WATER SAFETY PLAN[fl]
SPANISH TOWN WATER SUPPLY
ST. CATHERINE, JAMAICA
OCTOBER 2007

Developed with technical support from
PAHO/EPA/CDC for the Ministry of Health Jamaica
by

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PREFACE

The Pan American Health Organization (PAHO), the U.S. Centres for Disease Control and Prevention (CDC), and the U.S. Environmental Protection Agency (EPA) formed a partnership on December 10th, 2004 called the "PAHO/CDC/EPA Partnership to Improve Environmental Public Health in Latin America and the Caribbean" to work with health and environment sectors in Latin American and the Caribbean, to improve environmental public health practices and the coordination between the health and environment sectors.

In June 2005, ten countries were invited to participate in the first Workshop to introduce the WHO Water Safety Plans to Latin America and the Caribbean in Buenos Aires. Participating countries included: Argentina, Bolivia, Brazil, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, and Peru.

In October 2005, Jamaica was selected as the first Water Safety Plan (WSP) Demonstration site by the PAHO, CDC and EPA Partnership.

In January 2006, a technical team comprised of health and water experts from PAHO, CDC and EPA visited Spanish Town and met with representatives of various ministries and the water utility (the National Water Commission) to discuss the implications of developing a WSP there.

It was agreed that a WSP would be beneficial for the Spanish Town Water Supply System which serves the population of Spanish Town (482,308 in 2001 and projected to be 494,486 in 2006) with potable water.

A Task Force[1], comprised of various institutions represented by the Water and Wastewater Subcommittee of the Central Health Committee, was established in May 2006.

To guide the development of the Plan in Jamaica, a Task Force was created in June 2006 by the Central Health Committee - Water Subcommittee (CHC-WSc), chaired by Mr. Peter Knight, Director of the Environmental Health Unit (EHU) in the Ministry of Health and Courtney Lawes of the National Water Commission. To assist the Task Force a Consultant was engaged by the CDC/PAHO/EPA partnership in December 2006, to coordinate the development of the Water Safety Plan.

The preparation of the Water Safety Plan commenced in December 2006.

The goals of developing a WSP Project for Spanish Town include:

- Building collaboration between ministries of health, environment, and water sectors by creating a WSP committee where they all have a voice.
- Assisting the National Water Commission, operators of the Spanish Town Water Treatment Plant, to write a WSP, which will allow them to make informed decisions on how to change and/or improve the Spanish Town water system being addressed in this project.

[1] See Task Force Membership at Table 3

- Holding a Regional WSP Technical Workshop, which will allow other countries to see firsthand how a WSP Project is undertaken and how they can start a similar project in their own country.
- Sharing lessons learned with WHO's WSPortal (www.who.int/wsportal) to reach a global audience and further the promotion of WSPs within Jamaica and with other countries.

ACKNOWLEDGEMENTS

We acknowledge and thank the following agencies and their staff for their contribution to the process and support throughout the preparation of this Water Safety Plan for the Spanish Town Water Supply System in St. Catherine, Jamaica:

1. Pan American Health Organization (PAHO), the U.S. Centers for Disease Control and Prevention (CDC), and the U.S. Environmental Protection Agency (EPA) Partnership to Improve Environmental Public Health in Latin America and the Caribbean
2. Pan American Health Organisation (PAHO) Jamaica
3. Ministry of Health
4. Environmental Health Division in the Ministry of Health
5. National Water Commission
6. National Irrigation Commission
7. National Environment & Planning Agency
8. Water Resources Authority
9. Pesticides Control Authority
10. National Public Health Lab/Environmental Health Lab, Ministry of Health
11. St. Catherine Health Services
12. St. Catherine Parish Council
13. Environmental & Engineering Managers Ltd.

WATER SAFETY PLAN
SPANISH TOWN WATER SUPPLY SYSTEM, ST. CATHERINE

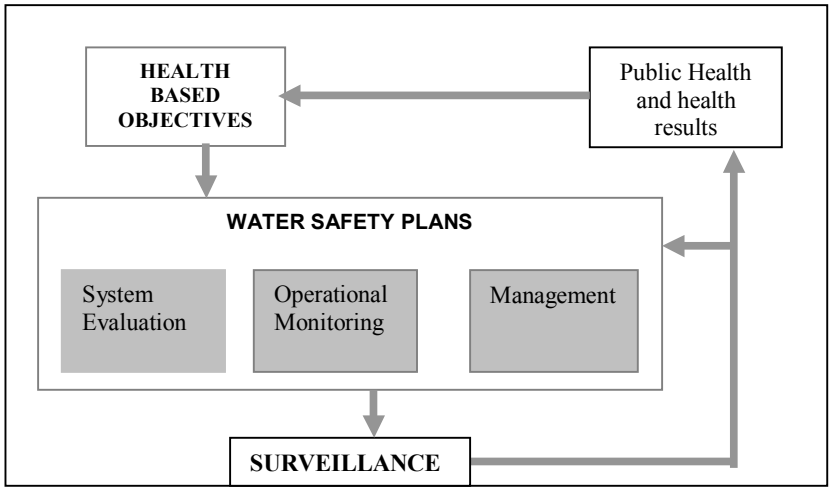
1.0 BACKGROUND

The safety and performance of a system for providing drinking-water depends upon the design, management and operation of the three principal components: source, treatment and distribution. If contamination has occurred and it is not controlled before it reaches the consumers' taps, illness or even death is possible. The system must therefore be designed to cope with all of the problems that could occur, and proper performance of the entire system must be ensured at all times. The most effective way to consistently ensure the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all of the steps in the drinking-water supply train from the catchment to the consumer. The World Health Organisation (WHO) has developed a systematized Water Safety Plan (WSP) approach based upon worldwide experiences of success in managing drinking-water quality (WHO 2004a). The WSP concept draws upon principles and concepts of prevention, multiple barriers and quality management systems such as Hazard Assessment Critical Control Points (HACCP) as used in the food industry.

As shown in Figure 1, a WSP has three key components guided by health-based targets (drinking-water standards and guidelines and codes), and overseen through surveillance of every significant aspect of the drinking-water system. The three components are:

- System assessment to determine whether the system as a whole (from source to consumer) can consistently deliver water that meets health-based targets. This includes assessment of design criteria for new systems as well as modifications.
- Measures to monitor and control identified risks (and deficiencies) and ensure that health-based targets are met. For each control measure, appropriate operational monitoring should be defined and instituted that will rapidly detect deviations.
- Management plans describing actions to be taken during normal operations or incident conditions, and documenting the system assessment (including system upgrades and improvements), monitoring, and communication plans and supporting programmes.

Figure 1 - Framework for Safe Drinking Water, WHO



The primary objectives of a WSP are the minimization of contamination of water sources, reduction or removal of contamination through appropriate treatment processes, and prevention of contamination during processing, distribution and storage.

The Water Safety Plan methodology, which is a health-based risk management approach to drinking water quality management, is described in Chapter 4 of the 3rd edition of the WHO Guidelines for Drinking-Water Quality (GDWQ/WHO/2004).

The health-based objectives are established by the highest health authority in consultation with the suppliers and consumers, being reflected in laws regulations and technical standards. The evaluation of the system, the operational monitoring and the management are prepared and applied by the providers of the water supply service. Finally, surveillance is the responsibility of an independent agency, normally represented by the Ministry of Health that periodically reviews all the safety aspects applied by the provider of the service and who all the time is the one responsible for quality control, the operational monitoring and to ensure the application of good operational practices.

2.0 INTRODUCTION

The Water Safety Plan (WSP) for Spanish Town Water Supply System has been developed for the Ministry of Health through a partnership between PAHO, CDC, USEPA and the various governmental organizations in Jamaica responsible for providing safe drinking water to the public. The initial step saw the formation of a Task Force in mid July 2006 and then the hiring of a Consultant in December 2006 to assist the Task Force in putting the Water Safety Plan together. The first meeting of the Task Force was held on December 14, 2006.

In developing the Water Safety Plan, examples of existing plans for Melbourne, Australia and Kampala, Uganda were reviewed.

Melbourne Water is located in Victoria, Australia and was the first bulk water supplier in Australia to implement and achieve HACCP certification in 1998. Kampala, the capital city of Uganda in East Africa, was the first water supplier in Africa to develop a Water Safety Plan in 2002. This was achieved with technical assistance from the Water, Engineering and Development Centre (WEDC) UK and funding from the Department for International Development (DFID) UK through their Knowledge and Research programme. The Kampala piped water supply is managed by the National Water and Sewerage Corporation (NWSC) with distribution operation let by management contract to Ondeo Services Uganda Limited (OSUL).

2.1 Intended Use of the Water Safety Plan

The Water Safety Plan will be used by the National Water Commission (NWC), the service provider, to enable them to focus on the critical areas that need to be managed to ensure that adequate water meeting the desired water quality standards is provided to Spanish Town.

It will also be utilised by:

- the MOH, defining the critical areas that need to be monitored to ensure that health based objectives are met
- the Water Resources Authority (WRA) to assist with surface and underground water resource protection utilised for drinking water
- the National Environment and Planning Agency (NEPA) to help identify and manage possible point and non-point sources of contamination of the water resources utilised for drinking water

2.2 Intended Use of Water

Water supplied by the National Water Commission for Spanish Town must meet the health based drinking water standard established in 1982 by the Ministry of Health referred to as the Interim Jamaica Criteria (IJAM). This standard was adapted/adopted from the WHO Drinking Water Guidelines. Table 1 shows the IJAM as well as drinking water quality (health-based) standards established by the USEPA and those recommended by WHO.

Table 1 - Treated Water Quality Standards for Jamaica and Other Jurisdictions

Contaminant or Parameter	IJAM mg/L	USEPA (1) mg/L	WHO 3rd ed. (2) mg/L
Fluoride	1.5	4.0	1.5
Nitrate (as N)	10.0	10.0	11.3
Arsenic	0.05	0.01	0.01
Barium	1.0	2.0	0.7
Cadmium	0.01	0.005	0.003
Copper	1.0	1.3	2.0
Chromium (Total)	0.05	0.10	0.05
Cyanide	0.20	0.20	0.07
Lead	0.05	0.015	0.01
Selenium	0.01	0.05	0.01
Mercury	0.002	0.002	0.001
Silver	0.05	0.10 *	NHBG
Manganese	0.05	0.05 *	0.4
Magnesium	1000 * *	Not Regulated	NHBG
Iron	0.3	0.3 *	NHBG
Zinc	1.5	5.0 *	NHBG
Chloride	250 **	250 *	NHBG
Calcium	200 **	Not Regulated	NHBG
TDS (Total Dissolved Solids)	500 **	500 *	NHBG
Turbidity	5NTU	1 NTU***	NHBG
pH	7 - 8.5	6.5 - 8.5 *	NHBG
Colour (Colour Units	15	15 *	NHBG
Odour (TON)	3	3 *	NHBG
Residual Chlorine	Always present	See Notes	0.5 ppm (Min)
Total Coliform	Maximum 10 %	Maximum 5 %	Maximum 5 %

Notes:
(1) - USEPA - US Environmental Protection Agency Drinking Water Regulations. July 2002.
(2) - WHO - World Health Organization Drinking Water Guidelines - 3rd Edition 2003.
* Secondary Standards set by USEPA. Others contaminants listed are MCL's - Maximum Concentration Level
** Recommended limits for distribution system, by IJAM
*** As of January 1, 2002, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month
NHBG - No Health Based Guidelines established by WHO for these contaminants.
Minimum chlorine residual concentrations not established by USEPA. Instead minimum CT (concentration X Time) levels established for certain classes of water.
For Total Coliform, IJAM and USEPA refers to maximum % positive per month. WHO refers to maximum % positive (TC) through out 12 month period.

2.3 Regulatory Framework

The Water Sector Policy (1999) establishes the framework for the management of water resources and the provision of potable water and irrigation water in Jamaica. It generally speaks to:

- the management of the quantity and quality water resources
- making potable water accessible to all in adequate quantities, including social water for those unable to pay for water supply services
- providing treated water efficiently and cost effectively

Although the supply of drinking water is closely monitored by the Ministry of Health (MOH) which has legal responsibility for sanitation matters, there are no laws governing the quality of drinking water supplied to the consumer in relation to the IJAM health based targets. The MOH is currently reviewing the IJAM standard and plans to develop Drinking Water Guidelines and Regulations for Jamaica.

The National Water Commission Act (1963) established the National Water Commission and outlined the roles and responsibilities of the organisation primary of which is the supply of potable water throughout the island. The Act does not speak to water quality and monitoring issues.

The Office of Utilities Regulations (OUR) in Jamaica has established overall and guaranteed (service) standards that must be met by the NWC for the supply of potable water under the 'Office of Utilities Regulation Act 1995 As Amended'. These "quality of service" standards are outlined in Table 2.

Table 2 - Quality of Service Standards (QSS)

CODE	FOCUS	DESCRIPTION	PERFORMANCE MEASURE
OVERALL STANDARDS			
WOS1	Water Quality	Testing samples for impurities	To ensure that water is within standards as specified by MOH
WOS2	Water Pressure	Minimum/maximum water pressure	Must maintain a pressure ranging from 20 to 60 psi
WOS3	Reliability of supply	Notify public of intention to interrupt supply – planned interruptions	Minimum notification time of 12 hours for short interruptions (less than 4 hours) and 24 hours for longer interruptions (more than 4 hours)
WOS4	Reliability of supply	Restoration after emergency lock -off	Maximum time of 24 hours to restore supply in urban areas. Maximum of 48 hours in rural areas.
WOS7	Water meters	Changing meters	NWC must provide consumers with details of the date of the change, meter readings on the day and serial numbers of the new meter
GUARANTEED STANDARDS			
WGS1	Access	Connection to supply	Maximum time of 10 working days
WGS2	Delivery of bills	Issue of first bill	Maximum time of 48 working days after connection
WGS3	Appointments	Keeping appointments	Must make and keep an appointment at customers request and must notify customer prior to appointed time, if cannot keep appointment.
WGS4	Complaints	Response to complaints not bill related	Maximum of 5 working days to acknowledge customer complaints, after receipt. Maximum time of 30 working days to complete investigation and respond, from date of receipt of complaint
WGS5	Complaints	Response to billing complaints	Maximum of 5 working days to acknowledge customer complaints, after receipt. Maximum time of 30 working days to complete investigation and respond, from date of receipt of complaint
WGS6	Account status	Issue of account status	Meter to be read on same day customer is moving, if on a weekday (within 2 days of move if on a weekend) providing 5 days notice of move is given. Maximum time of 15 working days to provide final bill after move

CODE	FOCUS	DESCRIPTION	PERFORMANCE MEASURE
WGS7	Water meters	Meter installation	Maximum of 30 working days to install meter on customer's request
WGS8	Water meters	Repair or replacement of faulty meters	Maximum time of 40 working days to repair or replace meter after being informed of defect
WGS9	Water meters	Meter reading	Maximum of 2 months between each meter reading and between bill issues
WGS10	Reconnection	Reconnection after payment of overdue amount	Maximum of 24 hours to restore supply in urban areas. Maximum of 48 hours to restore supply in rural areas. Not applicable in situations where NWC has removed infrastructure as a consequence of illegal connections.
WGS11	Compensation	Payment of compensation	Maximum of 60 days after claim is received to process and make payment. Customer must make claim within 2 billing periods or 60 days (whichever is longer) to make claims of perceived breach

Currently the NWC is unable to meet pressure requirements in some areas of the study area as required by the OUR QSS even though MOH and Jamaica Bureau of Standards are satisfied with the quality of the water. Generally the QSS complements the WSP goals and objectives.

More details on the overall and guaranteed service standards are included at Appendix 1.

3.0 WORKING TEAM

A multidisciplinary Task Force was established in July 2006 to prepare the Water Safety Plan for the Spanish Town Water Supply System. Table 3 provides information on the composition of the Task Force.

Table 3 - Members of the Task Force

NAME	ORGANISATION & POSITION	EXPERTISE
Michelle Watts	Senior Environmental Officer, Water Resources Authority	Co-Chair Task Force Geography, Hydrology (Water Resources Management), Water Quality Management: Development of Water Quality Standards and Regulations, Ground & Surface water Pollution Studies
Errol Matthie	Water/Wastewater Specialist, Environmental	Co-Chair Task Force, Environmental Health, oversees the Ministry of Health's water quality

NAME	ORGANISATION & POSITION	EXPERTISE
	Health Unit, Ministry of Health	monitoring programmes
Ianthe Smith	Consultant, Environmental & Engineering Managers Ltd.	Coordinator of Task Force; Civil and Environmental Engineering Consultant Environmental Engineer
Jermaine Jackson	Water Production Manager, National Water Commission	Mechanical Engineering specialising in chlorination systems
Calvert Selby	Senior Technical Officer – Chemistry, Eastern Laboratory, National Water Commission	Applied Chemistry, Water Quality
Garth Jackson	Senior Project Manager, National Water Commission	Civil Engineering, specialising in the design, implementation and management of water and wastewater capital projects; currently coordinating the implementation of the KMA Project
Paulette Kolbusch	Actg. Director Legal Standards & Enforcement Division, National Environment & Planning Agency	Industrial Chemistry, Environmental Chemistry
Peter Knight	Director, Environmental Health Unit, Ministry of Health	Environmental Health Practitioner, manages the Ministry of Health environmental health programmes
Rohan Stewart	Regional Systems Manager, National Irrigation Commission	General Agriculture; manages the irrigation services in the eastern region in accordance with policies and objectives of the NIC
Nilsia Johnson	National Public Health Lab/Environmental Health Lab, Ministry of Health	Chemical Engineering, wastewater and other environmental health issues; Lab Manager for the Environmental Health Laboratory.
Hyacinth Chin-sue	Registrar, Pesticides Control Authority	Agronomy and Crop Science
George Wright	Water Quality Control Manager St. Catherine, St. Catherine Health Services	Public Health Inspector; water quality management (water treatment systems, chemical bacteriological and chlorination procedures)
Rainford Blackwood	Superintendent Minor Water Supplies, St. Catherine Parish Council	Supervises workers (part time chlorinators) who collect samples to check for residual chlorine in minor water supplies; allocates work for maintenance of pipes associates with minor water supplies
Don Streete	Manager Quality Assurance, National Water	Analytical Chemistry, Coastal and Marine Environment Pollution Prevention and

NAME	ORGANISATION & POSITION	EXPERTISE
	Commission	Watershed Management
Pauline Adams-Russell	Area Manager, St. Catherine, National Water Commission	Electrical Engineering and Management, manages NWC water supply systems for the parish
Denise Haiduk	Environmental Health Specialist, Environmental Health Unit, Ministry of Health	Water and wastewater management
Ana Treasure	Environmental Health Adviser, PAHO	Solid waste management and water and wastewater systems
Dr. Francia Prosper-Chen	Medical Officer (Health) - St. Catherine Health Department	Public Health Practitioner with responsibility for the health of parish
Ms. Camille McDonald	Head of Sanitation Laboratory, National Public Health Laboratory	Medical Technologist responsible for drinking water quality analysis

The activity and responsibility matrix at Appendix 2 was used to guide the process of the development of the Water Safety Plan. It outlines the activities in sequential order as well as the persons with responsibilities. It was updated at each meeting of the Task Force with the target dates for completion of tasks.

4.0 DESCRIPTION OF THE STUDY AREA & ENVIRONS

St. Catherine is the third largest parish in Jamaica with an area of 1192.4 km^2 (460.4 $miles^2$ or 119,240 hectares) located in the southern section of Jamaica (Figure 2 – Map of Jamaica and Figure 3 - Parish of St. Catherine). The south of the parish is very flat except for the Hellshire Hills near the south coast while the central and northern sections are very mountainous. The northern border is on Mount Diablo which crosses over into St Ann and the highest point on that border is 686 metres (2,700 feet).

The plain is approximately 23,000 hectares (57,000 acres) and occupies the southern part of the Rio Cobre basin. The Rio Cobre river is one of the largest on the island and it is the only river which runs across the southern plain of St. Catherine. The river provides water to irrigate approximately 7,042 hectares (17,402 acres) on the plain and supplies domestic water for Spanish Town. The Rio Cobre watershed covers the entire parish of St. Catherine.

Average demand for irrigation water from 2002 to 2005 (based on fiscal year April to March) was 66.7 million m^3 per year. Based on projected land use patterns the National Water Irrigation (NIC) does not expect the demand to exceed 80 million m^3 per year in the next 5 to 10 years.

The main wetland areas which dominate the plain are the Hellshire/Cabaritta swamp, The Great Salt Pond and the Hunts Bay Dawkins Pond between Kingston and St Catherine.

There are no rare or endemic flora and fauna in the upper watershed but here is an endemic iguana habitat in the southern part of the parish in the dry limestone forests at Hellshire, St. Catherine. The southern part of the parish falls within the Portland Bight Protected Area declared under the Natural Resources Conservation Act (1991) in April 1999.

Mineral deposits found in the parish include bauxite, copper, limestone, commercial marble, clay, sand and gravel.

Figure 2- Map of Jamaica

Figure 3 - Map Showing St. Catherine

4.1 Meteorology

Jamaica has a tropical maritime climate. Mean daily temperatures range from a seasonal low of 26 degrees centigrade in February to a high of 28 degrees centigrade in August. Daily sunshine hours are fairly constant throughout the year, averaging about 8.2 hours in the southern plains (Evans, 1973).

Long term mean annual rainfall over the island is about 1,980 mm (Evans, 1973). Much of the rainfall results from the north-easterly trade winds, which deposit most of their moisture on the northern slopes of the axial mountain ranges, with the consequence that the southern half of the island is in the rain shadow. Rainfall on the north-eastern slopes of the Blue Mountain range is generally 3,000 to 5,000 mm/year, whereas in the south coastal plains of St. Catherine and Clarendon it is generally less than 1,500 mm/year. Island-wide long term mean annual rainfall exhibits a characteristic pattern, with the primary maximum in October and the secondary in May. The main dry season lasts from December to April.

