. These are at the upper portion of the Pra River basin in the Offin sub-basin. The colour and turbidity values for Odaso for 2011 and 2012 are shown in Figures 18 and 19. The raw water is mainly polluted by illegal mining operations which have reduced plant operations from 4 mgd to 0.5 mgd.

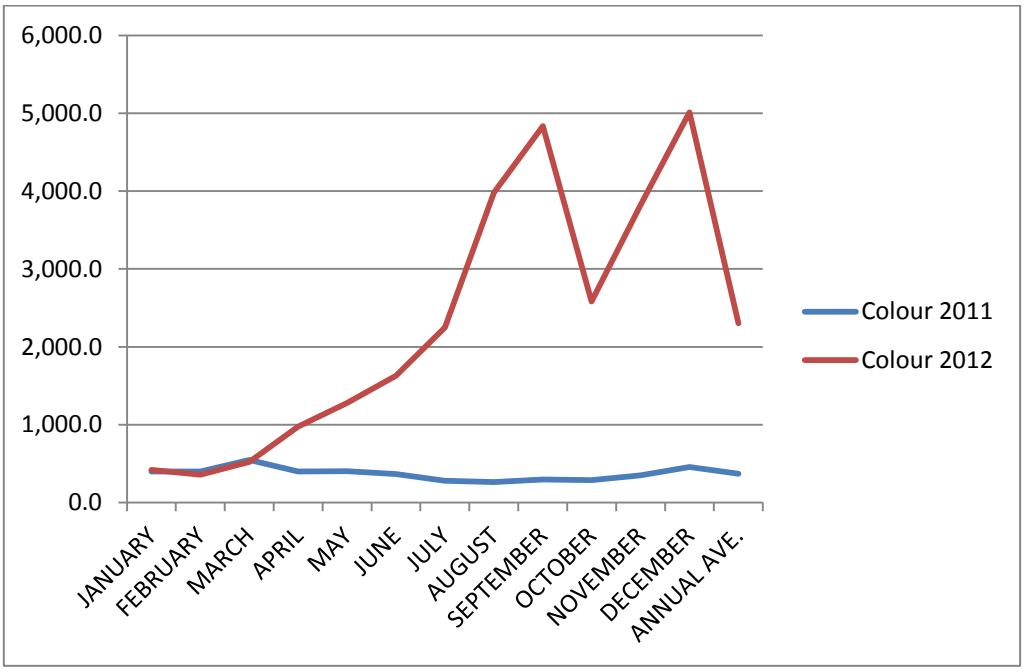


Figure 18: Colour Values for Odaso River

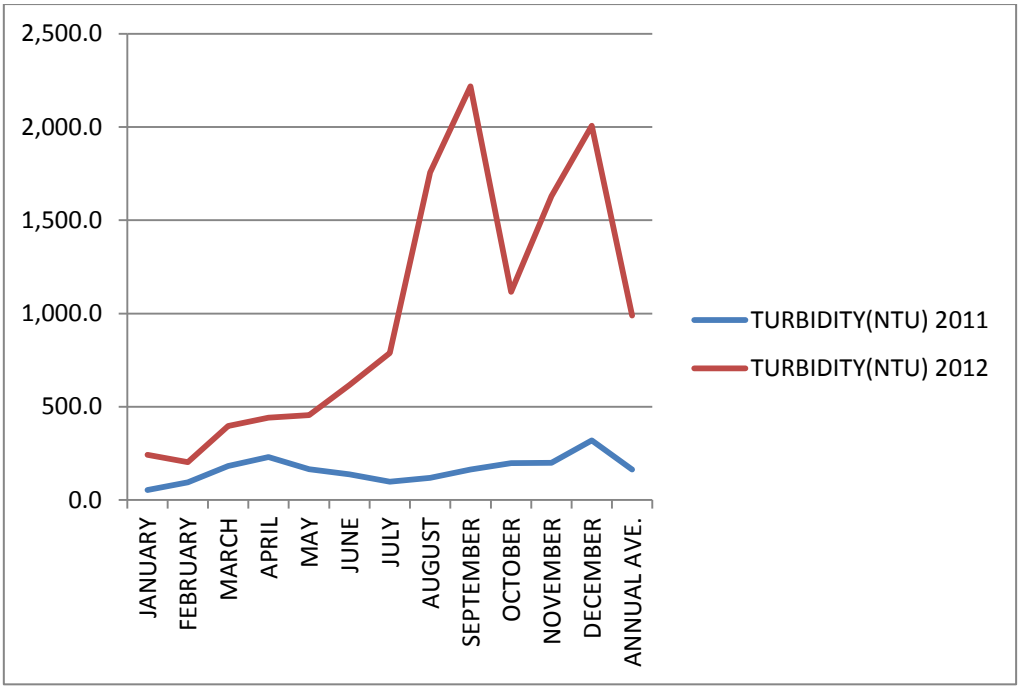


Figure 19: Turbidity Values for Odaso River

Similar colour values for Barikese for 2000-2006 are depicted in Figures 20 and 21. These show breaks in measurement as well as extreme values (May 2003 and July 2006) for some months.

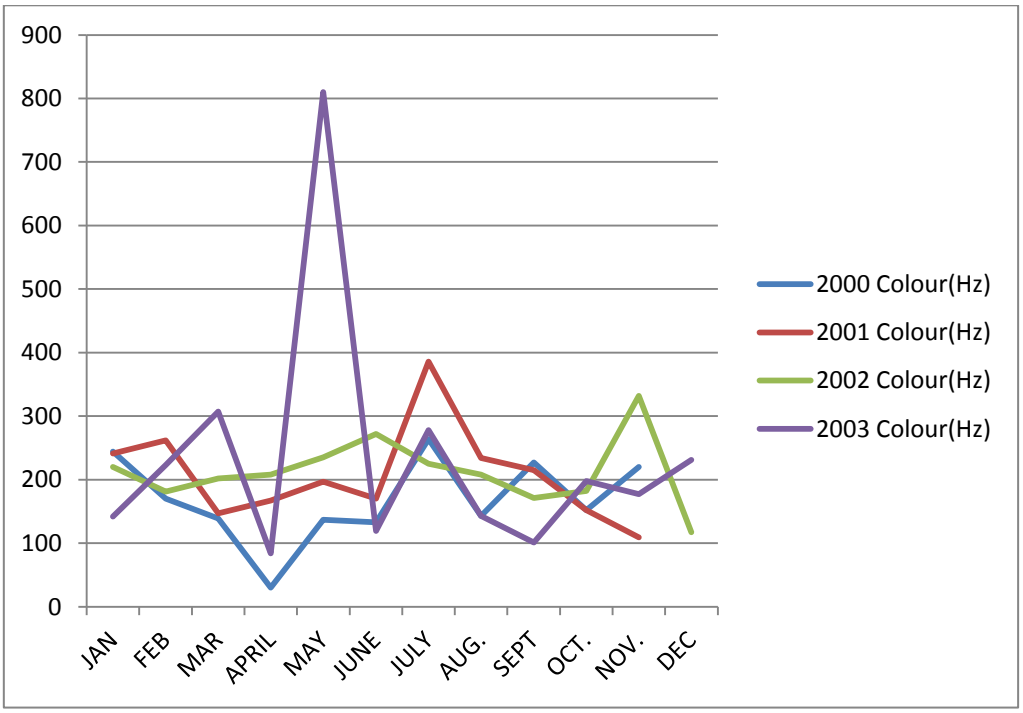


Figure 20: Colour Values for Barikese for 2000-2003

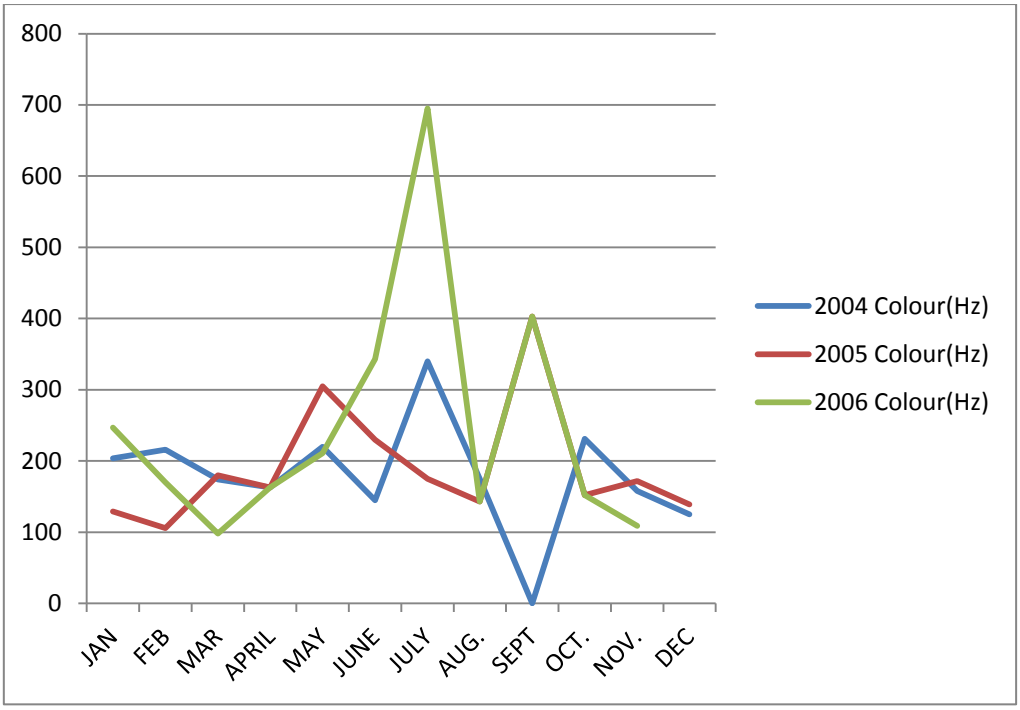


Figure 21: Colour Values for Barikese for 2004-2006

2.4 Water Quality Data for the Kakum River Basin

2.4.1 Water Supply Facilities

Cape coast is the capital of the Central Region. The existing water scheme supplies a large area which, besides the Cape Coast metropolis, includes all coastal towns from Elmina to the west and Saltpond to the east, and many rural communities to the north east and north west including Abrem, Agona, Abura Dunkwa and Jukwa which are all important towns with expanding settlements in the Central Region.

This water scheme is based on supply from the Brimsu WTP, served by the Kakum River, and the Sekyere Hemang WTP, which usies the Pra River as its source of raw water.

2.4.2 Water Quality Data

Raw water quality data for the Kakum River basin was collected from Ghana Water Company Limited. The measurements were taken from the Brimsu Water works. In analysing the data it was evident that the values have considerable errors, as values written on the hard copies frequently differed from the soft copies. This may be due to rounding off errors or wrong entries into the computer. There are also many instances of missing data. For example, there was raw water data for only the months of January and October for 2007 and March, August and September for 2008. Thus, values from 2007 to 2011 are not discussed.

The available data for colour and turbidity are shown in Figures 22and 23. The colour values are generally low for the Kakum River Basin from which Brimsu gets its raw water for treatment. These are about 400 HU which is comparable to those of Daboase for the same period. Due to the protection given to the Kakum National Park which forms a part

of the basin, there is no evidence of illegal mining. These apparent high colour values are due to decayed vegetation. Farming is also not permitted in the reserves, but only areas around it. The values are virtually constant throughout the year with those of 2003 to 2005 clustering together. Incidentally, those of 2006 are lower than the rest and no explanation is readily available. The same can be said of the raw water iron concentration discussed below. If data from 2007 were available, it might be easier to discern a trend with respect to the 2006 data.

The raw water from the Kakum generally has very high iron content (Fig. 24). Treated water is to have iron content of maximum of 0.3mg/l according to the Ghana Standards for drinking water. The high raw water values (upwards of 1mg/l) make treatment very difficult as well as the achievement of the standard. This iron is thought to come from the soil conditions of the basin. Turbidity values are all below 50NTU and are therefore not a serious concern as compared to those of Daboase which are about 100NTU and over. The presence of lead poses a serious threat to raw water quality for the Kakum River and thus the Brimsu Treatment Plant. These are sometimes above 5mg/l and are much higher than those of Daboase of about 0.005mg/l (Fig. 25). It is not known how lead gets into the raw water.

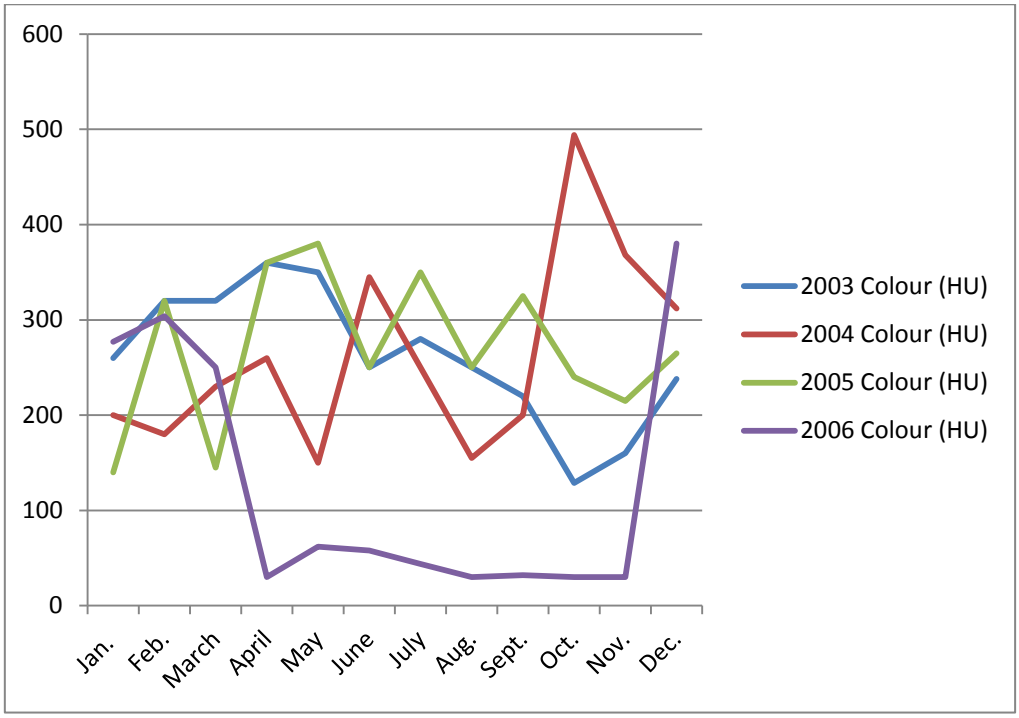


Figure 22: Monthly Colour Values for Brimsu Raw Water 2003-2006

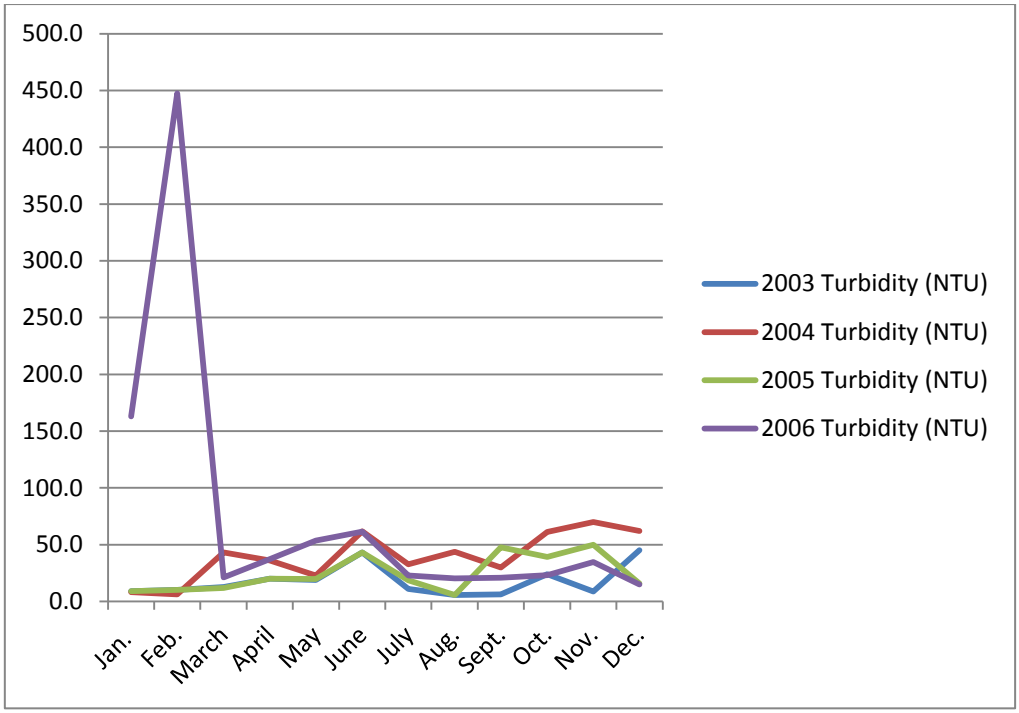


Figure 23: Monthly Turbidity Values Brimsu Raw Water 2003-2006

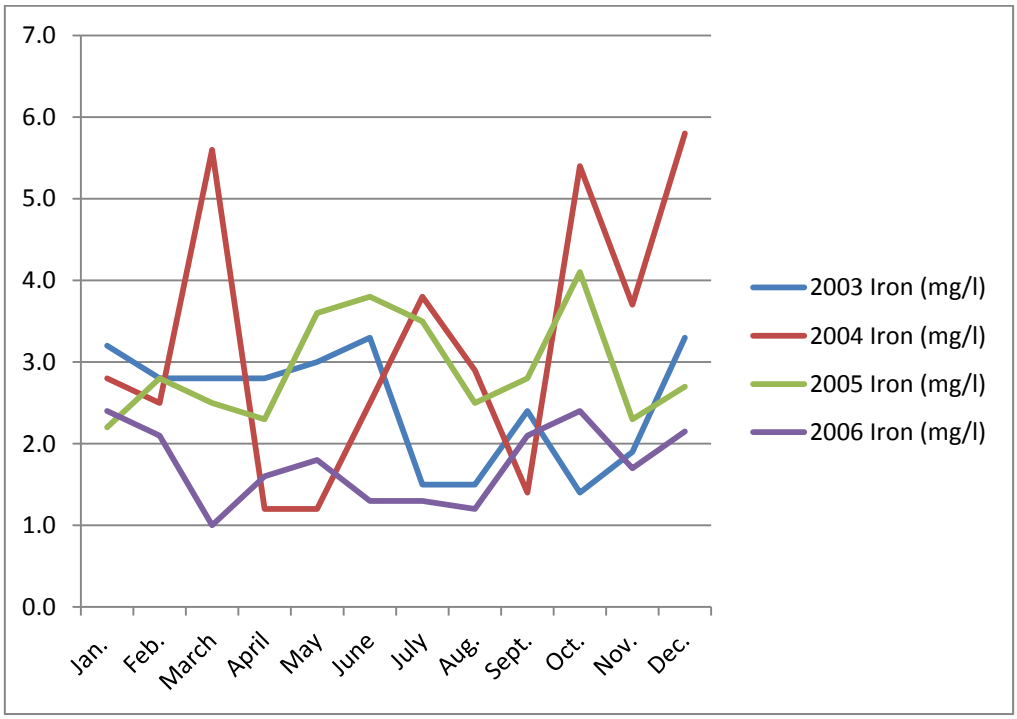


Figure 24: Monthly Iron Values for Brimsu Raw Water 2003-2006

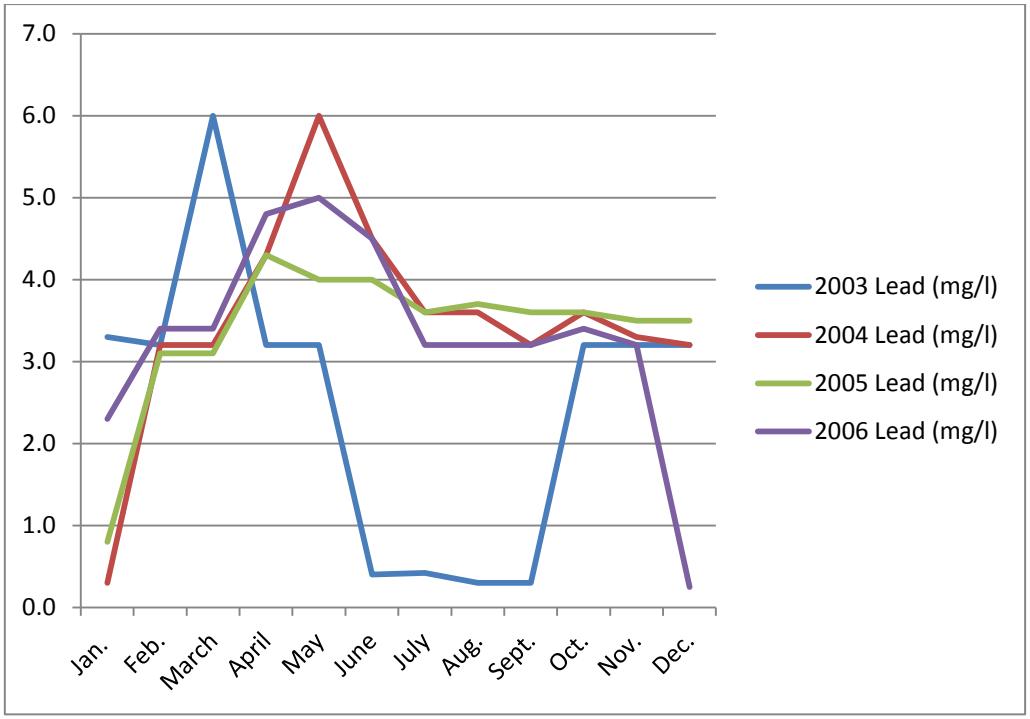


Figure 25: Monthly Lead Values of Brimsu Raw Water 2003-2006

2.5 Threats to Water Quality and Flow

According to the Water Quality Index (WQI) adopted by WRC in 2004, the water quality tested at all the sites sampled along the Pra Basin falls within the class II category, which represents fairly clean water, except in Barikese reservoir near Kumasi, where the value is lower than 50%, and therefore represents poor water quality. The poor quality of water in the reservoir is attributed partly to low dissolved oxygen content, a condition which discourages any form of aquatic life in the water body. This condition as observed in 2004 has however deteriorated over the years.

