OECS – ENVIRONMENT & SUSTAINABLE DEVELOPMENT UNIT

TECHNICAL MANUAL FOR POST-DISASTER RAPID ENVIRONMENTAL ASSESSMENT

VOLUME 2

(FORMS, GUIDELINES & REFERENCE NOTES)

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PREFACE

This Manual has been prepared as a resource document for Environmental and Disaster Response Agencies in the member-territories of the Organization of Eastern Caribbean Countries (OECS), for use in Post-Disaster situations. The objectives are:

i. to assess environmental damage caused by an adverse event, and

ii. to aid in addressing environmental concerns during activities undertaken in response to that event.

With regard to the former, this manual is intended to provide the assessment team with meaningful information on damage to the natural environment, based on a standardized approach. With regard to the latter, the manual seeks to ensure that activities undertaken in response to an event do not themselves create environmental problems. The manual is intended for use in Disaster Preparedness, Response and Recovery. It is envisaged, however, that the Rebuilding Stage will be informed by the damage assessments and environmental protection measures undertaken during the response and recovery stages respectively, but that normal environmental and planning controls will be reverted to during the Rebuilding Stage.

This document is intended for use in situations of disasters due to natural and human phenomena, as well as situations where an event has caused some degree of damage but that damage may not be so extensive as to define the event as a "disaster". The focus of the manual is the natural environment. This focus was chosen in recognition of the fact that the disaster response agencies in the OECS already address impacts on the human environment when preparing their response and recovery plans, so there is no need for duplication. The content of this Manual has been guided by the results of a survey of current (2002) practices with regard to environmental considerations in disaster response in the OECS (see R-1.1 in the Reference Notes, in Volume 2).`

Volume 1 of this Manual consists of 6 chapters. The first chapter discusses the Disaster Management Cycle as it is presently applied in the OECS, introduces the concept of rapid environmental assessment (REA) and provides an overview on "Using this Manual". Chapters 2 and 3 are relevant to the Preparedness Stage of the Disaster Management Cycle. Chapter 2 provides information on mapping and describing important components of the environment in the OECS, while Chapter 3 lists hazards.

Chapters 4, 5, and 6 are relevant to the Response and Recovery Stages of the Disaster Management Cycle. Chapter 4 highlights operational procedures, while Chapter 5 presents a system for rapid assessment of damage caused by an adverse event. Finally, Chapter 6 lists steps which may be taken to minimize the possibility of environmental damage during response and recovery activities following an adverse event.

Volume 2 of this manual contains forms, guidelines and reference notes, each in a separate Part with its own table of contents. The first Part includes forms for describing environmental assets, summarizing risk factors, assessing damage to environmental assets and identifying appropriate environmental protection measures for different activities. The other two Parts (Guidelines and Reference Notes) are arranged so that each sub-section aligns to a chapter in Volume 1. A Glossary is included in both volumes of this manual.

GLOSSARY

This Glossary contains definitions of terms used in Volume 1 of the Technical Manual. Definitions were obtained from various sources which include references listed in Part III of Volume 2 of this Manual, and a Glossary of Environmental Terms prepared in 1997 for use by the OECS. Definitions for disaster management terms were obtained from Guidelines for Rapid Environmental Impact Assessment in Disasters prepared by the Benfield Greig Hazard Research Centre and CARE International and Field Reference Guide prepared by CDERA, OFDA and USAID. A few definitions were developed by Ecoengineering in the course of our work and in some cases, definitions have been adapted to make them specific to this Manual.

Abundance:

The number of individual specimens of an animal or plant.

Adverse Event:

An occurrence (natural or man-made) with potential to precipitate a disaster.

Aquifer:

An underground geological formation, or group of formations, containing usable amounts of groundwater that can supply wells and springs.

Barrier Reefs:

These are reefs which are found fairly far away from the shore, usually with a lagoon formed in between the reef and the shore.

Baseline Condition:

The condition of an ecosystem/environmental asset before an adverse event occurs.

Bioaccumulation:

The uptake and assimilation of persistent chemicals in the environment by living organisms. These chemicals may then accumulate in the living tissues of these organisms, thus moving up the food chain.