Jamaica regularly comes under the influence of tropical storms and hurricanes during the period July to November, characterized by flood producing rainfall of high intensity and magnitude.

Mean monthly relative humidity on the south coast is near constant throughout the year, ranging from a low of 71 percent in August to a high of 77 percent in October and averaging 74 percent (Evans, 1973).

Rainfall data collected by West Indies Alumina Company (WINDALCO) at meteorological stations situated at Ewarton (in the Upper Rio Cobre Basin – Figure 6) over 5 years from 2000 to 2004 are presented at Table 4. The data indicates that:

(a) 2002 had the highest annual rainfall 1937 mm for Ewarton and these figures are in keeping with the long term mean annual rainfall for Jamaica
(b) Monthly average rainfall for Ewarton ranges between 98 and 161mm
(c) The month with the highest rainfall is September, followed by October then May which follows the characteristic rainfall patterns for the island
(d) The month with the lowest rainfall is February and the driest consecutive months are from January to March, in keeping with general trends for the entire island

Table 4 - Rainfall at Ewarton (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	**Total Annual**	**Avg Monthly**
2000	28	23	36	43	94	194	123	116	245	74	98	98	**1171**	**98**
2001	86	13	43	81	171	29	127	124	164	246	133	79	**1298**	**108**
2002	11	11	70	62	611	85	124	133	630	84	55	60	**1937**	**161**
2003	105	30	77	93	236	263	95	170	138	103	85	93	**1490**	**124**
2004	34	8	36	55	105	54	149	100	684	99	165	103	**1591**	**133**
5 yr total	**265**	**85**	**262**	**334**	**1218**	**625**	**619**	**644**	**1861**	**605**	**536**	**432**		
5 yr avg	**53.1**	**17.0**	**52.5**	**66.8**	**243.6**	**125.0**	**123.8**	**128.8**	**372.3**	**121.1**	**107.2**	**86.3**		

4.2 Major Industries & Sources of Employment in St. Catherine

The major source of employment is agriculture. There are a substantial number of small farmers who practise mixed farming - domestic and commercial crops which include bananas, coconuts, pineapple, citrus, pumpkins, pepper, coffee and calaloo. Larger properties produce mainly sugar cane, bananas and citrus.

There are several dairy farms in the parish. One of these is a one-thousand-acre farm in Old Harbour which is a model for the West Indies.

The Salt Ponds District between Spanish Town, Port Henderson and Passage Fort is noted for the fine fish especially calipera taken from the Hanson and Dawkins Salt Ponds in particular. Present fish sanctuaries within the parish are Galleon Harbour, Coquar Bay and Manatee Bay.

As an industrial centre St. Catherine is only second to Kingston and St Andrew. West Indies Alumina Company (WINDALCO) has a bauxite/alumina plant and offices near to Ewarton (Figure 3) and is one of the largest employers in the parish. The largest salt producing plant in the Caribbean is in Spanish Town (Figure 3). Nestles, a manufacturer of milk products, Tradewinds Citrus a fruit juice manufacturer and Jamaica Citrus Growers Ltd. another juice manufacturer all have factories in Bog Walk (Figures 3 and 6).

Old Harbour has the largest power plant in the island and several heavy industrial factories. Twickenham Park near Spanish Town is another industrial estate with mainly light industries including cigarettes, carpets, batteries, plastic items, medical and pharmaceutical products. Sulphuric acid used in the production of bauxite is also produced in the parish and Worthy Park and Bernard Lodge are two of the eight remaining sugar factories in Jamaica which are located in St. Catherine.

4.3 The Water Supply Area

The Water Safety Plan is being developed for the Spanish Town water supply system. Spanish Town, the capital of St. Catherine is comprised of commercial, industrial and residential areas and is one of the fastest growing towns in St. Catherine and Jamaica second only to Portmore which is also located in the same parish further south. The 2001 population of Spanish Town based on data from the Statistical Institute of Jamaica (STATIN) is 129,018 which is an increase of 17 % in 10 years above the 1991 population (for the same boundaries) of 110,379. Applying an annual population growth rate similar to what was experienced in the last ten years, it is estimated that the 2006 population for Spanish Town is about 140, 000.

It is instructive to note that the area defined as Spanish Town since 2001 is different from what it was defined as in 1991 as there has been a reduction in the number of communities comprising Spanish Town. Refer to Appendix 3 for Table showing the areas comprising Spanish Town in 1991 and 2001.

A map from the STATIN (Figure 4) defines the boundaries of Spanish Town (area within the green line) based on the 2001 population census. Figure 5 shows the zones served by the Spanish Town Water Supply System.

4.4 Catchment

The Rio Cobre basin occupies a 1,283 km^2 (128,300 hectares) area in south-east central Jamaica in the parish of St. Catherine. The basin is sub-divided into two sub-basins, the Upper and Lower Rio Cobre. The two principal aquifers in the basin are limestone and alluvial aquifers. These are the main sources for water supply development for Spanish Town.

The major river draining the Upper Rio Cobre sub-basin is the Rio Cobre with its larger tributaries being Rio Pedro, Rio Magno, Rio D'Oro and Thomas River. The upper basin is a closed hydrological unit with a single outlet through the Bog Walk Gorge. The Rio Cobre River is 52.5 km (31.6 miles) in length flowing south towards the sea (Hunts Bay, Kingston

Harbour) with an average flow of 1million m^3/d (WRA 1991). Figure 6 shows a map of the Rio Cobre Basin.

The Rio Cobre Diversion Dam (otherwise called the Headworks Dam) is located at the downstream end of the limestone gorge that separates the Upper and Lower Rio Cobre sub-basins (NIC 1992).

The watershed comprises areas that are severely degraded due to bauxite mining activities in the uppermost section of the parish of St. Catherine and other areas which are moderately degraded, mostly in the lower two thirds of St. Catherine.

Figure 4 - Map Delineating Boundary of Spanish Town (STATIN[SA2])

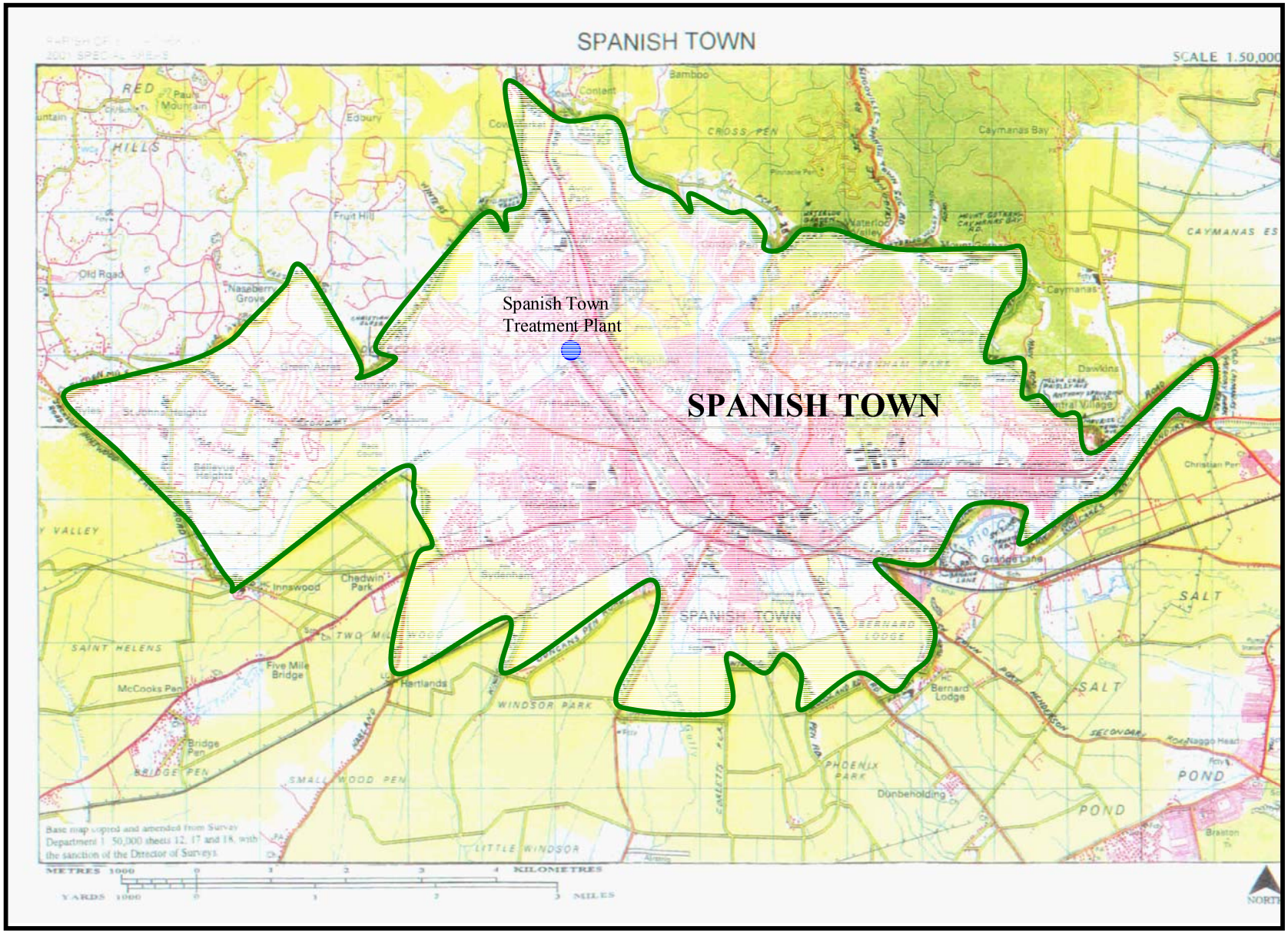
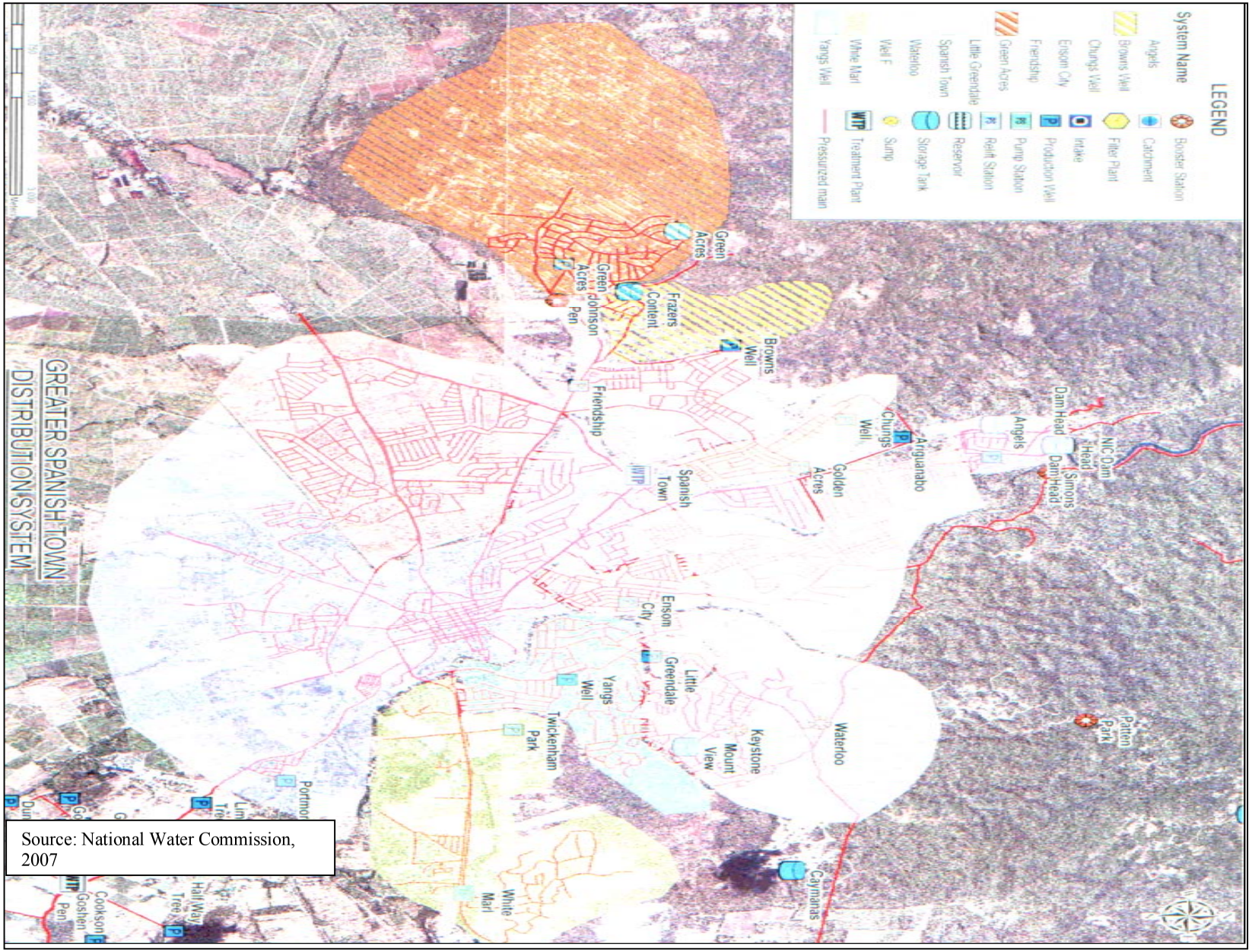
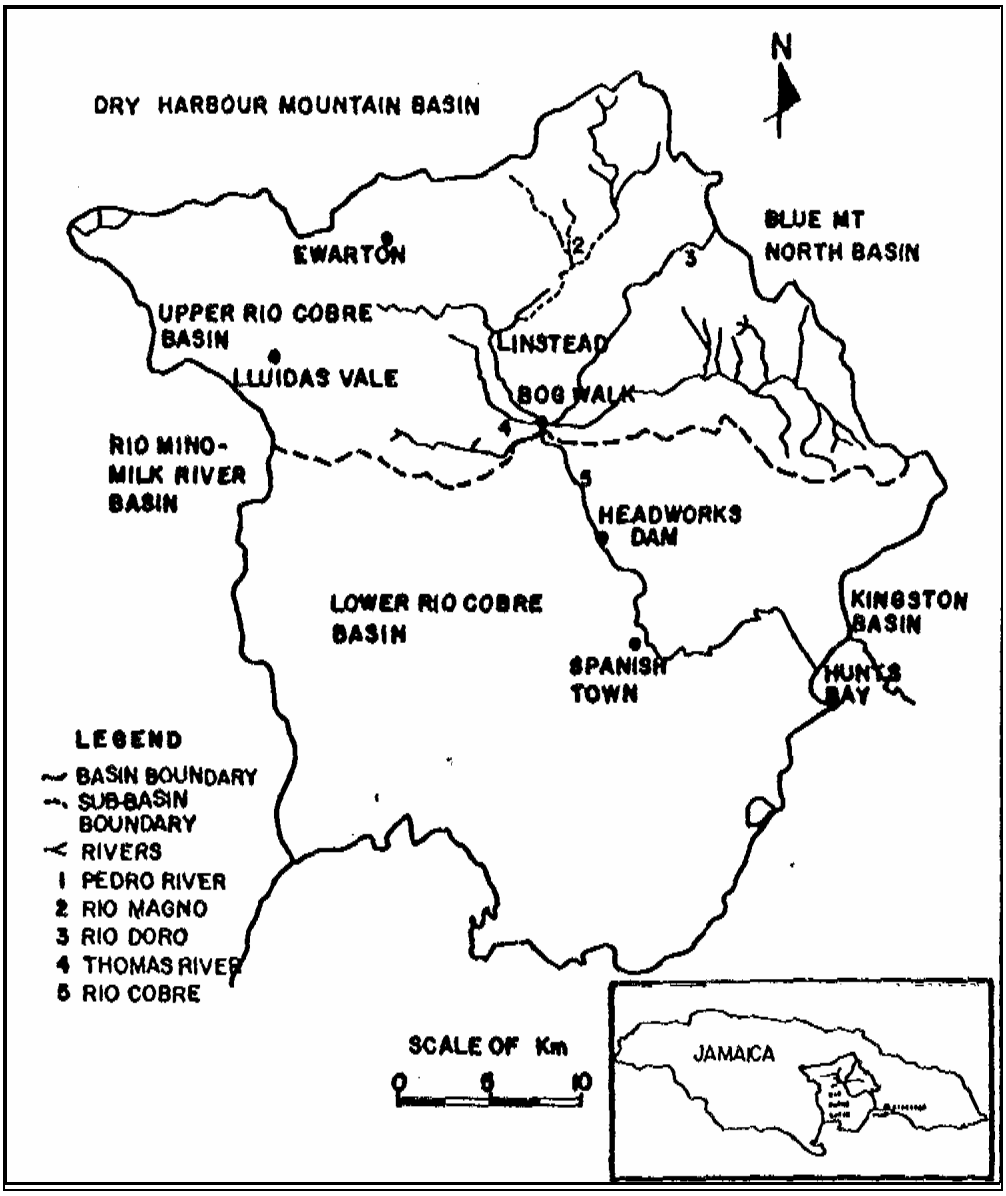


Figure 5 - Spanish Town Water Supply Service Area[f3][r4]



Source: National Water Commission, 2007

Figure 6 - Rio Cobre Basin



Source: Unpublished Report, 1995 (Natalie Morgan, Water Resources Authority)

4.5 Main Sources of Contamination of the Rio Cobre & Irrigation Canal

Rio Cobre River

a) Agro-industrial and Industrial Effluent

Agro industrial and industrial effluents are two of the primary sources of point source effluent discharges to the Rio Cobre upstream of the NWC intake works.

Nestle, a company which manufactures milk products discharges its effluent without treatment to the Moona Spring which flows into the Rio Cobre. Jamaica Citrus Growers

Ltd. a juice and milk manufacturing company discharges its wastewater directly to the Rio Cobre without treatment. Tradewinds Citrus another juice manufacturing company treats its wastewater using stabilisation ponds but the treatment process is not effective as the effluent which is discharged directly into the Rio Cobre cannot consistently meet NEPA's trade effluent standards. Figure 7 provides an indication of the effluent paths from these agro-industries to the Rio Cobre.

The bauxite alumina company at Ewarton occasionally has accidental caustic effluent spills that eventually reach the river increasing the pH and sodium content.

Wallenford Coffee Company operates a Coffee Pulpery which is located near to Bog Walk and discharges its effluent into the Thomas River, a tributary of the Rio Cobre. There is a settling tank to allow solids to be removed prior to discharge of the effluent however this is not always effective. Effluent discharges from this facility are seasonal as it only operates after coffee has been reaped.

The effluent quality from these establishments are monitored by the National Environment and Planning Agency (NEPA), but none of them have licences to discharge effluent as they were in existence prior to the enactment of the regulation requiring a licence. NEPA is developing Trade and Sewage effluent regulations that will require these establishments to obtain licences for effluent discharge in accordance with prescribed standards.

b) Sewage Effluent

There are ten (10) sewage treatment plants within the upper watershed (as shown on Figure 8) that discharge their effluent into the Rio Cobre either directly or via gullies and tributaries. Of these plants, Angels Estate, Ewarton (Windalco) and Charlemont (also known as Charlie Mount) Sewage Treatment Plants have licences from NEPA for effluent discharge but the others listed below existed prior to the effective date of the licencing regulations.

- Bushy Park Charlie Mount
- Mid Island Poultry
- GC Foster College
- Linstead Hospital
- Knollis
- Rosemount
- New Works

c) Agricultural Runoff

Another main source of contamination is turbidity from storm water and agricultural runoff and sand mining. The storm water also tends to contain pesticides used in agricultural activities. The Pesticides Control Authority (PCA) has indicated that in the past endosulfan and endrin, used in coffee and citrus farming, was detected in the river. Endrin is no longer used as it has been banned by the Pesticides Control Authority since 1991. Endosulfan is used in restricted qualities by the Coffee Industry based on limitations placed on its use by the PCA until the use of Integrated Pest Management strategies are fully implemented.

During 2004-2006, NWC did an assessment of the water quality in the lower Rio Cobre Basin which revealed that Diuron exceeds drinking water standards in the Lime Tree Canal sample as does the sum of pesticides and Atrazine was found in concentrations above method detection limits. Atrazine is no longer imported based on a recent ban placed on this pesticide by the PCA but Diuron is a common herbicide in wide use. Due to the higher half-lives of Diuron and Atrazine in groundwater compared to soils it was recommended in the assessment that the recharge of these compounds to the aquifers should be monitored, particularly in the alluvium.

d) Solid Waste

Improper solid waste disposal into tributaries of the Rio Cobre and the river itself is another source of contamination. Curbside collection is not provided in hilly areas or in areas where population density is low, so in the absence of other local solid waste management alternatives, persons often dispose of their waste in gullies, tributaries of the Rio Cobre and the Rio Cobre.

