DISASTER MITIGATION GUIDELINES FOR WATER SUPPLY AND SEWERAGE SYSTEMS IN THE Caribbean

1.0 INTRODUCTION AND OBJECTIVES

1.1 Introduction

- Problem Statement
- IDNDR, its targets and program framework
- The relationship between this document and the National Disaster Plan.

1.2 Objectives

1.2.1 To provide guidelines for the assessment of possible impact of hazards, identification of vulnerable components and to prioritize mitigation measures to be taken to correct the deficiencies in vulnerable components of existing water supply and sewerage systems.

1.2.2 To recommend economical measures that can be taken to reduce the vulnerability and impact of disasters on existing WS&S systems.

1.2.3 To provide guidelines for the design and construction of new water supply and sewerage systems components.

1.3 Target Group

- Managers and technical and administrative officers of water and sewerage utilities in the Commonwealth Caribbean.
- Decision and policy makers in the Caribbean.

2.0 POLICIES AND PLANNING

2.1 The Problem in Perspective

- Magnitude of losses, where, to whom.
- Changing approaches to management and in the magnitude of losses.
- Greater losses through changes in lifestyles, development of infrastructure
- Continuous vigilance and awareness necessary.

- Possible responses and attitude by Politicians, Technocrats etc.

2.2 Long Term and Comprehensive Planning.

- Relationship between the National land and Development Plans and Disaster Plans (control the development in areas which are prone to disasters, e.g. no water treatment plant in flood zone)

2.3 Comprehensive Disaster Plan

- Who does what and when.

2.3.1 Forecasting and warning systems and organizations.

2.3.2 Communications.

2.3.3 Setting up instruments, equipment, gauges for data collection.

2.3.4 Education and training.

2.3.5 Regular testing of systems.

2.4 Organization to Manage Program of Prevention and Mitigation.

2.4.1 Different national agencies each responsible for one aspect of the operation of the disaster plan.

2.4.2 One agency dealing with all aspects.

2.4.3 Responsibility shared with other unrelated functions in one agency.

2.4.4 Personnel requirement.

2.4.5 Public participation.

2.5 Types of Natural Phenomena

2.5.1 Summary of the more significant natural phenomena

2.5.2 Definitions of Terms

2.5.2.1 - hazards

2.5.2.2 - risks

2.5.2.3 - vulnerability

2.5.2.4 - disaster

2.5.2.5 - mitigation
- a. Preparedness
- b. Prevention

2.5.3 Earthquakes

2.5.3.1 definition and measurement

2.5.3.2 earthquake hazard

2.5.3.3 site risk

2.5.3.4 Caribbean experience

2.5.4 Volcanoes

2.5.4.1 Caribbean experience

2.5.4.2 site risks

2.5.5 Floods

2.5.5.1 rainfall

2.5.5.2 hurricanes

2.5.5.3 tsunamis

2.5.5.4 site risk

2.5.5.5 Caribbean experience

2.5.6 Hurricanes

2.5.6.1 definition (wind direction versus direction of path)

2.5.6.2 Classification

2.5.6.3 Site Risk

2.5.6.4 Caribbean experience

2.5.7 Landslides

2.5.7.1 site risk

2.5.7.2 Caribbean experience

3.0 ASSESSMENT OF HAZARDS

3.1. Hazard Vulnerability and Risk Assessment

- Brief description of vulnerability assessment methodology (source: Emergency Management of Environmental Health and Water Supply (PAHO, Slide Presentation, part 3, Vulnerability Analyses)