Bleaching:

A process by which corals expel their pigmented algal inhabitants and thus lose their colour, appearing white, the colour of their white limestone skeleton.

Berm:

An embankment which acts as a barrier between a lagoon or salt pond and the sea.

Bunker:

A large container or compartment for storage purposes.

Coral:

Rock-like substance composed of the skeletons of dead polyps.

Coral Polyps:

These are tiny, soft, transparent, flower-like animals which live together in groups or colonies.

Delphi Technique:

A technique for maximizing the reliability of the subjective judgements of a group of experts, using a planned programme of consecutive, iterative, individual interrogations interspersed with information feedback.

Disaster:

Any adverse event (natural or human-induced) which disrupts the basic fabric and normal functioning of a society or community, giving rise to casualties and/ or damage to property, infrastructure, essential services and means of livelihood on a scale which is beyond the capacity of the affected society to cope without assistance.

Disaster Management :

A collective term encompassing all aspects of planning for and responding to disaster, including both pre- and post- disaster activities. It refers to both the risk and consequences of a disaster.

Disaster Management Cycle:

Disaster management can be seen as a series of phases on a time continuum. The Disaster Management Cycle is a six-stage system on this continuum, designed for effectively managing disasters by relying on preventative, mitigatory and post-disaster measures.

Damage Assessment:

The preparation of specific, quantified estimates of physical and economic damage resulting from a disaster.

Disaster Mitigation:

Measures taken to reduce the loss of life, livelihood and property by hazards and disasters, either by reducing vulnerability or by modifying the hazard where possible.

Disaster Preparedness:

Actions taken in advance of a disaster to minimize loss of life and damage, organize temporary removal of people and property from a threatened location, and facilitate timely and effective rescue and relief rehabilitation after the disaster.

Disaster Prevention:

Measures taken to prevent hazards from giving rise to disasters.

Disaster Response/Relief:

Actions intended to save lives, alleviate suffering and provide basic care in the immediate aftermath of a disaster.

Diversity:

Richness of the number of species.

Elfin Woodland:

The type of vegetation usually encountered above 2,000 feet in elevation. It is generally short and wind-deformed and usually laden with mosses and epiphytes and matted with lianas.

Environmental Asset:

A valued feature of the natural or human environment.

Eutrophication:

The extreme growth of algae in a water body due to the presence of high concentrations of nutrients (nitrates, phosphates, etc).

Fish Kill:

Where masses of fish and other aquatic life (freshwater or marine) are killed, usually as a result of pollution.

Fringing Reefs:

These reefs grow out from the shores of the landmasses where the water is shallow.

Fumarole:

A small hole in the earth's crust near a volcano from which gases, smoke or steam are released.

Groundwater:

Water which is held in soil or in porous rock and which may be prevented from downward movement by an impermeable layer of rock beneath.

Hazard:

A potentially damaging phenomenon, whether natural or man-induced whose presence increases the probability of damage to life, health, property or the environment.

Hazardous Substance/ Material:

Any substance or material which may be classified into one of the following categories: toxic, corrosive, flammable, explosive or infectious.

Initial Damage Assessment (IDA):

An assessment usually carried out within the first 48 hours after the impact of a hazard, by trained evaluators, to obtain an initial evaluation of the damage to each sector.

Invasive Species:

An invasive species is one which, after introduction, begins to out-compete the existing/native species.

Lagoon:

A shallow part of the sea in the tropics, surrounded or almost surrounded by reefs.

Lens:

A layer of water which sits atop another layer of water, e.g. a layer of fresh water may be found floating on a more dense layer of salt water.

Littoral Woodland :

Salt spray tolerant vegetation which occurs near the coastline, where tree growth is asymmetrical due to the onslaught of sea breezes.

Mangrove:

A generic term used to describe a group of woody, salt tolerant plants that grow along sheltered tropical and sub-tropical coasts.

Material Safety Data Sheet:

This is a standard document provided by chemical manufacturers, which lists important information concerning the health, safety and environmental characteristics of the product being sold.

Montane Rain Forest:

Found above elevations where rainforest vegetation is found but below mountain peaks and ridges.

Montane Thicket:
The type of vegetation which occurs at elevations of approximately 3,500 feet.