Table 7: Criteria for Classification of Surface Water Bodies

Class	WQI- range	Description
I	> 80	Good - unpolluted water
II	50 – 80	Fairly good quality
III	25 – 50	Poor quality
IV	< 25	Grossly polluted water

Source*: Pra River Basin IWRM Plan (WRC 2012)*

Interactions held with stakeholders in the basin, together with observations made during the field visits point to the fact that water pollution is an emerging issue within the basin (see Figures 6-15). This is reinforced by reports of pollution stated in existing literature on the basin (WRC, 2012). The water resources of the Pra are under the threat of

pollution from organic substances from municipalities and urban settlements, nutrients from wastewater and farming, and hazardous substances from industry and mining. For example, nutrient enrichment has led to waterweed infestations of major reservoirs for water supply, including the Ajariago reservoir on River Anum/Oweri near Konongo-Odumasi, the Barikese reservoir on River Offin, and the Owabi reservoir on River Owabi. At both Barikese and Owabi, the coverage of weeds on the reservoirs was between 11% and 40% of the open water surfaces as at 1995 (see Fig 26). The Ajariago reservoir, on the other hand, had weed coverage of up to 20% of the open water surface and water column as at 1995. At Barikese and Owabi the weeds cause blockage of raw water intake screens, agitators and water filters of the treatment works. The algae-clogged filter beds at both reservoirs necessitated back-washing once every other hour in 1995. In addition, the raw water intake pumps were stopped every other hour to enable removal of weeds clogging the raw water intake screens at Barikese.

Figure 26: Weed Cover including Water Hyacinth at Owabi Reservoir

Biological Oxygen Demand (BOD) levels in the Pra system are on the whole, slightly above average for Ghanaian river background condition (~2mg/l) (WRC, 2012). However, high levels of faecal coliform counts in the basin have been detected as a result of direct waste discharges into the rivers. Counts ranging between 21 x 10^3counts/100ml and 44 x 10^{11} counts/100ml have been reported. There is no standard for the level of faecal coliform in raw water. Inadequate provision of basic sanitary and waste disposal facilities in most settlements has led to pollution of streams and rivers in the basin. The Subin River in Kumasi is one of the most threatened by urbanization and industrial effluent discharge. Dissolved Oxygen (DO) concentration in the river has

dropped below tolerable limits (WRC, 2012). The river is considered "dead" in some stretches which are permanently deoxygenated. As a result of direct waste discharges into the Subin River (Fig. 27), faecal coliform counts ranging between 21 x 10^3/100ml and 44 x 10^{11}/100ml have been recorded. Similarly, high levels of suspended solids and organic matter concentrations were recorded in the Birim sub-basin as a result of runoff from the towns during the rainy seasons. BOD values of between 4,376 kg/day and 3,521 kg/day have been recorded at Apoli and Akim-Oda respectively. All these flow into the Pra River.

Figure 27: Polluted River Subin in Kumasi City (Partially Lined)

The combined footprint from mining activities represents another considerable impact on the landscape and the flora/fauna of the basin, as shown in Figure 28 at Dunkwa-on-Offin in Dunkwa. A number of the mines have arsenopyrite as mineral in the ore and therefore high concentrations of arsenic are found in solid mining waste and in the liquid mine tailings. Occasional spillages of cyanide into streams do occur, but substantial spills are very infrequent. Illegal artisanal mining popularly known as 'galamsey' is currently posing a huge threat to the Pra River. The miners even dare to mine in the river bed.

Figure 28: Mining Activities on River Offin at Dunkwa-on-Offin

According to officials of the Ghana Urban Water Ltd, there is steady deterioration of the raw water quality from the Pra Basin. The turbidity, colour and pH of the raw water are gradually reaching unacceptable levels as can be seen in Figures 10-19.

Due to the current high turbidity levels, the treatment cost for raw water by the Ghana Water Company is increasing. High values of colour and turbidity bring about increase in coagulant chemical usage and the associated cost of water treatment. Operational loss hours also result when the levels are too high to be handled by the Treatment Plants. The Kibi system (Fig. 29) for example had to be shut down in 2009 and 2010 for periods of 2,830 hrs and 6475hrs respectively as a result of deteriorated raw water quality. The specific periods of plant shut down and related costs may be obtained from the Ghana Water Company Limited.

Figure 29: Highly Coloured Water at Kibi Water Supply Intake

When water treatment plants are shut down, consumers are inconvenienced and bear additional cost of securing water by their own vehicles, trucks or private water tankers. The tariff applied by the GWCL/GUWL for water tanker services is given in Appendix 6 in Ghana Cedis. Private water tankers of similar capacities charge about three or more times those amounts. The quality of this carriage water is not assured, however, that of the GWCL is safer.

High levels of conductivity have also been detected at some sites located on some tributaries of the Pra River. High conductivity is an indication of increased mineral (sulphates, phosphates, chlorites) content which makes the water unpalatable and can sometimes cause hardness and pose metal deposits in industrial boilers. However the Birim tributary which is less urbanised is noticeably soft with low conductivity (less than 100µS/cm) compared to the high levels detected in other tributaries such as Jimi and Oda Rivers.

Generally, the concentration of most metals in the Pra River is insignificant. However, high concentration of Arsenic has been detected at Ampunyasi (located along tributary of the basin) where values of about 1300µg/l [8]were measured in the dry season and 200µg/l during the high flow period. The large source of Arsenic is from the Obuasi mining area in the Jimi catchment. It is reported that the Arsenic concentration is also close to the recommended level in drinking water (by the WHO of 10µg/l) in the lower reaches of the Pra River, particularly at Daboase and Twifo Praso, confirming the existence of Arsenic sources along the lower Offin and Pra rivers. This can be attributed

[8] Pra River Basin Integrated Water Resources Management Plan

to the activities of illegal artisanal miners within the basin and is feared to increase beyond acceptable limits in the near future.

This poses a major concern as the Daboase and Inchaban water supply facilities are located in these reaches. Besides, the current technology and equipment being used by the Ghana Urban Water Ltd for water treatment is unable to remove these metals from the water supplied to consumers. Most stakeholders within the lower Pra catchment area are however at the moment not aware of this situation and therefore do not appear alarmed. A major concern with water from Brimsu is its high iron content[9]. The low final water pH cannot be adjusted with the application of lime as the soluble iron oxidises and is deposited, giving the water its brown colour. White clothes and cassava are stained when washed or boiled respectively.

According to existing literature (WRC, 2012), nitrate levels at the extreme downstream sites of the Pra Basin (from Twifo-Praso down to the coast) are low (<1mg/l) and do not currently pose any problems. However, increased inorganic farming and the proposed establishment of a fertilizer factory in the region, where fertilizer application will increase, is likely to pose some hazards if not attended to.

With regard to ground water quality, it is difficult to make meaningful conclusions mainly due to the paucity of data. Isolated incidents of poor groundwater quality arising from excess iron levels in some boreholes have been observed by the Community Water and Sanitation Agency (CWSA) in their operations in the Central Region. In general ground water quality in the basin is of satisfactory quality.

2.5.1 Underlying Causes of the Deterioration of Water Quality

The above stated poor water quality as well as poor flow of the Pra and Kakum Basins is mainly as a result of human activity. These activities are summarised below:

1. Mining (both legal and illegal) leading to siltation, high turbidity and the deposition of heavy metals.
2. Farming practices and human settlement along river banks and water bodies leading to siltation, turbidity and discharge of chemical fertilizers. An example is the tomato farming at Akomadan in the Ashanti Region.
3. Bush burning for farming purposes and wild bush fires or those set by hunters to forest reserves causing deforestation
4. Fishing with poisonous chemicals like DDT leading to the depletion of fish stocks. Nutrients in fish cultures from unconsumed feed also deteriorate water quality.
5. Timber logging (both legal and illegal chain saw operations) leading to deforestation since the loss of forest cover decreases a watershed's capacity to regulate flow and control soil erosion. Logging sometimes takes place within the 30-50 meter buffer of water bodies where logs are used as bridges across streams by timber loggers and not removed after use. The removal of stuck timber trucks also causes considerable siltation.
6. Discharge of waste (sewage, refuse, diapers, plastics, chamber pots, engine oil, etc) into water bodies causing siltation. For instance, the Owabi Reservoir spills throughout the year since it is silted up.

[9] The iron occurs naturally in the river basin

The Owabi reservoir is polluted by domestic and industrial waste by the communities of Ohwim, Abrepo, Suame and Bokankye. Private individuals also direct house sewers and septic tank waste into the river. The industrial waste comes from spillage of engine oil from Suame Magazine into the river. In 2009-2010, the Kumasi Metropolitan Assembly was dumping sewage into the Owabi River. Laterite has also been borrowed from the surroundings of the reservoir for road construction. There is also fishing in the reservoir. Political leadership and the Asantehene have inspected the site and intend to demolish residential structures on the banks of the river. Incidentally, encroachment (settlement and Laterite winning) is still going on. The case is most dire during the dry season as the dilution factor is reduced, resulting in eutrophication and very offensive odours.

In the case of the Barikese Reservoir, the concern is the logging of the riparian forest cover by illegal chainsaw operators who are reportedly well armed and mostly operate at night. Under the Kumasi Water Supply Expansion Project Module 5, the plant capacity has been increased from 24mgd to 30mgd. One thousand (1000) hectares of land around the Barikese is to be planted with trees and 450,000 has so far been planted leaving a balance of 50,000.

The above mentioned deforestation / human activities in Ghana contribute to global climate change as well as local water quality / base flow problems. According to Obuobie et al (2012), climate change exacerbates water scarcity in low-flow conditions. It may also exacerbate water quality problems in high-flow conditions if storms are more intense (more sediments / turbidity from upstream, sea water intrusion from storm surges). The negative effects on raw water quality from sea water intrusion on the Pra River could be reduced if mangroves restoration occurred.

2.6 Critical Ecosystems of the Pra and Kakum Watersheds

Ecosystems comprise the environment (surroundings) and the communities of living organisms (plants and animals). The environment describes the abiotic factors such as edaphic (soil, land, minerals, air) conditions and the climate (which is the weather condition over decades or centuries). Living organisms are adaptive to the environment in such a way that we find specific organisms in specific environments. However, only a few organisms can cope with both temperate and tropical environmental conditions. Ecological zones describe the sort of interactions that take place among the various components (living and non-living) in a particular environment.

This section identifies critical forest areas of the Pra and Kakum basins which should be conserved in view of the significantly important watershed services they provide to the basins. Declines in the services that these critical ecosystems provided could lead to further deterioration of raw water quality and rapid decline in raw water quantity with severe negative consequences. Thus, this section aims to assess the state (BAU) of these critical ecosystems..

Forest and wildlife reserves constitute a significant component of the Pra and Kakum River basins as they provide critical functions and services to the watersheds. These include catchments protection, erosion control, serving as barriers to destructive fires, and providing climate regulation etc. Forest reserves (gazetted forest areas) in particular are of critical importance to natural generation, quality and flow of freshwater in the basins in view of the high extent of deforestation and forest degradation in the off-reserves areas of the basins.

During Ghana's colonial era, a then newly formed forest department was empowered by the Forest Ordinance (CAP 157 of 1927) to reserve areas of the Gold Coast (now Ghana) in consultation with the original landowners (mostly native authorities) for management by the state. The justification of several of the gazetted forest reserves, among other reasons, was principally to safeguard water supply. As a result, a number of forest reserves were defined in the Pra and Kakum basins in the catchments of important streams and rivers, and in some cases the reserved area contains the source or water heads of important streams and rivers in the basins. For instance the Afram Headwaters, Offin Headwaters, Atewa and Tano Offin forest reserves were designated to protect river head waters of the Offin, Birim, and some other rivers of the upper Pra basin.

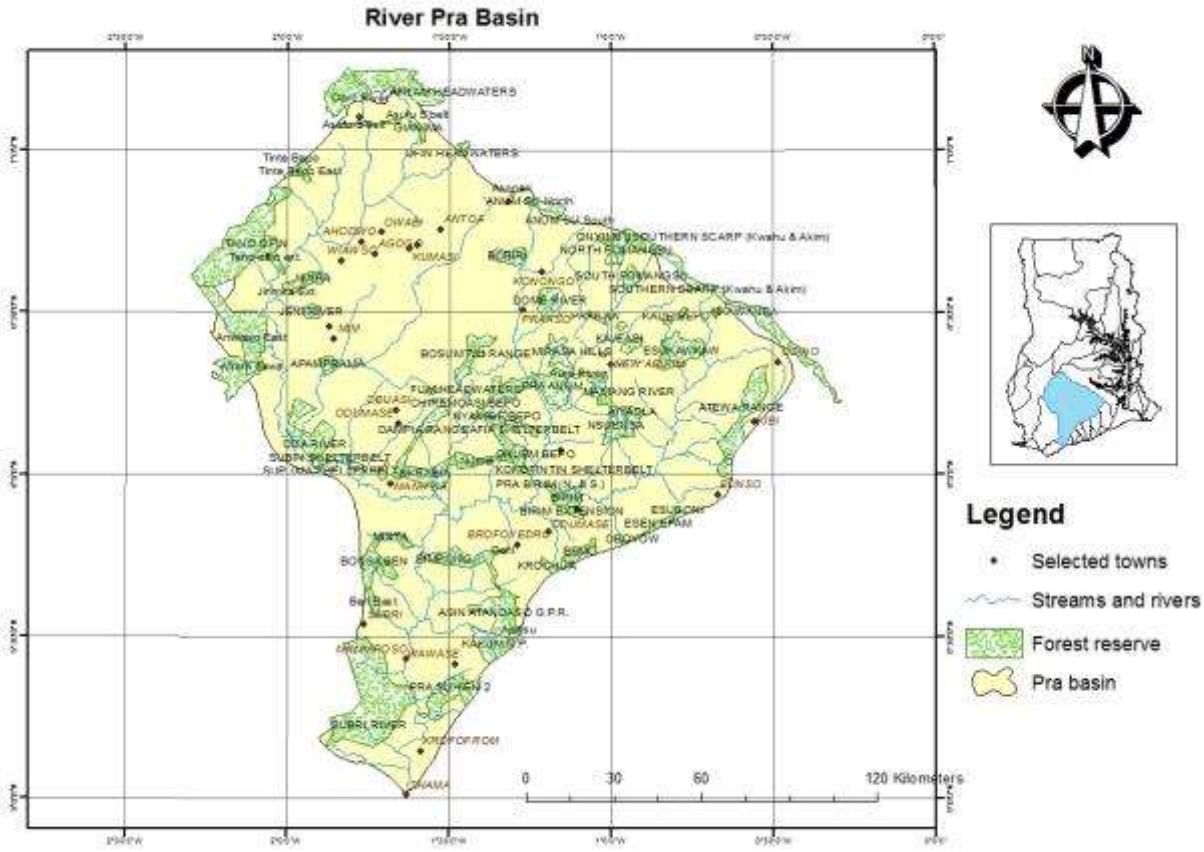


Figure 30: Forest Reserves in the Pra Basin

As noted in section 2.1.1 (page 16), the Pra River Basin Integrated Water Resources Management Plan (WRC 2012) estimates forest reserves as forming about 30% of the land use/cover type. Most reports simply list the forest reserves in the basin (WRC 2012, Baseline survey) and fall short of examining their ecological relevance, and the significance of the watershed services they provide. For instance, compartments containing critical headwaters of the major streams and rivers and the geographical coordinates of headwaters have not been provided or mapped.

The reserved forest areas of the Pra and Kakum River basins can be grouped into timber production forest reserve and protected wildlife/nature reserve categories. The management of the timber production reserves traditionally rests with the Forest Services Division (FSD) of the Forestry Commission, with a limited management responsibility assigned to Timber Utilization Contract (TUC) holders. The Wildlife Division

of the Forestry Commission is responsible for the management of wildlife and nature reserves in the basin.

Although managed for sustainable timber supply, some of the forest reserves in the basins contained protected compartments which are exempted from logging and the associated disturbances. Protected forest compartments of significant watershed ecosystem value include "Hill Sanctuaries" and "Swamp Protected Forest". Other categories of protection within timber forests which could offer beneficial watershed services because they are exempted from logging include Globally Significant Biodiversity Areas (GSBA) as found in the Subri Forest Reserve.

It is expected that most, if not all, of the forest reserves in the basins are providing one or more basic water catchment services or function. However, for any to be considered important or critical to the watershed, it is required that the basic service it provides should be of significantly critical importance to the sustenance of the basins. Because the gazetted area of each forest reserve is small in relation to the major river catchments, individual forest reserves are unlikely to provide the service across the entire catchment. They are likely to have this effect at a local scale. Further studies may be needed to confirm this assertion.

In this regard, each of the forest reserves within the two basins should be managed for the generation of raw water. The location of forests is critical to water quality and flows. Vegetative cover in riparian areas is particularly helpful to water quality, but these areas are also under pressure from agriculture. The forest reserves should be assessed to ascertain the extent and significance of the basic watershed services each provides. Further investigations involving topographic wetness index (TWI) analysis using GIS could help to ascertain the extent of water catchment functions of the forest reserves within the Pra and Kakum River basins.

2.6.1 Interpretation of Critical Ecosystems

The Pra and Kakum basins are vital water resources partly because a large population of people in several urban areas of Kumasi, Cape Coast, Takoradi, and others towns draw their drinking water from these basins. A forest area is considered a critical ecosystem if it covers the entire sub-catchment (catchment area forest) of a major river or stream of a basin, thus significantly regulating the quality and quantity of the water it produces.

Forests areas of the basins that provide protection against severe erosion or terrain instability and when impairment of the services they provide will lead to severe disturbance of the watershed are considered critical ecosystems. Such forest types play a vital role in landslide prevention (hill sanctuaries) and are considered critical ecosystems.

Afram, Atewa, Brimsu, Owabi, Sekondi, and Bia Headwater forests reserves provide protection for head waters of major streams and tributaries in the Pra basin and are thus considered critical ecosystems (WWF, 2006). In parallel, forests adjacent to reservoirs and waterworks for commercial production and distribution of portable water are also considered critical ecosystems. Specific examples include the Owabi Game Reserve, the Barikese Catchments Area Forest, and the Brimsu Forest Reserve.

Identification and preservation of critical ecosystems is advocated because land use conversion of such areas will further impair vital services with eventual implication for

soil water infiltration rates resulting in floods and erosion, soil organic matter and nutrient loss, reduced soil fertility and loss, and loss of vegetation cover and carbon stocks. These processes on land affect water resources through contamination, increased sediment transport, siltation and water shortages.

2.6.2 Identification of Critical Ecosystems

2.6.2.1 Atewa Range Forest Reserve

The Atewa Range Forest is considered a significantly important ecosystem of the Pra basin in view of the extent of the watershed services it provides to the basin. The forest is one of only two Upland Evergreen forest reserves in Ghana and is the source of several of the tributaries of the Pra-River (Fig. 31). It contains the headwaters of the River Supon and River Amaw, both of which drain into the Birim River.

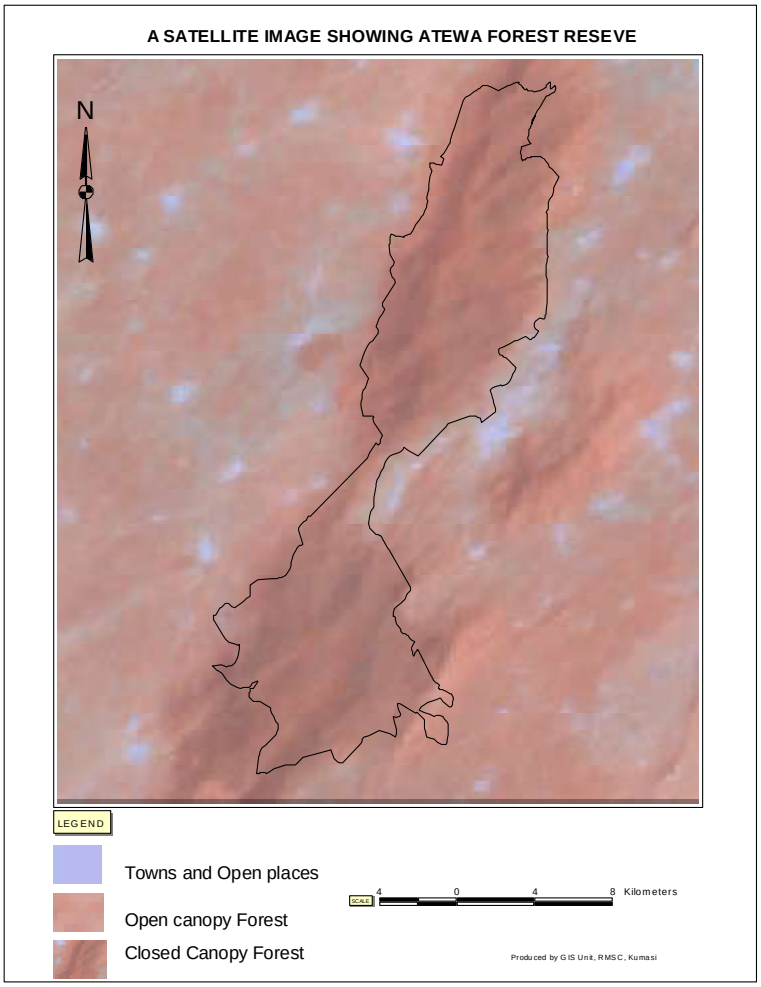
The Atewa Range Forest Reserve covers an area of approximately 258.3 km^2 (FC 2003), and provides protection cover for several deep gorges that are sources of many streams. The forest cover provides protection to the water heads of also River Densu and River Ayensu (and their tributaries) and plays a critical role in checking erosion of the steep slopes and hills. The plateau formation of the Atewa Range Forest Reserve is perceived to be important for cloud formation and thus rainfall in the area. Thus removal or significant degradation of the forest cover will impair critical watershed services and could result in severe erosion and drying up of the water heads.