3.1.1 (define) disaster and characteristics

3.1.2 (define) physical system components and support services

3.1.3 (determine the) effect of design disaster on system

3.1.4 (estimate) required service demand

3.1.5 (determine) systems capability to meet demand

3.1.6 (determine) critical and vulnerable components

3.1.7 (anticipate) other types of disasters

3.1.8 (consolidate information into) final assessment

3.2 Inventory of water supply system components

- Source
  surface water: lake, dam, river intake, spring;
  groundwater: wells, infiltration galleries;
  rainwater catchment:
- Pumping station
- Transmission main
  river crossings, junction tanks
- Treatment plant
  - control, pumping and storage buildings
  - chemical application systems
  - coagulation and flocculation tanks
  - sedimentation tanks
  - roughing filter
  - rapid sand filter and slow sand filter
  - clear water reservoir
  - Storage reservoirs
  - Distribution system
  - mains, valves and service connections
- Head Office
- Support systems
  - power supply
  - communications

- transportation
- stocks inc chemicals
- fuel storage at site
- storage of chemical supplies relating to hazards to human health

3.3 Inventory of Sewerage System components

- Collection systems
- trunk sewers
- pumping stations
- treatment plant
- final disposal facilities (liquid and solid)

3.4 Matrices for potential damage to Water Supply Systems components

- Introduce matrix as method for analyses of disaster scenarios (hurricanes, flood frequencies, earthquake, fault location), relating to extent of expected damage to structures and components, using past experience, Stress the fact that a combination of scenarios are possible, e.g. hurricanes and floods, earthquakes and land slides, rains and landslides.

3.4.1 Damage matrix for water sources (see sample matrix)
3.4.2 Damage matrix for pumping stations
3.4.3 Damage matrix for transmission mains
3.4.4 Damage matrix for treatment plants
3.4.5 Damage matrix for storage reservoirs
3.4.6 Damage matrix for distribution system
3.4.7 Damage matrix for head quarters
3.4.8 Damage matrix for support systems

3.5 Potential damage to sewerage systems components

- similar to sample matrix 3.4.1

3.5.1 Damage matrix for collection system
3.5.2 Damage matrix for trunks
3.5.3 Damage matrix for pumping stations
3.5.4 Damage matrix for treatment plant
3.5.5 Damage matrix for final disposal

4.0 PRIORITIZATION OF VULNERABLE COMPONENTS

4.1 Vulnerability assessment process/methodology

- expand from ref 2. slide 3.27 reliability factors, CE, Qp/Qn and rehabiltation time, hrs.

slide 3.27:

$$CE = \frac{\text{Quantity produced}}{\text{Quantity necessary}} \quad \text{or} \quad CE = \text{Rehabilitation Time}$$

print of slide 3.28, slide 3.29, slide 3.30

Vulnerability analyses worksheet (slide 3.32):

Data from the Rapid damage and needs assessment forms are input into this table.

SYSTEM COMPONENT	EFFECTS OF SCENARIO D.1	PRODUCTION CAPACITY (Qp)	RELIABILITY FACTOR
SOURCE	Wall damage	100	0.56
PIPELINE	Partial power outage	80	0.44
STORAGE	superficial cracks	100	0.56
TREATMENT	no effect	200	1.10

TOTAL DEMAND IS Qn = 180 liters/second

Vulnerability analyses worksheet (slide 3.33):

SYSTEM COMPONENT	TIME REQUIRED TO REPAIR COMPONENTS
A	---------- 13 days ---------->
B	----- 6 days ----->
C	-------- 8 days ------->
D	-- 4 days -->
TOTAL TIME	---------- 15 days ---------->

Vulnerability analyses worksheet (slide 3.34):

COMPONENT	RELIABILITY FACTOR					CRITICAL COMPONENT	
	D.1	D.2	D.3	D.4	D.5	Average	Order
Source	0.67	0.30	3.35	0.80	0.25	0.47	4
Catchment	0.56	0.30	0.35	0.80	0.25	0.45	2
Pipeline	0.44	0.40	0.40	0.50	0.35	0.42	1
Treatment Plant	1.10	0.40	0.40	1.20	0.30	0.68	6
[illegible]orage	0.56	0.35	0.35	0.60	0.50	0.46	3
[illegible]on	0.28	0.50	0.60	0.50	0.50	0.48	5
Networks	1.56	1.60	2.00	1.60	0.80	1.55	7

Use slides plus text showing and explaining vulnerability assessment, the comparison of vulnerability of different components, relating to vulnerability of system, stressing that system is more that the sum of its components, major subsystem assessment matrices, summary matrix and prioritization of vulnerable components.