Mossing:
The increased growth of mosses and algae which covers substrate and corals in hyper-nutrified waters often associated with sewage contaminated waters. See *Eutrophication*.

Natural Forest:
Native forest which has not been altered.

Patch Reefs:
These are isolated patches of reef on parts of the seafloor that rise close to the surface.

Plantation Forest:
Forest which has been cultivated for commerce, usually with a single species.

Polychlorinated Biphenyls (PCB's):
A group of compounds, formed by chlorination of a biphenyl compound. There may be mixtures of up to 209 individual chlorinated compounds. They are known carcinogens and may be toxic and persistent.

Post-Disaster:
Period following a disaster event, whether natural or human-induced.

Rain Forest:
A large, dense forest in a hot, humid region (tropical or subtropical), usually found above 1,000 feet in areas of abundant precipitation.

Rapid Environmental Assessment:
An assessment which is carried out in the period immediately following a disaster to determine the degree of damage suffered and the appropriate response.

Rebuilding/Reconstruction:
The medium to long-term repair of physical, social and economic damage and the return of affected communities to a condition equal to or better than before a disaster. This is usually undertaken after a period of rehabilitation and normally involves significant construction extending for several months or even years following an adverse event.

Recovery/Rehabilitation:
Short-term actions such as restoration of basic services undertaken after the immediate threat has passed, intended to bring life back to normal. This may be typically completed within 10-12 weeks of the disaster event.

Relief:
see *Disaster Response/Relief*.

Response:
see *Disaster Response/Relief.*

Rhizome:
Plant stem which lies underground and contains leaf buds (as opposed to a root which lies underground but is not a stem).

Risk Factor:
see *Hazard.*

Salt Pond:

An enclosed saltwater body found near to the sea formed by the barring off of part of the sea by a berm in which salinity may be highly elevated due to evaporation and fluctuations are great.

Sand Dunes:

These are waves of drifting sand, the height and movement of which are determined by the direction and intensity of the wind; they may form small hills or ridges, or crescents in the desert and may be covered with sparse grass near the sea.

Sand Migration:

The movement of sand along the seabed, beaches or coastlines by wave or wind action.

Scouring:

The erosion or removal of material by the action of running water.

Sea Grass:

True flowering marine plants found in clear, shallow seawaters, which grow prolifically via runners with emergent shoots.

Sea Grass Beds:

The marine habitat which supports sea grasses.

Secondary Containment:

An enclosure surrounding a primary containment vessel, which prevents dispersal of the material being stored in the event of a rupture to the primary containment vessel.

Secondary Forest:

Forest which has grown back in areas where the original forest has been cleared or logged.

Scrub Woodland:

The type of vegetation which occurs downslope of secondary rainforest vegetation.

Smothering:

The covering up of seabed communities (corals, sea grass beds, etc.) by the deposition of particulate matter (silt, ash, etc.) which cuts off the light to these communities required for their survival.

Spill Containment:

The process by which spills are contained within a given area. See *Secondary Containment*.

Staging Area:

A safe, clear area where resources (persons, equipment, supplies, etc.) are gathered and from which they are mobilized, following a disaster.

Tank Farm:

A collection of storage tanks within an area.

Wetlands:

Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

PART I

FORMS

This section contains a series of forms which can be used for:

- Describing environmental assets,
- Summarizing risk factors,
- Conducting assessments of damage to environmental assets, and
- Identifying appropriate environmental protection measures for implementation during disaster response and recovery activities.

These forms may be copied as frequently as required and can also be used as the basis for developing an electronic database. However, they should be modified by practitioners as necessary in particular circumstances.

The forms in this section are arranged as follows:

FORM #	TITLE	PAGE NO
DESCRIPTION OF ENVIRONMENTAL ASSETS		
2.1	DESCRIPTION OF A CORAL COMMUNITY	Forms – 5
2.2	DESCRIPTION OF A SEA GRASS BED	Forms – 6
2.3	DESCRIPTION OF A FISHING GROUND	Forms – 7
2.4	DESCRIPTION OF A SANDY BEACH	Forms – 8
2.5	DESCRIPTION OF A SALT POND	Forms – 9
2.6	DESCRIPTION OF A FOREST	Forms – 10
2.7	DESCRIPTION OF A WETLAND	Forms – 11
2.8	DESCRIPTION OF A SURFACE WATER BODY (RIVER, POND OR STREAM)	Forms – 12
2.9	DESCRIPTION OF GROUND WATER	Forms – 13
2.10	DESCRIPTION OF AN HISTORICAL/ARCHAEOLOGICAL SITE	Forms – 14
SUMMARY OF RISK FACTORS		
3.1	SUMMARY SHEET FOR RISK FACTORS	Forms – 15