The reserve also provides the local people a wide variety of services and products including fertile land for farming, bush meat, pestles, snails, mushroom, fish, wild fruits, water, medicinal plants, etc (FC 2003). The forest attracts conflicting interests as it is also perceived to have very rich deposits of bauxite and gold. Plans by the Ghana Government to allow private mining companies are putting immense pressure on the forest (A Rocha 2013, Pers. Comm.). Vimetco Ghana (Bauxite), a subsidiary of Vimetco N.V, has obtained bauxite prospecting licenses covering the Atewa forest and has carried out comprehensive geological surveys in the area. The company is expected to confirm a significant deposit of bauxite in the area (Vimetco, Annual Report 2011).

The Atewa Range Forest Reserve is also threatened by encroachment from cultivation, illegal logging, illegal small scale mining coupled with the relatively high prevalence of bush fires (FC 2003, A Rocha 2013). These have resulted in the depletion of important timber species. Trees such as mahogany, Odum, Obeche, and Emire, which were abundant before the 1960s are now locally rare. It is feared the effects of bauxite mining could further degrade the forest reserve with far reaching implications for the watershed services it currently provides. A Rocha Ghana, a local NGO is implementing the Atewa Critical Conservation Action Programme (ACCAP) aimed at addressing the serious issues occurring in Atewa through advocacy and public education.

The Begoro District office of the Forest Services Division is responsible for the management of the Atewa Range Forest Reserve. It classifies the area as a Hill Sanctuary for the protection of the fragile hill landscape and its water systems. It is important to note that the protection status of Atewa Forest was recently upgraded by the Forestry Commission by designating it as a Globally Significant Biodiversity Area (GSBAs) (NRMP, 1999). GSBAs are protected forest areas scientifically identified as having exceptionally high levels of biodiversity. They are equivalent to IUCN's protected

area category IV: areas designated mainly for the conservation of biodiversity (allow certain levels of NTFP harvest) through management intervention (IUCN 1994).



Source: Forestry Commission 2003.

Figure 31: Atewa Forest Reserve

2.6.2.2 Subri River Forest Reserve

The Subri Forest Reserve contains swamp sanctuaries which are critical to the Pra basin and offers to it significant watershed services including watershed protection. The forest reserve contains the headwaters of major tributaries including the Subri and the Bonsa Rivers. It provides sub-catchment protection to the Pra River, and full catchment protection to many of its tributaries (FC, 2007). Some of the rivers and tributaries that take their sources from the reserve are the Amotanaw, Enikawkaw, Aniafu and Abetumasu.

The Subri Forest Reserve lies between latitudes 5° 05′ and 5° 30′ North and longitudes 1° 35′ and 1° 55′ West. It covers gross area of 58,793 ha (587.93km^2) and falls within the Mpohor Wassa East Administrative District with its headquarters at Daboase. The

reserve is under the management of the Takoradi Forest District with its headquarters at Takoradi.

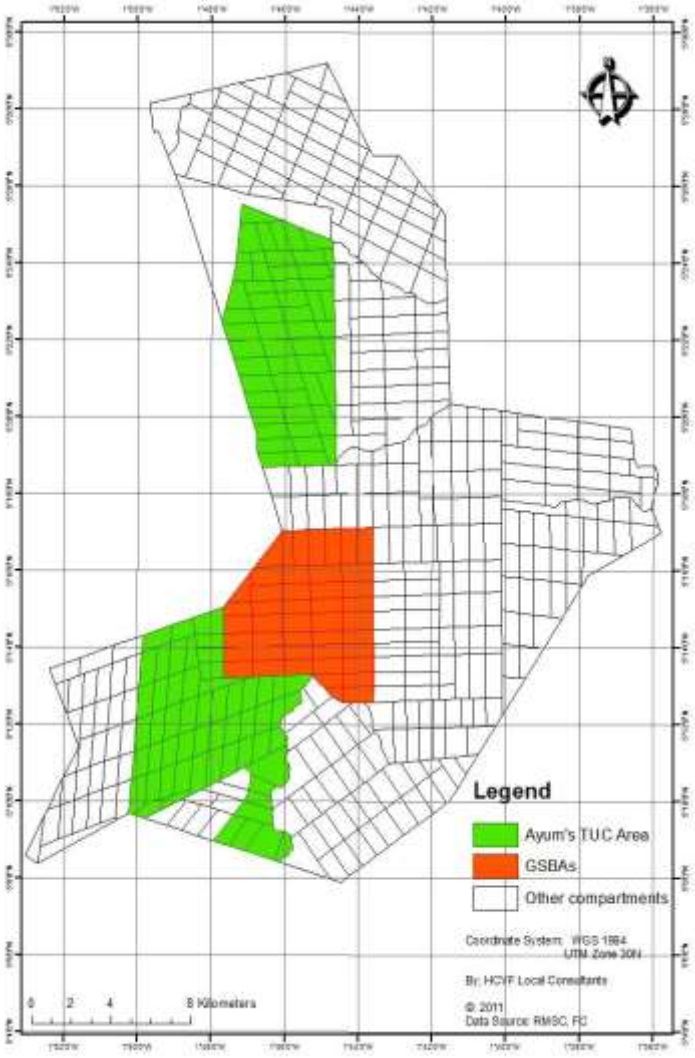


Figure 32 Subri River Forest Reserve

Source: Adjewodah et al 2011

Timber is harvested from the reserve using the selection system (only timber species of a certain size range are carefully selected and logged within a given felling circle), but some compartments were subjected to salvage felling (where all mature trees were removed) between 1966 and 1976 and the forest in these areas show signs of disturbance from logging including much opened canopies (FC 2007).

Hawthorne and Abu-Juam (1995) using a forest condition scoring system with scores ranging from 1 (late/virgin secondary forest) to 6 (none forest <2% forest left), and based on assessment of natural forest patches and degree of disturbance, gave a condition score of 3 to the Subri Forest Reserve (which means the forest was slightly degraded with good forest predominant).

It is not unlikely that the condition of the forest may have deteriorated since the last assessment (data on current condition score lacking) as a result threats from illegal logging, hunting, and mining. An area of 31.25km^2 of the reserve falls under the

concession of Golden Star, a mining company working the adjoining landscape of the reserve (FC 2007).

Because of the high conservation values of the reserve, a portion has been designated as GSBA. The RMSC database indicates 67 GSBA compartments for the reserve, while the management plan of the Subri FR GSBA (FC 2007), and a recent management plan of the Subri Forest Reserve (FC 2011) prepared by the District Office of the FSD, listed 45 compartments as being under GSBA protection.

2.6.2.3 Kakum Conservation Area

The Kakum Conservation Area consists of the Kakum National Park and the adjoining Assin Attandaso Game Reserve which together covers an area of 360km2 (Fig. 29). The forest is a critical component of the Pra and Kakum basins, as it contains the headwaters of important rivers and tributaries. River Kakum, River Ongwa, River Amisa and River Obuo all take their source from the Kakum Conservation Area. River Obuo, and River Ongwa are major tributaries of the Pra River, while the Kakum River is the primary surface water of the Kakum basin. Thus any disturbance of this forest will significantly impair its ecosystem services such as protection for headwater sources, erosion control, control of pollutants etc with significant implications for the two river basins.

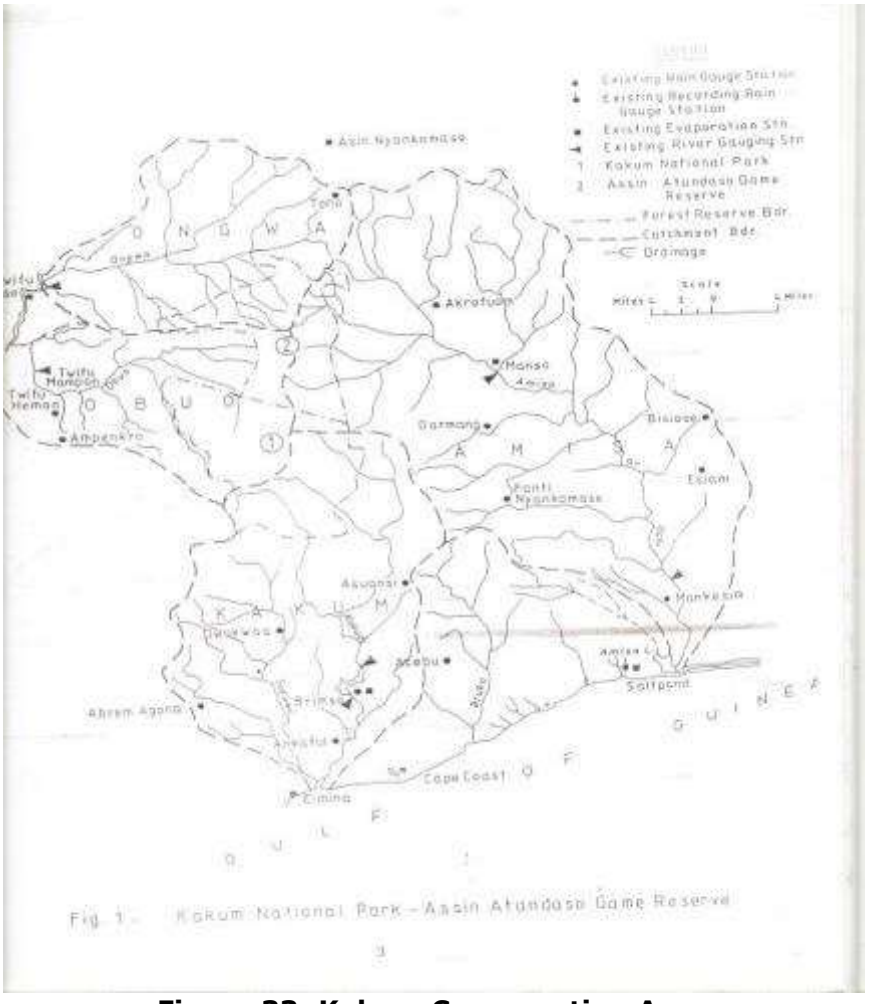


Figure 33: Kakum Conservation Area

2.6.2.4 Off-reserve riparian forest

Off reserve riparian forests include vegetation along the immediate banks of the major rivers and streams in the Pra and Kakum basins. This area is defined as falling within 50-100m from major streams and the rivers (MWRWH. 2011). The soils in this strip of land are more valuable to farmers than adjacent upland soils (Tiessen and Stewart 2007) because they can be cultivated without the application of fertilizer and the location provides easy access to water for irrigation. The Pra River basin, especially the riparian zone, contains gold ore which attracts small scale illegal mining.

On the other hand riparian forests provide critical services to the watershed and are important in protecting the quality of surface waters from land-based sources of pollution (sediments and solutes). They are considered critical ecosystems based on the view that riparian forests are fragile and their degradation could result in severe consequences for the watershed as a whole. In fact, several of the issues affecting the Pra River basin including the high levels of siltation, pollution, earlier discussed in this report can be traced to the severe degradation of the riparian vegetation in several localities of the basin. Unless firm measures such as gazetting and enforcement of buffer strips are introduced, any remaining riparian forests of the basin will be degraded or completely lost as agriculture and mining continue to be the principal activity of most inhabitants.

2.6.2.5 Others

Other forest areas within the basins which are regarded critical ecosystems include the Owabi Wildlife Sanctuary which provides significant catchment protection for the Owabi dam in the upper catchment of the Pra basin. The forest covers an area of about 13km^2 and is centred on an old reservoir which were fresh water for several settlements in Kumasi is drawn by the GWC. Similarly, the catchment forests of the Barikese dam and the Birimsu reservoir are considered critical ecosystems requiring fine grained management attention.

A couple of other forest reserves within the basins and which have been designated to protect river headwaters but which have not been individually described in detail in this section could be considered critical watershed ecosystems in view of the extent of watershed services they provide. These would include the Afram Headwaters Forest Reserve, Offin Headwaters Forest Reserve, and the Tano Offin Forest Reserve.

Chapter 3 Existing Mapping of Pra and Kakum Watersheds

3.1 Significance of Maps to Watersheds

River basins are large masses of land which have clearly defined boundaries, thus giving them a specified area of influence. They consist of interrelated components including water bodies (streams, rivers, estuaries), and land forms/cover types (scalp, valley, forest, crop, fallow, etc.), which are in regular interaction with human settlements and consequently a range of human activities. For instance, the interaction between surface water and topography enables a river emanating from a higher point of the land to flow downstream to the lower point by gravity; and to join either another river body or flow directly into the sea. This interaction between surface water and contours is best analysed, described, and visually depicted using maps. Maps are the ideal tools for displaying the location and extent of watershed services and activities such as farming, mining, logging, water supply, sewage disposal, etc. Examples of watershed maps include base maps of landform, habitat characteristics, land-use etc.

3.2 Review of Available Existing Maps

3.2.1 Topographic sheets

Available maps of the Pra River basin are the topographical sheets covering the whole basin between Latitudes 50 N and 70 30’ N, and Longitudes 20 30’ W, and 00 30’ W, in south-central Ghana. These sheets are of scale 1:50,000 and are available at the Survey Department and can be obtained at a fee from the national and regional offices of that department. The topographical sheets do not specifically define the river basin, though they show important features such as forest reserves. They also contain vital information on the contours, settlements, and infrastructure such as roads, bridges, footpaths, railway lines, and notable buildings among others. These are good and adequate for general references and a portion of one such sheet is shown in Figure 34.

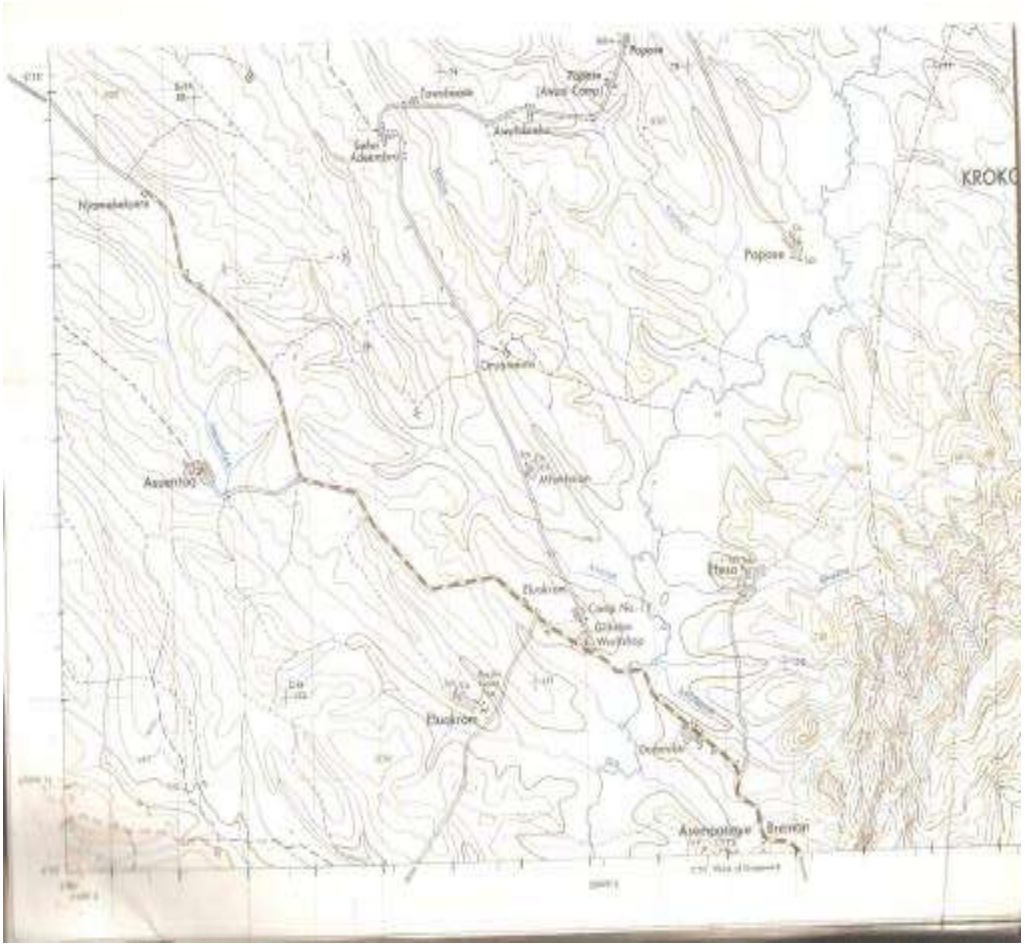


Figure 34: A Scanned Section of a typical Topographical Sheet of the Pra Basin

In view of the size and scale of the toposheets relative to the size of the river basins, several copies are required to cover the entire basin. This causes handling difficulties when working with the toposheets. Because the sheets are static hard copies, they cannot be easily edited to reflect the dynamics of the basin. In addition, most of the maps that are on sale at the Survey Department are out dated, as they were produced using photographs taken during aerial surveys of Ghana in the 1970s and earlier. However, the contours will not change and will still be useful except that some roads and other infrastructure may change. Topo maps are being used to outline sub-basins for the purposes of prioritizing areas for intervention.

3.2.2 Google satellite maps

Satellite maps of the Pra and Kakum basin are available for free on Google via their website: www.gooleearth.org. Google maps provide general information on vegetation cover, drainage, and settlement of the basins. Finer scale satellite maps can be obtained for a fee at Google map or from other sources in the country.

3.2.3 Water Resources Commission maps

In Ghana, the WRC is responsible for the regulation and management of the utilization of water resources and for the co-ordination of any policy in relation to them. The WRC therefore has to have adequate maps and data covering all water bodies in Ghana to enable it perform its mandate properly. However, the WRC is relatively young and has not been able to gather sufficient data on all the river basins in Ghana. Data on the

Kakum basin in particular is scanty. There is no management plan covering this basin. A Water Quality and Demand Assessment of the Kakum Basin (Nana-Amankwaah E., and Ampomah B. Y. 1997) one of the few reports on the Kakum basin provides a map of the basin showing township, rivers, and forest reserves (Fig. 33). The available maps of the Pra Basin in the possession of the WRC are contained in the Pra River Basin Integrated Water Resources Management Plan, 2012).

These maps include:

1. Location map of the Pra River Basin
2. Geo-Political Composition of the Pra Basin
3. District Map of the Pra Basin
4. Geological map of the Pra Basin
5. Topographical Map of the Pra Basin
6. Hydrometric Map of the Pra Basin
7. Vegetative Cover Map of the Pra Basin
8. Protected Areas Map of the Pra Basin
9. Land Use Patterns Map of the Pra Basin
10. Annual Rainfall Distribution in the Pra Basin
11. Schematic View of Water Allocation in the Pra Basin
12. Location Map of the Kakum River Basin

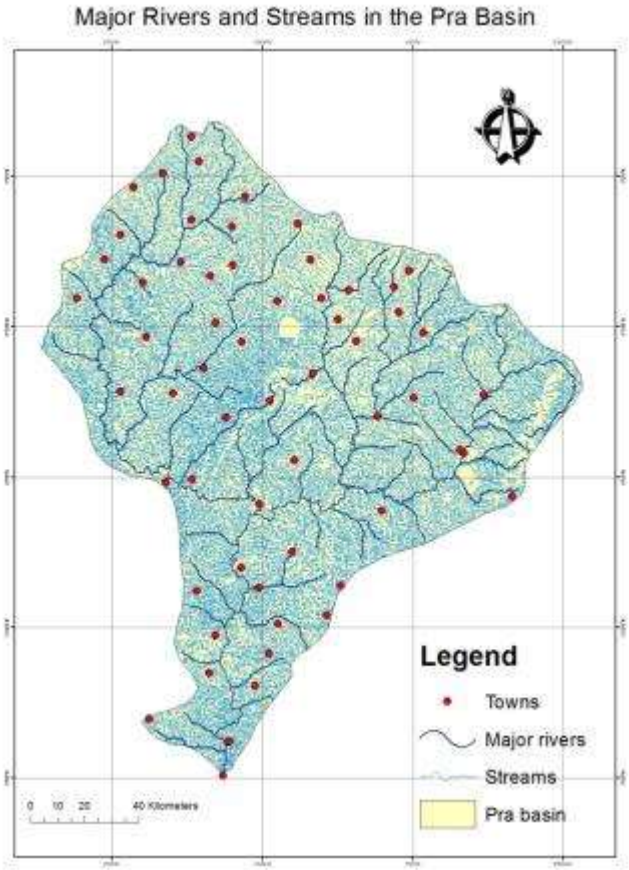


Figure 35: Major Rivers, Streams and Towns of the Pra Basin

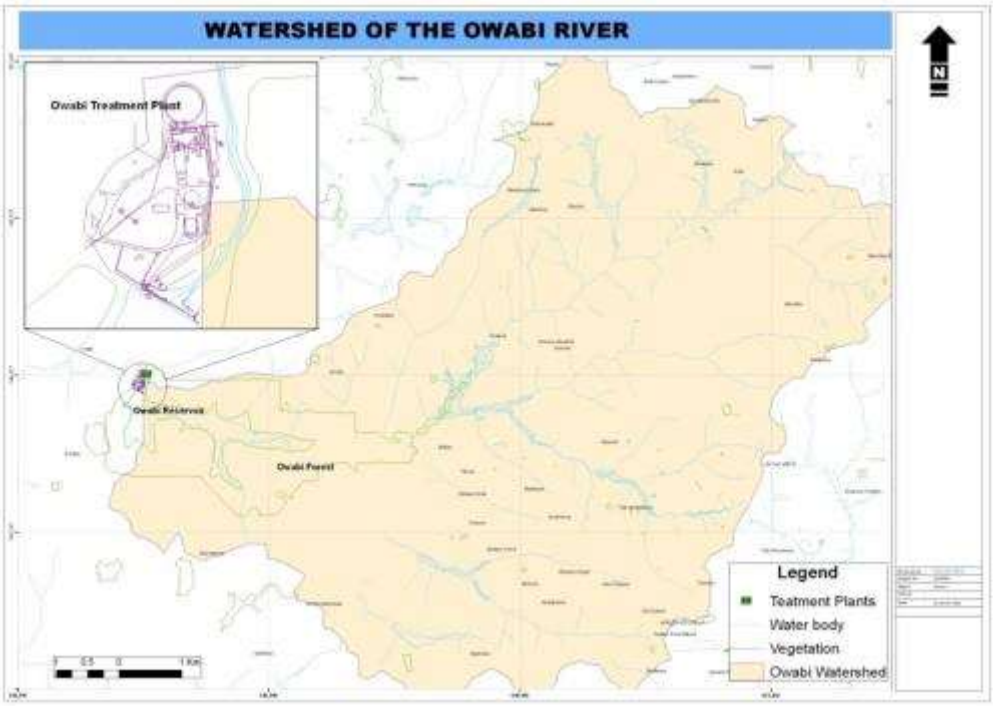


Figure 36: Watershed of the Owabi Reservoir of the Upper Pra Basin

Several of the corporate bodies and government agencies working in the basins may have maps covering their specific interest areas of operation. For example, the Ghana Water Company has a GIS unit attached to its Regional offices where maps of their operations including their distribution lines and dams can be obtained (Fig. 36 and 37). The Minerals Commission, Forestry Commission, and the Geological Survey Department have maps of their operation areas as well. However these maps are limited in scope and extent.