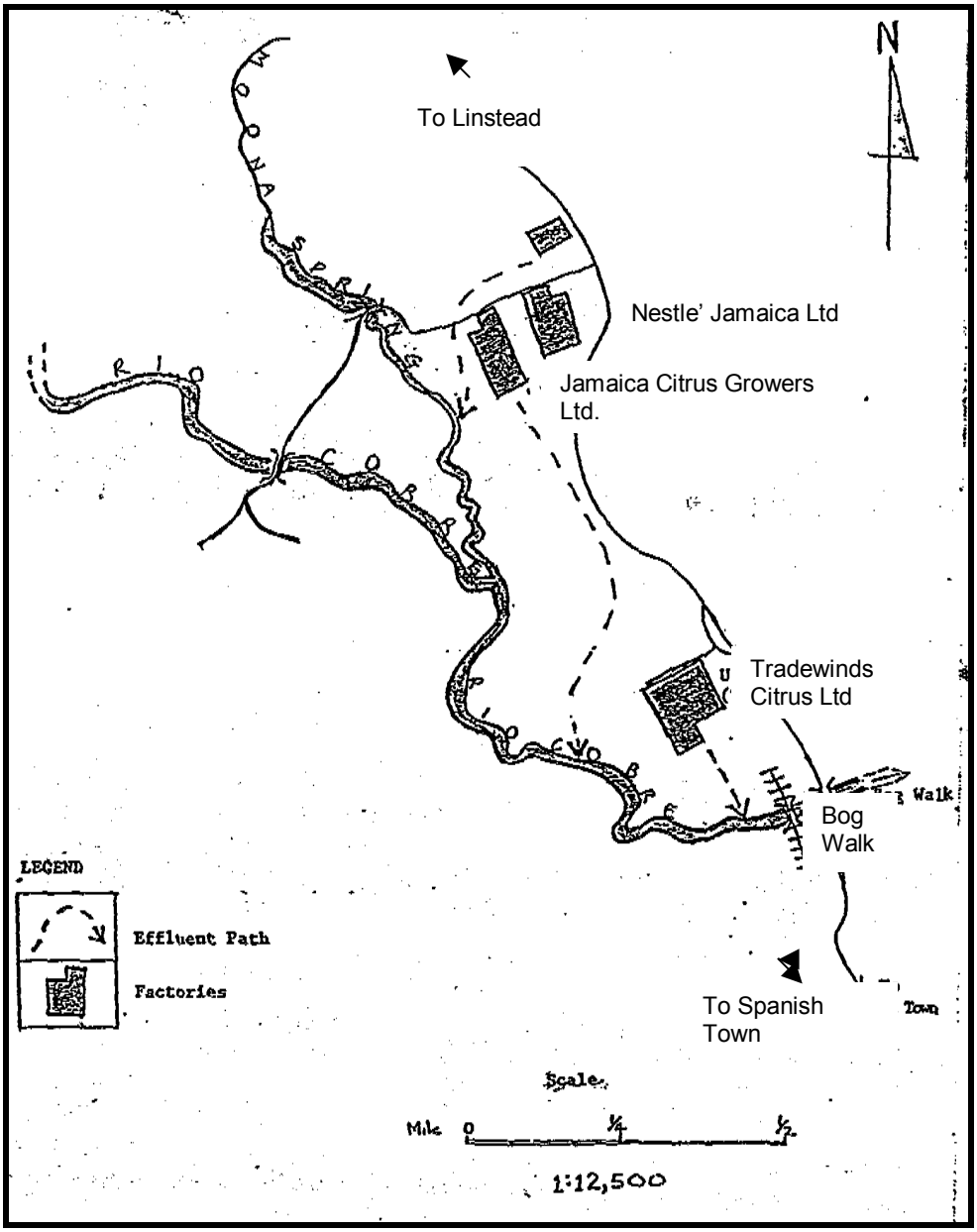
Irrigation Canal

The NIC irrigation canal on which the NWC has its intake works is affected by contamination from:

- Improper solid waste disposal
- Untreated sewage effluent from informal settlements alongside the canal
- Untreated wastewater from informal activities such as car washes and cook shops

Figure 9 shows the vulnerable areas along the irrigation canal upstream of NWC's intake works.

Figure 7 - Effluent Path from Agro Industries to Rio Cobre



Source: Unpublished Report, 1991 (Prepared by M.Wint -Water Resources Authority)

Figure 8 - Sewage Treatment Plants in the Rio Cobre Watershed[f5]

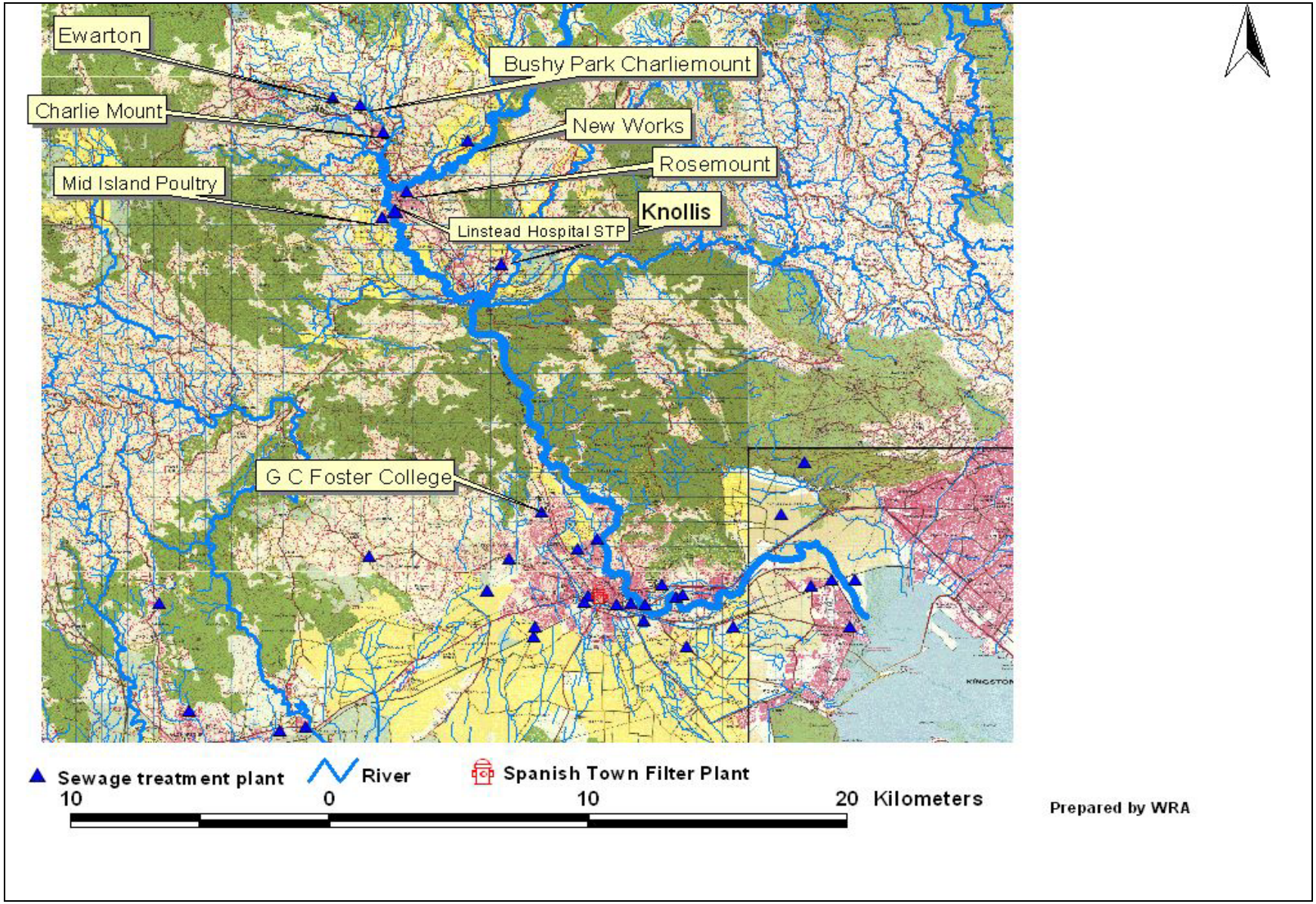


Figure 9 - Areas along NIC Irrigation Canal Vulnerable to Contamination[f6]

Source: Prepared by J. Jackson, National Water Commission

5.0 WATER SUPPLY SYSTEM

The Rio Cobre Diversion Dam is the point at which the National Irrigation Commission (NIC) diverts water from the river usually up to a maximum of about 0.276 million m^3/d into an open channel canal to provide irrigation water for agricultural activities on the plains. The National Water Commission (NWC) has intake works for its water treatment plant on the NIC canal to supply Spanish Town with water for domestic use and abstracts water up to a maximum rate of 18,176 m^3/d (4 migd[2]). The NIC manages the diversion of flows to ensure that there is sufficient water to meet the needs of the NWC as well as the water demand for irrigation.

Spanish Town is supplied with potable water from a combination of wells and surface water from the Rio Cobre River which have a highly interconnected distribution network. The service area for the Spanish Town Water Supply System is shown on a map at Figure 5 indicating wells, booster stations and storage tanks. The boundaries of the service area tend to expand and contract based on water availability and demand.

Based on the 2001 Population Census, Spanish Town has 37,656 households. 33,075 receive water from public sources. Of this number, 21,760 receive water from the public supply system directly to their dwelling. Of the remaining 11,315:

- 9,883 have access to water from the public supply piped in to the yard
- 730 obtain water from standpipes and
- 702 obtain water from public catchments[3]

Table 5 – Source of Water Supply to Spanish Town Households

Area	Total Households	Public Source				Private Source		Spring/ River	Other	Not reported
		Piped into dwelling	Piped into yard	Standpipe	Catchment	Piped into dwelling	Catchment			
Spanish Town	37,656	21,760	9,883	730	702	1,477	891	30	1,240	943

In cases where water supply is interrupted, or there is inadequate water pressure, water is trucked to the affected communities by:

- the National Water Commission using their own trucks
- private contractors hired by the NWC
- Rapid Response water trucks (Ministry of Water) based on requests from NWC

5.1 The Wells

The first 10 wells listed in Table 6 below are the primary wells that supply Spanish Town with total production of approximately 9 migd. These wells are located in the Western Limestone Aquifer of the lower Rio Cobre Basin. The other 6 wells supply Kingston and

[2] migd – million imperial gallons per day
[3] Catchment refers to a public tank; persons obtain water by going to the tank

other areas outside of Spanish Town with some water diverted to supplement the water supply for Spanish Town.

The sources which comprise the Spanish Town Water Supply System and the communities they serve are listed in Table 6 as follows:

Table 6 - Water Sources and Areas Supplied

		SOURCES	AREAS SERVED
Wells Serving Spanish Town	1.	Friendship Well	Fairfield Road, St. Johns Road, Homestead Clayton Heights, Fletcher's Lane, Willowdene Hopedale, Villanova, Old Harbour Road Syndenham, Cromarty Housing Scheme, Leiba Gardens, Horizon Park, McCooks Pen, Hartland.
	2.	Yang's Well	St. Jago Heights, Thompson Pen, sections of Twickenham Heights, Tryall Heights, sections of Greendale, sections of Mount View.
	3.	Twickenham Park Well	Twickenham Park Industrial Estate, sections of Spanish Town, Greendale, section of Lauriston
	4.	Central Village Well (a.k.a. White Marl)	Windsor Heights, parts of Greendale, Central Village, Twickenham Park Industrial Estate, Twickenham Park H/S, Parts of Spanish Town.
	5.	Browns Well	Ebony Vale, Friendship Housing Scheme, Fairview Park, Paul Mountain, Frazers Content Dark Hole, Banana Hole, Kitson Town
	6.	Golden Acres Well	Golden Acres, Stratmore Gardens, Coles Pen
	7.	Ensom City Well	Ensom City
	8.	Green Acres Well	Green Acres, Bellevue Heights, St. Johns Heights, St. Johns Meadows, Mercury Gardens, Bendon, part of St. Jago Heights
	9.	Little Greendale Well	Little Greendale, St. Jago Heights South, part of Tredegar Park
	10.	Angels Well	Angels Phase 1 & 2
	11.	Spanish Town Treatment Plant	Spanish Town, Westmore, Hampton Green, Lakemore, Newton Avenue, Nugent Street, McCoy's Land, Mayfair Mews, Brunswick Avenue, Job's Lane
Wells Serving Kingston and Portmore	12.	Bybrook Well #2	Tulloch Springs, parts of Kingston, parts of Portmore, Simon, Job Lane, Eltham
	13.	Bybrook Well #4	Tulloch Springs, parts of Kingston, parts of Portmore, Simon, Job Lane, Eltham
	14.	Tulloch Springs	Tulloch Springs, parts of Kingston, parts of Portmore, Simon, Job Lane, Eltham
	15.	Eastern Headworks Well H	Portmore and Kingston
	16.	Eastern Headworks Well E	Portmore and Kingston
	17.	Eastern Headworks Well W	Portmore and Kingston

Figure 10 shows a simple schematic of the wells and surface water sources for the Spanish Town Water Supply System and Table 7 shows the current and future production of these wells. The future production rates of the wells in 2008-2010 were obtained from the Kingston Metropolitan Area (KMA) Water Supply project documents. These rates were determined from projected water demand based on population growth and the production capacities of the wells.

The first 9 wells listed in Table 7 are all in need of above ground and below ground rehabilitation. The performance of the wells has declined after a long period of operation without proper maintenance. Assessment of the need for and extent of below ground rehabilitation that will be required and execution of the necessary rehabilitation works will be done as a part of the KMA Water Supply Project.

Above ground works already identified for attention generally includes:

- Repairs to and upgrading of the chlorination system to allow adequate chlorine contact time for disinfection as there are currently no chlorine contact chambers
- Repairs to and upgrading of well/relift pumps and motors
- Modification of discharge piping to include proper arrangements for electromagnetic metering of well water production
- Replacement of delivery valving
- Building repairs e.g. installation of doors, windows and security grills and civil site works such as access roads and fencing
- Switchgear Electrical work at site

Elevated chloride levels have been detected in most of the Spanish Town Water Supply wells such as Yang's, Twickenham, Central Village/White Marl, Ensom City, Friendship, Golden Acres and Greendale Wells however the Water Resources Authority (WRA) indicates that this is not due to saline intrusion from pumping but it appears to be linked to geological structures within the limestone.

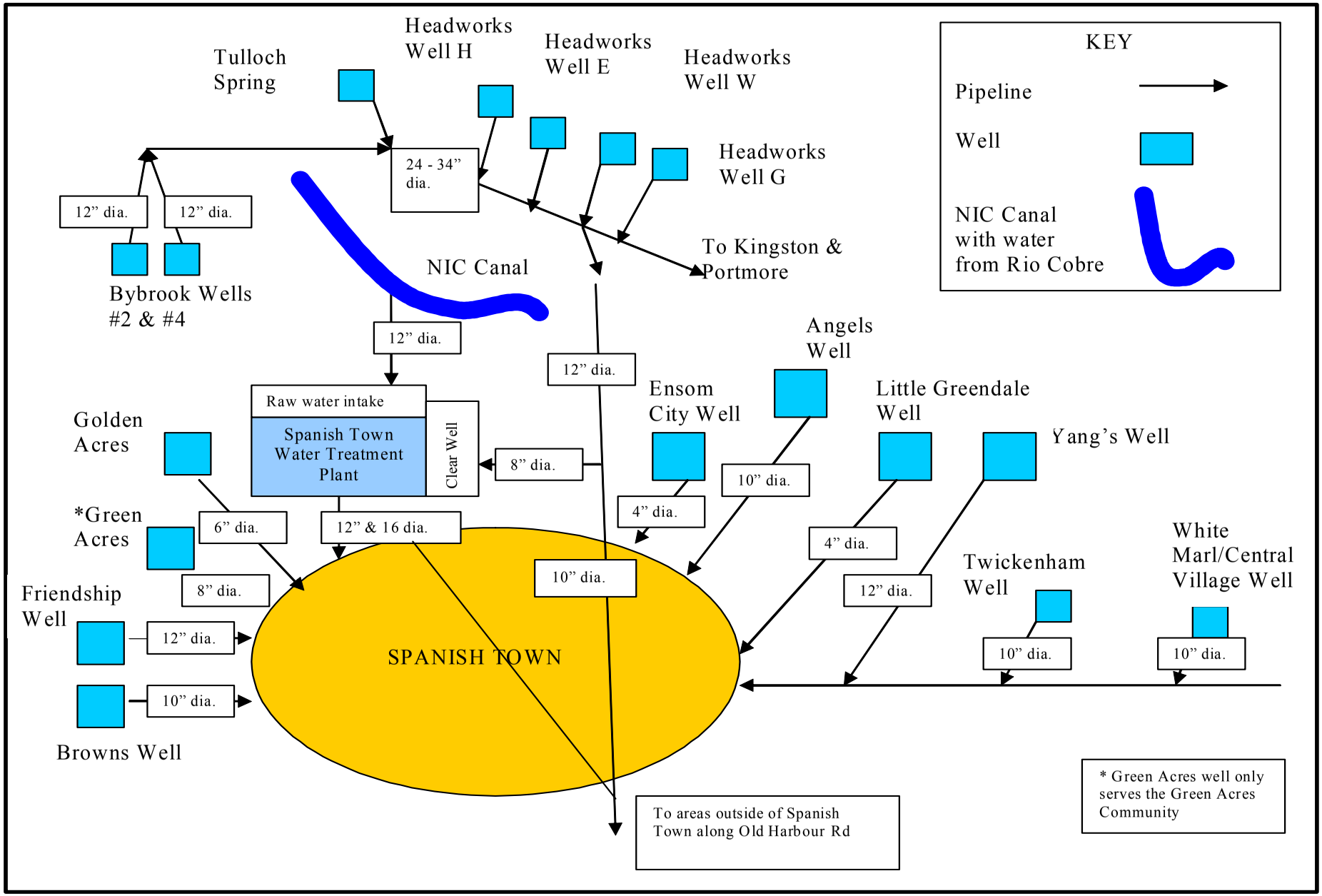
As shown in Table 7, the intention is to retire two of the wells (Golden Acres and Ensom City) affected with this problem and to decrease the abstraction from Central Village and Yang's.

All well water is chlorinated prior to entering the distribution system. The dosage is set at a level to achieve 2.0 mg/L residual chlorine in the water leaving the facility. The chlorine dosing at each well installation is indicated in Table 7.

Table 7 - Production Capacities of Wells and the Spanish Town Treatment Plant

	LOCATION	PRODUCTION MIGD		CHLORINE DOSING LBS/DAY
		Actual	Future (2008-2010)	
1	Bybrook Well #2	2.68	3.01	
2	Bybrook Well #4	2.55	3.01	
3	Eastern Headworks Well H	1.08	2.22	
4	Eastern Headworks Well E	0.53	1.68	
5	Eastern Headworks Well W	0.53	2.38	
6	Friendship Well	1.05	1.51	20-25
7	Yang's Well	1.48	1.06	10-15
8	Twickenham Park Well	0.50	0.50	10-15
9	Angels #1 Well	0.75	0.63	15
10	Green Acres	0.98	2.03	15-20
11	Ensom City	0.59	To be retired	10
12	Little Greendale	0.16	0.55	2
13	Golden Acres	0.57	To be retired	10-15
14	Central Village Well	1.48	0.75	20
15	Browns Well	0.85	0.42	20-25
	Spanish Town Treatment Plant	2.50	3.50	

Figure 10 - Simple Schematic of Spanish Town Water Supply System



5.2 Water Treatment Plant Process – Spanish Town Water Treatment Plant

Surface water is treated at the Spanish Town Water Treatment Plant as outlined in the simple schematic diagram in Figure 11 and Figure 12 shows the existing layout of the treatment plant (prior to the KMA Water Supply Project rehabilitation Works).

The existing works (numbered accordingly on Figure 12) consists of the following:

1. Raw water abstraction pumps – transferring water from the Rio Cobre irrigation canal
2. Pre-treatment chlorination – dosed into the raw water transfer main
3. Rectangular settling tank (settling tank no. 1) - with aluminum sulphate (alum) dosing prior to a mixing basin on the tank inlet
4. Circular settling tank (settling tank no. 2)
5. Low Lift Pump Station – transferring water from the settling tanks to the filtration block.
6. Rapid Gravity Filtration
7. Chlorine disinfection
8. High lift pumps to distribution
9. Two treated water basins which are presently unused

Water is abstracted from the Rio Cobre via three pumps at an average rate of 11,365 – 13,183 m^3/d (2.5 – 2.9 migd) up to a maximum rate of 18,200 m^3/d (4 migd) which is the design capacity of the plant. The abstraction pumps are very old and the settings have been changed over time so information on their performance specifications is not available. However due to their age and repeated adjustments over many years their efficiency is low and new reliable pumps are required.

The raw water is fairly high in turbidity, varying from as low as 2 NTU to as high as 150 NTU. The current practice is to shut the Water Treatment Plant down at turbidity values greater than 30 NTU.

Both alkalinity and hardness are typically in the order of 200 mg/L $CaCO_3$, with a pH around 8. This translates into a water quality which is highly buffered, scale forming, with solids that are not easily settled. Subsequently, the colloids tend to shield harmful microorganisms during disinfection.

The raw water is pre-chlorinated (from a 1 ton chlorine tank) at an average rate of 3.8 mg/L (using a booster pump and ejector). Pre-chlorination at this dose is necessary because the NWC has found that contamination from decaying vegetation, effluents and agricultural runoff together with tropical conditions favour a high bacteria level in the raw water. It also prevents algae from fouling the filters in the treatment plant. The pre-chlorination building and equipment are outdated and in need of replacement.

After chlorination, aluminium sulphate (alum) is dosed at 12mg/L. Dosing is done manually and there are no mechanisms in place to prevent under or overdosing of alum. The original design of the Spanish Town Water Treatment plant did not include infrastructure for coagulation and flocculation. This feature was retrofitted into the original design to what exists today however this system has never functioned effectively due to design limitations.

Coagulation and flocculation take place in a rectangular tank with a design capacity of 15,570 m^3 but due to the build up of silt in the reservoir, which is difficult to clean due to the design of the tank, the effective depth has been reduced from 5.5m to 4.5m so the effective volume of the tank is about 12,740 m^3. Additionally, an appropriate flash mixer is lacking which prevents coagulants from mixing properly resulting in low sediment removal rates. This has contributed to the need to shut down the raw water intake works at turbidity greater than 30 NTU.