4.2 Suggestions for the level of mitigation.

4.2.1 Modify impact by the design and construction of protective works.

4.2.2 Modify susceptibility by shifting position of structures.

4.2.3 Modify loss burden by setting up warning system, Replacement Fund, Insurance.

4.2.4 Bear total loss - will require alternative method of supply and disposal.

4.3 Method of selection of choices

method of reaching final choice:

	comp 1	comp 2	comp3
factor			
cost benefit			
capital required			
persons served			
nstitutional cons.			
sum			

each factor has a max score of 10,

4.3.1 Cost benefit analysis of options.

4.3.2 Capital requirement and availability.

4.3.3 Political considerations.

4.3.4 Humanitarian considerations.

4.3.5 Institutional constraints.

5.0 ECONOMICAL MITIGATION MEASURES

5.1 Strengthening vulnerable components in Water Supply System

5.1.1 Mitigation matrix for water sources (see sample matrix)

5.1.2 Mitigation matrix for pumping stations

5.1.3 Mitigation matrix for transmission mains

5.1.4 Mitigation matrix for treatment plants

5.1.5 Mitigation matrix for storage reservoirs

5.1.6 Mitigation matrix for distribution system

5.1.7 Mitigation matrix for head office

5.1.8 Mitigation matrix for support systems

5.2 Strengthening vulnerable components of sewerage systems

5.2.1 Mitigation matrix for collection system (see similar water sources matrix

5.2.2 Mitigation matrix for trunks

5.2.3 Mitigation matrix for pumping stations

5.2.4 Mitigation matrix for treatment plant

5.2.5 Mitigation matrix for final disposal

6.0 EMERGENCY ACTION

6.1 Disaster preparedness plan

- plan from chapter #.# should be put in place;
- warnings should be taken seriously;

6.1.1 Warning period activities

- activate disaster preparedness plan and protect vulnerable components
- deal with priority components first

.2 Immediate post disaster activities

6.1.2.1 Rapid damage and needs assessment

6.1.2.2 Evaluation and prioritization of relief, transport and communications needs.

7.0 REHABILITATION AND RECONSTRUCTION

7.1 Evaluation.

- upgrade the assessment and preparedness plans with disaster experience.

7.2 Redesign on basis of experience.

- designers of new systems should be aware of lessons learned from inappropriate design from existing systems.

7.3 Construction and rehabilitation

- in light of local and similar experience elsewhere.

8.0 CASE STUDY OF CARIBBEAN COUNTRY (MONTSERRAT?) IN DISASTER MODE

iDENTIFICATION OF SOURCES OF INFORMATION

PAHO LIBRARY
CEHI LIBRARY (SMALL ISLAND WATER MANAGEMENT PROJECT)
CDB LIBRARY
REGIONAL WATER AUTHORITIES

Mr Hamilton St. George will further develop outline, Mr. McCabe will be available for comments on draft document and matrices, these drafts should also be sent to the regional water authorities for comments and inclusion of their specific systems.