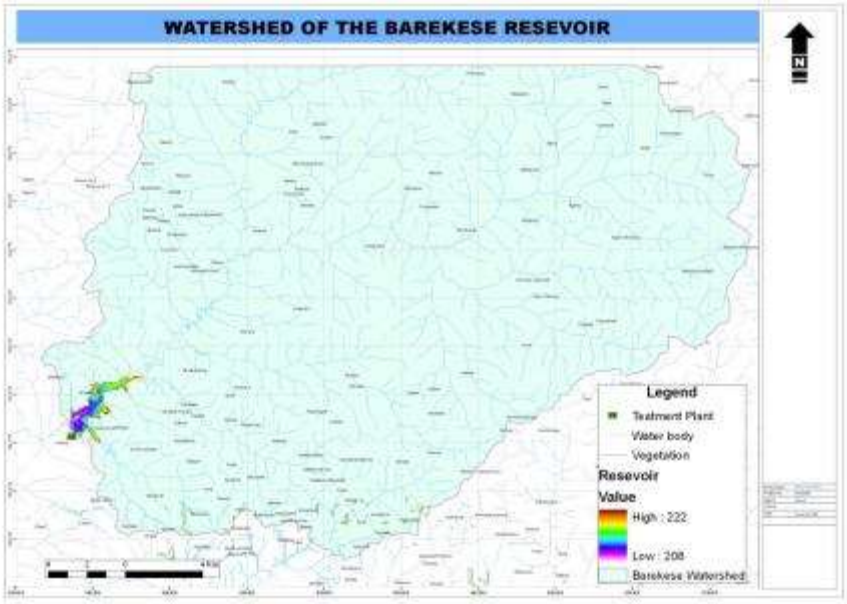


Figure 37: Watershed of the Barikese Reservoir of the Upper Pra Basin

3.3 Mapping Gaps

The Kakum basin does not seem to have a GIS database. However, the paper by Obuobie et al of Water Research Institute indicates that there has been some SWAT modeling of the Pra basin, which requires some kind of database. Available maps of the two basins are scatted among several institutions, and they come as static hard copies or as electronic versions which do not reflect the dynamics and developments in the two basins. Because the available maps of the basins are developed outside a centralized and regularly updated GIS database, they will require many hours of editing to reflect changes and current trends. There are no base maps of the basins on a fine scale for analyzing vegetation dynamics, particularly of the riparian forest on the immediate banks of any of the major rivers in the two basins. Also missing are maps showing localities of illegal small scale mining even though this activity is currently rampant in the Pra basin and sporadic in the Kakum basin. Base maps showing headwaters and the sources of streams and rivers that feed the basins are critically necessary but are not readily available. A map of streams and rivers in the Pra basin (Fig. 35) generated from the Ghana GIS database by a Geo-information Analyst however do not provide names to the streams and rivers.

Because the available maps of the two basins are generated from isolated databases at different times rather than from a central source, they most often have different scales. This makes it practically impossible to overlay them and to make meaningful deductions.

Difficulties associated with the current mapping scenario of the two basins would be resolved to a large extent if a centralised GIS database for the basins is established and maintained through regular updates. Updating of the GIS database by each institution individually will be more expensive and more difficult to disseminate as the institutions are scattered. This will enable managers and policy makers to evaluate multiple environmental issues to resolve a broad range of watershed issues rather than in a piece-meal fashion, as is the current business as usual scenario.

A GIS database will provide a rapid, convenient method to create maps that display analyzed, sorted, and summarized data needed by managers and stakeholders. It will serve as an integrated assessment tool for improved evaluation and problem solving of a broad spectrum of issues. It will enable managers of the basins to evaluate environmental contaminants by bringing multiple stressors (chemical contaminant data) together with natural resource information and model their relationships. Currently (Business-as-Usual Scenario) individual stressors can only be evaluated in isolation and without the context of the environment in which they were found.

Chapter 4 Roles and Responsibilities of Institutions

Institutions have been established for specific purpose regarding the exploitation of the resources of the environment of which the Pra and Kakum River basins form a part. In this section, we examined the roles and responsibilities of these institutions at the district, regional and national levels in upstream watershed management and downstream distribution and supply of water. The context of the examination of roles and responsibilities of institutions is the Ghana National Water Policy. We further examined barriers inhibiting the execution of these mandates by key institutions.

4.1 The Ministry of Water Resources Works and Housing

The Ministry of Water Resources Works and Housing (MWRWH) is responsible for providing the overall policy direction for the water sector in Ghana. Its mandate is to ensure the delivery of water and sanitation services to the populace in collaboration with allied sector ministries including the Ministry of Local Government and Rural Development (MLGRD), and the Ministry of Finance and Economic Planning (MoFEP). The MWRWH through its Water Directorate (WD) has developed a National Water Policy (NWP) and is coordinating the implementation of same working in collaboration with key stakeholders of the sector.

The MWRWH relies on principal sector agencies at regional, district and grassroots levels in the implementation of its programs. These include the WRC (for Water Resources management), GWCL (urban water supply), and CWSA (for rural water supply and related sanitation provision).

The NWP clearly proposes an IWRM approach for water resources management in Ghana and underscores the focus on the following principles:

i. the principle of meeting the social needs for water as a priority, while recognising the economic value of water and the goods and services it provides;
ii. the precautionary principle that seeks to minimise activities that have the potential to negatively affect the integrity of all water resources;
iii. the principle of polluter pays, to serve as a disincentive to uncontrolled discharge of pollutants into the environment;
iv. the principle of subsidiarity in order to ensure participatory decision-making at the lowest appropriate level in society;
v. the principle of solidarity, expressing profound human companionship for common problems related to water;
vi. the principle that international cooperation is essential for sustainable development of shared basins;
vii. the principle of the greatest common good to society in prioritising conflicting uses of water;
viii. the principle of improving equity and gender sensitivity.

4.2 The District Assemblies

The bedrock of the administration of the country is at the district level with the promulgation of the District Assembly Act 462 of 1993. The District Assembly is the highest political authority in the district. The functions of the District Assembly are:

(1) Subject to article 245 of the 1992 Constitution and to this Act, a District Assembly shall exercise political and administrative authority in the district, provide guidance, give direction to, and supervise the other administrative authorities in the district.

(2) For the purpose of subsection (1), a District Assembly shall perform deliberative, legislative and executive functions.

(3) Without prejudice to subsections (I) and (2), a District Assembly

a) is responsible for the overall development of the district and shall ensure the preparation and submission through the regional co-ordinating council
    (i) of development plans of the district to the National Development Planning Commission for approval, and
    (ii) of the budget of the district related to the approved plans to the Minister responsible for Finance for approval;
b) shall formulate and execute plans, programmes and strategies for the effective mobilization of the resources necessary for the overall development of the district;
c) shall promote and support productive activity and social development in the district and remove any obstacles to initiative and development;
d) shall initiate programmes for the development of basic infrastructure and provide municipal works and services in the district;
e) is responsible for the development, improvement and management of human settlements and the environment in the district;
f) is responsible in co-operation with the appropriate national and local security agencies, for the maintenance of security and public safety in the district;
g) shall ensure ready access to Courts in the district for the promotion of justice;
h) shall initiate, sponsor or carry out studies that are necessary for the performance of a function conferred by this Act or by any other enactment; and
i) perform any other functions provided for under any other enactment.

(4) Subject to this Act and to government policy, a District Assembly shall take the steps and measures that are necessary and expedient to:

(a) execute approved development plans for the district;

(b) guide, encourage and support sub-district local government bodies, public agencies and local communities to discharge their roles in the execution of approved development plans;

(c) initiate and encourage joint participation with any other persons or bodies to execute approved development plans;

(d) promote or encourage other persons or bodies to undertake projects under approved development plans; and

(e) monitor the execution of projects under approved development plans and assess and evaluate their impact on the people's development, the local, district and national economy.

(5) A District Assembly shall co-ordinate, integrate and harmonise the execution of programmes and projects under approved development plans for the district, any and

other development programmes promoted or carried out by Ministries, departments, public corporations and any other statutory bodies and non-governmental organisations in the district.

(6) Without prejudice to subsection (5), a District Assembly in the performance of its functions,

(a) is subject to the general guidance and direction of the President on matters of national policy, and

(b) shall act in co-operation with the appropriate public corporation, statutory body or non-governmental organisation which shall co-operate with a District Assembly.

(7) In the event of a conflict between a District Assembly and an agency of the Government, a public corporation, statutory body, non-governmental organisation or an individual over the application of subsection (5) or(6), the matter shall be referred by either of the parties or both to the Regional Co-ordinating Council for resolution.

4.3 The Environmental Protection Agency (EPA)

The EPA is mandated to act by itself or in collaboration with the WRC to control and prevent discharge of waste into the environment. Illegal small scale mining activities in the Pra basin in particular involve hazardous chemical such as mercury and is leading to the degradation of the riparian vegetation. This problem has now become a national issue and no single government agency is equipped to deal with the menace on its own. The EPA is formally mandated to issue environmental permits, in concert with the Minerals Commission and District Assemblies, for small scale mining and is required to ensure compliance with laid down environmental impact assessment procedures in the execution of small scale mining activities. However given the nature and scale of this problem, the government has established a national task force and committee on lands and natural resources under the National Security Council which is tasked with addressing the issue. Members of this committee and task force include the EPA, WRC, Minerals Commission, Ghana Immigration Services, and a number of other entities.

The EPA Act 490 was passed in 1994 with a number of stated functions (section 2). These include:

a) to advise the Minister on the formulation of policies on the environment and in particular to make recommendations for the protection of the environment;
b) to co-ordinate the activities of bodies concerned with the technical or practical aspects of the environment and serve as a channel of communication between those bodies and the Ministry;
c) to co-ordinate the activities of the relevant bodies for the purposes of controlling the generation, treatment, storage, transportation and disposal of industrial waste;
d) to secure by itself or in collaboration with any other person or body the control and prevention of discharge of waste into the environment and the protection and improvement of the quality of the environment;
e) to collaborate or co-ordinate with foreign and international agencies for the purposes of this Act;
f) to issue environmental permits and pollution abatement notices for controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or any other source of pollutants and of substances which are hazardous or

potentially dangerous to the quality of the environment or a segment of the environment;

g) to issue notice in the form of directives, procedures or warnings to any other person or body for the purpose of controlling the volume, intensity and quality of noise in the environment;
h) to prescribe standards and guidelines relating to the pollution of air, water, land and any other forms of environmental pollution including the discharge of waste and the control of toxic substances;
i) to ensure compliance with the laid down environmental impact assessment procedures in the planning and execution of development projects, including compliance in respect of existing projects;
j) to act in liaison and co-operation with government agencies, District Assemblies and any other bodies and institutions to control pollution and generally protect the environment;
k) to conduct investigations into environmental issues and advise the Minister on these issues;
l) to promote studies, research, surveys and analyses for the improvement and protection of the environment and the maintenance of sound ecological systems in the Republic;
m) to initiate and pursue formal and non-formal education programmes for the creation of public awareness of the environment and its importance to the economic and social life of the country;
n) to promote effective planning in the management of the environment;
o) to develop a comprehensive database on the environment and environmental protection for the information of the public;
p) to conduct seminars and training programmes and gather and publish reports and information relating to the environment;
q) to impose and collect environmental protection levies in accordance with this Act and the Regulations;
r) to regulate the import, export, manufacture, distribution, sale and use of pesticides; and
s) to perform any other functions conferred on it under this Act or any other enactment.

The EPA also has the authority to set up regional and district offices with adequate staff for the purposes of executing its mandate as determined by its board. Thus the greatest responsibility lies with the EPA to protect the environment and it has the mandate to do so. For any activity that poses a serious threat to the environment or to public health, the EPA can serve on the person responsible for the undertaking, an enforcement notice requiring that person to take the steps stipulated by the Board to prevent or stop the activities (section 13). The EPA can also appoint environmental protection inspectors under section 15 and their mandate to inspect, investigate, seize and arrest and prosecute offenders as in section 54 of the Act and penalties applied on summary conviction. The penalty should not exceed two hundred and fifty penalty units or a term of imprisonment not exceeding one year or to both the fine and the imprisonment, and in the case of a continuing offence an additional penalty not exceeding ten penalty units in respect of each day during which the offence is continued. The offender may also forfeit the equipment, pesticide or appliance used in the commission of the offence to the Republic and that a licence issued under this Act shall be suspended for the period directed by the Court or be cancelled.

4.4 The Water Resources Commission (WRC)

The WRC was also established by Act 522 of 1996 to:

1. be responsible for the regulation and management of the utilization of water resources and for the co-ordination of any policy in relation to them.
2. Without prejudice to subsection (1) of this section, the Commission shall -

(a) propose comprehensive plans for the utilization, conservation, development and improvement of water resources;
(b) initiate, control and co-ordinate activities connected with the development and utilization of water resources;
(c) grant water rights;
(d) collect, collate, store and disseminate data or information on water resources in Ghana;
(e) require water user agencies to undertake scientific investigations, experiments or research into water resources in Ghana;
(f) monitor and evaluate programmes for the operation and maintenance of water resources;
(g) advise the Government on any matter likely to have adverse effect on the water resources of Ghana;
(h) advise pollution control agencies in Ghana on matters concerning the management and control of pollution of water resources; and
(i) perform such other functions as are incidental to the foregoing

Thus the WRC is mandated to take overall responsibility over the water resources of Ghana. Specifically, the Commission is mandated to coordinate government policy for the water sector and to regulate and manage the country's water resources. It is required of the WRC to regulate water use (through water allocation), and to approve/coordinate interventions involving appropriation, utilization, exploitation, development, control, conservation and protection of Ghana's water resources.

4.5 The Minerals Commission

Another body that operates within the river basins is the Minerals Commission. The commission established by Act 450 of 1993 requires it to:

1. be responsible for the regulation and management of the utilization of the mineral resources of Ghana and the co-ordination of the policies in relation to them
2. and for purposes of subsection (1) above, the Commission shall—

(a) formulate recommendations of national policy for exploration and exploitation of mineral resources with special reference to establishing national priorities having due regard to the national economy;
(b) advise the Minister on matters relating to minerals;
(c) monitor the implementation of laid down government policies on minerals and report on this to the Minister;
(d) monitor the operations of all bodies or establishments with responsibility for minerals and report to the Minister;
(e) receive and assess public agreements relating to minerals and report to Parliament
(f) secure a firm basis of comprehensive data collection on national mineral

resources and the technologies of exploration and exploitation for national decision making; and
(g) perform such other functions as the Minister may assign to it.

4.6 The Forestry Commission (FC)

On the other hand, the Forestry Commission also exist by Act 571 of 1999 to

1. be responsible for the regulation of the utilization of forest and wildlife resources, the conservation and management of those resources and the co-ordination of policies related to them.

2. Without limiting the scope of subsection (1) of this section the Commission shall-

(a) Regulate the utilization of forest and timber resources by

i. vetting and the registration of contracts to market timber and such other forest and wildlife products as the Commission may determine;
ii. the establishment of procedures to track the movement of timber, wood and wildlife products;
iii. monitoring the harvesting, marketing of forest and wildlife products and related contracts;
iv. promoting the development and dissemination of appropriate industrial standards and trade guidelines for timber, wood and wildlife products;
v. the conduct of pre-shipment inspection and examination of timber, wood and wildlife products;
vi. advising on approvals to establish new timber industries and the registration of approved timber processors and traders in forest and wildlife products;

(b) Manage the nation's forest reserves and protected areas by

i. Proper planning for the protection, harvesting and development of forest and wildlife resources in a sustainable manner;
ii. Monitoring the condition and extent of the nation's forest and wildlife resources;
iii. Controlling the harvesting of forest and wildlife products;
iv. Making recommendations to the Minister on the grant of timber rights and wildlife licenses;
v. Advising the Minister on forest and wildlife policy with particular regard to management practices that sustains resources and improve productivity;

(c) Assist the private sector and the other bodies with the implementation of forest and wildlife policies by

i. Advising and the provision of technical services with regard to matters of resource protection, management and development and of market intelligence pertaining to the timber and wildlife industries;
ii. Co-operating and liaising with national and international bodies and organizations on forestry and wildlife conservation and utilization;
iii. Supporting the development of forest plantations for the restoration of degraded forest reserves, the increased production of industrial timber and the expansion of the country's protected forest cover;
iv. The provision of training management and technical skills for related industries;
v. Advising the appointing authority on matters concerning employment, discipline and training of staff;

(d) Undertake the development of forest plantations for the restoration of degraded forests areas, the expansion of the country's forest cover and the increase in the production of industrial timber; and
(e) Undertake such other functions as are incidental to the foregoing, or as the Minister may direct. Ministerial responsibility and directions by the Minister
The Act setting up the Minerals Commission mandates Government departments and agencies and all public authorities to co-operate fully with the Commission in the performance of its functions under the Act.

4.7 The Public Utilities Regulatory Commission

The functions of the Public Utilities Regulatory Commission are as follows:

(a) to provide guidelines on rates chargeable for provision of utility services;
(b) to examine and approve rates chargeable for provision of utility services;
(c) to protect the interest of consumers and providers of utility services;
(d) to monitor standards of performance for provision of a services;
(e) to initiate and conduct investigations into standards of quality of service given to consumer;
(f) to promote fair competition among public utilities;
(g) to conduct studies relating to economy and efficiency of public utilities;
(h) to make such valuation of property of public utilities as it considers necessary for the purposes of the Commission;
(i) to collect and compile such data on public utilities as it considers necessary for the performance of its functions;
(j) to advise any person or authority in respect of any public utility;
(k) to maintain a register of public utilities; and
(l) to perform such other functions as are incidental to the foregoing.

4.8 Ghana Water Company Limited

The objects of the Ghana Water and Sewerage Corporation (GWSC) by Act 310 of 1965 were:

a) the provision, distribution and conservation of the supply of water for public domestic and industrial purposes, and
b) the establishment, operation and control of sewerage systems.

For the purposes of the above, the Corporation shall:

(a) prepare long-term plans in consultation with the appropriate co-ordinating authority established by the President;
(b) conduct research relative to water, sewerage and connected subjects;
(c) make engineering surveys and plans;
(d) construct and operate works;
(e) set the standards relative to water supply and sewerage in collaboration with the appropriate authorities selected for the purposes of this Act by the President;
(f) determine adequate rates, charges or fees, and effective methods for collection of the fees for water and sewerage services furnished to users; and
(g) conduct any other related or incidental activity.

GWSC was converted to GWCL by Act 461 and carries out its mandate within the Pra and Kakum River Basins as shown by the treatment plants it has established indicated in

Table 6. The Ghana Urban Water Limited is a subsidiary of GWCL mandated to operate all its water supply facilities.

4.9 Barriers to Effective Delivery of Functions by Institutions

The District Assemblies are political divisions which do not necessarily match with the geographical landscape and therefore the river basins. Traditional divisions and land ownership similarly do not necessarily conform to river basin boundaries. Due to the size of river basins there is more than one district or traditional authority or land owner within a basin. This makes management of the basin complex as more stakeholders with different objectives are involved. For successful management of river basins, collaboration among stakeholders is key.

It is the mandate of a District Assembly to co-ordinate, integrate and harmonise the execution of programmes and projects under approved development plans for the district, any and other development programmes promoted or carried out by Ministries, departments, public corporations and any other statutory bodies and non-governmental organisations in the district. A District Assembly is also required to develop, improve and manage human settlements and the environment in the district. It shall act in co-operation with the appropriate public corporation, statutory body or non-governmental organisation which shall co-operate with a District Assembly. However, because conflicts may arise, the Act requires such a matter to be referred by either of the parties or both to the Regional Coordinating Council for resolution. A concern here may be how the matter will be resolved when the other partner is not subject to the directives of the Regional Coordinating Council and more than one Regional Coordinating Council may be involved.

The Metropolitan, Municipal and District Assemblies are required to carry out Waste Management in their respective areas. They are required to provide waste management services directly or indirectly through private contractors or franchises. The Environmental Protection and Standards Enforcement Units of the Assemblies in collaboration with the EPA are responsible for monitoring and enforcing environmental standards and regulations set by the EPA and the WRC. This includes responsibility for monitoring the environmental impact of Assemblies' own waste management activities.

The high levels of pollution of streams in the catchments of the Pra observed during this study can also be attributed to improper waste management. Most of the water tributaries of the Pra River within urban centres are polluted with solid and liquid waste. The underlying causes include the lack of enforcement of sanitation by-laws and proper waste management by the Assemblies.

Whist EPA is responsible for the protection of the general environment (see section 2 (b), (c), (d), (f) (h), (j), (m) and (p) of the Act; WRC is specifically responsible for managing the water resources. Apart from the role of coordinating the activities of all institutions concerning the technical and practical aspects of the environment, the EPA is expected to set standards and guidelines against polluting water, conduct seminars and training programmes and educate the public about the importance of the environment to the economic and social life of the country. For any activities that pose a serious threat to the environment or to public health, the EPA also has the mandate to issue enforcement notices specifying:

i. the offending activity,
ii. the steps required to be taken,
iii. the time within which the steps shall be taken, and
iv. the immediate cessation, where necessary, of the offending activity.