The water then flows to a circular sedimentation tank with a design capacity of 3,890 m^3. This tank also has accumulated sediments which are difficult to clean due to the design of the tank, reducing its effective depth from 5.5m to 4.5m so the effective volume of the reservoir is about 3,182 m^3.

The current design, condition and operation of the sand filters contribute to their poor performance. Information from NWC on the design of the original filters and their current performance is described as follows:

- Filters operate at high overflow rate with high solids loading (12 NTU mean, 4.5 $kg/m^2.d$).
- Filtration rate during five-filter operation is 149.3 m/d and 186.6 m/d during four-filter operation (one out for backwashing).
- Backwashing is carried out manually (based on operator experience) and the frequency depends upon demand; typically every 24 hours during dry weather and every 48 hours during wet.
- Backwashing is done at night at a rate of 0.44m/min (26.4m/h) with two pumps each with a capacity of $5.33m^3$/min.
- Air scour duration is typically 3 –5 min, flowrate from air scour blowers is 22m/h.
- Backwash is conducted with treated water, typically 1min, at 26.5m/h, before the inlet valve is opened as a sweep for approximately 10 min; thereafter the wash is continued for about 5 min with treated water.
- There is no instrumentation for flow, loss of head, high water level, etc.
- The underdrain system consists of pipes with nozzles while the filter media consists of graded gravel and sand
- The grading and depth of the media appear to be incompatible with the filtration duty

In order to improve the performance of the filters the existing media must be replaced with new media of appropriate grading and increased bed depth. The backwash pumps and air scour blowers (including associated delivery pipework) need to be changed to increase flow to approximately 35m/h and 55m/h respectively.

Refurbishment of the filters would also need to include the header/lateral underdrain system with a standard or proprietary collection system.

After filtration, the water is conveyed to the clear wells. Clear well #1 has a capacity of 138 m^3 and Clear well #2 has a capacity of 886 m^3.

Post chlorination dosing ranges from 1.2 to 2.4 mg/L using water from the discharge line from Clear well #2 for mixing. Chlorine is supplied from a 150 pound cylinder. The aim is for water to leave the plant with a residual chlorine level of 2.0 mg/L based on the combination of pre and post chlorination. The existing chlorination system provides effective chlorine contact time for disinfection as there is a chlorine residual of 1.0 to 1.5 mg/L in the water coming off the filters so only a small amount of chlorine needs to be added to the water prior to distribution.

Water is discharged at an average rate of 11,365m^3/d to the distribution system using two out of four functioning distribution pumps, via 16 and 12 inch diameter mains to the Spanish Town supply area.

Water quality assessments carried out at the NWC Spanish Town Water Treatment Plant during 2003 showed that the turbidity of the treated water was generally higher than the required standard and there are regular instances where bacteriological levels were also high in the treated water.

The current poor performance of the treatment plant is partly due to ineffective coagulation and settlement before the filters. This is due to a number of factors including non-optimised chemical dosing, in terms of coagulation pH, dose rate and inefficient mixing, as well as short-circuiting in the settlement tanks.

The resultant feed to the filters is therefore of poor quality and results in poor performance of the filters, with a final water quality well above 1 NTU.

It should be noted that the plant has no sludge dewatering and drying facilities.

Figure 11 - Simple Schematic of Spanish Town Water Treatment Plant Process

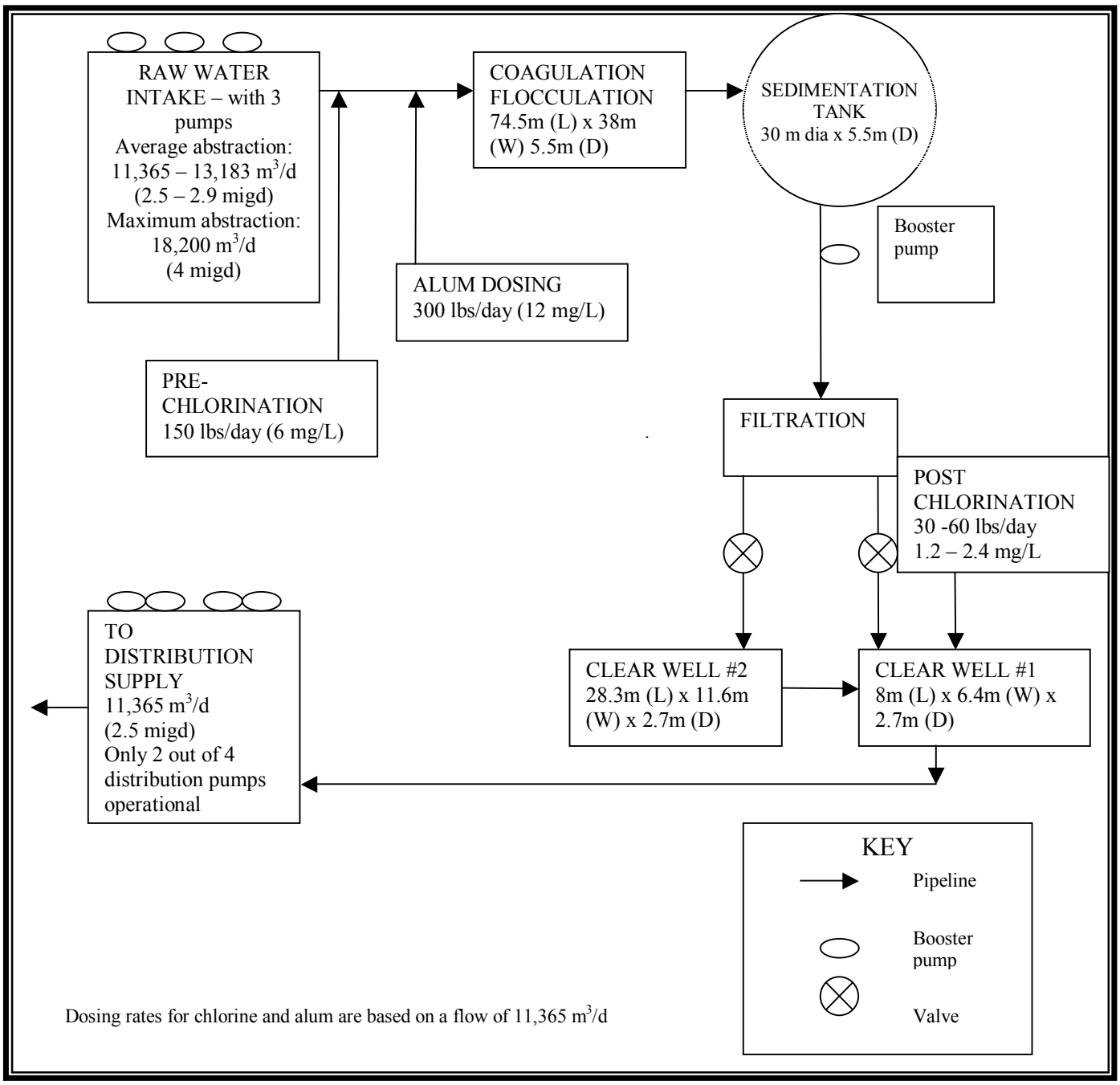
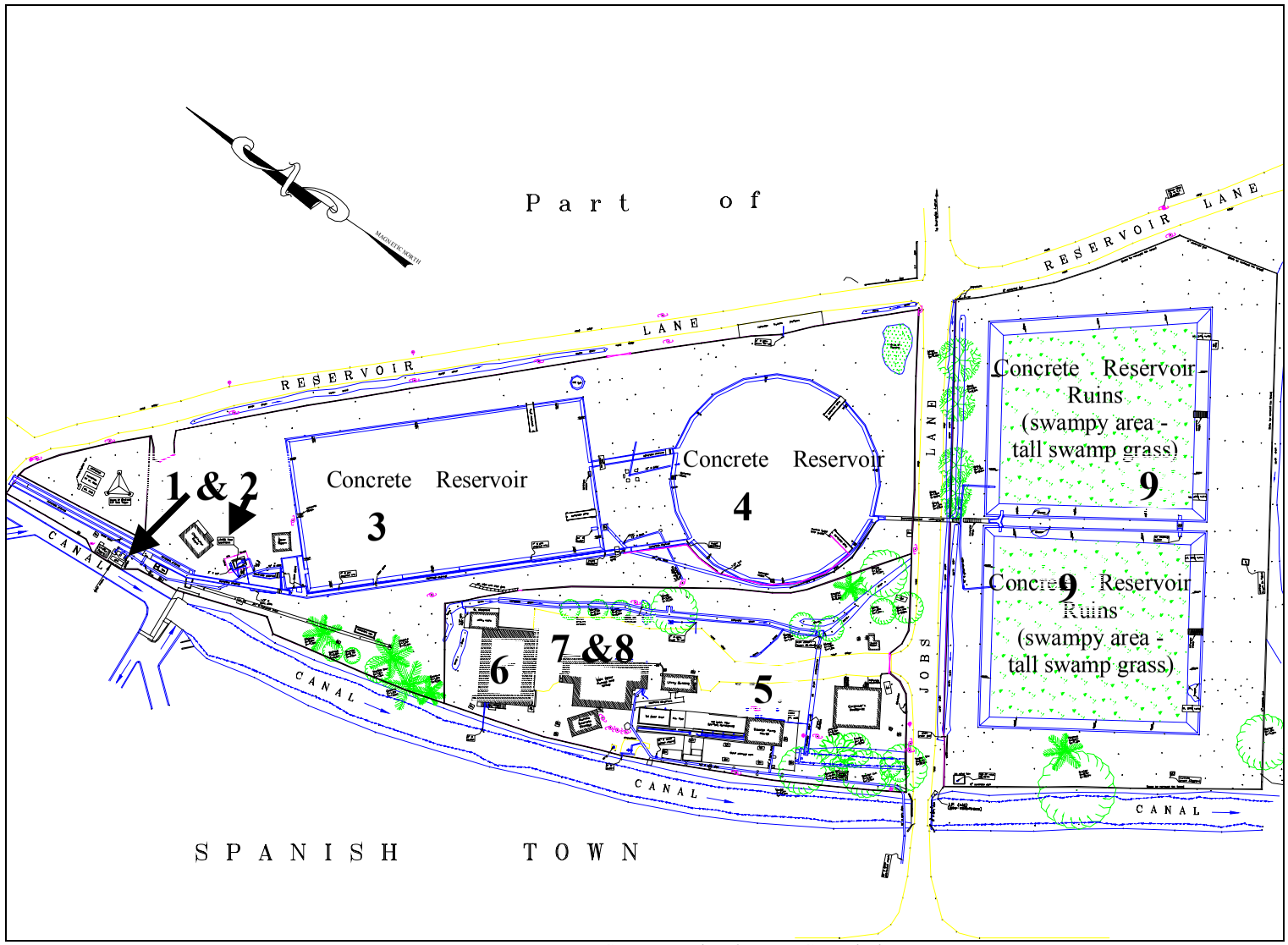


Figure 12[f7] **- Layout of Existing Spanish Town Water Treatment Plant**



Source: National Water Commission

5.3 Distribution System

The distribution network in Greater Spanish Town (which comprises the town centre also known as Old Spanish Town and surrounding areas) is rather complicated, consisting of trunk mains and branches to distribution zones which are interconnected to each other.

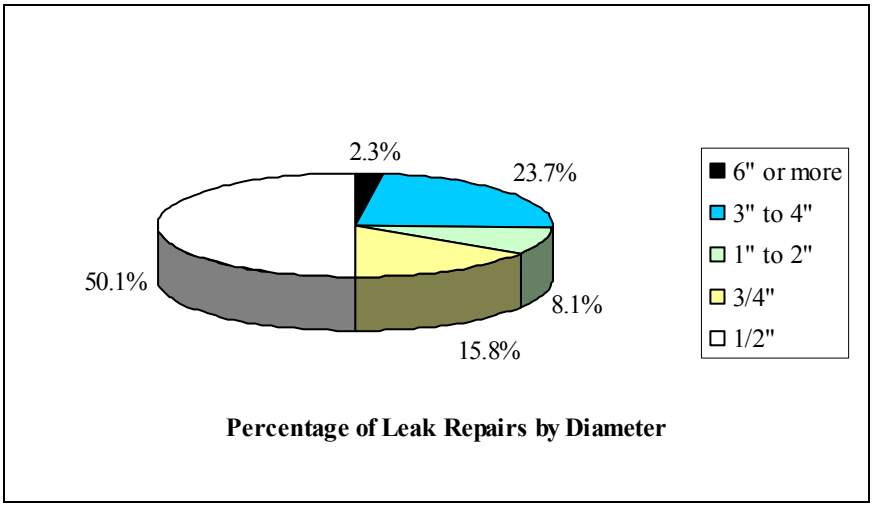
Much of the early system dating back to 1836 is thought to be still included in the distribution network even with the pipe replacement that has taken place over the years.

A GIS-based inventory of distribution mains in the Greater Spanish Town area prepared by the NWC identified a total length of 312.6 km in the distribution network as of November 2002. The diameters of the identified mains vary from 1" to 24" and the predominant diameter is 4" which covers 78% of the total length.

The inventory classifies the conditions of the mains into 'Very Good', 'Good', 'Fair', 'Poor', 'Bad' and 'Very Poor'. More than 60% of the mains are classified as 'Poor', 'Bad' or 'Very Poor'.

The records of leak repairs for 1999-2001 by NWC Spanish Town District Office indicate that the number of leaks of diameter 3" or larger mains in Greater Spanish Town accounts for 26% of the total number of leaks. However, the data also shows that the majority of leaks take place in the 2" or smaller diameter category which is typically service pipes and individual connections. The leak repair record by diameter (1999 – 2000) is shown graphically below in Figure 13. NWC has rehabilitated and repaired some of these pipes in their routine maintenance programme but no large scale exercise has been undertaken to resolve all the leaks. Some additional rehabilitation is planned under the KMA Water Supply Project.

Figure 13 - Percentage of Leak Repairs by Diameter Pipe



Source: National Water Commission

5.3.1 Types of pipelines

The present system of water pipelines comprises many different types, due in part to the very old age of the distribution system in Old Spanish Town (town centre) and the repairs done over the years using different types of pipelines.

Types of pipes in the distribution system include:

- Cast iron pipes (CIP)
- Ductile iron pipes (DIP)
- Polyvinyl chloride (PVC)
- Asbestos cement (AC)

Some of the trunk distribution pipes in the Old Spanish Town area have non-standard pipe diameters less than 200 mm diameter. Hydraulic analysis taking into consideration future demand in the area suggests that all trunk distribution pipes should have a minimum diameter of 200 mm for optimal operations.

5.3.2 Valves

Some isolation valves on the existing distribution system are very old and some cannot be located as they have been covered by repeated road resurfacing over many years. If there is a defective valve on the distribution system connected to old pipelines, the valve and the pipelines have to be replaced as in many cases the existing pipeline has either disintegrated or is too fragile to accommodate the installation of the new valve.

Water hammer is another problem on the distribution system which has weakened pipelines causing repeated ruptures and leaks. This in many cases is due to the absence of sufficient air relief valves on the distribution line.

5.3.3 Aged Mains

Aged mains laid more than 40 years ago are concentrated in the area of Old Spanish Town. Such aged mains would have deteriorated by external corrosion and encrustation resulting in low performance of the distribution network. Even though the leaks in Old Spanish Town are not comparatively large in number, the replacement of the aged mains is a principal requirement for improving the performance of the distribution network in the town centre.

5.3.4 Leakage Problems

Some areas served by the Spanish Town Water Supply system such as Willowdene and neighbouring areas have a high incidence of leakage determined by the frequency of repairs. Willowdene is a housing area approximately 2 to 3 km west of Spanish Town presumed to have been started in around 1960. High incidence of leakage has been quantified as greater than 10 repairs /km/year. The NWC Spanish Town District Office cites the major causes of leaks as external corrosion of pipes

due to the high chemical content of the soil. This is said to originate from residual fertilizer used in the past when the area was used as farm lands. Other areas such as Golden Acres and Strathmore Gardens are also affected by the same problem although to a lesser extent in terms of frequency of leaks.

The integrity of some distribution pipelines which have not been supplying water or have been supplying water at low pressures is unknown at this time and the pipelines are therefore not slated for replacement under the KMA Water Supply project. However, it is envisaged that these mains may fail or leak after the implementation of the KMA Water Supply Project which will result in more water being conveyed through these pipes at higher pressures.

5.3.5 Metering

Metering is currently inadequate to accurately determine how much water enters the water supply system and how much is being distributed throughout the supply area.

The metering strategy proposed for the NWC's on-going UfW[4] Reduction Programme is summarised as follows:

i. The first level of metering is based on source meters and a small number of key trunk main/supply meters, which simply split the Spanish Town Distribution System into 2 discrete zones. These zones are known as Water-Into-Supply Zones or WIS Zones.

ii. The second level of metering, sub-divides the large WIS Zone into several relatively straightforward trunk main systems, denominated as Supply Zones or SZs. There are 8 SZs in Spanish Town.

iii. The third level of metering divides the SZs into operationally more manageable areas known as District Metered Areas or DMAs. The precise measurement of UfW at the DMA level, enables accurate prioritization and focusing of UfW Reduction resources. 21 DMAs in Spanish Town have been identified, and meter sites located.

The DMAs provide the UfW Control Team with a powerful operational tool for indicating increased UfW and quickly homing in on its cause. The un-metered boundaries to DMAs need to be closed by a cordon of 'Keep-Shut' valves (KSVs), most of which will need to be installed for that purpose.

The Supply Zones serve both to monitor the integrity of the DMAs and their meters, as well as to monitor the trunk main network that supplies them.

The WIS Zones provide an accurate measurement of the total supply to the major supply areas and to enable the overall performance of the UfW Reduction and Control Programme to be properly audited.

[4] UfW – Unaccounted for Water

The metering strategy provides for permanent metering installations (as opposed to the use of portable meters used temporarily at a variety of locations).

The KMA Water Supply project proposes the following improvements to the metering which currently exists:

i. Use of full bore electromagnetic meters for reliability and accuracy, and to enhance accuracy, meters should be sized to maintain velocities through the meter at the highest levels consistent with acceptable head losses through the overall installation.

ii. Source meter installations (and uni-directional distribution meter installations) shall allow for straight pipe of a length of five (5) times the meter diameter immediately upstream and of length two (2) times downstream. Distribution meter installations where flow reversal may occur shall have straight pipe of length of 5 times meter diameter both upstream and downstream

iii. Use of meters, data logging and communication equipment fully powered by long-life lithium batteries (rather than relying on the unreliable electricity power supply) at all sites providing a central monitoring capability.

iv. Use of meter sensors of proven quality for direct burial

v. Meter installations at certain water production facilities require the meters to be installed in a "u" tube arrangement – to ensure that the meter would be guaranteed to run full.

5.3.6 Pumping Stations

Relift pumping stations and booster stations are important infrastructure within the water supply area. Relift pumping stations take treated water from atmospheric pressure and pump to a higher elevation while booster pumping stations add energy to the water as it flows through the main.

Within the Spanish Town Water Supply System, the Yang's Well is not functioning in accordance with the original design requirements and need to be rehabilitated as follows:

- replace existing pumps and motors
- provide spare pump if non-existent
- concrete repair
- general electrical, building and civil site work
- refurbishment of valve, switchgear

5.3.7 Distribution Storage

Reservoirs and storage tanks are valuable assets in the water distribution system. Their main function is to store treated water near demand zones. During periods of peak consumption, they stabilize the supply of water to users at an adequate pressure while during sudden shutdown of supply, they can provide emergency water supply. Through the use of reservoirs, more efficient operations are also expected. This is because pumping storage can be conducted during the night when the pumping costs are generally lower.

Similar to other assets of the distribution system, reservoirs require periodic maintenance to function at the intended level of service, however periodic maintenance had fallen behind for the reservoirs in the supply area.

There are 9 distribution storage tanks (listed below) in the supply areas and none are in use due to water supply limitations such as insufficient quantity and inadequate pressure.

1. Spanish Town Hospital Tank
2. Sligoville Road (Mt. View Estate)
3. Windsor Heights Tank #1
4. Windsor Heights Tank #2
5. Angels Tank
6. Fraser's Content Tank
7. Green Acres Tank
8. Twickenham Park Reservoir
9. Patton Park

All tanks need repairs but some tanks may be retired and taken out of the distribution system rather than being repaired based on the hydraulic design for the new KMA Water Supply System. The typical repairs required include:

- reconstruction of base foundation
- sandblasting and repainting of steel works (for steel tanks)
- concrete repair works
- installation of altitude valves
- refurbishing of pipes and valves
- general site works
- replacement of float valves
- interior waterproofing (using epoxy resins or other equivalent) and sterilization
- improved roofing condition
- replacement of access ladders (exterior and interior)
- repair of access hatch
- foundation grouting
- provision of roof vents

6.0 EXISTING MONITORING REGIME

6.1 Ministry of Health (MOH) Water Quality Monitoring and Surveillance

The MOH has overall responsibility for the monitoring and surveillance activities with regard to potable water. The Ministry's roles and responsibilities include:

- Developing policies, standards, guidelines and regulations
- Serving as the central point for the collection collation and analysis of water quality data from providers of public water supply (National Water Commission (NWC), Parish Councils (PC) and private entities).
- Monitoring drinking water, wastewater and recreational water quality.
- Making recommendations to relevant agencies and clients.
- Auditing water and wastewater treatment systems and laboratories.
- Providing laboratory services for testing and supporting health departments monitoring activities.

Currently the MOH utilises the following Regulatory Framework as the basis for their surveillance activities.

- The Public Health Act, 1974.
- The Public Health (Nuisance) Regulations, 1995
- The Interim Jamaica Criteria (IJAM) - specifies water quality contamination limits and sampling frequency for water at source and in the distribution system.
- The WHO guidelines on drinking water also set out the requirements for potable water.