FORM 2.1: DESCRIPTION OF A CORAL COMMUNITY

NAME, LOCATION AND MAP REFERENCE:

EFFECTIVE DATE:

ITEM		DESCRIPTION
TYPE OF COMMUNITY		
APPROXIMATE AREA		
COMPOSITION BY AREA	Live Coral	
	Dead Coral	
	Sand	
	Other (specify)	
STONY CORAL	Diversity	
	Abundance	
SOFT CORAL	Diversity	
	Abundance	
FISH	Diversity	
	Abundance	
MACRO-INVERTEBRATES	Diversity	
	Abundance	
DAMAGE / DISEASE	Mechanical Damage	
	Smothering	
	Mossing	
	Bleaching	
	Other (specify)	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.2: DESCRIPTION OF A SEA GRASS BED		
LOCATION AND MAP REFERENCE: EFFECTIVE DATE:		
ITEM		DESCRIPTION
APPROXIMATE AREA		
COMPOSITION BY AREA	Live Sea Grass	
	Dead Sea Grass	
	Sand	
	Rock or Rocky Ledge	
	Other (specify)	
FISH	Diversity	
	Abundance	
MACRO-INVERTEBRATES	Diversity	
	Abundance	
DAMAGE / DISEASE	Mechanical Damage	
	Smothering	
	Trash/Garbage	
	Other (specify)	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.3: DESCRIPTION OF A FISHING GROUND

LOCATION AND MAP REFERENCE:

EFFECTIVE DATE:

ITEM		DESCRIPTION
Associated Coral Reefs		Refer to Table F-1
Associated Sea Grass Beds		Refer to Table F-2
WATER QUALITY	Solid Waste	
	Temperature	
	Total Suspended Solids	
	pH	
	Oil & Grease	
	Biochemical Oxygen Demand	
	Total Coliform	
	Faecal Coliform	
FISH LANDINGS	Species	
	Weight	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.4: DESCRIPTION OF A SANDY BEACH		
LOCATION AND MAP REFERENCE: EFFECTIVE DATE:		
ITEM		DESCRIPTION
BEACH WIDTH OR BEACH PROFILE		See prepared sketches, attached.
CONSISTENCY OF SAND: Subjective	Fine sand (0.1mm -1mm)	
	Coarse Sand (1mm - 2mm)	
	Gravel (2mm – 100mm)	
	Cobble (100mm – 200mm)	
	Boulder (greater than 200mm)	
CONSISTENCY OF SAND: Laboratory Analysis		See results of laboratory analysis, attached.
STRUCTURES	Type	
	Location	
POLLUTION	Garbage/Debris (Natural, Human Activity)	
	Hydrocarbons	
	Sewage	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

<table>
<tr><th colspan="3">FORM 2.5: DESCRIPTION OF A SALT POND</th></tr>
<tr><td colspan="3">LOCATION AND MAP REFERENCE:

EFFECTIVE DATE:</td></tr>
<tr><td colspan="2">ITEM</td><td>DESCRIPTION</td></tr>
<tr><td colspan="2">Salinity</td><td></td></tr>
<tr><td colspan="2">Physical status of the berm</td><td></td></tr>
<tr><td colspan="2">Siltation</td><td></td></tr>
<tr><td rowspan="2">COMMUNITY COMPOSITION</td><td>Species</td><td></td></tr>
<tr><td>Abundance</td><td></td></tr>
<tr><td>POTENTIAL THREATS FROM NATURAL HAZARDS</td><td>HAZARD</td><td>POSSIBLE IMPACT</td></tr>
<tr><td>HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood</td><td>CAUSED BY</td><td>DAMAGE/ IMPACT</td></tr>
<tr><td>DATE:</td><td></td><td></td></tr>
</table>