A person who acts contrary to an enforcement notice is liable on summary conviction to a fine not exceeding two hundred and fifty penalty units and in default to a term of imprisonment not exceeding one year or to both the fine and the imprisonment.

Apart from the National office situated in the capital, the EPA has representation in the Regional capitals. Activities of the Western Regional office which oversees the Lower Pra-basin include environmental education, consultations with stakeholders, issuance of permits and others. The offices have not extensively monitored the uses of pesticides along the river, nor has it been able to tackle the issue of pollution and riparian degradation resulting from the activities of small scale and alluvial mining in the River Pra. It is not sufficient for the EPA only to inform the Regional Coordinating Council and District Assemblies about pollution of the environment. It has the power to enforce. The EPA has also the mandate to levy fees and has the National Environment Fund to execute its mandate (sections 16 and 17 of Act 490).

The EPA is a key regulatory agency on matters pertaining to the environment in general. It is responsible for monitoring and ensuring compliance and enforcement of regulations particularly pertaining to the use of environmentally harmful chemicals which are potential sources of water pollution. The performance of the EPA thus directly impacts negatively or otherwise on the water resources of the Pra and Kakum basins. However, the EPA faces several challenges in living fully to its mandate as outlined above. The limitations as explained by the EPA are inadequate offices, staffing and budget.

As is the case for most institutions on government subvention, the EPA lacks the resources it needs (in the right quantum and on time) to manage the myriad of environmental issues confronting the Pra and Kakum basins. Though the Pra basin for instance stretches over multiple regions and districts in Ghana, the EPA is present only at the regional level as it has no district offices. Compliance and enforcement activities are therefore carried out by far stretched regional officers that may be far removed from the problem by distance and by time.

It falls within the mandate of the EPA to put in check the devastating effects of illegal small scale mining activities in the Pra basin. The EPA however complained that its task is made difficult by institutional failure of the Ghana Immigration Service (GIS) and Traditional Authorities who are custodians of the land. The GIS is blamed for the influx of immigrants into small scale mining sector which is a preserve for Ghanaians. Though the EPA is mandated to register small scale mining operations, and to monitor their activities and prosecute offenders, most of the operators however are well armed and resist registration making it difficult for the EPA to do its work. Under the circumstance, the EPA will need the support of the National Security Establishments such as the Police and Army.

The EPA complains that the authorities at district, regional and national levels are fully aware of the infiltration of the small scale mining sector by foreigners who are causing environmental damage but they lack enough political will to resolve the issue. Officials of the EPA in Kumasi feel helpless as it is believed that some influential Ghanaians including politicians, government officials, traditional rulers, security personnel, business

men and opinion leaders are behind illegal small scale mining in the country. Even when steps are taken to enforce the law, interferences by influential people come in the way of the EPA.

The roles of EPA and WRC are not contradictory but rather complimentary. The Ghana Water Company Limited is the direct beneficiary of the WRC since it gets its raw material through water rights from the WRC to produce potable water. The quality of this raw water must be at an acceptable level to allow cost effective treatment. WRC has guidelines for raw water quality (WRC, 2003) and Water Quality Index from 2005 and these should serve as a guide for GWCL to insist that the raw water meets this specification. The WQI is an index that measures the suitability of water resources for domestic purposes based on the weighted concentrations of a set of parameters. The index is used to describe the state of water quality as a whole instead of looking at individual parameters and different weights are assigned to each of the parameters based on their perceived effects on primary health care. The WQI is based on ten water quality parameters comprising: Dissolved Oxygen, Biochemical Oxygen Demand, Ammonia- N, Faecal Coliform, pH, Nitrate- Nitrogen, Phosphate- Phosphorus, Suspended Solids, Electrical Conductivity and Temperature. It should be noted that the quality of raw water in the Pra basin has deteriorated since this index was calculated.

Table 8: Calculation of WQI at Monitoring Sites, Pra Basin, (July 2010)

Parameter	Monitoring Stations								
	Adiembra	Barikese Reservoir	Osino	Lake Bosumtwi	Dunkwa-On-Offin	Daboase	Twifo-Praso	Akim-Oda	Akim-Brenase
Dissolved oxygen (DO) (% saturation)	69	48	82.7	101	84	103	97	93	92
BOD (mg/l)	3.10	3.50	4.10	4.80	3.74	3.40	3.10	3.8	4
Ammonia-nitrogen(mg/l)	0.214	0.884	0.366	0.344	0.202	0.801	1.62	1.64	1
pH	7.78	7.35	7.99	9.09	7.96	8.10	7.72	7.66	7.62
NO3-N (mg/l as N)	0.245	0.251	0.402	0.080	0.434	0.484	0.476	0.441	0.299
Faecal coliform (counts/100 ml)	2	0	32	30	16	40	9	14	80
PO4-P (mg/l as P)	0.094	0.049	0.298	0.097	0.255	0.206	0.237	0.15	0.118
Suspended solids (mg/l)	17	5	95	6	116	225	224	115	24
Elect conductivity (µS/cm)	164	126	108	1508	164	133	130	98.6	152
Temperature (°C)	29.1	33.7	24.9	26.2	24.3	30.6	26.6	29.3	29.3
Total Score-S (%)	77	69	73	76	76	75	76	76	77
WQI = S^2/100	**59.3**	**47.6**	**53.3**	**57.8**	**57.8**	**56.3**	**53.3**	**57.8**	**59.3**

Source: Pra River Basin IWRM Plan (WRC 2012a)

The location map of the GWCL[10] water treatment plants is shown in Figure 38.

[10] Aqua Vitens Rand Limited (AVRL) was the Operator for GWCL at the time this information was captured (See Table 6 also). GUWL has replaced AVRL

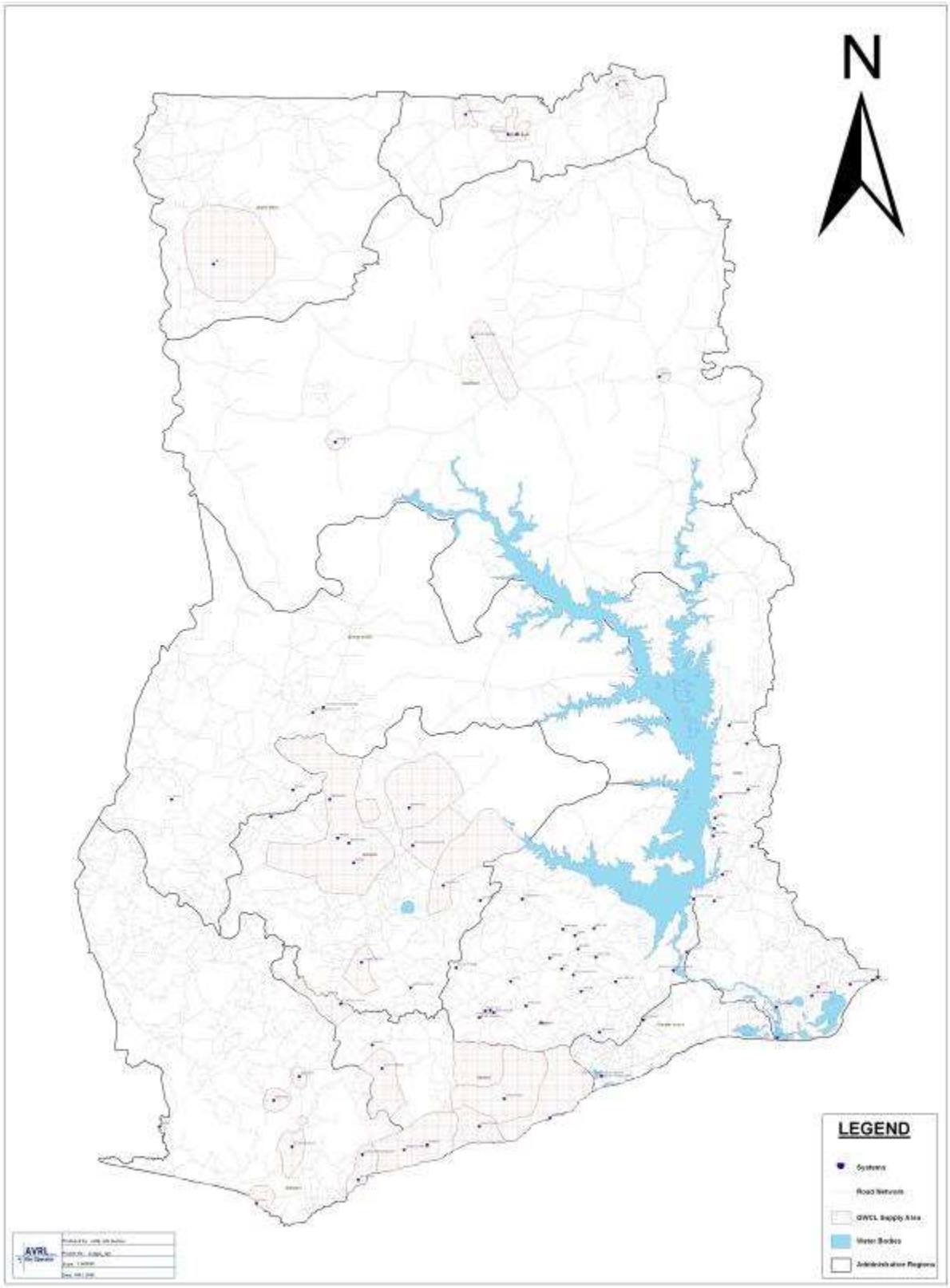


Figure 38: GWCL Water Treatment Plants Locations

The Water Resources Commission is a relatively new water bureaucracy which needs sufficient injection of funds to consolidate its human resources and logistics base. However, government allocations to the Commission have rather consistently fallen from

GH¢94,500 (in 1997) to GH¢60,845 (in 2009), in the face of rising expectations (MWRWH, 2009: Water and Sanitation Sector Performance Report 2009). Even more worrying is the fact that the money from the allocations that actually hits the accounts of the Commission have been extremely low (6.3% in 2007, 11.7% in 2008 and 3.2% in 2009). It is estimated that Government releases to the Commission in the past few years constitute only about 3% of its internally generated funds. The late release of funds from government to the Commission is equally worrying and a barrier to effective delivery of its mandate.

Thanks to international development partners, the WRC relied heavily on them for support since 1999. However, this support is now decreasing. A European Union grant in 2010 provided initial investment for setting up the Pra Basin Management Project, which allowed grassroots management structures to be formed for the Offin sub section of that basin.

It appears the WRC does not have adequate staff strength, particularly at the basin levels, to execute planned activities at the basin office. The organisational structure of the WRC shows that it operates on river basins basis with basin offices irrespective of the political divisions of the regions which cut across river basins (Appendix 5). At present, the Commission implements its mandate through its river basin offices. The Pra Basin is under the management and supervision of the Pra Basin Secretariat of the WRC located in Kumasi. The Secretariat is assisted by the Basin Board (made up of key stakeholder institutions in the basin) to execute its functions/activities

Due to the large extent of the basin relative to staff strength and logistics availability, the secretariat which has only two technical officers is currently concentrating on the Offin sub-basin only. The Birim and Lower Pra sub-basins receive much less attention from the Pra Basin secretariat. Activities carried out by the Kumasi Secretariat include:

- Ecological monitoring three times a year on the Offin sub-basin for the monitoring of water quality and human activities along the banks. No quantitative data is collected except in a few cases.
- Participation in radio talk shows, and holding of community durbars to raise awareness for the conservation of water bodies. A community durbar took place at Abofor where some members of the Basin Board were present. Cost is estimated at ghc 5,000.00.
- Sensitization of school children to "catch them young" not to pollute water bodies by involving them in World Water Monitoring Challenge activities which includes the monitoring of quality parameters (i.e. pH, turbidity, water temperature and dissolved oxygen).
- Registration and identification of water users for permits to be granted them for a fee.
- Collaboration with other institutions such as the EPA and Town and Country Planning Department that demarcates the buffer zone along water bodies.

Allied institutions with representation of the WRC are required to assist the commission to successfully carry out its mandate. These institutions include the Environmental Protection Agency (EPA), The Forestry Commission (FC), the Minerals Commission (MC), the Ghana Water Company Limited (GWCL), and Municipal and District Assemblies. The WRC works with and through relevant institutions for the fulfilment of its mandate at the grassroots. For instance monitoring and allocation of water use rights are supposed to be undertaken by District and Municipal Assemblies with the help of traditional authorities. However, the Assemblies are not well equipped themselves and are already

overwhelmed by their core mandate. Their staff lack adequate motivation, and at times capacity for the requisite assignment and are often poorly funded. As a result social networking and political patronage, more than water rules and regulations, rather influence resource allocation and activities to the benefit of better connected actors.

In terms for policy deficiency, the delay in enforcing the Buffer Zone policy is greatly hampering the WRC from living to its mandate. This is because much of the threats facing critical water resources in the Pra basin can be traced to degradation of the river banks either by illegal mining or encroachment by settlements and crops. The buffer zone policy was fashioned to address these issues and to ensure that land strips/areas along open water bodies are designated and managed as conservation areas. The Buffer Zone policy has been approved by Cabinet for implementation. However, the Legislative Instrument (L.I.) is yet to be prepared for Parliamentary approval for enforcement.

With the coming into force of Statutory Corporation (Conversion to Company) Act 461 GWCL is no more responsible for the establishment, operation and control of sewerage systems. That role has been passed on to Metropolitan/Municipal/District Assemblies. The responsibilities of setting water quality standards and tariffs have been taken over by the Ghana Standards Authority (GSA) and the Public Utilities Regulatory Commission (PURC) respectively. Unfortunately, GSA does not set raw water quality standards. It is also not prudent for the WRC to set raw water quality standards since that can be seen as the player and referee. WRC should not superintend itself. The water tariffs approved by PURC take into account among other factors the treatment cost of water. It is a given fact that the cost of treatment depends on the quality of raw water. The more polluted the raw water is the more expensive and difficult the resulting treated water. This cost will ultimately be passed on to the end user-the consumer. It is therefore necessary to take preventive measures to maintain clean raw water.

The role of the Minerals Commission in the water sector cannot be over-emphasised as it is mandated to assist the EPA and the WRC in ensuring compliance with environmental regulations by mining companies. However the Minerals Commission is itself confronted with many challenges already discussed above which are impediments especially with regards to tackling the menace in the small scale mining sector.

The Commission is constrained by inadequate funding and logistics to fund its anti-illegal mining security task force. As a result it is unable to monitor and ensure that the small scale mining licenses it issued to Ghanaians are not abused or sold out to foreigners as is commonly the case. The MC also counts on the Ghana Immigration Service to ensure that foreign nationals arriving in the country on tourist visas are not engaged as workers in the small scale mining sector. Beside the issue of inadequate funding and logistics for Minerals Commission to enable it carryout it mandates effectively, a seeming lack of sufficient political will to enforce compliance to the later has been cited as a barrier.

All the laws and mandated institutions seem adequate to ensure a clean environment where watershed services can be optimised for socio-economic good of the people. However, the reality is that the environment is being polluted in careless abandon due to a number of reasons.

1. Institutional failures from Ghana Immigration Service, traditional rulers and EPA. Many Chinese do not have work permits, yet they are working in Ghana in an illegal way. The

law has to be enforced by Ghana Immigration Service. EPA is mandated to register them, but the Chinese resist it and are also armed to the teeth. The authorities of the district assemblies, regional coordinating councils and at national level are fully aware, but seem quiet about it.

2. Involvement of traditional rulers, landowners and "big men" who benefit from the illegal activities that harm the environment.
3. Unemployment. The unemployed are able to raise money for their livelihood by engaging in illegal mining
4. Attitudinal behaviour of Ghanaians.

Unless each institution works to its mandate and all applicable laws are enforced, the watersheds will continue to suffer from wilful pollution. IWS will however help educate the public and provide alternative livelihoods to the people to sustainably use the services of the watersheds.

Chapter 5 Watershed Management: Initiatives, Laws & Recommendations

5.1 Watershed Management Initiatives in Ghana

Ghana's water vision for 2025 has the main objective to "*promote an efficient and effective management system and environmentally sound development of all water resources*". The overall goal of the National Water Policy is to "achieve sustainable development, management and use of Ghana's water resources to improve health and livelihoods, reduce vulnerability while assuring good governance for present and future generations". Water Resources Management is topmost among the relevant issues intended to be addressed. Current trends point to the fact that an Integrated Water Resources Management (IWRM) approach is needed to safeguard the water needs of the country. This approach has been adopted in Ghana with the purpose "to promote an efficient and effective management system and environmentally sound development of all its water resources" based on IWRM principles[11].

Over the ages, communities in Ghana and other parts of the world had been particular about managing watersheds due to the worth of valuable resources that watersheds hold. It is common knowledge that in some traditional settings in Ghana water bodies are recognized as gods and therefore one must not enter water bodies with any foot wear. Invariably, no farmer is allowed to weed right up to the bank of water bodies.

Lately, the treasured traditional arrangements to manage or conserve watersheds is being eroded through modernity to such an alarming extent that people violate watersheds with impunity and total disregard for law and order. These detrimental trends have made watershed issues a public concern.

In view of this the Government of Ghana passed new legislations or Acts of Parliament to augment already existing ones to ensure that the pressure on water resources and poor sanitation as a result of population explosion and poorly planned settlements are addressed to ensure sustainability of the consumption and regeneration of water resources as well as improving the sanitation situation in all watersheds in Ghana.

5.1.1 Laws/Acts of Parliament on Watershed Management

Laws on watershed management have been passed to ensure sustainable utilization and management of water resources as well as the provision of sanitation services in watersheds and include:

- Beliefs and rules on water use and sanitation that are well entrenched in the traditional settings in Ghana
- Volta River Development Act 46 of 1961
- PNDCL 256 Fisheries Law of 1991
- 1992 Constitution of the Republic of Ghana
- Local Government Act 462 of 1993
- Ghana Water Company Act 461 of 1993
- Minerals Commission Act 450 of 1993
- Environmental Protection Agency Act 490 of 1994
- Lands Commission Act 483 of 1994

[11] *Ghana National Water Policy, 2007*

- Water Resources Commission Act 522 of 1996
- Public Utilities Regulation Commission Act 538 of 1997
- National Water Policy of 2007

It is important to note that the laws outlined in the fore going continually evolve Legislative Instruments for the efficient execution of the laws.

Table 8 shows the relevance of the laws assembled above and how they seek to enhance adequate and good quality raw water for various uses as well as production of potable water for domestic and industrial use.

Table 9: Relevant Laws on Watershed Management

Water and Sanitation Legal Document	Relevant Section	Remarks
Traditional beliefs and rules on water and sanitation	Specific traditional beliefs related to water resources management, hygiene / sanitation	The traditional norms that conserved water resources and ensured sanitation were effective in the good old days.
1992 Constitution of the Republic of Ghana	Article 269, Section 1	Article 269 of the 1992 Constitution makes provision for the setting up of Natural Resources Commissions to conserve and protect all or most of the natural resources and sustain the natural ecosystem.
Local Government Act 462 of 1993	Sections 10, 14, 38 and 61 - 64	These sections of the Local Government Act 462 provides for the functions of the Metropolitan, Municipal and District Assemblies to set up Departments such as the Environmental Health and Sanitation, Waste Management and Works Departments to see to sanitation, hygiene and orderliness within the environment.
The Minerals Commission Act 450 of 1993 and The Minerals and Mining (Amendment) Act 475 of 1994	Section 15 of Act 450 of 1993	Section 15 of The Minerals Commission Act states that 'Government departments and agencies and all public authorities shall co-operate fully with the Commission in the performance of its functions under this Act.
The Environmental Protection (EPA) Agency Act 490 of 1994	Sections 2 (h) and 3	Section 2(h) states as part of the functions of the Agency that the Agency exists 'to prescribe standards and guidelines relating to the pollution of air, water, land and other forms of environmental pollution including the discharge of wastes and the control of toxic substances.
The Volta River Development Act 46 of 1961	Section 10 (d) and (e), Section 14 (2), Sections 18 and 29	The Act provides for the development of the lake of the Akosombo Dam as source of fish and for the transportation of goods and passengers as well as recreational amenity for the health and well-being of fringe communities. Sections 14 (2), 18 and 29 relates to catchment protection/conservation in collaboration with

		public institutions.
Water Resources Commission Act 522 of 1996	The entire Act and more especially Sections 1, 2, 3 (2), 7, 12 to 38	The Act in its entirety provides for collaboration with key stakeholders that normally could lead to the establishment of committees to manage and regulate the use of water resources as well as co-ordinate policies in relation to them.
Council for Scientific and Industrial Research (CSIR) Act 521 of 1996	Sections 2 (b, c, e, h), 16 and 28	The CSIR Act 521 of 1996 provides for setting up of research institutes, units, centres and projects as it considers necessary for the carrying out of its functions. The Water Research Institute (WRI) of the CSIR carries out research on water for sustainable national development.
PNDCL 256 Fisheries Law of 1991	PART II 3, PART IV 16, 20 and 23	This law prescribes the issuance of fishing licenses, prohibition of fishing in specified zones and restrictions on the use of some fishing methods and gear to sidestep over fishing and pollution of the various water bodies.
Lands Commission Act 483 of 1994	Sections 2 and 3	The Lands Commission Act established the Commission to on behalf of the Government manage public land and any land vested in the President by the Constitution or by any other law or any other lands vested in the Commission.
Public Utilities Regulation Commission (PURC) Act 538 of 1997	Sections 1, 3, 4, 29, and 47	This Act provides for the establishment of the Public Utilities Regulatory Commission to regulate and oversee the provision of utility services by public utilities to consumers and to cater for related issues.
National Water Policy of 2007	Entire document	The National Water Policy of Ghana is intended to provide a framework for the sustainable development of Ghana's water resources.

It is abundantly clear that Ghana has so far, enough legislation on water and sanitation and that hardly any gaps exist in the current laws governing water and sanitation in watersheds. The main problem now is lack of enforcement by the appropriate authorities.