The Drinking Water Monitoring Programme comprises:

- Systems designs, evaluation and approval. which is done by the Environmental Health Unit in the Ministry of Health
- Watershed monitoring to identify possible sources of water pollution done by the Water Resources Authority and the National Environment and Planning Agency
- Compliance inspection of water treatment plant and distribution systems done by the Ministry of Health and the National Environment and Planning Agency
- Chemical and physical assessment of raw and treated water, including packaged/bottled water (Nitrate, Phosphates, Alkalinity, Chlorides, pH, Turbidity, etc.)
- Biological assessment of raw and treated water
- Chlorine Residual testing at treatment plants and wells throughout distribution systems

For a raw water source to be used for potable water supply, it must meet the physical chemical and biological requirements as set out in the IJAM Criteria. All raw water sources used for potable water supply are to be monitored twice yearly by the MOH as well as the provider, the National Water Commission (NWC).

Water is monitored at the treatment plant as well as at designated sampling points within the distribution system for residual chlorine, physical and bacteriological quality by the MOH.

The Ministry of Health through the parish health departments conducts surveillance sampling for these parameters as set out in the IJAM Criteria.

Providers are also required to do their own monitoring, keep records of results, and submit results to the health department on a monthly basis as well as make records available to health department officials on request.

The IJAM treated water quality monitoring requirements for NWC's treated water leaving the plant and in the distribution system are outlined in Tables 8 and 9. Table 8 indicates the minimum monitoring requirements for treated water leaving the treatment plant just prior to its entering the system. The Spanish Town Water Treatment Plant minimum monitoring requirements for water leaving the plant should be in accordance with the population range greater than 10,000. Table 9 presents the number of samples to be taken by the NWC in the distribution system. The minimum number of samples is given for the largest number in the population range to which it refers. The minimum monitoring requirements for water in the distribution system should be in accordance with the population range greater than 100,000.

Table 8 - IJAM Water Quality Monitoring Requirements for NWC (Leaving the Treatment Plant)

POPULATION RANGE (l ,000)	**MAXIMUM INTERVAL**	
	Residual Chlorine	**Bacteriological**
> 10	Each Shift	Daily
5 -10	Daily	Weekly
1 - 5	Daily	Twice / month
< 1	Weekly	Monthly

Table 9 – IJAM Water Quality Monitoring Requirements for NWC (Distribution System)

Population Served (1,000)	**Chlorine Residual**		**Bacteriological**	
	Max. Interval (Days)	**Min. # Monthly**	**Max. Interval (Days)**	**Min. # Samples Monthly**
Standards	**I - JAM**	**I - JAM**	**I-JAM**	**I - JAM**
> 100		1 / 5,000		1/5,000
50 - 100	-	1 /2,500	-	1/5,000
20 - 50	-	1 /2,500	-	1/5,000
15 - 20	1	30	4	8
10-15	2	20	6	6
5 - 10	3	10	10	4
1 - 5	5	6	14	3
<1	14	3	30	1

In addition to the samples taken by the NWC, the MOH is required to collect samples in order to provide surveillance. The MOH determines residual chlorine and collects bacteriological samples in the proportion to those collected by the NWC as outlined in Table 10.

Table 10 - Ministry of Health Sampling Requirements

OWNER	MOH SAMPLING AS % OF OWNER SAMPLING	
	Distribution System	**Source**
NWC	33⅓	Samples as if % for distribution systems applied.

The Ministry of Health recommends that a chemical analysis be done of the drinking water at least twice annually. Table 11 shows a list of the chemicals that should be analysed at least twice per year.

Table 11 – MOH Recommended Test Parameters for Physical and Chemical Analysis of Drinking Water

Chemical & Physical Characteristics	***Chemical Analysis Inorganic***	***Chemical Analysis-Organic Pesticides***
Aluminium	Arsenic	Acrylamide
Chloride	Cadmium	Aldrin and Dieldrin
Colour	Chromium	Benzene
Hardness	Cyanide	Chlordane
Hydrogen Sulphide	Fluoride	2,4-D
Iron	Lead	DDT (total isomer)
Manganese	Mercury (total)	1,2 - dichloroethane
pH	Nitrate - NO3-	1,1 - dichloroethane
Sodium	Copper	Hexachlorobenzene
Sulphate	Selenium	Lindane
Taste and Odour	Uranium	Methoxychlor
Turbidity		Penta -Chloorphenol
Zinc		

6.2 Ministry of Health Field testing Kits

In recent years a number of field-testing kits have been made available to Ministry of Health Water Quality Officers in the parishes.

These kits enable officers to carry out on-the-spot tests which allow for quick water quality assessment. Tests that are done include:

- Total Coliform
- pH
- Total Dissolved Solids

Microbiological tests done using these kits supplement testing of microbiological samples sent to the National Laboratory which is done on a less frequent basis (maximum one sample/plant/month).

6.3 Laboratory Auditing

The Environmental Health Laboratory of the National Public Health Laboratory established a programme about one (1) year ago to audit local laboratories that analyse water for health-based parameters at least once a year. Due to the recent commencement of this programme not all labs have been audited to date.

The Environmental Health Laboratory of the National Public Health Laboratory is presently going through an accreditation process (to ISO 17025 standards) with the local accreditation body which falls under the Ministry of Commerce and Technology. This body gets its license from the International Organisation for Standardization (ISO).

6.4 National Water Commission "In-Plant" Water Quality Monitoring

The raw water from the Rio Cobre is routinely monitored for pH and turbidity while the treated water is monitored for pH, turbidity, residual chlorine and coliform bacteria.

The treated water from the wells is routinely monitored for coliform bacteria and residual chlorine and the raw water is monitored for chloride, nitrate, and other parameters depending on the chemical quality of the water. Every one or two years, a total chemical analysis is done on the wells.

Table 12 summarises the water quality monitoring regime inside the treatment plant that the NWC has in place for the Spanish Town Water Treatment Plant and associated wells. There is a separate monitoring regime for the distribution system as described in Section 6.1, Table 9.

Table 12 - NWC Water Quality Monitoring Regime at the Treatment Plant by Operator

	Location	Parameter Monitored	Frequency	Limits
	SPANISH TOWN WATER TREATMENT PLANT			
1.	Raw water intake pumps	Flow rate	Once per day at the same time usually 7:00 a.m.	
2.	Raw water line	Turbidity	Every hour	If 30 NTU or greater the intake is shut off
3.	Raw water line	pH	Every hour	Helps to determine the required alum dosing levels
4.	Settling Tanks #1	Chlorine	Random	

	Location	Parameter Monitored	Frequency	Limits
	& #2			
5.	Prior to filtration	Chlorine	Every 2 hours	2.0 mg/L
6.	Distribution line leaving plant	Chlorine	Every 2 hours	If less than or greater than 2.0 mg/L chlorine dosing is adjusted
7.	Distribution line leaving plant	Turbidity	Every hour	<3NTU
8.	Distribution line leaving plant	Pressure	Every hour	12"dia. 25psi 16" dia. 30psi
9.	Treatment system	Flows	Continuous	Digital sensors throughout treatment plant (not working)
WELLS				
10.	Distribution pipeline inside well station	Chlorine	Twice per day	2.0 mg/L
		Pressure	Twice per day	20 – 60 psi
		Flows	Once per day	Record spot reading

6.5 Water Quality Monitoring and Surveillance System Weaknesses

A review of the drinking water quality monitoring programme of the Ministry of Health was done by PAHO in March 2005 which found some deficiencies in the water quality monitoring and surveillance programme. These included:

- Lack of a comprehensive water quality surveillance plan which addresses the rationale for the ratio of quantity of sampling versus population served, frequency of sampling, integrity of samples, location of sampling points, frequency and scope of sanitary surveys reporting and coordination mechanism between the Parish Councils, NWC and the Ministry of Health
- The need to decentralise the water quality monitoring programme to ensure that sample integrity is preserved
- Need for the regular review of the IJAM criteria for drinking water quality with reference to WHO standards
- Need for improved reporting format and data management
- No accreditation of laboratories conducting analyses of water quality parameters
- Absence of a documented programme for pesticides testing in raw water for those sources considered to be at risk

The Ministry of Health has already started to address all of these weaknesses in order to improve their surveillance programme.

7.0 EARLY WARNING SYSTEM FOR WATER QUALITY

The Early Warning System is defined as speedy identification of a problem that may affect the water quality and the necessary steps to be taken as a response mechanism. This system was developed by a number of agencies (Ministry of Health, National Water Commission and the Water Resources Authority) and has been in effect for a number of years.

The Early Warning System (E.W.S.) will respond to the following conditions:

1. Low/ No Residual Chlorine
2. Presence of Faecal Coliform
3. Poor Raw Water Quality
4. Presence of Toxic (and other prohibited) Substances
5. Incidents, spills and disasters.

The information presented below on the early warning system for water quality was taken from a Ministry of Health document which was developed by a number of stakeholders in 2005 and consists of the following components:

1. Low / No Residual Chlorine

There is an established set of points along the distribution system where the Public Health Inspector in charge of water quality and personnel from National Water Commission (NWC)/Parish Council take samples, as per Interim Jamaica Criteria (I-Jam). Should the residual chlorine of less than 0.2mg/l be detected the following procedure should be adhered to:

a. Check a minimum of five (5) additional points on the system upstream and downstream of the original sampling point to determine the extent of the low chlorine residual problem.
b. Take water samples for bacteriological analysis at same points as indicated above. Analysis should be done either by way of field kit or if unavailable at the appropriate laboratory.
c. If residual chlorine tests confirm low or no residual chlorine, alert the treatment plant that low residual problem has been detected. The Water Quality Officer should check the chlorination records and have the operators check the chlorination system.
d. Alert Parish Officer or NWC/Parish Council of the findings, and advise that samples for bacteriological analysis had been taken. Request solution to problem and improvement of water quality in 24 hours.
e. Serve a notice instructing the relevant operation to effect improvement of the water quality within 24 hours.
f. If Low / No Residual Chlorine problem is not resolved in 24 hours, the Parish Health Department will issue an advisory to the public indicating the following:
    - The specific water supply is unsafe for domestic use. The entire distribution system should be identified.
    - The methods of treating the water to make it safe / potable.
    - The duration of the advisory.

2. Faecal Coliform in Water

In the event that Faecal Coliform is detected in water by way of bacteriological analysis then:

a. Medical Officer (Health) (MO(H), Chief Public Health Inspector (CPHI)or Public Health Inspector (PHI) in charge of Water Quality should advise Water Quality Parish / Regional Officers from NWC / Parish Council by facsimile / telephone, and in writing of results and request:
   - Historical data re: the supply including test results and time
   - Improvement of water quality within 24 hours.
b. PHI in charge of water quality should collect for bacteriological analysis a minimum of five (5) samples of the supply and distribution system based on agreed network samples approach. The original sampling point should be included. The sampling procedure should be as per distribution system protocol.
c. If at least one (1) of the batch of five (5) samples taken show the presence of faecal coliform and there is residual chlorine, the MO(H), CPHI or PHI in charge of Water Quality should serve a notice on the Parish Water Quality Officer of the NWC or Parish Council, specifying findings and indicating that corrections are required within 24 hours and failure to do so may result in legal action being taken and an advisory will be issued.
d. If **'2c'** is not obeyed an advisory is issued as per **'1f'** and legal action is pursued as needed.
e. The advisory issued will remain in force until improvement is achieved. The PHI in charge of Water Quality should carry out consistent sampling / testing in order to verify improvement. No water supply should be activated or reactivated without written consent of the MO(H). If any water supply is de-activated, the MO(H) should be informed in writing. Also, no water supply should be declared safe without the written consent of the MO(H).

3. Poor Raw Water Quality

If there is high turbidity (that is) in excess of five (5) nephelametric turbidity units (NTU) or five (5) Jackson Turbidity Units (JTU)

a. The Water Treatment Plant Operator (WTP) and the PHI in charge of Water Quality should inform the MO(H) or CPHI immediately.
b. Samples / tests of the raw and treated water are to be taken and submitted for immediate analysis.
c. If there is high turbidity and any sample is faecal coliform positive, the Parish / Regional Water Quality Office for the NWC / Parish Council should be informed by fax / telephone and in writing of the findings and told that an advisory will be issued immediately.
d. MO(H) should issue an advisory as per **'1f'**
e. No water supply should be activated or reactivated without written consent of the MO(H). If any water supply is de-activated, the MO(H) should be informed in writing. Also, no water supply should be declared safe without the written consent of the MO(H).

4. Presence of Toxic (and other prohibited) Substances

a. If any water sample analysis shows the presence of toxic (or other prohibited) substances of any level higher than guidelines values then the Parish / Regional Water Quality Officer for the NWC / Parish Council should be informed by fax or

phone of the findings and that an advisory will be issued immediately. The specific details should be communicated by letter afterwards.

b. MO(H) should issue an advisory as per **'1f'**
c. No water supply should be activated or reactivated without written consent of the MO(H). If any water supply is de-activated, the MO(H) should be informed in writing. Also, no water supply should be declared safe without the written consent of the MO(H).

5. Incidents, Spills and Disasters

In the event of spills, incidents and disasters the NWC, Parish Council, Fire Department, ODPEM should inform the Local Health Department and the appropriate action taken.

8.0 HAZARDS AND THREATS

The likelihood and severity categories used to assess the hazards affecting the Spanish Town Water Supply System were developed based on a WHO template. However, minor modifications were made to the definitions of the severity categories so that they were appropriate to the system being assessed. Table 13 shows the Likelihood and Severity Categories used to determine the risk level.

Table 13 - Likelihood and Severity Categories

Level	Descriptor	Definition	Score
Likelihood categories			
A	Almost certain	Almost every day	5
B	Likely	Two to four times per month	4
C	Moderately likely	Monthly	3
D	Unlikely	Once or twice per year	2
E	Rare	Once every 5 years or longer	1
Severity categories			
1	Catastrophic	Potentially lethal	5
2	Major		4
3	Moderate	Potentially harmful	3
4	Minor		2
5	Insignificant	No impact or not detectable	1

Physical, chemical and biological hazards in the water supply system from the catchment to the consumer were considered by the Task Force members based on expertise and experience as well as observations by the consultant/coordinator from site visits conducted in January 2007, the details of which are outlined at Appendix 4. Table 14 shows the Risk Severity Matrix for Ranking Risks and Table 15 shows the actual scores assigned to the hazards. The scoring exercise was done collectively by members of the Task Force and risks were categorised as insignificant, minor, moderate major or catastrophic.

Table 14 - Risk Scoring Matrix for Ranking Risks

Level	Likelihood	Severity of consequences				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
		1	**2**	**3**	**4**	**5**
A	Almost certain	5	10	15	20	25
B	Likely	4	8	12	16	20
C	Moderately likely	3	6	9	12	15
D	Unlikely	2	4	6	8	10
E	Rare	1	2	3	4	5

KEY

	Low	1 to 4
	Moderate	5 to 12
	High	15 to 16
	Very High	20
	Catastrophic	25

Table 15 - Hazard Analysis and Risk Characterisation for the Spanish Town Water Supply System

	Hazard	Types	Symbol
1	Physical	Sediments, Turbidity, Colour, Odour	P
2	Chemical	Pesticides, Disinfecting agents,	C
3	Biological	Bacteria, parasites, viruses	B

	Hazard	Hazard event/source/cause	Likelihood	Severity	Score	Risk
		CATCHMENT & INTAKE - RIVER				
1	B, C, P	Agro-industrial effluent	4	3	12	Moderate
2	C, P	Bauxite/alumina plant effluent	2	3	6	Moderate
3	B, C	Informal solid waste dump	1	1	1	Low
4	B, C, P	Dumping of solid waste into rivers due to infrequent or non-existent garbage collection in watershed	5	2	10	Moderate
5	B, C, P	Informal residential settlements along canal prior to intake without sewage treatment & disposal systems	5	4	20	Very high
6	B, C, P	Informal commercial activities e.g. car washes, cook shops, garages, along canal prior to intake without wastewater treatment/disposal systems	5	4	20	Very high
7	B, C	Disposal of effluent into rivers by Cesspool emptiers	3	4	12	Moderate
8	C	Pesticide residues in storm water run-off from farming activities within the watershed	3	4	12	Moderate
9	P	High sediments in storm water run-off from clear cutting of land associated with farming and other construction activities and sand mining within the watershed	4	2	8	Moderate
10	B, C	Sewage effluent from (approved) systems which utilise on-site absorption pits	2	1	2	Low
11	B, C, P	Security risk - Canal conveying raw water vulnerable to unscrupulous actions which can contaminate water quality	2	5	10	Moderate
12	C	Pre-chlorination of raw water with elevated organics forming carcinogenic by-products	5	3	15	High
13	B, C	Low river flows during drought	2	3	6	Moderate
		CATCHMENT & INTAKE - WELL				
14	B, C	Sewage effluent, particularly nitrates, from (approved) systems which utilise on-site absorption pits	5	2	10	Moderate

	Hazard	Hazard event/source/cause	Likelihood	Severity	Score	Risk
15	B, C	Informal residential settlements without sewage treatment & disposal systems up gradient of ground water resources	5	2	10	Moderate
		TREATMENT - SURFACE WATER				
16	P	High turbidity of raw water causing silt to accumulate in reservoir limiting the quantity of water treated and reducing the treated water quality	4	3	12	Moderate
17	B, C, P	No back up power supply	3	2	6	Moderate
18	C	Uncertain raw water quality due to wide range of possible contaminants (pesticides, industrial effluents etc.)	3	3	9	Moderate
19	B	Under dosing of chlorine	4	4	16	High
20	C	Over dosing of chlorine	1	4	4	Low
21	P, C	Ineffective flocculation due to design limitations such as infrastructure and pH control	5	1	5	Moderate
22	B, P	Ineffective filtration and backwashing due to age of system and design limitations	4	3	12	Moderate
23	B	Check valves on distribution pumps- absent or ineffective	1	3	3	Low
24	B	Booster Pump (to filters) failure	2	3	6	Moderate
		TREATMENT - WELLS				
25	B	No chlorination due to theft of chlorine tanks	4	5	20	Very high
26	B, C	Under dosing of chlorine	4	4	16	High
27	C	Over dosing of chlorine	1	4	4	Low
28	B, C, P	Tampering due to unrestricted access & illegal connections to raw and treated water pipes at well facilities	5	2	10	Moderate
29	B, C, P	No back up power supply	4	3	12	Moderate
30	B, C, P	Non standard system design and components causes delays in addressing maintenance issues as it is not cost effective to stock wide variety of large costly spare parts	3	2	6	Moderate
31	B, C	Ineffective and inefficient disinfection due to the absence of chlorine contact chambers	5	3	15	High
		STORAGE - TREATMENT PLANT				
32	B, C, P	Insufficient reservoir storage to meet peak demand	5	3	15	High
33	B, C, P	Non removal of silt from sedimentation basin in a timely manner due to design limitations	3	2	6	Moderate
		DISTRIBUTION SYSTEM				

	Hazard	Hazard event/source/cause	Likelihood	Severity	Score	Risk
34	B, C, P	Limited use of existing distribution storage tanks and an inability to provide consumers with minimum of 6 hours water in case of a plant shut down	5	3	15	High
35	B, C, P	Illegal connections to distribution system contributing to the high % of unaccounted for water	5	3	15	High
36	B, C, P	Unmetered water supply (social water such as standpipes) and malfunctioning meters contributing to the high % of unaccounted for water	5	3	15	High
37	B, C, P	Leaks on trunk main and distribution system, old pipes in some areas contributing to the high % of unaccounted for water	5	3	15	High
38	B, C, P	Demand exceeding supply - inadequate supply coverage; unserved communities; new residential developments; no change in quantity of water supplied	5	3	15	High
39	B, C, P	Low system pressure if one supply source is out of service	5	3	15	High
40	B, C, P	Some location of valves unknown due to absence of drawings and being carelessly covered during roadworks	5	2	10	Moderate
41	B, C, P	Destruction of distribution system components due to negligence of other utilities e.g. JPSCo., Cable & Wireless and Cable service providers	5	2	10	Moderate
42	B, C, P	Damage to water pipelines and domestic plumbing infrastructure due to absence of air relief valves	5	2	10	Moderate
43	B, C, P	Check valves household - absent or ineffective	5	3	15	High
44	B, C, P	Dead ends on distribution lines causing stagnation in the water line	2	2	4	Low

9.0 CONTROL MEASURES AND PRIORITIES

Control measures were identified for all hazards identified in Table 15 and these are presented at Appendix 5. The risks were prioritised with 1 being the highest and 4 being the lowest. The responsible agencies for implementing the control measures to manage the risks were identified as well as the organisation or person(s) responsible for monitoring the control measure, the deviation procedure or corrective action if the control measure is not effective, verification procedure and records where applicable.

Table 16 below presents the potential hazards that were considered high risk (by the Task Force) with scores of 3 and 4 and priority ratings of 2 and 1 respectively.