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DAMAGE MATRIX	Earthquakes	Volcanoes	Hurricanes	Floods	Landslides
SOURCES (general)	change of aquifer, loss of source.				
water quality	increased turbidity	Increased turbidity, temp and toxins	Increased turbidity, organic matter	Increased turbidity, bacterial contamination	Increased turbidity.
Springs	change of aquifer, loss of source. disappearance of physical structure, cracked retaining box, wall or weir, dislocated pipe, blockage of filters by silt, debris.	change of aquifer, loss of source; physical damage by lava flow;	physical damage by windblown debris, blockage of screens	Undermining of structure, physical damage to weirs and pipes by floating debris, blockage of filters by silt, debris, etc.	Burrying of spring, physical damage to weirs, walls, pipielines
River intakes	Structural damage to weir, filter box, side or under cutting by water flow, dislocated or broken outlet pipe(s), valve controls dislocated or misaligned.	physical damage by lava flow and falling rocks, filling with rocks and ashes,	Physical damage by windblown and floating debris, blockage of screens, siltation and filling of reservoir	Undermining of structure; physical damage to weirs and pipes by floating debris; side scouring of banks, siltation;	redirection of river bed, flow alterations, burrying of intake, physical damage to walls, weirs, screens, pipes,
Dams and impoundments	Structural damage to weir, filter box, side or under cutting by water flow, dislocated or broken outlet pipe(s), valve controls dislocated or misaligned, overtopping by flood wave generated by earthquake.	physical damage by lava flow and falling rocks, filling with rocks and ashes,	Physical damage by windblown and floating debris, blockage of screens, siltation and filling of reservoir, overtopping,	Undermining of structure, physical damage to weirs and pipes by floating debris; side scouring of banks, siltation,	loss of impoundment volume, burrying of intake, physical damage to walls, weirs, screens, pipes,
Groundwater Well	Shearing of the casing, collaps of casing wall, loss of well.	physical damage by lava flow and falling rocks, collapse of cover by ashload.		Flooding of pump and motor, electrical equipment,	burrying of well, physical damage to pumps
Infiltration gallery	Physical damage to box\retaining structure, dislocation of outlet pipes.	physical damage by lava flow and falling rocks,	Physical damage by windblown and floating debris, clogging of roughing filters and screens,	Undermining of structure, physical damage by flooting debris to roughing filter and screens, side scoaring of banks, siltation,	burrying of gallery, physical damage
Artificial rain-water catchment	Physical damage to concrete structure, break up of slab, cracking of reservoir, dislocation of outlet pipes,	physical damage by lava flow and falling rocks.	Physical damage and blockage by windblown debris.	Undermining of structure, physical damage by flooting debris to wall weirs and pipes, side scoaring of banks, siltation,	Burrying, physical damage,

MITIGATION MATRIX	Earthquakes	Volcanoes	Hurricanes	Floods	Landslides
SOURCES (general)					
water quality					
Springs	contruct earthquake proof; use flexible joints;	decentralise sources	keep site clear of lose debris; cover collection box, channels with protective slabs;	deeper foundations;	
River intakes	construct earthquake proof; use sheet piling; extent wing walls; use flexible joints;	decentralise sources	install stop-logs upstreams; install intake and sediment tank several foot upstream of weir, and aside of the main channel (see fig. x);	sheet piling under foundation; provide stop-logs rock fill river banks; construct rubble masonry wall;	
Dams and impoundments	construct earthquake proof, use sheet piling; extent wing walls; use flexible joints; slooping banks below and above water line; provide parapet wall;	decentralise sources	provide access for silt removing equipment; install stop-log (boom); install airjet cleaner behind screens; provide parapet wall;	construct grout curtain; earth fill corners; provide stop-logs rock fill river banks; construct rubble masonry wall;	
Groundwater Well	increase strength of casing by adding liner if possible;	decentralise sources; know location of alternative well sites;		raise the pump house install exterior flood wall, dyke	
Infiltration Gallery	construct earthquake proof; flexible joints;	decentralise sources	install wood sheeting or Gabion baskets along the bank creating a sedimentation area;	Undermining of structure, physical damage by flooting debris to roughing filter and screens, side scoaring of banks, siltation,	
Artificial rainwater catchment	install water proof flexible expansion joints; use flexible copplings;	decentralise sources	Keep environs clean of loose debris; fencing and ditching perimeters;		