5.1.2 Watershed Management Initiatives by the Water Resources Commission (WRC) in Ghana

The National Secretariat of the Water Resources Commission was set up in Accra in Cantonments in 1998, upon the passing of its establishment law – Act 522 of 1996. The Commission is composed of a Chairman who shall not be a Minister or a Deputy Minister and one person representing each of the following institutions:

- the Ghana Water Company Limited
- Organizations producing potable water
- the Hydrological Services Department of the Ministry of Water Resources, Works and Housing
- the Volta River Authority
- the Irrigation Development Authority
- the Water Research Institute
- the Ghana Meteorological Agency
- the Environmental Protection Agency
- the Forestry Commission

- the Minerals Commission and
- the Executive Secretary (WRC Act 522, 1996).

The Commission, alongside the Ministry of Water Resources, Works and Housing, contracted several consultants from the public and private sectors to conduct baseline studies to inform the WRC on the way forward. With support from DANIDA, the following baseline studies were carried out from 1998 to 2004, besides watershed pollution control activities throughout Ghana:

- Water Resources Management Study of the Coastal, South-western and Volta River Systems of Ghana (MWRWH, 1998)
- Water Resources Management Problem Identification, Analysis and Prioritization Study in Ghana(WRC, 2000)
- Rapid Environmental Assessment of the Densu Basin (WRC, 2000)
- Identification of Major Trends in the Socio-economic Development in the Densu Basin of Relevance for Integrated Water Resources Management (IWRM) and Compilation of Participatory Methods of Relevance for IWRM in the Densu Basin (WRC, 2003)
- Groundwater Assessment of the Densu Basin (WRC, 2003)
- Towards Establishment of an IWRM Structure for the Densu Basin (WRC, 2004)
- Training Needs Assessment of Stakeholders and Vegetation Cover Survey in the Densu Basin (WRC, 2004)

Recommendations from the baseline studies informed the selection and setting up of the Densu Basin Management Structure and instituted a good number of the initial interventions with respect to the introduction of IWRM in the Densu Basin. Globally, IWRM is defined as:

> *"... a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*[12] *..."*

Indeed, from early 2002 up to mid 2004, the Densu Basin Officer was hired, the Densu Basin Board (DBB) was established and inaugurated and the Densu Basin Secretariat was set up in Koforidua in the Eastern Region of Ghana. The DBB is made up of representatives from the:

- WRC
- six key local government assemblies within the Basin
- Eastern Regional Co-ordinating Council
- Environmental Protection Agency (EPA)
- Forestry Commission
- National Commission on Culture
- Ghana Water Company Limited (GWCL)
- Department of Women of the Ministry of Women and Children's Affairs
- Earth Service – a nongovernmental organization
- Akyem Abuakwa Traditional Council
- Ministry of Health

[12] *Global Water Partnership (GWP): Integrated Water Resources Management, Technical Advisory Committee, TEC Background Paper No. 4 (2000)*

- Ministry of Food and Agriculture
- Birim River Basin

The Birim Basin is represented on the DBB due to the massive pollution in the Birim Basin as a result of illegal mining activities which has become a national issue and therefore requiring immediate attention. The arrangement is that the Densu Basin Secretariat must take charge of the Birim Basin in the interim.

The Densu Basin Secretariat collaborates with all representatives on the Board as well as other relevant public and private entities to service the Board for the Quarterly Board Meetings, Ecological Monitoring, Awareness Creation, Education and Training and handling of cases on pollution and encroachments.

By dint of hard work, the Densu Basin management of the WRC has been able to:

- develop the IWRM Plan for the Basin
- organise various entities who are voluntarily working to ensure adequate vegetative cover within and around the Basin to curb erosion and siltation
- dredge segments of the midstream of the river to save seasonal flooding
- identified and registered over forty raw water users and well drillers who are complying with the Water Use Permit and Drilling Licence Regulations.

These have resulted in steady improved water quality within the Densu Basin due to changing attitudes in spite of some occasional point source pollution incidences.

It is worth noting that the funds that are generated out of the issuance of the Water Use Permits and the Drilling Licences mainly constitute the Water Management Account, which goes to support the service functions of the WRC which is representative of the concept of the Investment in Watershed Services (IWS). The correlation between the Water Management Account and the IWS would be elucidated in Chapter 6.

Without any loss of generality, the WRC replicated the watershed management initiatives pioneered in the Densu Basin in the:

- White Volta Basin
- Ankobra Basin and
- Pra (Offin) (recently initiated) and Tano River Basins.

Studies of the river systems in Ghana have revealed that every river has its own peculiar issues that management effort focuses on. In this regard, the formation of committees of the various river basin boards takes into consideration the peculiar nature of basins. In the Densu Basin for instance, the committees of the DBB are:

- Awareness Creation and Education Committee
- Land Use Management Committee
- Waste Management Committee
- Programmes and Budget Committees

The White Volta Basin also has a committee on trans-boundary issues because the river spans Burkina Faso and Ghana. It is the entire Volta River that spans over six countries namely; Benin, Burkina Faso, Ivory Coast, Ghana, Mali and Togo. The committees of the basin boards meet at least once a year to plan and prosecute programmes to push

forward the national agenda of working to ensure the recovery of the ecological health of all of Ghana's watersheds.

In areas where the WRC has not established a basin secretariat, it collaborates with relevant public and private institutions to tackle watershed management issues effectively. Alternatively, the closest basin secretariat is requested to take charge and report adequately for support from the national secretariat (Head Office).

5.1.3 Law Enforcement Challenges and Trends in Water Supply and Sanitation Services in Watersheds in Ghana

Ghana has a good number of laws on the management of watersheds as indicated in Section 5.1.1 above. However, these are not adequately enforced due to a number of challenges which include:

- Familiarity among the Ghanaian populace that is derived through family relations, school and work place colleagues, church membership links, etc.
- Attitudes of people that are not willing to change
- Poor planning, management and maintenance culture
- Poverty and
- Lack of the requisite logistics or equipment for law enforcement agencies.

Each of these challenges would have to be drastically dealt with to realize adequate water for all and good sanitation in watersheds countrywide.

As outlined above, watershed management initiatives for the Pra and Kakum River Basins, dates back to antiquity. Upon the realization that the traditional rules and regulations were no longer adequate, it became evident that public laws need to be instituted to instil discipline in the use and exploitation of resources of watersheds. This accounts for the existence of the public institutions that are responsible for the conservation and maintenance of the natural or physical environment or the terrestrial and aquatic ecosystems. It is important to underscore that there is a long history of initiatives by the informal sector to manage and maintain watersheds. Over here, reference is being made to the Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs), Faith-based Organizations (FBOs) and concerned individuals. Although the operations of such entities either alone, in collaboration with or in partnership with public institutions is known to be fragmented. This is because watershed management is not their primary responsibility. This among other related factors is what inspired the setting up of the WRC to take up as its primary responsibility, watershed management and to co-ordinate policies as well as play a lead role in activities towards the conservation of watersheds.

The WRC has done thorough baseline studies encompassing management recommendations on the need to conserve the Pra and Kakum River Basins. The management recommendations placed premium on:

- the need for institutional reforms for efficiency and effectiveness
- sustained public awareness creation or raising, education and training of stakeholders to promote understanding, ownership and support from the populace
- the introduction of IWRM
- stakeholder consultations and networking among partners on IWRM

- the initiation of the establishment of buffer zones
- promotion of community livelihood systems
- administering and monitoring compliance of the Water Use Permit and the Well Drilling License as a way of regulating water resources
- the drawing of an IWRM Plan and more specifically, the;
- establishment of a biosphere reserve in the Lake Bosumtwi catchment area and
- collaboration with public and private organizations to conserve the Kakum Basin as an important coastal river system.

Figure 39 shows the close and coastal neighbourhood of the Pra and Kakum River Basins. This presupposes that the two rivers have similarities in their macro climate, ecology and hydrology. It is obvious that if it had not been due to the existence of the Kakum National Park, the Kakum Basin would have been abused very badly through mining, farming and other human activities.

For a little over a year ago, the WRC, with reference to the Water Resources Management Problem Identification, Analysis and Prioritization Study, (WRC, 2000) has set up the Pra Basin Board and Secretariat at Kumasi, to in the interim, focus attention on managing the Offin sub catchment of the Pra River. The Secretariat has so far:

- established links with Ashanti Regional Coordinating Council, the Local Government Assemblies within the sub-catchment, NGOs, CBOs, FBOs and concerned individuals to tackle issues relating to pollution and encroachment
- assisted in the drawing up of the IWRM Plan
- created awareness in a few communities, radio and television stations and
- partnered various entities to carry out catchment protection and rehabilitation works such as tree planting, clean up exercises among others.

In the case of the Kakum River Basin, the WRC has not set up any management structure yet. As has been indicated above, the definite opportunity available to the WRC is the existence of the Kakum National Park that has been instituted by the Wildlife Division of the Forestry Commission. Currently, the presence of the Park and the works of all existing management entities within the Basin are partially serving as the management initiative for the Kakum River Basin.

All the investments that went into setting up the Kakum National Park and the Pra (Offin) Basin Secretariat as well as those from NGOs, fringe communities and philanthropists therefore constitute IWS. These IWS investments would revolve to the WRC, Forestry Commission and even the fringe communities through the issuance of Water Use Permits, Well Drilling Licences, Park Fees and honouring of social responsibilities.

Baseline studies of the WRC and the National IWRM Plan provide strong recommendations to manage all the watersheds of Ghana, including the Kakum River Basin. It is therefore expected that in the very near future the WRC will set up basin level management structures for the Kakum River Basin.

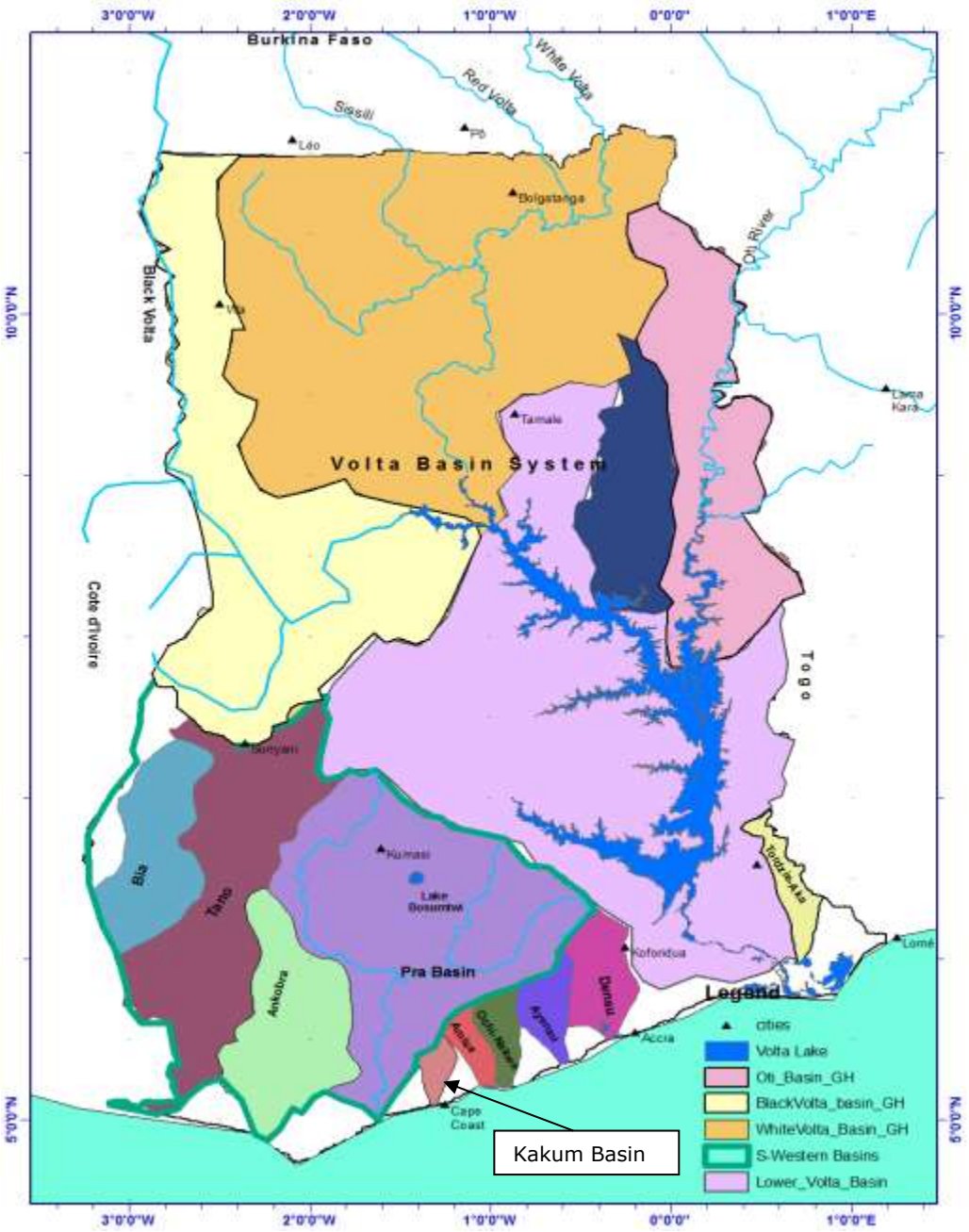


Figure 39: River Basins of Ghana

5.2 Pre-conditions for Successful River Basin Management Practices

Ecosystem changes take place due to natural or human factors termed drivers, and there are direct and indirect drivers of ecosystem change. These direct drivers which are physical and can be identified and monitored include:

- changes in local land use and land cover (land conversion,
- modification of river flow and water extraction);
- species introductions and removals;
- discharge of pollutants and overuse of fertilizers;

- harvest of plants and animals (and other species); and
- climate variability and change.

In the case of indirect drivers which operate by altering the level or rate of change of one or more direct drivers, the Millennium Ecosystem Assessment (MA) lists five namely:

- demographic (population growth and distribution);
- economic (globalization, markets);
- socio-political (governance and legal framework);
- science and technologies (agricultural technologies); and
- cultural and religious (choices about what and how much to consume).

These drivers are therefore to be taken into account in any watershed management strategies. In view of the colossal ecosystem services derived from the two basins watersheds, there is the need to work assiduously and strategically to ensure their successful management. So far, the WRC has two success stories in the Densu and the White Volta Basins. The genesis of the preconditions for successful river basin management is that there should be a river basin that is stressed with the presence of primary and secondary stakeholders. Primary stakeholders are those whose livelihoods directly depend on the water resources e.g. vegetable growers, fishermen, tradesmen, and communities drawing water from the basin. Secondary stakeholders are those whose livelihoods may not directly be attached to the water resources in the basin but who engage in activities that affect use, protection and conservation of the water resources. Table 10 below gives examples of watershed primary and secondary stakeholders.

Essentially, stakeholders need to be identified at various levels to provide contemporary information about current uses of water resources for consideration. Furthermore as stakeholders are identified, specific programmes in IWRM in the basin can be implemented with various stakeholder groups in mind because activities of various stakeholders are different and certainly have varying impacts.

There must also be a management structure in place supported by adequate financial and material resources to be able to implement a successful integrated water resources management.

Table 10: Stakeholders in a Typical Coastal River Basin such as Pra and Kakum Basins

Primary Stakeholders	Secondary Stakeholders
Staple Food Growers	IWRM Board
Vegetable Growers	District Assemblies
Fishermen	Unit Committees
Herdsmen	EPA
Domestic water users	CBOs
Commercial water users	Chiefs, queen mothers and their elders
Industrial water users	Opinion leaders/other groups e.g. Youth and Women groups, Teachers
Poor and disadvantaged groups, etc.	NGOs, etc.

Source: *Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report*

The chronology of events that lead to successful river basin management upon prioritization and selection of a particular river basin are as follows:

- Commissioning of baseline studies on the selected River Basin
- Preparatory arrangements to introduce IWRM at stakeholders' workshop to discuss membership of the Basin Board and office accommodation
- Holding of stakeholders' workshop
- Writing to selected institutions or organizations for nominations to serve on Basin Board
- Collation of the list of nominees to serve on the Board
- Preparation of Operational Guidelines of Basin Board (Constitution/Mode of Operation)
- Appointment of Basin Officer
- Nomination and approval of Board Chairperson and Vice Chairperson at maiden meeting
- Inauguration of Basin Board
- Setting up and inauguration of Basin Secretariat
- Establishment of links and partnerships with Regional Coordinating Councils, Local Government Assemblies, NGOs, CBOs, FBOs and concerned individuals
- Avoidance of the duplication of functions but collaborates and institute micro projects and support micro projects through IWS (micro projects involves awareness creation, education and training of stakeholders, cleanup exercises, catchment rehabilitation works, etc.)
- Institution of Water Quality Monitoring and Ecological Monitoring to establish trends.

The preconditions outlined above, is the approach adopted by the WRC for the realization of the successes in the five river basins being managed currently. It must be noted that the approach used follows national standards of setting up natural resources management structures. One basic issue is that attitude of stakeholders need to change to ensure absolute recovery of watersheds in Ghana.

5.3 Proposed IWS Initiatives for Pra and Kakum Basins

In as much as the WRC has achieved successes through the adoption of the processes intimated in Section 5.2, it is evident that the same approach needs to be adopted for the Pra and Kakum River Basins with innovations where appropriate. Investments in Watershed Services as a financial mechanism can complement IWRM. The existing Water Resources Management Account is an IWS mechanism which needs to be strengthened / expanded. Ideally, IWS helps to align the long-term economic interests of the various IWRM stakeholders, connecting the watershed investments with beneficiaries, ideally with clear performance metrics. In other words, help those who are paying to 'see' the benefits from their investment in natural capital in terms of water quality and flow. The WRM account could be strengthened by connecting the various abstraction fees to water quality and flow benefits, so that people are not just paying a fee (always to be avoided) but perceive the payment as being linked to improvements in the quality of water they receive and to deterioration in the quality of water for those further downstream.

Perhaps the strong point should be taking advantage of the existence of the Kakum National Park and the other Nature Reserves all through the two Basins. The Densu Basin has similar privileges due to the presence of the Atewa Forest Reserve and the

Densu Delta Ramsar Site. Some of these protected areas are already benefiting from IWS complementary interventions. The implementing institutions (Appendix 7) should be involved during any stakeholder consultation and engagement for IWS in the basins.

Chapter 6 Water Resources Management Account

6.1 Institutional Management Accounts

In the operations of any institution, financial resources are needed. Therefore, the institutions in Ghana whose operations have an impact on raw water quality and quantity are no exception. Even though the institution in Ghana responsible for the management of the water resources receives funding from government, these are not adequate. Therefore there is interest in establishing an IWS fund. It is therefore critical to know how existing funds for various institutions operate and under what mandate so that if the IWS fund is established, it can be appropriately situated.

A number of institutions set up by the state are permitted under their mandate to raise additional funds other than from the Government of Ghana Consolidated Fund for the execution of such mandates. In some cases, the use or purpose of such additional funds are specified. For example, the EPA has a National Environment Fund which consists of

1. grants in aid from the Government for the protection or improvement of the environment,
2. levies collected by the Agency in the performance of its functions, and
3. donations and gifts to the Agency.

It is clearly spelt out that the Fund shall be used for:

1. environmental education of the general public,
2. research, studies and investigations relating to the functions of the Agency,
3. human resource development, and
4. any other purpose determined by the Board in consultation with the Minister.

It further requires the Fund to be administered by the Board and the Controller and Accountant General or two representatives of the Controller and Accountant-General.

In the case of the Minerals Commission, its funds shall include:

a) Government subventions;
b) any loans granted to the Commission;
c) any monies accruing to the Commission in the course of the performance of its functions under this Act or any other enactment;
d) gifts; and
e) monies from any other source.

The Forestry Commission also generates additional funds as its sources include:

a) such monies as Parliament may provide to the Commission for the performance of its functions;
b) monies due to the Commission under this Act and any other enactment;
c) loans granted to the Commission; and
d) grants.

In the particular case of the WRC, its funds include:

a) Government subvention
b) any loans granted to the Commission

c) any monies accruing to the Commission in the course of the performance of its functions under this Act or any other enactment
d) gifts and
e) monies from any other source

In order to raise funds under c) and e) above, the WRC in 2001 instituted the Water Use Permit (WUP) through the development of the Legislative Instrument (L.I.) 1692 of 2001. Additionally, the Drilling Licence and Groundwater Development were also instituted by the WRC, through the passing of the Legislative Instrument (L. I.) 1827 of 2006. It is important to indicate that these two legal instruments were derived from the parent Act 522 of 1996. At the moment, the WRC is working on two other regulations; the Buffer Zone Regulations and the Dam Safety Regulations. The L.I.s are meant to make practical, the parent Act 522 of 1996. Water uses include:

- Domestic,
- Commercial,
- Industrial,
- Agricultural,
- Power generation,
- Fisheries (aquaculture),
- Recreational, and
- Under water (wood) harvesting.

The provisions of LI 1692 include:

1. The various water uses that should be permitted
2. Application procedure
3. Public Hearing
4. Priority of water use in cases of conflict between and among uses.
5. Objections on the Commission's decisions and resolution.
6. Exemptions in terms of mode of abstraction and given thresholds.
7. Registration of water uses that do not need permits and the role of District Assemblies.
8. Grant of Permit (reasons for the grant or otherwise of a permit)
9. Appeals (procedure to lodge complaint for refusal of permit)
10. Cessation of permit (actions to be taken by WRC)
11. Non-Transferability of permits
12. Payment of water charges to facilitate informed management of the water resources.

The purpose of the LI 1827 is to:

- Provide licences to companies that prospect for and drill water wells;
- Regulate in an environmentally sustainable manner the development of Ghana's groundwater resources; and
- Gather information on the groundwater resources availability in Ghana and its exploitation for effective planning and management of groundwater development activities.

The Regulations are followed by four Schedules, which set out provisions on:

1. Application forms;
2. Fees;
3. Notice of intention to undertake well construction; and

4. Water quality parameters to be analyzed by licence holders.

Twenty-nine (29) well drilling licenses were issued during the reporting year 2009 to twenty-nine contractors including four (4) foreign contractors bringing the total number of companies issued with licenses to fifty seven (57) by the end of that year. At the end of 2011 forty-one (41) well drilling licenses were issued bringing the total to one hundred and two (102) as compared to the fifty-seven (57) in 2010.