Table 16 - Control Measures for Hazards Identified for Priority 1 & 2 Risks

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring
CATCHMENT & INTAKE - RIVER						
1.	Informal residential settlements along canal prior to intake without sewage treatment & disposal systems	Implement an education campaign about sanitation, provide infrastructure to prevent waste from reaching the canal	1	Health Dpt./MOH, Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	Start no later than March 2008 -	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
2.		Maintain buffer zone around canal		Health Dpt./MOH, Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
3.		Upgraded WTP under KMA Water Supply Project to effectively treat water with contaminants		NWC	4th Q 2008	Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month
4.		Requests for new connections are screened to ensure that NWC does not provide connections to informal settlers		NWC	Ongoing	Senior Customer Relations Manager assesses applications
5.	Informal commercial activities e.g. car washes, cook shops, garages, along canal prior to intake without wastewater treatment/disposal	Implement an education campaign about sanitation, provide infrastructure to prevent waste from reaching the canal	1	Health Dpt./MOH, Parish Council, Squatter Mgt. Unit,	Start no later than March 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008

[5] NSWMA – National Solid Waste Management Authority

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring
	systems			Min. of Housing & NIC		
6.		Maintain buffer zone around canal		Health Dpt./MOH, Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
7.		Upgraded WTP under KMA Water Supply Project to effectively treat water with contaminants		NWC	4th Q 2008	Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month
8.		Requests for new connections are screened to ensure that NWC does not provide connections to informal settlers		NWC	Ongoing	Senior Customer Relations Manager assesses applications
9.	Pre-chlorination of raw water with elevated organics forming carcinogenic by-products	Test treated water in the distribution system to determine the by products formed and conduct a local risk assessment of the health implications of using chlorine for disinfection of drinking water	2	NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee to assess status in December 2008
TREATMENT - SURFACE WATER						
10.	Under dosing of chlorine	New chlorination system designed for upgraded WTP under KMA Water Supply Project	2	NWC	4th Q 2008	Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month
11.		Monitor residual chlorine throughout treatment process		NWC	Ongoing	NWC T/P operator monitors Cl_2 residual levels hourly at the plant
TREATMENT - WELLS						
12.	No chlorination due to theft of chlorine cylinders	New chlorine handling procedures since January 2007; security guards on site at large installations, installation of grills & doors, operators to visit site at least 2 times per shift, tracking system in place	1	NWC	Ongoing	Water Production Manager tracks movement of cylinders weekly

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring
		for movement & location of cylinders; Community awareness programme				
13.	Under dosing of chlorine	New chlorination system designed for wells	2	NWC	4th Q 2008	Water Quality Inspector (Health Department) checks on wells at least once per month
14.	Ineffective and inefficient disinfection due to the absence of chlorine contact chambers	To be addressed under the KMA Water Supply project	2	NWC	4th Q 2008	Water Quality Inspector (Health Department) checks on wells at least once per month
STORAGE - TREATMENT PLANT						
15.	Insufficient reservoir storage to meet peak demand	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by installing new clear water reservoirs;	2	NWC	4th Q 2008	Water Quality Inspector (Health Department) checks on treatment plant at least once per month
DISTRIBUTION SYSTEM						
16.	Limited use of existing distribution storage tanks and an inability to provide consumers with minimum of 6 hours water in case of plant shut down	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by installing new distribution storage tanks	2	NWC	Ongoing	Field Operator monitors distribution system
17.		Ensure good operational practices to utilise distribution storage when installed		NWC	Ongoing	Field Operator monitors distribution system
18.	Illegal connections to distribution system contributing to the high % of unaccounted for water	(1) Reduce pressure on distribution system supplying "Red Areas"; community outreach programmes;	2	(1) NWC	Ongoing	Field Operator monitors distribution system
19.		(2) Enforce the law		(2) Parish Council & NWC	Ongoing	
20.	Unmetered water supply (social water such as standpipes) and malfunctioning meters contributing to the high % of unaccounted for water	(1) Rationalise Government policy re social water;	2	(1) Ministry of Water; NEPA, Ministry of Health, NWC	March 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring
21.		(2) Ensure that existing meters are functional and meter unmetered customers		(2) NWC	Ongoing	Field operations personnel/ meter readers to report on non-functional or missing meters
22.	Leaks on trunk main and distribution system, old pipes in some areas contributing to the high % of unaccounted for water	Continue unaccounted for water control programme including leak detection & repair, pressure zoning, flow control; ensure good operational network; KMA project will install new distribution mains	2	NWC	Ongoing	Non Revenue Water (NRW) Coordinator – Eastern Identifies problems to be addressed by Field Operations Manager
23.	Demand exceeding supply - inadequate supply coverage; unserved communities; new residential developments; no change in quantity of water supplied	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by the installation of new distribution mains, more treated water storage and increased production at wells up to sustainable limits; coordination between development planners and water supply system operators; prerequisite for development approval to confirm the availability of water; promote demand side management through policy and regulations	2	Ministry of Water, Ministry of Local Government; St. Catherine Parish Council, NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
24.	Low system pressure if one supply source is out of service	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project; maximize interconnectivity on the distribution system, ensure good operational and maintenance protocols; secure valves and access points on distribution system,	2	NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
25.		Install pressure gauges under KMA project		NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008
26.	Check valves household - absent or ineffective	Replace ineffective check valves and install missing check valves; have sufficient uniformity within system so that large variety of different types of pumps do not have to be kept in inventory	2	NWC & Parish Council	Ongoing	Water Production Manager and Field Operations personnel tracks percentage of households without check valves as well as households with defective check valves

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring
		New policy under consideration to install check valves on household connections. KMA project to address to a limited extent				
SURVEILLANCE SYSTEM						
27.	Lack of a comprehensive water quality surveillance plan	Comprehensive water quality surveillance plan which addresses the rationale for the ratio of quantity of sampling versus population served, frequency of sampling, integrity of samples, location of sampling points, frequency and scope of sanitary surveys reporting and coordination mechanism between the Parish Councils, NWC and the Ministry of Health	1	MOH	March 2008	Central Health Committee, Water Quality Subcommittee will assess in June 2008
28.	Outdated drinking water quality standards	Review & revise IJAM criteria for drinking water quality with reference to WHO standards and establish regime for regular review	1	MOH	March 2008	Central Health Committee, Water Quality Subcommittee will assess in June 2008
29.	Inefficient data management	Improve reporting format and data management by developing an Environmental database	1	MOH	January 2008	Central Health Committee, Water Quality Subcommittee will assess in March 2008
30.	Laboratories conducting analyses of water quality parameters not accredited	Only use accredited laboratories for conducting water quality analyses Audit of private labs – those that MOH approval can be used ultimately want to accredit labs	1	MOH	2008-2009	Central Health Committee, Water Quality Subcommittee will assess annually

10.0 OPERATIONAL MONITORING

The Task Force identified the Critical Control Points (CCPs) on the NWC unit processes at the treatment plant and wells. The aim was to focus on those critical steps in the process areas that if not controlled could pose a risk to the health and safety. Table 17 presents the CCPs along with the:

- Critical limits
- Monitoring procedures
- Deviation Procedures
- Verification procedures
- Records

Generally operators of the treatment plant err on the side of caution by shutting down the plant in the event of high turbidity and/or the likelihood of other contaminants as indicated in the table.

Table 17 – CCPs on Water Treatment Process

CCP	Critical Limits	Monitoring Procedures	Deviation Procedures	Verification Procedures	Records
SPANISH TOWN WATER TREATMENT PLANT					
CCP1 - Intake works	• 20 NTU Turbidity (Existing) • 150 NTU Turbidity (New) • pH 6.5- 8.5	• Operator Guided by Standard Operating Procedures (SOPs) • Operator monitors pH using pH meter and turbidity using turbidity meter every hour	Shut down intake works when (a) pH is trending (after three consecutive readings) towards the upper or lower limits and (b) turbidity reaches limit	• Calibrate pH meters in buffer solution every month • Calibrate turbidity meter in standard suspension • Water Production Team Leader checks records every week, random observation of operations, annual audits	• Hourly logs of pH and turbidity • Calibration records for pH and turbidity meters • Non-conformances and corrective actions • Records of Team Leader audits
	• Average abstraction: 11,365 – 13,183 m3/d (2.5 – 2.9 migd)	• Operator Guided by Standard Operating Procedures (SOPs) • Operator monitors flowrate once per day at the same time, usually 7:00 a.m.	Check intake screens to see if they are blocked or if canal is filled with debris Shut down plant and immediately assign water man to clean canal and intake screens	• Water Production Team Leader checks to see that screens and canal are properly cleaned before plant is put back into service	• WTP operator logs
	• Chemical analysis of water	• NWC lab conducts twice per year full chemical analysis of raw water in accordance with standard test methods	Investigate source of chemicals detected above allowable limits and take necessary action to reduce or eliminate source Adjust treatment process if possible to address problem	• Calibrate test equipment	• Water quality results • Calibration results
CCP2 - Pre-chlorination	2 mg/L residual on filter	• Operator Guided by Standard Operating Procedures (SOPs) • Operator checks every hour using chlorine comparator	• Manually adjust chlorine feed rate or water inflow rate	• Properly cleaned Chlorine comparators • Check comparator against (international) standard solution (traceable to France) • Water Production Team Leader checks records	• Hourly logs of residual chlorine levels • Non-conformances and corrective actions • Calibration records • Log of chlorine feed rates • Records of Team Leader audits

CCP	Critical Limits	Monitoring Procedures	Deviation Procedures	Verification Procedures	Records
				every week, random observation of operations, annual audits	
CCP3 - Alum dosing & mixing	• Dosed at 15 mg/L - 50 mg/L • Turbidity at Clearwell <1NTU • MOH Turbidity </=5NTU	• Operator Guided by Standard Operating Procedures (SOPs) • Operator doses within recommended range • Operator checks every other hour using turbidity meter after filtration	• Operator conducts a number of system checks - Intake turbidity, clearwell turbidity & water level, alum feed rate from previous shift • Shut off booster pump and backwash filter(s) • Manually adjust Alum feed rate or water inflow rate	• Calibrate turbidity meter in standard suspension • Water Production Team Leader checks records every week, random observation of operations, annual audits	• Logs of alum feed rates • Logs of turbidity readings • Non-conformances and corrective actions • Calibration records • Records of Team Leader audits
CCP5 - Post-chlorination	2 mg/L residual in distribution line	• Operator Guided by Standard Operating Procedures (SOPs) • Operator checks distribution line at point of leaving the plant every hour using chlorine comparator • Ministry of Health checks distribution line at least once per month	Manually adjust chlorine feed rate (after filtration) or water inflow rate	• Properly cleaned chlorine comparators • Water Production Team Leader checks records every week, random observation of operations • Check comparator against (international) standard solution (traceable to France)	• Hourly logs of residual chlorine levels (distribution line) • Non-conformances and corrective actions • Calibration records • Log of chlorine feed rates • Records of Team Leader audits • MOH results
	• Total coliform - 0 MPN/100mL • E. Coli - 0 MPN/100mL	• Operator guided by SOPs check bacteria daily • Ministry of Health checks distribution line at point of leaving the plant at least once per month	Activate early warning system (Refer to Section 7 of Water Safety Plan)	• Calibrate test equipment • National Public Health Lab to conduct annual audit of labs doing water quality analysis	• Test equipment calibration records • Records of results • Results of lab audits • Non-conformances and corrective actions • MOH results
Distribution line	• Plant flows • Average flowrates 11,365 –	• Continuous readout of plant flows at established points throughout system	Troubleshoot system to determine cause of problem in accordance with SOP, e.g. pump	• Calibrate test equipment	• Daily logs • Records verifying that the digital sensors are working correctly

CCP	Critical Limits	Monitoring Procedures	Deviation Procedures	Verification Procedures	Records
	13,183 m3/d (2.5 – 2.9 migd)		failures		
	• 12"dia. 25psi • 16" dia. 30psi	• Operator Guided by Standard Operating Procedures (SOPs) • Operator checks pressure on the distribution lines leaving the plant every hour	Troubleshoot system to determine cause of problem in accordance with SOP	• Calibrate test equipment	• Daily logs • Calibration records for pressure gauge
WELLS					
CCP1 - Distribution line leaving well	2 mg/L residual	• Operator Guided by Standard Operating Procedures (SOPs) • Operator checks twice per day using chlorine comparator • Ministry of Health checks distribution line at least once per month	• Manually adjust chlorine feed rate or water inflow rate	• Properly cleaned Chlorine comparators • Check comparator against (international) standard solution (traceable to France) • Water Production Team Leader checks records every week, random observation of operations, annual audits	• Daily logs of residual chlorine levels • Non-conformances and corrective actions • Calibration records • Log of chlorine feed rates • Records of Team Leader audits • MOH results
	• Total coliform - 0 MPN/100mL • E. Coli - 0 MPN/100mL	• Operator guided by SOPs check bacteria daily • Ministry of Health checks distribution line at point of leaving the plant at least once per month	Activate early warning system (Refer to Section 7 of Water Safety Plan)	• Calibrate test equipment • National Public Health Lab to conduct annual audit of labs doing water quality analysis	• Test equipment calibration records • Records of results • Results of lab audits • Non-conformances and corrective actions • MOH results
	• Pressure 20-60 psi	• Operator Guided by Standard Operating Procedures (SOPs) • Operator checks twice per day	• Troubleshoot system to determine cause of problem in accordance with SOP	• Calibrate test equipment	• Daily logs • Calibration records for pressure gauge

CCP	Critical Limits	Monitoring Procedures	Deviation Procedures	Verification Procedures	Records
	• Flows	• Operator Guided by Standard Operating Procedures (SOPs) • Operator takes spot reading once per day	• Troubleshoot system to determine cause of problem in accordance with SOP	• Calibrate test equipment	• Daily logs • Records verifying that the flowmeter is correct

[6] NSWMA – National Solid Waste Management Authority

11.0 VERIFICATION & AUDIT

The Treatment Plant and wells are operated by plant and field operators respectively, in accordance with NWC Standard Operating Procedures. The operators continuously monitor the water quality and service quality (pressures and flows) throughout the treatment process at the treatment plant and wells, as outlined in Table 17, to verify that the water quality targets and the OUR Quality of Service Standards are being met.

The Water Production Team Leader has responsibility for conducting random checks of the operations by observing the operators while they do their work. The Water Production Team Leader also conducts annual audits of the operating system. The Water Quality Inspector for the Health Department of the Parish Council does independent assessments of the operating procedures at the plant and distribution system at least once per month and notifies the Water Production Team Leader of any concerns in writing.

In addition to the monitoring done by the Water Quality Inspector for the Health Department of the Parish Council, the Ministry of Health has responsibility for auditing the quality of the water supplied by the Spanish Town Treatment Plant and associated wells. Audits will be conducted at least annually and a report written and submitted to the National Water Commission.

The NWC will review and update the Water Safety Plan annually and the implementation of the Water Safety Plan will be audited annually by a suitably qualified external auditor appointed by the Central Health Committee, Water Quality Subcommittee.

The Office of Utilities Regulation (OUR) assessment of the Quality of Service Standards will also be used as a measure of customer confidence and satisfaction with the service provided by the NWC.

12.0 THE KMA PROJECT

There are plans currently underway to rehabilitate the water supply system for the Kingston Metropolitan Area (KMA) which includes the parishes of Kingston, St. Andrew and St. Catherine. This means that the Spanish Town Water Supply system will benefit from improvements under this project which is being funded by the Japan Bank for International Cooperation (JBIC) and implemented by the NWC. Lot 1 of the KMA project which incorporates the rehabilitation of the Spanish Town Water Treatment Plant started in mid February 2007 and is expected to last 18 months. Completion is therefore anticipated in mid August 2008.

The rehabilitation objective for the Spanish Town Water Treatment Plant (STWTP) is to provide for reliable production of 18,200m^3/d (4 migd) of potable water meeting NWC standards at all times - irrespective of the turbidity of the available raw water.

This is to be accomplished under the KMA project primarily by addressing treatment issues as follows:

- construction of a new reinforced concrete flocculation/sedimentation facility complete with coagulant preparation and dosing facilities – for the use of powdered poly aluminum chloride as the coagulant of choice for high turbidity (up to 150 NTU) – and associated

sludge drying beds. The area occupied by the existing Sedimentation Basin #1 will be restructured to form appropriate foundations for these new facilities.

- modification of the existing rapid gravity filter facility to improve backwash arrangements – inclusive of the construction of an elevated backwash tank to replace the existing back wash pumping arrangements – and the refurbishment of the filter machinery generally

In addition, the three raw water pump units and their associated switchgear will be replaced, a new rising main laid to the inlet of the new sedimentation facility and appropriate modifications made to the existing main switchgear to accommodate the electrical requirements of the new works.

The works will allow the retirement of the existing pre-chlorine facility (the building to be retained for general storage purposes), the intermediate "clarified water" low lift pump facility and Sedimentation Basins 2 through 4.

Under a separate part of the project, the modifications of the overall STWTP installation will include:

- the replacement of the existing high lift pumping plant with intermediate head units to lift production into twin above ground 8000 m^3 clear water service reservoirs to be constructed on the site of the old sedimentation basins 3 and 4 across Job Lane,
- upgrading chlorination arrangements and revising the main power arrangements (with standby power generation facilities) and
- providing a new final distribution pumping plant (adjacent to the new reservoirs).

APPENDIX 1 – OFFICE OF UTILITIES REGULATION QUALITY OF SERVICE STANDARDS FOR NWC

Overall Standards

A. Drinking Water Quality

Objective: To ensure that the water supplied is always of the highest quality and fit for consumption.

WOS1 - Testing samples for impurities

Definition: It is the duty of the NWC to make periodical analyses of water samples to ensure quality. NWC is required to take any water samples necessary for analysis, at both source and distribution points, and check if the samples are within the standards specified by The Ministry of Health (MOH) Environment Control Division. 100% of all samples should meet the required standards. The NWC must also comply with the sampling regime established by MOH.

B. Water Pressure

Objective: NWC is required to maintain a pressure in the pipes that will ensure that customers receive an adequate supply of water.

WOS2 - Minimum/Maximum water pressure

Definition: NWC should ensure that the pressure of water supplied to consumers is within the range of 20 to 60 psi at all times. During drought conditions, NWC should repeatedly advise customers of areas affected by low pressure or no supply. This standard will be waived for the period that the drought persists. The NWC must notify the Office of the existence of drought conditions, etc.

C. Reliability of Supply

Objective: To minimize and manage interruptions to supply for planned and unplanned (emergencies) work effectively and allowing customers to plan for such events.

WOS3 - Notice of planned work

Definition: NWC is required to inform customers at least 24 hours beforehand when there is need to turn off the water supply for more than 4 hours and the duration of the outage. NWC also has to give at least 12 hours notice of work that is expected to last between 1 and 4 hours. The public is to be advised and apologies issued in the appropriate medium if the NWC cannot restore water supply at the specified time. Notification of outage, in the first instance, should be by means to enable the most effective communication to the affected customers. The required notification time should be given for at least 90% of planned interruptions, (for work of duration not more than 4 hours as well as those of duration more than 4 hours). 1 Unless otherwise stated, references to days are “calendar days”.

WOS4 - Restoration after emergency lock-off
Definition: If there is a burst water main or other emergency, NWC may not be able to warn customers that there will be water lock-offs. NWC should, however, inform customers by making announcements on at least one radio station within 2 hours after interruption. NWC will be required to provide an alternative supply of water if necessary (trucking water to affected areas), and to restore supply within 24 or 48 hours (for urban or rural customers, respectively). NWC must inform customers of unplanned lock-offs (within 2 hours after interruption) at least 90% of the time. Similarly, supply must be restored within 24 or 48 hours (for urban and rural areas) at least 90% of the time. Alternative supply of water, if necessary, must be provided to at least 95% of affected customers.

D. Sewerage

Objective: To ensure acceptable effluent quality and minimize flooding from sewers.

WOS5 - Correction of sewerage problems

Definition: NWC must correct all problems, which result in flooding from sewers, within 24 hours of being informed.

WOS6 - Testing effluent samples to verify that plant are operating in compliance with NEPA requirements

Definition: NWC is required to periodically take any effluent samples necessary for analysis and check if the samples are within the standards specified by The National Environment and Planning Agency (NEPA). 99% of all samples must meet the required standards.

E. Water Meters

Objective: To ensure that customers are promptly provided with a properly functioning meter.

WOS7 - Changing meters

Definition: If NWC needs to change a customer's meter, they are required to leave written details of the date of the change, meter readings (of old and new meters) on the day and serial numbers of the new meter at all times.

<u>Guaranteed Standards</u>

A. Access

Objective: To ensure that new customers are promptly connected to NWC's system.

WGS1 - Connection to Supply

Definition: NWC is required to connect all new customers, where water supply is available at the property boundary, within 10 working days after signing the contract for connection.

Guarantee: If NWC fails to connect a customer within the specified period, NWC will be liable to compensate the customer after a claim is made.

B. Delivery of Bills

Objective: To ensure that new customers receive first bill, in a timely manner.

WGS2 - Issue of First Bill

Definition: NWC must issue (print and mail) a bill to a new customer within 48 days after connection.
Guarantee: If NWC fails to issue a bill within the specified period, NWC will be liable to compensate the customer after a claim is made.

C. Appointments

Objective: To minimize the inconvenience to customers of having to wait for NWC's representatives to attend appointments.

WGS3 - Keeping appointments

Definition: NWC has a responsibility to satisfy a customer's request for a representative to visit the customer's premises to deal with an identifiable problem. Appointments should be made with NWC (and its field officers) for either morning (9:00am to 12:00pm) or afternoon (12:00pm to 5:00pm). NWC must guarantee to keep all appointments or to notify the customer prior to the appointed time, if an emergency prevents them from keeping the appointment. If upon arrival at premises, the customer has already left, the field officer should leave details, including time of visit, meter reading and number and contact number, on a door hanger. If customer cannot be contacted, the NWC should notify him/her within 5 days and advise of new appointment within 10 days.
Guarantee: If for any reason NWC does not keep an agreed appointment or does not give notice of a change, NWC will be liable to compensate the customer after a claim is made. If the customer does not keep the appointment, he/she will not be entitled to payment on the subsequent rescheduled appointment.

D. Complaints

Objective: To ensure that, customers' complaints (written, by telephone or in person) are dealt with promptly and satisfactorily by NWC.

WGS4 - Response to complaints not related to billing
(Complaints not related to billing include, faulty meters, low pressure, poor water quality)

Definition: If a complaint is made in writing to the NWC, the NWC must acknowledge the complaint 5 working days after receipt of complaint (by dispatching letter and any other mode of communication). It should also undertake, in the response, its intent to conclude its investigation and reply within 30 working days of the receipt of the complaint. NWC is required to take details of complaints made by telephone or in person, at the time of the call or visit. If the complaint requires investigation, conclusion of investigation as well as response to customer should be within 30 working days of receipt of complaint.

Guarantee: If NWC does not make the necessary response within the specified time, it will be liable to compensate the customer after a claim is made.
WGS5 - Response to complaints about billing matters

Definition: NWC is required to acknowledge complaint within 5 working days and reply to all complaints whether written or by phone regarding bills within 30 working days of receiving the inquiry.
Guarantee: If NWC does no make the necessary response within the specified time, it will be liable to compensate the customer after a claim is made.

E. Account status

Objective: To ensure that a customer moving from a premises receives bill for relevant consumption.

WGS6 - Account status request

Definition: If a customer is moving and requests an account status and/or service to cease, NWC is required to read the customer's meter on the day the customer is moving, if on a working day, as long as (5) working days notice of the move is given to NWC. If the customer is moving on a weekend, NWC should read the meter within two (2) days of the move. NWC is also required to provide the relevant bill within 15 working days of the customer's moving.
Guarantee: If NWC fails to meet this standard it will be liable to compensate the customer after a claim is made.

F. Water Meters

WGS7 - Meter installation

Objective: To ensure that customers are promptly provided with properly functioning meters.

Definition: NWC is required to fit a meter, where an un-metered customer requests one, within 30 working days of receiving the customer's order. If, for some reason, the NWC is unable to meet the request, the NWC should so advise the customer and make a commitment as to when the meter will be provided. In these circumstances, the NWC must automatically make the compensatory payment. Should the NWC not meet this commitment, it constitutes a further breach of the standard and the customer will be eligible for a compensatory payment.
Guarantee: If the NWC fails to meet the above standard, it will be liable to compensate the customer after a claim is made.

WGS8 - Repair or replacement of faulty meters

Objective: To ensure that meters are functioning properly to assure the integrity of bills tendered by the NWC.

Definition: If a customer's meter is verified by the NWC as faulty, the NWC will repair or replace it within 40 working days of being first informed of defect by the customer, or within 40 working days after detection by NWC if the fault was discovered by NWC.

Guarantee: If NWC fails to meet this standard, it will be liable to compensate the customer after a claim is made.

WGS9 - Meter reading

Objective: To minimize the number of estimated bills issued by the NWC.

Definition: NWC has the responsibility to provide at least one bill every two months and will guarantee to read customers' meters at least once every two months as long as it can be accessed. (NWC should make arrangements to relocate inaccessible meters)
Guarantee: If NWC fails to meet this standard, it will be liable to compensate the customer after a claim is made.

G. Reconnection

Objective: To encourage prompt reconnection of customers after payment of overdue amounts

WGS10- Reconnection after payment of overdue amounts

Definition: NWC is required to reconnect customers, whose supply has been locked off for debt and who have settled their accounts, within 24 or 48 hours (for urban or rural customers, respectively) after debt settlement.
This standard does not apply in those circumstances where the supply has been illegally reconnected and the NWC has subsequently removed all infrastructures. In these circumstances a request for reconnection will be treated as a new connection and the WGS 1 would apply.
Guarantee: If NWC fails to reconnect customers within the specified time, it will be liable to compensate the customer after a claim is made.

H. Compensation

Objective: To ensure that the value of the compensation is not undermined by late receipt of payment.

WGS11 - Payment of Compensation

Definition: NWC has 60 days after claim is received to process and make payment due under the Guaranteed Standards scheme. Customer must make claim within 2 billing periods or 60 days (whichever is longer) of the perceived breach.
Guarantee: If NWC fails to make a compensatory payment within the specified time it will constitute a breach of the guaranteed standard and makes the customer eligible for compensatory payment. If the payment due under a particular standard is not paid within the specified period, the NWC is liable to customers after claim is made. This will repeat itself for subsequent periods until payment is made. Breach of the individual standards will, however, attract only one payment

APPENDIX 2 – ACTIVITY/RESPONSIBILITY MATRIX

	ACTIVITY	ORGANISATION RESPONSIBLE
	DEFINE STUDY AREA	
1.	Define Study Area • Review what predefined area known as Spanish Town encompasses based on information from the Parish Council • Obtain a map of Spanish Town from the Parish Council	Catherine Parish Council
	• Obtain maps of watershed and areas served by the Spanish Town Water Treatment Plant	NWC
	DESCRIPTION OF WATER SUPPLY SYSTEM – From catchment and wells to distribution system. Information to include: • **Population served (current & projected)** • **Communities served** • **Number of metered customers** • **Water rates** • **Average water consumption (per capita per day)** • **Social water/non-revenue water consumption** • **Plant capacity (current and future)** • **Well abstraction rates(current and future)** • **Type of service provided (home, yard, standpipe)** • **Population unserved** • **Storage capacity (raw and potable water)** • **Demand vs. supply data (including seasonal variations)** • **Reliability of water service to consumer** • **Loss due to leakages and illegal connections** • **Raw and treated water quality** • **Treatment process**	
2.	Identify representative from NIC to be a part of the Task Force	MOH
3.	Obtain a simple diagram of the drinking water supply system from catchment to distribution with a description from NWC and NIC	NWC NIC
4.	Obtain a spatial drawing from WRA showing the watershed/catchment and description of the catchment	WRA
5.	Obtain information from Mines and Geology about underground water quality in study area	Consultant
6.	Finalise the Description of the Water Supply System based on all information provided	Consultant
	CATCHMENT & INTAKE – Obtain information on the potential points of contamination of raw water at the catchment and prior to the intake (Hazard Analysis of Critical Control Points)	
7.	Obtain data on the following pollutants: • sedimentation causing turbidity • Sewage & excreta	NWC

	ACTIVITY	ORGANISATION RESPONSIBLE
	• Solid waste	
8.	Obtain data on the impact of the bauxite alumina and agro industries on the Rio Cobre (prior to intake) and underground water resources	WRA
9.	Obtain data on the impact of the point sources/effluent discharges from bauxite alumina, sewage treatment facilities and agro industries on the Rio Cobre (prior to intake) and underground water resources Obtain information on non-point sources	NEPA
10.	Invite PCA to be a member of the Task Force Invite RADA to be a co-opted member of the Task Force	MOH
11.	Obtain information from PCA on the types of pesticides and herbicides used by agro industries in the watershed	PCA
12.	Obtain information on the impacts from hospital sewerage systems on the Rio Cobre and underground water resources	MOH
13.	Obtain information from UWI Chemistry Department (Professor Kahwa and Professor Dasgupta) on Studies that may have been conducted on chemical and pesticide discharges to the Rio Cobre	Consultant
14.	Obtain information on the business activities along the Rio Cobre	St. Catherine Parish Council
15.	Obtain information from NIC (Spanish Town Office) about any sources of contamination that they know about	Public Health, St. Catherine
16.	Obtain information from NSWMA on any illegal dumpsites that may impact on the Rio Cobre and from Mines and Geology on sand mining activities	Consultant
17.	Compile data received • Conduct **Hazard Analysis and Risk Characterization** • Determine **Critical Control Points**	Consultant
18.	Present data to Task Force – Discuss proposed actions for aspects of the system that are not under control	Consultant
19.	Finalise documentation for this section of the WSP	Consultant
	TREATMENT AT PLANT AND WELLS - Obtain information on the potential points of contamination of water supply during treatment (Hazard Analysis and Risk Characterization)	
20.	Obtain information on the following pertaining to the NWC water treatment plant: • Intake quality fluctuations & uncertainties re pollutants • Security • Treatment process • Staff qualifications • Storage • Power supply (reliability and backup supply) • Design constraints • Supply of chemicals for treatment	NWC

	ACTIVITY	ORGANISATION RESPONSIBLE
	• Activities within the vicinity of the treatment plant that could contaminate open storage tanks	
21.	Obtain information on the following pertaining to the NWC Wells: • Challenges associated with disinfection • Power supply (reliability and backup supply) • Water Quality fluctuations & uncertainties re pollutants • Supply of chemicals for disinfection	NWC
	STORAGE & DISTRIBUTION - Obtain information on the potential points of contamination of water supply during storage and distribution (Hazard Analysis and Risk Characterization)	
22.	Obtain information on: • the design of the distribution network (including dead-ends and pipeline materials) • maintenance of the storage and distribution infrastructure • the current integrity of the storage and distribution infrastructure	NWC
	OTHER - Obtain other information on the potential points of contamination of water supply (Hazard Analysis and Risk Characterization)	
23.	Check if building code has any provision for non-return valves on household connections to prevent "back siphonage"	St. Catherine Parish Council
24.	Obtain information on hazardous chemicals used for fishing in the Rio Cobre	NWC
25.	Check to see if colour coding of PVC pipelines is in place in other jurisdictions to ensure that pipes of the correct specifications are used and to prevent mistakes when connecting pipelines	NWC
26.	Obtain information about sewer pipes and proximity to water pipes, possible contamination.	NWC
27.	Compile data received • Conduct **Hazard Analysis and Risk Characterization** • Determine **Critical Control Points**	Consultant
28.	Present data to Task Force – Discuss proposed actions for aspects of the system that are not under control	Consultant
29.	Finalise documentation for these sections of the WSP	Consultant
	WATER SAFETY ACTION PLAN	
30.	Develop Action Plan based on Critical Control Points to address weak areas in water supply system in a meeting with Task Force	Consultant
	WATER SAFETY PLAN	
31.	Prepare Draft Water Safety Plan & submit to Task Force for their review	Consultant
32.	Task Force meeting to Review WSP	Task Force & Consultant
33.	Stakeholder Presentation – Draft Water Safety Plan	Stakeholders
34.	Finalise WSP and submit to Task Force	Consultant

	ACTIVITY	ORGANISATION RESPONSIBLE
35.	Present Final WSP to Task Force	Consultant
	HEALTH IMPACT EVALUATION	
36.	Obtain background diarrhoeal disease data – hospitals and public clinics, private clinics, community nurse aides	Surveillance unit, Kingston St. Catherine Parish Health Centre
37.	Conduct health and water use practices survey	Survey organization to be identified
38.	Match survey data to water distribution/source maps	
39.	Determine health impact feasibility and appropriate follow up	

APPENDIX 3 – SPANISH TOWN POPULATION DATA FOR 1991 & 2001

Communities	1991	2001
Caymanas Estate/Christian Pen	3446	
Gregory Park	1908	
Meadowvale	2907	
Waterford	17288	
Portsmouth	4998	
Passagefort	6133	
Independence City	5688	
Portmore Gardens/Cumberland	9117	
Westchester	4481	
Garveymeade	2676	
Westmeade	1539	
Westport/Bridgeview	1500	
Edgewater	4149	
West Bay	481	
Port Henderson/Fort Augusta	934	
Bridgeport	6045	
Southboro	4257	
Braeton	6925	
Marine Park	993	
Old Braeton	3466	
Naggo Head	1928	
Newlands	2927	
Bernard Lodge	1853	2291
Jones Pen	1904	1893
Twickenham Park	2266	4522
Central Village	7620	8832
Dovecot District	1714	1669
Leiba Gardens	1093	2768[7]
Cromarty/Windsor Park	1155	1724
Fairview/Ebony/Friendship	5176	7964
Frazers Content	1566	1819
Green Acres	1221	1943
St. Johns Heights	578	1309
Bellevue	870	1063

[7] Includes population of Hopedale

Communities	1991	2001
Keystone	1396	2417
St. Jago Heights	625	597
Tryall Heights	1318	1788
Tredegar Park	1286	2115
Thompson Pen	1448	1633
Greendale	2448	2626
Lauriston	2023	3170
Strathmore Gardens	601	981
Angels /Avon Park	3633	3726
Angels Estate		1452
Eltham Park	4492	5190
Gordon Pen/Leigh Farm	3019	4806
Golden Acres	1528	1449
Winters Pen	1952	1995
Irish Pen	1572	1975
Westmore Gardens/Sunnyside Villa	4709	5111
Eltham View	1185	3958
Ensom City	4912	4813
Highfield	1735	1575
Hampton Green	1277	1831
Spanish Town Central	17324	12738
Tawes Pen		1822
Newton Park	766	901
Dela-Vega City	2965	
Homestead Park	1565	1200
Homestead	5070	5775
Willowdene Estate	2863	1618
Willowdene		1645
Hopedale	790	(included in Leiba Gardens)
Sydenham	2035	3266
Horizon Park	2344	2353
Beggars Bush	887	1121
Corletts Pen/March Pen/Duncans Pen	5595	5574
TOTAL based on 1991 boundaries	**204,165.00**	
TOTAL based on 2001 boundaries	**110,379.00**	**129,018.00**

APPENDIX 4 – STATUS OF WATER SOURCES FOR SPANISH TOWN WATER SUPPLY SYSTEM, JANUARY 2007

LOCATION OR SOURCE	STATUS
Central/Village/White Marl	• Surface pump motor • Site untidy; building housing the chlorine equipment in disrepair and is not secure due to vandalism • Fence in disrepair; site not secure • Illegal connections to incoming raw water line from well • Bordered by informal settlements without water supply or sewage disposal • Difficulty experienced removing illegal connections • Informal settlements supplied with treated water via a trunk distribution main to which they make their own connections • Nitrates are high in the groundwater due to the informal sewage disposal system in the hills surrounding communities
Twickenham	• Submersible well • Building housing the chlorine equipment in disrepair and is not secure due to vandalism • Plant has been vandalized in the past to make bleach • Water pumped straight to distribution mains • On occasion water is pumped to waste to improve water quality
Yang's	• Building housing the chlorine equipment in disrepair and is not secure due to vandalism
Friendship	• Deep well • Building housing the chlorine equipment in disrepair and is not secure due to vandalism • Surrounded by informal settlements without sewerage systems
Browns	•
Bybrook 1 & 2	• Provides additional water to Spanish Town when the high turbidity in the Rio Cobre causes the plant to shut down • There is no perimeter fence • No door on the control room • Repair required for the 1 ton cradle
Tulloch Spring	• Provides additional water to Spanish Town when the high turbidity in the Rio Cobre causes the plant to shut down • Some parts of the plant (Control Room, chlorine room & bathroom) were damaged during hurricane Ivan which have not be repaired to date
Headworks Wells E, H, W, G	• Provides additional water to Spanish Town when the high turbidity in the Rio Cobre causes the plant to shut down • These wells are managed by the Kingston Office
Wells - General	• Theft of chlorine tanks to make bleach
Spanish Town Treatment Plant	• Design capacity 3.5 migd; 2.5-2.8 migd actual production • Turbidity of incoming water affects the ability of the plant to treat up

LOCATION OR SOURCE	STATUS
	to its maximum capacity • Algal blooms (due to high nutrient loading) occur in the Rio Cobre upstream of intake on occasions • No backup power supply for the plant; electricity supply unreliable with surges and outages experienced • Chlorinator is linked to the pump so if the pump does not work there is no chlorination; system set up so that chlorinator starts before pump distributing water
General	• Unauthorised trucks, sometimes un-sanitised, selling water to some communities

APPENDIX 5 – Hazards and Control Measures Associated with Spanish Town Water Supply System

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
	CATCHMENT & INTAKE - RIVER									
1.	Agro-industrial effluent	(1) Licence agro-industrial effluent discharged in watershed above intake & ensure compliance with licence requirements	3	(1) NEPA	(1) 2008	(1) Task Force will check on status in June 2008				Trade effluent licences
2.		(2) Upgrade WTP to effectively treat high nutrient levels		(2) NWC	(2) 4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
3.		(3) Monitor river for algal blooms		(3) NWC		(3) NWC Lab Technicians visually inspects river between flat bridge & dam based on seasons for algal bloom	(3) Algal blooms observed	(3) NWC T/P Operator to check for taste and odour problems at the plant Treat according to SOP with activated carbon if detected	Taste & Odour tests done by panel in accordance with standard method Panel consist of – Water Production Team	Lab Technician Daily log Results of Taste and Odour tests

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
								and/or increase Cl_2 dosage at pre-chlorination stage	Leader, Production Manager, Zone Team Leader, Field Operations Manager	
4.	Bauxite/ alumina plant effluent	(1) Licence bauxite/alumina plant effluent discharged in watershed & ensure compliance with licence requirements	3	(1) NEPA	(1) 2008	(1) Central Health Committee, Water Quality Subcommittee will check on status in June 2008				Trade effluent licences
5.		(2) Review, revise and update early warning system		(2) NEPA/JBI/ WRA/Bauxite Plant	January 2008	Central Health Committee, Water Quality Subcommittee will assess in March 2008			Desk top drill	Revised Early Warning System Records of drill and recommendations for improvement (if necessary)
6.		(3) Establish and activate early warning system to notify NWC & NIC of any spill to the Rio Cobre		(3) NEPA/JBI/ WRA/ Bauxite Plant	Ongoing	WRA, NEPA conduct regular monitoring of the watershed and bauxite alumina industries NWC Lab technicians conduct visual monitoring of river	Spill to Rio Cobre upstream of dam	Activate early warning system to notify NWC NWC T/P Operators closes intake works to plant and NWC Lab assesses water quality	NWC Lab analyses of raw water samples to assess water quality in accordance with standard test procedures using equipment	Spill and/or accident report from offending person/entity submitted to NEPA NWC T/P Operators Daily Log Lab analyses

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
									calibrated to the required standard until water quality is satisfactory to allow reopening of treatment plant intake works	Calibration records
7.	Informal solid waste dump	NSWMA to close dump &	4	NSWMA[8]	January 2008	Central Health Committee, Water Quality Subcommittee will assess in January 2008				
8.		Prohibit further dumping			Ongoing	NSWMA Inspectors to monitor area weekly	Solid waste dumped	Clean up area Investigate to determine source of problem	Update provided to Central Health Committee, Water Quality Subcommitt ee quarterly	NSWMA Inspectors monthly reports
9.		Treatment plant screen at raw water intake		NWC	Ongoing	NWC operator visually inspects the intake screen every shift	Reduced raw water inflow (low water level in sedimentatio n basin; settling tank	NWC Waterman cleans screens If there is significant debris in the canal the plant	NWC T/P Operator checks that canal is clean	NWC T/P Operators Daily log

[8] NSWMA – National Solid Waste Management Authority

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
							booster pump trips, level sensor trips distribution pumps)	is shut down until canal is cleaned		
10.	Dumping of solid waste into rivers due to infrequent or non-existent garbage collection in watershed	(1) Work with communities to develop alternative programmes for waste management Collect waste in those communities that can receive collection	3	(1) NSWMA	March 2008	Central Health Committee, Water Quality Subcommittee to check on status June 2008				
11.		(2) Treatment plant screen at raw water intake		(2) NWC	Ongoing	NWC operator visually inspects the intake screen every shift	Reduced raw water inflow (low water level in sedimentation basin; settling tank booster pump trips, level sensor trips distribution pumps)	Waterman cleans screens If there is significant debris in the canal the plant is shut down until canal is cleaned	NWC T/P Operator checks that canal is clean	NWC T/P Operators Daily log
12.		(3) Upgraded WTP to effectively treat water with solid waste		(3) NWC	4th Q 2008	(3) Water Quality Inspector (Health Department) checks on	Ineffective water treatment	Water Quality Inspector reports problems to Water	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		contamination				treatment plant operations at least once per month		Production Manager at NWC who ensures that deficiencies are addressed		deficiencies MOH annual audit findings
13.		(3) Maintain buffer zone around canal		(4) Parish Council	Ongoing	Central Health Committee, Water Quality Subcommittee to assess in March 2008				
14.	Informal residential settlements along canal prior to intake without sewage treatment & disposal systems	(1) Implement an education campaign about sanitation, provide infrastructure to prevent waste from reaching the canal Relocate settlements where possible	1	(1) & (2) **Health Dpt./MOH,** Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	(1) start no later than March 2008 -	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				
15.		(2) Maintain buffer zone around canal		(1) & (2) **Health Dpt./MOH,** Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
16.		(3) Upgraded WTP to effectively treat water with contaminants		(3) NWC	4th Q 2008	(3) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
17.		(4) Requests for new connections are screened to ensure that NWC does not provide connections to informal settlers		(4) NWC	Ongoing	Senior Customer Relations Manager assesses applications	Zero water supply connections to informal settlements	Disconnect supply	NWC Internal Audit	Audit report
18.	Informal commercial activities e.g. car washes, cook shops, garages, along canal prior to intake without wastewater treatment/disposal systems	(1) Implement an education campaign about sanitation, provide infrastructure to prevent waste from reaching the canal	1	(1) **Health Dpt./MOH,** Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	(2) start no later than March 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				
19.		(2) Maintain buffer zone around canal		(2) **Health Dpt./MOH,** Parish Council, Squatter Mgt. Unit, Min. of Housing & NIC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
20.		(3) Upgraded WTP to effectively treat water with contaminants		(3) NWC	(3) 4th Q 2008	(3) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
21.		(4) Requests for new connections are screened to ensure that NWC does not provide connections to informal settlers		(4) NWC	Ongoing	Senior Customer Relations Manager assesses applications	Zero water supply connections to informal settlements	Disconnect supply	NWC Internal Audit	Audit report
22.	All waste (agro industrial and industrial effluents and solid waste)	Implement measures to support Watershed Management Policy	3	NEPA	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status at March 2008				
23.	Disposal of effluent into rivers by Cesspool emptiers	(1)Promulgate regulations for Cesspool servicing companies Institute manifest system to track movement of waste Prosecute operators involved in this	3	(1) Ministry of Health, Parish Council,	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status at December 2008				Legislation