The WRC classifies drilling companies under three categories: A Category 'A' company must possess more than four drilling rigs; a category 'B' company must possess between two and five drilling rigs; a Category 'C' company either hires rigs or possesses only one drilling rig.

Out of the total of 57 licensed companies, 39, representing about 68% were in Category 'C', while 18, representing 32% were in Category 'B'. None of them were in Category 'A' (www.wrc-gh.org, 2013).

The Drilling Licence is about regulating groundwater exploitation that has good relevance in water resources conservation in view of the fact that indiscriminate tapping of groundwater could result in subsidence. Similar administrative procedure is followed in the issuance of the Drilling Licence as in the case of the WUP. Application forms for the WUP and the Drilling Licence are obtainable from the WRC. These regulations promoted the development of the WRC Water Management Account.

6.2 Basis of the WRC Water Management Account

The Water Management Account exists to enable the WRC to carry out its services relating to watershed management. Since its inception up to date, the Account has supported and sustained awareness creation and education, watershed catchment rehabilitation works such as tree planting, cleanup exercises and research work among others. The Account therefore promotes the establishment of strong links among the various stakeholders; primary and secondary alike. In the Densu and the White Volta Basins for instance, a number of secondary stakeholder groups have been supported for various micro projects on:

- Awareness creation, education and training through community durbars, symposia, consultation and on radio and Television.
- Tree planting and establishment of buffer strips
- Cleanup exercises, dredging and restoration of the ecological health of watersheds.

6.3 Sources of Funding of the Account

The main sources of funding that grow the Water Management Account are the Water Use Permit (Table 11) and the Drilling Licence. The fee is based on the volume of water abstracted and the abstraction permit is renewed annually. All the funds generated out of the issuance of the WUP and the Drilling Licence is deposited into an account referred to as the Water Management Account. The Water Management Account of the WRC is also fed by a source such as the hiring of the conference room of the Densu Basin Secretariat at Koforidua.

Table 11: Administrative and Processing Fees for Approved for use by WRC

Category of Use	Fee (GH¢)	Category of Use	Fee (GH¢)
Industrial	1,000.00	Commercial	500.00
Mining	1,500.00	Livestock Watering	500.00
Domestic/Municipal	500.00	Construction	1,000.00
Irrigation	500.00	Damming	1,500.00
Hydropower	1,500.00	Dewatering	1,500.00
Navigation	500.00	Diversion (all categories)	200.00
Recreation	500.00	Dredging	1,000.00
Aquaculture (Cage)	1,000.00	Underwater Wood Harvesting	1,500.00
Aquaculture (Pond)	500.00	Spillage (Freshwater)	1,000.00
Small Town Domestic Water System	500.00	Application Forms	20.00

Source: fees and Charges (Amendment) Instrument, 2012 (L.I. 2191)

Table 12: Water Use Charges 2012 by L.I. 2191

Category of Use	Fee (GH¢)
Industrial per annum for $10m^3$	0.03
Mining per annum for $10m^3$	0.04
Domestic/Municipal per annum for $10m^3$	0.02
Small Town Domestic Water System per annum for $10m^3$	0.01
Irrigation Private Schemes per annum for $10m^3$	0.02
Irrigation Small Scale Schemes per annum per Hectare (per season)	0.02
Livestock Watering per annum for $10m^3$	0.02
Aquaculture (Pond) per annum for $10m^3$	0.02
Aquaculture (Cage)per annum for 1,000m3 of surface area of water body used	0.16
Commercial per annum for $10m^3$	0.03
Dewatering per annum for $10m^3$	0.04
Hydropower per annum for 10KWh	-
Hydropower per annum for $100,000m^3$	1.00
Navigation per annum for Hp of vessel engine	15.60
Recreation per annum for Hp of vessel engine	15.60
Rent for Water Body acquired as concessionary area Hectares	1.00
Commercial Dredging per annum Hectare	300.00
Underwater Wood Harvesting per annum Hectare	1.00
Construction per annum Permit granted	2,000.00
Damming per annum Permit granted	5,000.00
Diversion Primary river per annum Permit granted	5,000.00
Diversion Secondary river per annum Permit granted	3,000.00
Diversion Tertiary river per annum Permit granted	2,000.00

Source: fees and Charges (Amendment) Instrument, 2012 (L.I. 2191)

6.4 Operations of the Account

The WRC has been administering the Water Management Account and therefore has registers covering major water users such as the Ghana Water Company Limited, WaterHealth, among others and all the prominent well drillers. Funds received from the

WUP and the Drilling Licence is deposited in a bank account and administrative and technical services of the WRC are supported from the Account. Examples of the technical services are the support to community micro-projects, regulating pollution and awareness creation, education and training of stakeholders. Undoubtedly, the technical services are IWS schemes.

The Water Resources Commission's Water Management Account is managed like any other public account. Procurement of goods and services is done according to the Procurement Law to ensure transparency and accountability. The accounts are audited by the Auditor General's Department annually. One of the methods of conserving watersheds is the use of community micro-projects and the procedure adopted for implementation is outline below:

- Applications for support are made on approved application forms
- Programmes and Budget Committee of River Basin Board reviews applications for micro-project support
- Support is granted upon approval by the Committee
- Micro-project implementation is strictly monitored to achieve set goal or objective.

Some examples of the services or micro-projects supported in the Densu and the White Volta Basins were:

- Water catchment rehabilitation works
- River bank cleanup exercises
- Awareness creation and education campaigns in the form of community durbars, Radio TV programmes, community drama shows, Mobile Van announcements, training, etc.
- Provision of sanitation facilities
- Provision of watershed monitoring equipment
- Pollution/encroachment control through law enforcement using security or law enforcement personnel among others.

In the pursuit to promote adequate interest in watershed management through community micro-project support, the following successes have been realized:

- Gradual improvement in the quality of water in the Densu and the White Volta Basins
- Establishment of links among stakeholders
- Efforts at ensuring adequate vegetative cover at some segments of the Densu and White Volta Basins

WRC in fulfilment of the provisions of section 11(5) of the Water Use Regulations 1692 of 2001, published the third Water Use Register at the end of 2010. There were a total of 171 registered water users in 2011 as against one hundred and fifty-four (154) as at 2009. Sixty-three (63%) of the total registered users are engaged in domestic and/or municipal water supply, about 15% mining and industry takes about 6% (www.wrc-gh.org, 2013).

6.5 Appropriateness for IWS Purposes

The WRC is the statutory body responsible for regulation and management of the utilization of water resources in Ghana and is thus required to prepare comprehensive plans for the utilization, conservation, development and improvement of the water

resources. In fulfilling this mandate, the WRC requires funding. At present, the funds provided from government subvention as well as those generated from Water Use Permits (WUP) and Well Drilling Licences is inadequate to meet necessary expenditures of Investment in Watershed Services (IWS).

The operational budgets prepared by WRC for 2010-2013 are presented in Appendix 4 showing the amount of money expected to be generated and spent from Internal Generated Funds (IGF). Table 12 shows the proposed budget, actual total receipts and expenditure from IGF for 2009 t0 2012 all in Ghana Cedis.

Table 13: Budget, Receipts and Expenditure of WRC IGF

Year	Budget (GHc)	Receipts (GHc)	Expenditure (GHc)	Receipts to Budget (%)
2009	519,275.00	333,080.09	333,080.09	64.14
2010	519,275.00	409,677.86	408,827.17	78.89
2011	651,109.67	734,743.21	744,296.98	112.84
2012	794,320.00	794,358.35	792,313.68	100.01
TOTAL	2,483,979.67	2,271,859.51	2,278,517.92	91.46

Except in 2011 where receipts exceeded budget, the WRC has not been able to generate the expected revenue from internal sources. In some years, WRC has not been able to spend all the revenue it generated in the same year even though the budget permitted them to suggesting a possible lack of capacity to do so. Another reason is that the monies are collected at the end of the year.

With the method of accounting adopted by the WRC, it was not possible to determine the amount expended only on investment in watershed services (IWS).

The WRC seems to be the most appropriate body to implement IWS in Ghana and any available resources may be channelled to it for the purpose.

Chapter 7 Conclusions and Recommendations

7.1 Findings and Conclusions of the Study

Apart from the Volta Basin, the raw water quality of all the river basins in the south-western part of Ghana is threatened by human activities. Most water supply systems in Ghana, especially those of the STMA and CCEMA are currently experiencing shortfalls in water supply due to harmful human activities.

River basins boundaries defy district or traditional or land ownership boundaries. District Assemblies, traditional rulers and land owners as stakeholders have different interests which need to be considered in the management of the watersheds.

The Environmental Protection and Standards Enforcement Units of the Metropolitan, Municipal and District Assemblies in collaboration with the EPA are responsible for monitoring and enforcing environmental standards and regulations set by the EPA and the WRC. These Metropolitan, Municipal and District Assemblies are unable to enforce sanitation by-laws and ensure proper waste management practices.

The limitations as explained by the EPA for its inability to execute its stated mandate are inadequate offices, staffing and budget.

The structure of the WRC is still not well defined and implemented. WRC presently does not have regional representation in all the regions and does not also cover all the river basins in Ghana. It also has skeletal staff where it has a presence in the basins. Funding is a constraint for all the government institutions even though some of them are allowed to raise additional funds.

7.2 Recommendations for the Way Forward

The following recommendations are essential for the development and maintenance of the Pra and Kakum basins. These include recommendations for IWS in terms of the most important short and longer-term steps to move forward with its piloting in the targeted basins, and recommendations that apply to other stakeholders in the management of the watersheds that create better enabling conditions.

7.2.1 Recommendations for Investments in Watershed Services

- In-depth consultations and engagement of the various stakeholders is a critical prerequisite for piloting IWS in the Pra and Kakum basins because of the myriad of agencies involved in the use and protection of the water and other related resources of the two basins. The stakeholder consultations and engagement process should allow consensus on the introduction of an IWS levy for an IWS Fund and the necessary mechanism for its successful piloting by the WRC.

- Based on the outcome of the stakeholder consultations, an IWS levy may be determined and charged by the WRC as part of its abstraction fees. The fund should not replace but supplement Public-Private Partnership and donors support. A similar arrangement is currently in place with the Community Water and Sanitation Agency (CWSA) where a 2% surcharge on water bills is meant for rural water supply and sanitation services.

- The IWS Account should be used solely to prevent watershed degradation and/or restore the watersheds to maintain clean water supplies, thus reducing water treatment costs and freeing up funds for better waste water treatment/waste disposal facilities. The IWS Fund could also support community livelihoods systems to make them more sustainable than is currently the case. Sustainable farming methods, establishment of buffer zones, controlled exploitation of forest and non-timber forest products, and provision of potable water and other social services to upstream communities, should be supported.

- Undertake quantification and valuation of watershed services within the basins. This should involve comprehensive identification of the suite of watershed services (and other ecosystem services) and the beneficiary groups of people or sectors. Such an investigation will take the question of willingness to pay further, and will provide clarification on which watershed services should be considered, what are the monetary values of the services, who has ownership of what service, who does the payment and, who is entitled to payment?

- Investigate the relationship between deteriorating vegetative cover in the Pra basin and artisanal mining upstream and the cost of water treatment to establish whether indeed improvements in land management practices can reduce water treatment needs/costs. The study should establish a baseline status or trend regarding costs of water treatment in the absence of improvements upstream.

- The WRC and the IWS project partners should institute a monitoring mechanism for water quality and related variables in the selected basins. This mechanism should formulate monitoring indices, establish baseline data, and set Performance Standards. Citizen monitoring could be considered an integral part of the monitoring mechanism as this could provide scientifically useful data and also facilitates public interest, education and awareness on the relevant issues.

- Identify and assess the critical ecosystems of the Pra River and Kakum River basins and determine their status and condition, the location of headwaters/ aquifers of significantly important streams and rivers and ascertain current management regimes and their implication for the intended IWS initiative particularly with regards to water quality and flow. The forest reserves should be assessed to ascertain the extent and significance of the basic watershed services each provides. Further investigations involving Topographic wetness index (TWI) analysis using GIS will ascertain the extent of water catchment functions of the forest reserves within the Pra and Kakum River basins.

- Undertake an assessment of land cover /land use dynamics of critical riparian areas of the basins. These areas provide critical protection for surface water quality, but are also perceived to contain gold deposits; and are preferred zones for cropping because of easy access to water for irrigation. An assessment of riparian zones of the basins will ascertain current riparian uses and implications, identify critical areas for restoration and protection and will inform the stakeholders about how to manage the conflicting motivations for these areas.

- Model future scenarios base on BAU data to serve as a compelling evidence and justification for PWS intervention. This will as well inform policy makers, generate public interest and greater support for PWS.

7.2.2 Recommendations for the WRC and Other Stakeholders

- Community based watershed restoration partnerships should be considered for the Pra and Kakum basins, and the WRC should consider setting up River Basin Secretariats in the Kakum and the rest of the Pra basin. It can be further noted that the Densu Basin Secretariat is now extending it's responsibility to the Birim segment of the Pra.

- GSA or another body should be mandated to set raw water quality standards for compliance by the WRC that is mandated to conserve the water resources of the country.
- All Metropolitan, Municipal and District Assemblies and relevant institutions working in the watersheds should be adequately staffed and resourced to carry out their mandates.

- WRC should guide/recommend enforcement actions by EPA in areas that are of primary concern to the quality of water for WRC customers. Some proceeds of IWS schemes could complement EPA resources for enforcement action

- Better wages and salaries must be determined and paid by employers of law enforcement officials to motivate them. Other incentives apart from salary should be explored to assist law enforcement personnel to withstand the temptation of bribery. Employees who compromise their mandate must be punished severely to deter others.
- Town planning must be done properly and coordinated to avoid future sanitation problems. There is the need to strengthen management and maintenance schemes of providers of water and sanitation services countrywide.
- Poverty reduction programmes must be intensified and sustained by Government and development partners to break recalcitrance.

- Public education to change the attitude of Ghanaians to question sources of wealth of people and not adore the wealthy no matter the source of their riches. The education is not targeted to destroy the extended family system but to emphasise the precedence of the law and discipline over erring relations.

- Establishing Public-Private Partnerships to ensure improvements in water supply especially in the Western and Central Regions, mainly due to the oil and gas investments and associated future investments. Beyond these regions, other big private sector players in the basin (e.g. AngloGold Ashanti Ltd, GHAPOHA, etc) could also be brought on board as they are all beneficiaries of the watershed services

- The WRC in collaboration with stakeholders should initiate a Watershed Database and Mapping Project for the Pra and Kakum River basins as well as all other river basins in Ghana. The database should enable the WRC to combine data on variables of interest to it and other stakeholders with the characteristics of each watershed. The database should provide a rapid, convenient method to create maps that display analyzed, sorted, and summarized data needed by the WRC

and other stakeholders, and to provide maps with the following details which are currently unavailable:

- Massive education, awareness and advocacy are needed as part of the strategy. Options for alternative livelihoods need to be carefully thought through as it has not yielded good results in other initiatives. It might be necessary to combine PWS with integrated Watershed management using green and gray infrastructure to address all the water issues in the basins.
- WRC's river basin website links could be used as a source of information for the public to advocate the proper integrated management of the water resources of the country.

Lastly, Investments in Watershed Services (IWS) as a financial mechanism towards environmental conservation offers WRC and other water management institutions another option to explore in their efforts to sustain the water resources of the country. If successfully implemented, it would have a potentially huge impact on the Western and Central Regions and eventually on the water security of the country through up-scaling to other river basins.

Deforestation, certain farming practices, and untreated waste from expanding settlements, mining and industrial activities, along with tax compliance with and enforcement of laws related to riparian activities, are leading to increases in sediments and bio-chemical contamination that increases water pre-treatment costs and reduces the availability of clean water for consumption by Ghanaian citizens and businesses. Ghanaian society has tended to prioritize the accumulation of financial wealth in the short term over management of ecosystems on which most of Ghana's riches and the health of its people depend. Therefore, agencies responsible for dealing with these problems are under-resourced and unable to check the deterioration in water quality.

Therefore, having known what the Business as Usual scenario is, we conclude that the present scenario is unacceptable and should not be allowed to continue. A more desirable scenario for the future must be proposed and mechanisms to achieve it determined.

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Appendices

Appendix 1: Contact List of Stakeholders

No	Name	Designation	Institution	Contact details
1	Opoku Ware	Station Head	GWCL (Barikese TP)	Vincent.darko@ghanawater.info 0244727419
2	Nana Agyapong	General Secretary	Pra Basin Board	0243418730 Waterfriends89@yahoo.co.uk
3	Richard Kottoe?	Executive Director	GOFA	0277847376/0267847376
4	Christopher Coffie	Ag. Chairman	GOFA	0242363218
5	Boahpiah	Team Manager		054704681
6	Doris Fremah	Accountant		P. O. Box 22, East Akim Municipal Assembly
7	Sampson Ata Boadi	System Manager		0244153578
8	Frank Fiagbedu	Senior Tech. Assistant	GWCL (Kwabeng TP)	0244924947
9	Kwadwo Opoku-Mensah	Ass. Program Officer	EPA, Western Region	0242938695 jazzimoo@yahoo.co.uk
10	Robert Allou	Director of Finance	Coastal Resources Centre	0244158116 robert@gmail.com
11	Joseph Kwateng	Ass. Maintenance Officer	GWCL, Daboase	0244935471
12	E. T. Aryee	Regional Engineer	GWCL	
13	Enoch Ashie	Park Manager , Kakum NP	Forestry Commission	0232222957
14	Atuahene Nyako	Ass. Reg. Manager, Central Reg.	Forestry Services Division	Yatuahene70@yahoo.com
15	Ebenezer Mensah	District Manager, Cape Coast	Forestry Services Division	phorus2020@yahoo.com
16	Boakye Frimpong		GWCL, Ashanti Region	Boakye.frimpong@ghanawater.info 0244256601
17	Charles Tulashie		GWCL, Ashanti Region	Nawuz24@yahoo.com 0244619662
18	James Ware	Ass. Regional Manager	FSD, Ashanti Region	Jkware12@yahoo.com 0244475691
19	Oman Hene Kwaku Boateng	Principal Prog. Officer	EPA, Ashanti Region	Boatkb2003@yahoo.com 0244222941

20	Abena Dufie Wiredu Bremang	Ag. Pra Basin Officer	WRC	dufie.adupakgh@gmail.com 0244536469

Appendix 2: Protocol for Institutional Consultation

Date:

1. Institution

Name:	operational area:
Institutional address:	email:

2. Person

Name:	position:	email:	mob:

3. What are the current water supply situation and challenges in your area of operation

3.1 3.2

4. What are the threats (natural and human) to water security in the Pra basin?

Threat	Underlying Factor	Intervention	Start Date	End Date	Collaborators	Impact of Intervention	Proposed Intervention.

5. What are the programmes ongoing or planned for the Pra basin?

Programme	Collaborator	Role	Project Area	Period	Status	Contact

6. What are the barriers to effective delivery of your role and function in the water sector?

6.1 6.2 6.3 6.4

7. What are the pre-condition for successful IWS for the Pra basin
8. What are the existing legal and institutional frameworks that would support IWS in the Pra basin?
9. What are the possible challenges for IWS implementation in Ghana?
10. What strategies and potential options for IWS in the Pra basin would you suggest?
11. What is your assessment of the willingness to pay by consumers?