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		activity								
24.		(2) Upgraded WTP to effectively treat water with contaminants		(2) NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
25.		(3) Chlorinate raw water		(3) NWC	Ongoing	NWC T/P operator monitors Cl_2 residual levels hourly at the plant; Water quality samplers visually observe river between flat bridge and dam for algal blooms;	Residual Cl_2<2mg/l after pre-chlorination Algal blooms observed	NWC T/P Operator troubleshoots pre Cl_2 equipment at plant, increase dose if equipment okay, if Cl_2 is low after post Cl_2, increase dose & observe for 2 hours, no improvement shut down plant	Properly cleaned chlorine comparators Water Production Team Leader checks records every week, random observation of operations Check comparator against (internationa l) standard	Hourly logs of residual chlorine levels (distribution line) Non-conformances and corrective actions Calibration records Log of chlorine feed rates Records of Team Leader audits

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
									solution (traceable to France)	
26.	Pesticide residues in storm water run-off from farming activities within the watershed	(1) Continue to regulate the types of pesticides used and provide training to farmers in the use of pesticides and the disposal of pesticide waste	3	(1) PCA & RADA	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status annually				
27.		(2) Upgraded WTP to effectively treat water with contaminants		(2) NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
28.		(3) Check pesticide levels in raw water upstream of dam		(3) NWC	Twice per year	NWC Lab monitors in accordance with standard procedures	WHO Guidelines	Notify PCA of findings. If required PCA to identify source and address problem	Test Equipment calibrated as required	Results of tests for pesticides Calibration records for test equipment

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
29.	High sediments in storm water run-off from clear cutting of land associated with farming and other construction activities and sand mining within the watershed	(1) Institute regulatory measures to (a) prohibit illegal mining and (b) to manage licensed sand mining in the Rio Cobre and its tributaries e.g. using sediment traps	3	(1) Parish Council, Commissioner of Mines		Central Health Committee, Water Quality Subcommittee will assess status at December 2008				
30.		(2) Upgraded WTP to effectively treat high turbidity water e.g. using coagulant capable of treating turbidity levels up to 150 NTU		(2) NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
31.	Sewage effluent from (approved) systems which utilise on-site absorption pits	(1) Ensure set-back distances from the river are enforced	4	(1) Parish Council	Ongoing	Central Health Committee, Water Quality Subcommittee to assess status in March 2008				
32.		(2) Upgraded WTP to effectively treat water with contaminants		(2) NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
								deficiencies are addressed		
33.	Security risk - Canal conveying raw water vulnerable to unscrupulous actions which can contaminate water quality	Low risk hazard – no specific strategies to address it as yet	3							
34.	Pre-chlorination of raw water with elevated organics forming carcinogenic by-products	Test treated water in the distribution system to determine the by-products formed and conduct a local risk assessment of the health implications of using chlorine for disinfection of drinking water	2	NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee to assess status in December 2008				
35.	Low river flows during drought	Even in drought conditions when river is low, canal level remains constant; there are no water restrictions at this plant due to low flows	3							
	CATCHMENT & INTAKE - WELL									

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
36.	Sewage effluent, particularly nitrates, from (approved) systems which utilise on-site absorption pits	(1) Continue to monitor well water quality so that appropriate measures can be taken when nitrates exceed the threshold value;	3	(1) NWC	Ongoing	Public Health Inspector conducts on-site inspections within the watershed at least once per year NWC Lab tests for nitrates once per month	Nitrates > 45 mg/l as NO_3	Microbiological monitoring and observation of trends by NWC and MOH NWC shuts down well when nitrates approach/exceed critical limit	Test equipment calibrated according to requirements	Monitoring results for nitrates and bacteria Calibration records Public Health Inspector's Annual Report on Watershed
37.		(2) Upgraded wells under KMA Water Supply Project will improve Cl_2 contact time		(2) NWC	4^{th} Q 2008	(2) Water Quality Inspector (Health Department) checks on wells at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
38.		(3) Where possible provide alternative on-site sewage treatment facilities which utilise effective treatment methods other that soil		(3) Parish Council, MOH &WRA	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				
39.	Informal residential settlements without sewage	(1) Continue to chlorinate water	3	(1) NWC	Ongoing	Public Health Inspector conducts on-site inspections	Nitrates > 45 mg/l as NO_3	Microbiological monitoring and observation of	Test equipment calibrated according to	Monitoring results for nitrates and bacteria

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
	treatment & disposal systems up gradient of ground water resources					within the watershed at least once per year NWC Lab tests for nitrates once per month		trends by NWC and MOH NWC shuts down well when nitrates approach/exceed critical limit	requirements	Calibration records Public Health Inspector's Annual Report on Watershed
40.		(2) where possible provide alternative on-site sewage treatment facilities which utilise effective treatment methods other that soil		(2) Parish Council	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				
41.	Sewage effluent for formal or informal sources	Chlorinate water	3	NWC	Ongoing	NWC T/P operator monitors Cl2 residual levels hourly at the plant; Water quality samplers visually observe river between flat bridge and dam for algal blooms;	Residual Cl2<2mg/l after pre-chlorination Algal blooms observed	NWC T/P Operator troubleshoots pre Cl2 equipment at plant, increase dose if equipment okay, if Cl2 is low after post Cl2, increase dose & observe for 2 hours, no improvement shut down plant	Properly cleaned chlorine comparators Water Production Team Leader checks records every week, random observation of operations Check comparator	Hourly logs of residual chlorine levels (distribution line) Non-conformances and corrective actions Calibration records Log of chlorine feed rates Records of Team Leader audits

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
									against (internationa l) standard solution (traceable to France)	
42.	**TREATMENT - SURFACE WATER**									
43.	High turbidity of raw water causing silt to accumulate in reservoir limiting the quantity of water treated and reducing the treated water quality	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project; new equipment and additional chemicals to enable treatment of water with turbidity > 20 NTU up to 150 NTU	3	NWC	4th Q 2008	(3) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
44.		Flocculation & sedimentation		NWC	Ongoing	Operator Guided by Standard Operating Procedures (SOPs) Operator doses within recommended range Operator checks every other hour	Dosed at 15 mg/L - 50 mg/L Turbidity at Clearwell <1NTU MOH Turbidity </=5NTU	Operator conducts a number of system checks - Intake turbidity, clearwell turbidity & water level, alum feed rate from previous shift	Calibrate turbidity meter in standard suspension Water Production Team Leader checks records every week,	Logs of alum feed rates Logs of turbidity reading Non-conformances and corrective actions Calibration records

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
								Shut off booster pump and backwash filter(s) Manually adjust Alum feed rate or water inflow rate	random observation of operations, annual audits	Records of Team Leader audits
45.	No back up power supply	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project, standby generator proposed	3	NWC	4th Q 2008	Maintenance Team Leader conducts regular PM checks on installed generator	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed Regulate water flows to communities as required	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
46.	Uncertain raw water quality due to wide range of possible contaminants (pesticides, industrial effluents etc.)	Early warning system	3	NWC	Ongoing	WRA, NEPA conduct regular monitoring of the watershed and bauxite alumina industries NWC Lab technicians conduct visual monitoring of river	Spill to Rio Cobre upstream of dam	Activate early warning system to notify NWC NWC T/P Operators closes intake works to plant and NWC Lab assesses water quality	NWC Lab analyses of raw water samples to assess water quality in accordance with standard test procedures using equipment	Spill and/or accident report from offending person/entity submitted to NEPA NWC T/P Operators Daily Log Lab analyses

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
									calibrated to the required standard until water quality is satisfactory to allow reopening of treatment plant intake works	Calibration records
47.	Under dosing of chlorine	New chlorination system designed for upgraded WTP;	2	NWC	4th Q 2008	(3) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC deficiencies who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
48.		Monitor residual chlorine throughout treatment process		NWC	Ongoing	NWC T/P operator monitors Cl_2 residual levels hourly at the plant; Water quality samplers visually observe river between flat bridge and dam for algal blooms;	Residual Cl_2<2mg/l after pre-chlorination Algal blooms observed	NWC T/P Operator troubleshoots pre Cl_2 equipment at plant, increase dose if equipment okay, if Cl_2 is low after post Cl_2, increase dose & observe for 2	Properly cleaned chlorine comparators Water Production Team Leader checks records every week, random	Hourly logs of residual chlorine levels (distribution line) Non-conformances and corrective actions Calibration records

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
								hours, no improvement shut down plant	observation of operations Check comparator against (internationa l) standard solution (traceable to France)	Log of chlorine feed rates Records of Team Leader audits
49.	Over dosing of chlorine	Monitor residual chlorine throughout treatment process	4	NWC	Ongoing	NWC T/P operator monitors Cl_2 residual levels hourly at the plant; Water quality samplers visually observe river between flat bridge and dam for algal blooms;	Residual Cl_2<2mg/l after pre-chlorination Algal blooms observed	NWC T/P Operator troubleshoots pre Cl_2 equipment at plant, increase dose if equipment okay, if Cl_2 is low after post Cl_2, increase dose & observe for 2 hours, no improvement shut down plant	Properly cleaned chlorine comparators Water Production Team Leader checks records every week, random observation of operations Check comparator against (internationa l) standard solution (traceable to France)	Hourly logs of residual chlorine levels (distribution line) Non-conformances and corrective actions Calibration records Log of chlorine feed rates Records of Team Leader audits

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
50.	Ineffective flocculation due to design limitations such as infrastructure and pH control	New coagulation and flocculation system designed for upgraded WTP	3	NWC	4th Q 2008	(3) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC deficiencies who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
51.		Monitor turbidity throughout treatment process		NWC	Ongoing	Operator Guided by Standard Operating Procedures (SOPs) Operator doses within recommended range Operator checks every other hour	Dosed at 15 mg/L - 50 mg/L Turbidity at Clearwell <1NTU MOH Turbidity </=5NTU	Operator conducts a number of system checks - Intake turbidity, clearwell turbidity & water level, alum feed rate from previous shift Shut off booster pump and backwash filter(s) Manually adjust Alum feed rate or water inflow rate	Calibrate turbidity meter in standard suspension Water Production Team Leader checks records every week, random observation of operations, annual audits	Logs of alum feed rates Logs of turbidity reading Non-conformances and corrective actions Calibration records Records of Team Leader audits

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
52.	Ineffective filtration and backwashing due to age of system and design limitations	Filtration and backwash system to be upgraded under the KMA Water Supply Project; install loss of head gauge to indicate when filters need to be backwashed	3	NWC	4th Q 2008	(3) Water Quality Inspector (Health Department) checks on treatment plant operations at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC deficiencies who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
53.		Monitor turbidity throughout treatment process		NWC MOH	Ongoing	Operator Guided by Standard Operating Procedures (SOPs) Operator doses within recommended range Operator checks every other hour	Dosed at 15 mg/L - 50 mg/L Turbidity at Clearwell <1NTU MOH Turbidity </=5NTU	Operator conducts a number of system checks - Intake turbidity, clearwell turbidity & water level, alum feed rate from previous shift Shut off booster pump and backwash filter(s) Manually adjust Alum feed rate or water inflow rate	Calibrate turbidity meter in standard suspension Water Production Team Leader checks records every week, random observation of operations, annual audits	Logs of alum feed rates Logs of turbidity reading Non-conformances and corrective actions Calibration records Records of Team Leader audits

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
54.	Check valves on distribution pumps- absent or ineffective	Replace ineffective check valves and install missing check valves; have sufficient uniformity within system so that large variety of different types of valves do not have to be kept in inventory;	4	NWC	Ongoing	Water Production Manager checks each month	Reverse flows	Valve crew called to address problem	Water Production Team Leader checks	Field Operators Logs
55.	Booster Pump (to filters) failure	Ensure that spare is available; have sufficient uniformity within system so that large variety of different types of pumps do not have to be kept in inventory	3	NWC	Ongoing	Maintenance Team Leader does Preventative Maintenance checks at least twice per month				Maintenance records
	TREATMENT - WELLS									
56.	No chlorination due to theft of chlorine cylinders	New chlorine handling procedures since January 2007; security guards on site at large installations, installation of grills & doors, operators to visit site at least 2 times per shift, tracking system	1	NWC	Ongoing	Water Production Manager tracks movement of cylinders weekly	Missing chlorine cylinder	Shut down well, replace missing cylinder immediately; Notify NWC Security Manager		Tracking logs; investigation reports

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		in place for movement & location of cylinders; Community awareness programme								
57.	Under dosing of chlorine	New chlorination system designed for wells	2	NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on wells at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC deficiencies who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
58.		Monitor residual chlorine in distribution line leaving the well station	3	NWC	Ongoing	Field operator monitors Cl_2 residual levels at least once per shift	Residual Cl_2<2mg/l after pre-chlorination	Field Operator troubleshoots Cl_2 equipment at well, increase dose if equipment okay & observe for 2 hours, no improvement shut down well	Properly cleaned chlorine comparators Water Production Team Leader checks records every week, random observation of operations	Field operator logs of residual chlorine levels (distribution line) Non-conformances and corrective actions Calibration records Log of chlorine feed rates

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
									Check comparator against (internationa l) standard solution (traceable to France)	Records of Team Leader audits
59.	Over dosing of chlorine	Monitor residual chlorine in distribution line leaving the well station	4	NWC	Ongoing	Field operator monitors Cl_2 residual levels at least once per shift	Residual Cl_2<2mg/l after pre-chlorination	Field Operator troubleshoots Cl_2 equipment at well, increase dose if equipment okay & observe for 2 hours, no improvement shut down well	Properly cleaned chlorine comparators Water Production Team Leader checks records every week, random observation of operations Check comparator against (internationa l) standard solution (traceable to France)	Field operator logs of residual chlorine levels (distribution line) Non-conformances and corrective actions Calibration records Log of chlorine feed rates Records of Team Leader audits

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
60.	Tampering due to unrestricted access & illegal connections to raw and treated water pipes at well facilities	Repair and install fences, install doors & windows; relocate sample taps to prevent easy access to prevent illegal tapping into line; utilise non-conventional sample taps rather than traditional taps; institute neighbourhood watch programmes to protect the facilities	3	NWC	4th Q 2008	Mobile operator checks twice per shift and reports breaches to Water Production Manager	Breaches in infrastructur e	Repair defects		Mobile operator reports
61.	No back up power supply	Install standby generators with appropriate housing for those well installations that supply essential services e.g. hospitals and ensure that there is sufficient interconnectivity between distribution zones; truck water as required	3	NWC	2007-2008	Mobile operator checks twice per shift and reports to Water Production Manager when standby power is in use	No electrical power	If standby generator is not functioning during power failure the Mobile Operator notifies the Water Production Manager and arrangements are made to get a mobile unit to location, otherwise		Mobile operator reports

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
								restrict/regulate water supply to affected area until power returns		
62.	Non standard system design and components causes delays in addressing maintenance issues as it is not cost effective to stock wide variety of large costly spare parts	Standardise system components when designing and/or repairing aspects of the system to facilitate greater flexibility in the system and develop a mechanism in donor negotiations to support standardisation as a priority	3	NWC	Ongoing					
63.	Ineffective and inefficient disinfection due to the absence of chlorine contact chambers	To be constructed under the KMA Water Supply project	2	NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on wells at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC deficiencies who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
	STORAGE - TREATMENT PLANT									
64.	Insufficient reservoir storage to meet peak demand	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by installing new clear water reservoirs;	2	NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
65.	Non removal of silt from sedimentation basin in a timely manner due to design limitations	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by redesigning sedimentation basin;	3	NWC	4th Q 2008	(2) Water Quality Inspector (Health Department) checks on treatment plant at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings
66.		Ensure good operational & maintenance practices		NWC	Ongoing	(2) Water Quality Inspector (Health Department) checks on treatment plant at least once per month	Ineffective water treatment	Water Quality Inspector reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of T/P operations by MOH	Water Quality Inspector report Letter(s) to NWC regarding deficiencies MOH annual audit findings

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
	DISTRIBU-TION SYSTEM									
67.	Limited use of existing distribution storage tanks and an inability to provide consumers with minimum of 6 hours water in case of plant shut down	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by installing new distribution storage tanks	2	NWC	Ongoing	(2) Field Operator monitors distribution system	Ineffective water distribution	Field Operations personnel reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of distribution system by MOH Office of Utilities Regulation (OUR) determines if Quality of Service Standards (QSS) are met	Field operator's report Letter(s) to NWC regarding deficiencies MOH annual audit findings OUR findings
68.		Ensure good operational practices to utilise distribution storage when installed		NWC	Ongoing	Field Operator monitors distribution system	Ineffective water distribution	Field Operations personnel reports problems to Water Production Manager at NWC who ensures that deficiencies are addressed	Annual audit of distribution system by MOH Office of Utilities Regulation (OUR) determines if Quality of Service Standards (QSS) are met	Field operator's report Letter(s) to NWC regarding deficiencies MOH annual audit findings OUR findings
69.	Illegal connections to distribution system	(1) Reduce pressure on distribution system supplying	2	(1) NWC	Ongoing	Field Operator monitors distribution system	Illegal connection	Field Operator reports illegal connection to Water		Field operator's report

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
	contributing to the high % of unaccounted for water	"Red Areas"; community outreach programmes;						production Team Leader and Non-revenue Water (NRW) Department		
70.		(2) Enforce the law		(2) Parish Council & NWC	Ongoing					
71.	Unmetered water supply (social water such as standpipes) and malfunctioning meters contributing to the high % of unaccounted for water	(1) Rationalise Government policy re social water;	2	(1) Ministry of Water; NEPA, Ministry of Health, NWC	March 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				
72.		(2) Ensure that existing meters are functional and meter unmetered customers		(2) NWC	Ongoing	Field operations personnel/ meter readers to report on non-functional or missing meters		Estimate water consumption		Records of metered customers versus unmetered customers
73.	Leaks on trunk main and distribution system, old pipes in some areas contributing to the high % of unaccounted for water	Continue unaccounted for water control programme including leak detection & repair, pressure zoning, flow control; ensure good operational network; KMA project will install new	2	NWC	Ongoing	NRW Coordinator – Eastern Identifies problems to be addressed by Field Operations Manager				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		distribution mains								
74.	Demand exceeding supply - inadequate supply coverage; unserved communities; new residential developments; no change in quantity of water supplied	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project by the installation of new distribution mains, more treated water storage and increased production at wells up to sustainable limits; coordination between development planners and water supply system operators; prerequisite for development approval to confirm the availability of water; promote demand side management	2	Ministry of Central Health Committee, Water Quality Subcommittee will assess status in June 2008; St. Catherine Parish Council, NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008		Restrict water supply as necessary to ensure that OUR QSS are not contravened	Compliance with OUR QSS	OUR Report

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		through policy and regulations								
75.	Low system pressure if one supply source is out of service	Will be addressed in the design of the upgraded water treatment plant under the KMA Water Supply Project; maximize interconnectivity on the distribution system, ensure good operational and maintenance protocols; secure valves and access points on distribution system,	2	NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				
76.		Install pressure gauges under KMA project		NWC	4th Q 2008	Central Health Committee, Water Quality Subcommittee will assess status in June 2008				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
77.	Some location of valves unknown due to absence of drawings and being carelessly covered during roadworks	(1) Coordination between NWC, NWA and Parish Council	3	(1) NWC, NWA and Parish Council	January 2008	Central Health Committee, Water Quality Subcommittee will assess status March 2008				
78.		(2) Librarian ensures that all documentation maintained (electronic & hard copy) Comprehensive GIS in place		(2) NWC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status June 2008				
79.	Destruction of distribution system components due to negligence of other utilities e.g. JPSCo., Cable & Wireless and Cable service providers	(1) Coordination between utilities, the Parish Council and NWC	3	NWC & Parish Council		Central Health Committee, Water Quality Subcommittee will assess status March 2008				
80.		(2) NWC maintains drawings		NWC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status June 2008				
81.	Damage to water pipelines and domestic plumbing infrastructure due to absence of	Approval by the NWC & Parish Council of pipeline system designed by Developer	3	NWC & Parish Council	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status June 2008		Prevent developer from commissioning pipeline		

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
	air relief valves									
82.	Non-sterilisation of new/repaired pipelines	NWC and Parish Council to provide MOH with report on sterilisation of new/repaired pipelines and if pipelines are constructed according to design	1	MOH	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status June 2008				
83.	Check valves household - absent or ineffective	Replace ineffective check valves and install missing check valves (KMA project to address to a limited extent); have sufficient uniformity within system so that large variety of different types of pumps do not have to be kept in inventory Develop and implement policy to install check valves on household connections.	2	NWC & Parish Council	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status June 2008				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
84.	Dead ends on distribution lines causing stagnation in the water line	Design dead ends with washout valves to enable flushing of the system Avoid dead end designs where possible Modify existing dead ends where possible Flushing programme where dead ends occur Develop water tank Installation Standards including the use of chlorine compatible check valves	4	NWC	Ongoing	Central Health Committee, Water Quality Subcommittee will assess status June 2008				
	SURVEIL-LANCE									
85.	Lack of a comprehensive water quality surveillance plan	Comprehensive water quality surveillance plan which addresses the rationale for the ratio of quantity of sampling versus population served,		MOH		Central Health Committee, Water Quality Subcommittee will assess status June 2008				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		frequency of sampling, integrity of samples, location of sampling points, frequency and scope of sanitary surveys reporting and coordination mechanism between the Parish Councils, NWC and the Ministry of Health								
86.	Outdated drinking water quality standards	Regular review of the IJAM criteria for drinking water quality with reference to WHO standards		MOH	2007-2008	Central Health Committee, Water Quality Subcommittee will assess status June 2008				
87.	Inefficient data management	Improve reporting format and data management by establishing environmental database by Jan 2008		MOH	January 2008	Central Health Committee, Water Quality Subcommittee will assess status June 2008				
88.	Laboratories conducting analyses of water quality parameters not accredited	Audit private labs – those that MOH approves can be used for conducting water quality analyses		MOH	2008-2009	Central Health Committee, Water Quality Subcommittee will assess status June 2008				

	Hazard event/source/ cause	Control Measures	Priority	Responsible Agency	Time Frame	Monitoring Procedures	Critical Limits	Deviation procedures	Verification	Records
		Eventually implement programme to only use labs accredited by a 3rd party								