Appendix 3: Raw Water Quality Data of Daboase Intake

PARAMETER	UNIT	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average
Temperature	(^{O}C)	28.492	26.875	28.033	28.038	27.633	27.965	28.011	27.418	27.558	27.468	27.749
pH	-	7.117	7.225	7.617	8.023	7.617	7.322	6.850	6.926	6.798	6.928	7.242
Colour	(HU)	177.500	209.583	176.364	188.333	199.667	220.537	340.870	464.927	668.540	1,491.848	413.817
Turbidity	(NTU)	37.703	41.492	32.800	44.127	53.633	73.733	121.856	199.666	406.715	797.861	180.959
Conductivity	(µS/cm)	143.633	149.375	147.467	145.063	164.617	125.380	128.863	107.891	107.997	145.400	136.569
Total Dissolved Solids	(mg/l)	67.583	67.667	70.000	67.667	80.500	66.392	61.889	51.636	53.774	68.165	65.527
Total Suspended Solids	(mg/l)	18.583	24.017	13.500	14.417	25.250	24.956	53.667	103.909	166.182	445.500	88.998
Dissolved Oxygen	(mg/l)	3.219	1.938	3.840	5.066	0.000	0.000	0.000	2.381	1.095	5.243	2.278
Total Hardness	(mg/l)	42.667	36.917	39.250	41.417	48.083	40.271	57.625	47.718	53.427	69.728	47.710
Total Alkalinity	(mg/l)	45.667	40.000	52.083	39.591	40.333	48.357	51.270	46.028	44.434	52.100	45.986
Calcium Hardness	(mg/l)	27.875	29.583	30.083	31.667	38.000						31.442
Magnesium Hardness	(mg/l)	14.708	7.333	9.167	9.750	25.000						13.192
Nitrate	(mg/l)	4.650	0.000	3.689	4.096	3.329	17.546	8.375	16.600	2.800	5.658	6.674
Nitrite	(mg/l)	0.023	0.000	0.011	0.067	0.014	0.092	0.028	0.084	0.169	0.077	0.057
Ammonia	(mg/l)	0.000	0.000	0.519	0.628	0.769	0.650	1.180	0.547	0.437	1.423	0.615
Chloride	(mg/l)	11.479	13.417	12.417	34.792	31.125	51.806	16.833	24.455	21.333	31.975	24.963
Phosphate	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.615	0.540	1.224	0.238
Suplhate	(mg/l)	15.167	18.500	15.000	22.458	21.417	14.850	26.667	36.273	26.833	5.111	20.228
Sulphide	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	112.723	45.635	3.971	16.233
Fluoride	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.823	0.304	0.034	0.959	0.083	0.220
Cyanide	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.032	0.004	0.016	0.008
Manganese	(mg/l)	0.000	0.000	0.000	0.000	0.580	0.545	1.720	5.490	0.510	0.358	0.920
Iron	(mg/l)	1.750	1.221	1.503	1.032	1.408	1.893	2.414	5.999	3.007	6.368	2.659
Aluminium	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.025	0.077	0.034	0.146	0.002	0.028
Zinc	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.119	0.310	0.302	0.211	0.691	0.163
Copper	(mg/l)	0.000	0.000	0.000	0.000	0.050	0.194	0.373	1.692	1.853	0.661	0.482
Chromium	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.032	0.007
Sodium Chloride	(%)	0.010	0.010	0.009	0.010	13.118	0.000	0.000	0.003	0.001	0.909	1.407
Lead	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.001	0.005	0.001
Silica	(mg/l)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	9.333	0.935
Free Carbon Dioxide	(mg/l)	2.900	2.067	1.844	0.000	0.000	0.000	0.000	7.273	17.917		3.556
Salinity	(%)	0.100	0.100	0.100	0.083	0.143	0.100					0.104

Appendix 4: Budgets of WRC

WATER RESOURCES COMMISSION
PRIORITY PROGRAMMES, PROJECTS AND ACTIVITIES FOR 2010
IGF Source (GHC)

Policy Area	Description of Programme/Specific Intervention	Target/ Time Frame	Budget
Water Resources Regulation and Management Programmes	Continuous public awareness, education campaign and water conservation programmes on radio and TV. Regular fora for water resources user agencies, NGO's and District Assemblies	Jan. – Dec. 2010	75,000.00 35,000.00
	Undertake inspections of water abstraction points, processing, approve water use applications and issue licenses to users. Monitor licensed users and enforce compliance of water use regulations	Jan. – Dec. 2010	65,000.00 45,000.00
	Continue with awareness creation for compliance to Drilling License Regulations Implement, monitor and enforce the Drillers Regulations (LI 1827)	Jan. – Dec. 2010	32,000.00
	Initiate and complete development of Integrated Water Resources Management (IWRM) plans for all major river basins Design a Decision Support System (DSS) as a tool for water resources management and allocation	Jan. – Dec. 2010	45,000.00
	Initiate, and promote bilateral technical cooperation with riparian countries through the signing and implementation of agreements and protocols	Jan. – Dec. 2010	30,000.00
	Set up and make functional a basin office and a Basin Board for the Pra Basin with a special focus on the Offin sub-basin and Lake Bosumtwi Set up and make functional a basin office and Basin Board for the Tano River Basin	Jan. – Dec. 2010	104,795.00 47,480.00
	Improve human and institutional capacity for effective management of water resources	Jan. – Dec. 2010	40,000.00
TOTAL			**519,275.00**

WATER RESOURCES COMMISSION
PRIORITY PROGRAMMES, PROJECTS AND ACTIVITIES FOR 2011
IGF Source (GHC)

Objective	Outputs and Programmes	Service	Investment	Total
	Harmonized Buffer Zone Policy developed and adopted by Cabinet	10,000.00		10,000.00
	Buffer Zones developed for the protection of rivers and other water bodies	45,000.00	56,000.00	101,000.00
	Well protected coastal zones and wetlands	30,000.00	50,000.00	80,000.00
	A national policy document on sustainable use of rainwater	30,000.00	45,000.00	75,000.00
	Basin Offices set up and Integrated water resources management (IWRM) plans developed for established basin offices	8,000.00	200,000.00	208,000.00
	National IWRM plan developed	5,000.00		5,000.00
	Water resources database enhanced	35,000.00		35,000.00
	Improved capacity to management water resources	25,000.00		25,000.00
	Awareness in water management issues enhanced	77,109.00		77,109.00
	Cooperation within riparian states enhanced	35,000.00		35,000.00
	TOTAL	**300,109.00**	**351,000.00**	**651,109.00**

PROGRAMMES, PROJECTS AND ACTIVITIES FOR 2012

POLICY AREA	SECTOR OBJECTIVE	DESCRIPTION OR SPECIFIC INTERVENTION	TARGET/ TIME FRAME	SOURCE OF FUNDING/ BUDGET			IMPLEMENTING AGENCIES	
				GOG (GHc)	DONOR (GHc)	IGF (GHc)	LEAD	COLLABORATING
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Administer the Water Use Regulations – issue water use permits and monitor compliance	Jan – Dec 2012	6,000.00		79,200.00	WRC	EPA, MC
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Administer the Drilling License and Groundwater Development Regulations – license drillers, develop database and monitor groundwater development	Jan – Dec 2012	6,000.00		60,000.00	WRC	WRI, GAEC, CWSA
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Develop Regulations and set up of a National Dam Safety Unit for uniform and adequate level of safety for all dams throughout Ghana.	Jan 2012 – Dec 2013		783,100.00	0.00	WRC	AG Dept, IDA, GWCL, VRA, WRI, GMet, Chamber of Mines
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Initiate the implementation of WRC Communication Strategy (2012 – 2016) and maintain continuous and sustained education and awareness creation.	Jan 2012-Dec 2016			75,000.00	WRC	DAs, RCC, GES, NGOs, Media, CONIWAS, etc.
Water Resources Regulation and	To ensure efficient management of water	Complete and initiate the implementation of developed river basin (Densu, White Volta,	Jan – Dec 2012			43,200.00	WRC	DAs, GWCL, EPA, FC, HSD, GMet, NADMO, etc.

Management Programmes	resources	Ankobra, Pra and Tano) and national IWRM plans to address major issues.						
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Complete the establishment and promote functionality of the initiated River Basin offices and Boards	Jan – Dec 2012	90,068.00		179,740.00	WRC	RCCs, DAs, NGOs, EPA, FC, MC, etc.
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Adopt the Buffer Zone Policy and initiate its implementation by introducing harmonised protected land strips/areas along open water bodies (rivers and lakes) in the country.	Jan – Dec 2012			78,800.00	WRC	FC, DAs, NGOs, EPA, etc.
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Undertake staff training and development including implementation of the WRC Gender and Water Resources Management Strategy	Jan – Dec 2012			107,300.00	WRC	
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Implement organisational development plan and improve the internal management information and knowledge systems	Jan – Dec 2012	23,848.00		270,345.00	WRC	FWSC, PSC
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Enhance trans-boundary cooperation through ratification of UN Watercourses Convention and engagement in international organisations' programs	Jan – Dec 2012			31,420.00	WRC	MWRWH, AG's Dept

		including the Volta Basin Authority.						
				125,916.00	**913,585.00**	**794,320.00**		

WATER RESOURCES COMMISSION

PRIORITY PROGRAMMES, PROJECTS AND ACTIVITIES FOR 2013

POLICY AREA	SECTOR OBJECTIVE	DESCRIPTION OR SPECIFIC INTERVENTION	TARGET/ TIME FRAME	SOURCE OF FUNDING/ BUDGET			IMPLEMENTING AGENCIES	
				GOG (GHc)	DONOR (GHc)	IGF (GHc)	LEAD	COLLABORATING
Water Resources Regulation and Management Programmes	To ensure efficient management of water resources	Administer the Water Use Regulations – issue water use permits and monitor compliance	Jan – Dec 2013	-		20,000.00	WRC	EPA, MC
		Administer the Drilling License and Groundwater Development Regulations – license drillers,	Jan – Dec 2013	-		10,120.00	WRC	WRI, GAEC, CWSA
		Adopt the Regulations and set up of a National Dam Safety Unit for uniform and adequate level of safety for all dams throughout Ghana.	Jan – Dec 2013	-		45,000.00	WRC	AG Dept, IDA, GWCL, VRA, WRI, GMet, Chamber of Mines
		Undertake nationwide water quality and groundwater monitoring	Jan – Dec 2013	-		32,520.00	WRC	GAEC, WRI

Water Resources Regulation and Management Programmes		Continue implementation of WRC Communication Strategy (2012 – 2016) and maintain continuous education and awareness creation.	Jan 2012-Dec 2016	-		63,030.00	WRC	DAs, RCC, GES, NGOs, Media, CONIWAS, etc.
		Initiate implementation of developed river basin (Densu, White Volta, Ankobra, Pra and Tano) and National Integrated Water Resources Management plans	Jan – Dec 2013	-		367,850.00	WRC	DAs, GWCL, EPA, FC, HSD, GMet, NADMO, etc.
		Rehabilitate River Basin offices and ensure functionality of the Basin Boards	Jan – Dec 2013			461,900.00	WRC	RCCs, DAs, NGOs, EPA, FC, MC, etc.
		Initiate implementation of Buffer Zone Policy by introducing pilot schemes on protected land areas / strips along open water bodies.	Jan – Dec 2013			138,230.00	WRC	FC, DAs, NGOs, EPA, etc.
		Undertake Climate Change adaptation interventions for water security, and flood risk reduction in the 3 northern regions	Jan – Dec 2013		1,016,620.00	-	WRC	FC, DAs, NGOs, HSD, MOFA, etc.
		Undertake staff training and development including implementation of the WRC Gender and Water Resources Management Strategy	Jan – Dec 2013			57,850.00	WRC	

		Implement organisational development plan and improve the internal management information and knowledge systems	Jan – Dec 2013	-		19,450.00	WRC	FWSC, PSC
		Ensure the ratification of UN Watercourses Convention and engage in bilateral and multilateral programs including the Volta Basin Authority.	Jan – Dec 2013			87,500.00	WRC	MWRWH, AG's Dept
				-	**1,016,620.00**	**1,286,000.00**		

IGF (2009)

	Approved Budget	Actual Receipts	Expenditure
PE		-	-
ADMIN	263,223.00	136,246.10	136,246.10
SERVICE	171,827.00	80,133.99	80,133.99
INVESTMENT	84,225.00	116,700.00	116,700.00
TOTAL	**519,275.00**	**333,080.09**	**333,080.09**

IGF (2010)

	Approved Budget	Actual Receipts	Expenditure
PE	-	-	-
ADMIN	263,223.00	220,169.35	220,334.56
SERVICE	171,827.00	171,689.00	170,984.61
INVESTMENT	84,225.00	17,819.51	17,508.00
TOTAL	**519,275.00**	**409,677.86**	**408,827.17**

NOTE: The approved budget for 2009 and 2010 were the same.

IGF (2011)

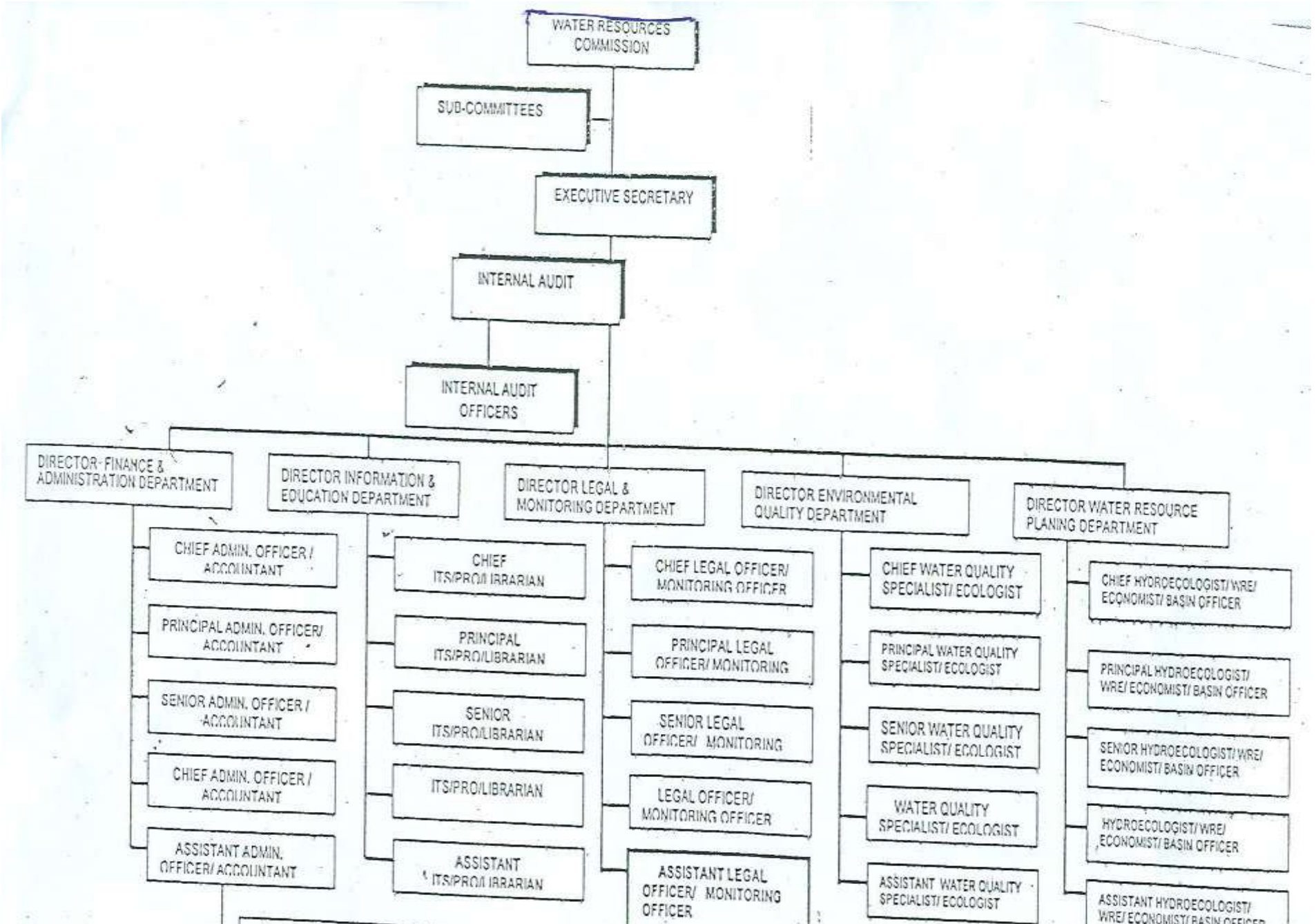
	Approved Budget	Actual Receipts	Expenditure
PE	-	-	-
ADMIN	375,928.17	259,010.75	258,596.81
SERVICE	212,111.00	278,862.32	288,830.03
INVESTMENT	63,071.50	196,870.14	196,870.14
TOTAL	**651,109.67**	**734,743.21**	**744,296.98**

IGF (2012)

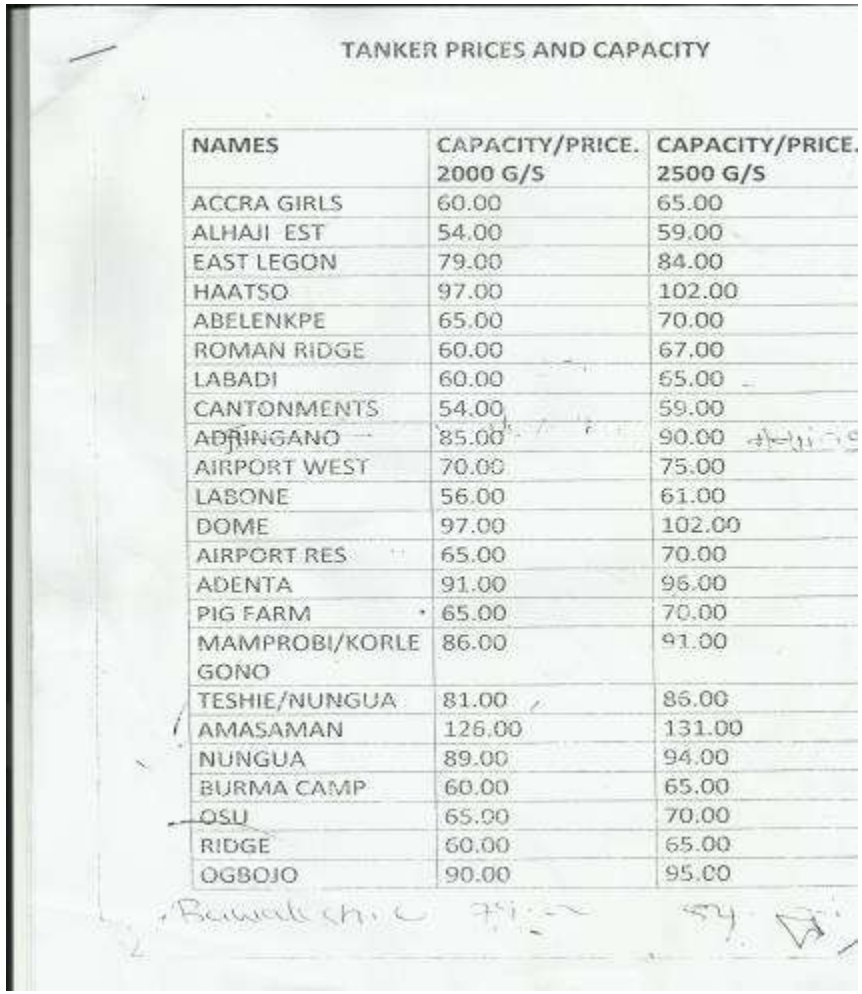
	Approved Budget	Actual Receipts	Expenditure
PE	-	-	-
GOODS & SERVICES	536,320.00	672,241.69	764,668.78
ASSETS (CAPITAL)	258,000.00	122,116.66	27,644.90
TOTAL	**794,320.00**	**794,358.35**	**792,313.68**

NOTE: From 2012 'Admin' and 'Services' have been put together as 'goods and services' and investments renamed as Assets (capital)

Appendix 5: Organogram of WRC


WATER RESOURCES COMMISSION
SUB-COMMITTEES
EXECUTIVE SECRETARY
INTERNAL AUDIT
INTERNAL AUDIT OFFICERS
DIRECTOR FINANCE & ADMINISTRATION DEPARTMENT
DIRECTOR INFORMATION & EDUCATION DEPARTMENT
DIRECTOR LEGAL & MONITORING DEPARTMENT
DIRECTOR ENVIRONMENTAL QUALITY DEPARTMENT
DIRECTOR WATER RESOURCE PLANING DEPARTMENT
CHIEF ADMIN. OFFICER / ACCOUNTANT
PRINCIPAL ADMIN. OFFICER/ ACCOUNTANT
SENIOR ADMIN. OFFICER / ACCOUNTANT
CHIEF ADMIN. OFFICER / ACCOUNTANT
ASSISTANT ADMIN. OFFICER/ ACCOUNTANT
CHIEF ITS/PRO/LIBRARIAN
PRINCIPAL ITS/PRO/LIBRARIAN
SENIOR ITS/PRO/LIBRARIAN
ITS/PRO/LIBRARIAN
ASSISTANT ITS/PRO/LIBRARIAN
CHIEF LEGAL OFFICER/ MONITORING OFFICER
PRINCIPAL LEGAL OFFICER/ MONITORING
SENIOR LEGAL OFFICER/ MONITORING
LEGAL OFFICER/ MONITORING OFFICER
ASSISTANT LEGAL OFFICER/ MONITORING OFFICER
CHIEF WATER QUALITY SPECIALIST/ ECOLOGIST
PRINCIPAL WATER QUALITY SPECIALIST/ ECOLOGIST
SENIOR WATER QUALITY SPECIALIST/ ECOLOGIST
WATER QUALITY SPECIALIST/ ECOLOGIST
ASSISTANT WATER QUALITY SPECIALIST/ ECOLOGIST
CHIEF HYDROECOLOGIST/ WRE/ ECONOMIST/ BASIN OFFICER
PRINCIPAL HYDROECOLOGIST/ WRE/ ECONOMIST/ BASIN OFFICER
SENIOR HYDROECOLOGIST/ WRE/ ECONOMIST/ BASIN OFFICER
HYDROECOLOGIST/ WRE/ ECONOMIST/ BASIN OFFICER
ASSISTANT HYDROECOLOGIST/ WRE/ ECONOMIST/ BASIN OFFICER

Appendix 6: GWCL Water Tanker Prices and Capacities for Some Destinations in Accra[13]



TANKER PRICES AND CAPACITY

NAMES	CAPACITY/PRICE. 2000 G/S	CAPACITY/PRICE. 2500 G/S
ACCRA GIRLS	60.00	65.00
ALHAJI EST	54.00	59.00
EAST LEGON	79.00	84.00
HAATSO	97.00	102.00
ABELENKPE	65.00	70.00
ROMAN RIDGE	60.00	67.00
LABADI	60.00	65.00
CANTONMENTS	54.00	59.00
ADJIRINGANO	85.00	90.00
AIRPORT WEST	70.00	75.00
LABONE	56.00	61.00
DOME	97.00	102.00
AIRPORT RES	65.00	70.00
ADENTA	91.00	96.00
PIG FARM	65.00	70.00
MAMPROBI/KORLE GONO	86.00	91.00
TESHIE/NUNGUA	81.00	86.00
AMASAMAN	126.00	131.00
NUNGUA	89.00	94.00
BURMA CAMP	60.00	65.00
OSU	65.00	70.00
RIDGE	60.00	65.00
OGBOJO	90.00	95.00

[13] Tanker capacities are in Gallons and amounts in Cedis.

Appendix 7: IWS Complementary Initiatives of The Pra And Kakum Basins

No	Initiative	Nature the of intervention	Implementing organization(s)	Project area
1	Exploration of the Relationship between Forest Cover and Rainfall Generation	Remote Sensing and lab based analysis	NCRC/ Centre for Tropical Forestry, Oxford University	Forests of Southwest Ghana (including the Pra and Kakum basins)
2	Atewa Critical Conservation Action Programme (ACCAP)	Advocacy and public education against mining in Atewa Forest Reserve	A Rocha Ghana	Atewa Forest Reserve and fringe communities
3	Civil society support participation in the conservation of river basins.	Public education and awareness, pollution control , riparian tree planting	Global Organization for Fundamental Aid	Densu basin
4	Man and Biosphere project	Community Education/Tree planting/Alternative livelihood training	UNISCO Ghana/A Rocha Ghana/FORIG	Lake Bosomtwi
5	Catchment Forest Cover Restoration	Tree planting	GWC, Ashanti Region	Barikese
6	Conservation and monitoring of the Upper Pra basin	Ecological monitoring/Public education and awareness programs/Water quality data	Pra-basin office of the WRC	Offin basin
7	Conservation/management of the Pra-basin	Public education and awareness creation	Pra Basin Board/WRC	Upper Pra-basin
8	Catchment conservation	Regular patrol/Forest Cover protection/Public education	Wildlife Division	Owabi Wildlife Sanctuary