FORM 2.6: DESCRIPTION OF A FOREST

NAME, LOCATION AND MAP REFERENCE:

EFFECTIVE DATE:

ITEM		DESCRIPTION
TYPE OF FOREST		
APPROXIMATE AREA		
AVIFAUNA	Diversity	
	Abundance	
OTHER FAUNA	Diversity	
	Abundance	
HUMAN INTRUSION	Hiking	
	Camping	
	Hunting	
	Logging	
	Reaping	
	Other (specify)	
DAMAGE / DISEASE	Cleared Areas	
	Fire Damage	
	Invasive Plants	
	Invasive Animals	
	Other (specify)	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.7: DESCRIPTION OF A WETLAND		
NAME, LOCATION AND MAP REFERENCE: EFFECTIVE DATE:		
ITEM		DESCRIPTION
TYPE OF WETLAND		
APPROXIMATE AREA		
AVIFAUNA	Diversity	
	Abundance	
OTHER FAUNA	Diversity	
	Abundance	
FISH	Diversity	
	Abundance	
MACRO-INVERTEBRATES	Diversity	
	Abundance	
Diminished Water Quality	Foul Odors	
	Foaming	
	Anoxic Conditions	
	Trash and Garbage	
	Other (specify)	
DAMAGE / DISEASE	Cleared Areas	
	Fire Damage	
	Invasive Species	
	Silting-up	
	Other (specify)	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.8: DESCRIPTION OF A SURFACE WATER BODY (RIVER, POND, STREAM)		
LOCATION AND MAP REFERENCE: EFFECTIVE DATE:		
ITEM		DESCRIPTION
WATER QUALITY: Analytical	Temperature	
	Total Suspended Solids	
	pH	
	Salinity	
	Biochemical Oxygen Demand	
	Total Coliform	
	Faecal Coliform	
WATER QUALITY: Gross Indicators	Debris/Garbage	
	Oil Sheen	
	Odour	
FISH	Diversity	
	Abundance	
MACRO-INVERTEBRATES	Diversity	
	Abundance	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.9: DESCRIPTION OF GROUND WATER		
LOCATION AND MAP REFERENCE: EFFECTIVE DATE:		
ITEM		DESCRIPTION
WATER QUALITY: Analytical	Total Suspended Solids	
	pH	
	Salinity	
	Total Coliform	
	Faecal Coliform	
	Iron	
	Arsenic	
	Organic	
PRODUCTIVITY	Location of Recharge Area	
	Size of Recharge Area	
	Number of Wells	
	Rate of Extraction	
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 2.10: DESCRIPTION OF AN HISTORICAL/ARCHAEOLOGICAL SITE		
LOCATION AND MAP REFERENCE: EFFECTIVE DATE:		
ITEM		DESCRIPTION
DESCRIPTION	Date	
	Structure	
	Artefacts	
DISTURBANCE	Structure	
	Artefacts	
PROTECTIVE & PRESERVATION MEASURES		
POTENTIAL THREATS FROM NATURAL HAZARDS	HAZARD	POSSIBLE IMPACT
HISTORICAL IMPACTS BY ANY HAZARD e.g. Oil spill/flood	CAUSED BY	DAMAGE/ IMPACT
DATE:		

FORM 3.1: SUMMARY SHEET FOR RISK FACTORS	
NAME OF FACILITY:	CONTACT PERSON:
LOCATION:	PHONE OR RADIO CONTACT:
	MAP REFERENCE:
MATERIAL OF CONCERN (NAME AND DESCRIPTION):	
TYPE OF STORAGE:	
SECONDARY CONTAINMENT:	
HEALTH EFFECTS:	PERSONAL EXPOSURE LIMITS:
HANDLING REQUIREMENTS AND PERSONAL PROTECTIVE EQUIPMENT:	
FLAMMABILITY LIMITS Flash Point: Upper Explosive Limit: Lower Explosive Limit:	FIRE FIGHTING INFORMATION Flame Temperature: Extinguishing Medium:
FIRST AID REQUIREMENTS:	
THREAT TO THE ENVIRONMENT:	THREATENED ENVIRONMENTAL ASSET:
SPILL CONTAINMENT AND RECOVERY METHODS:	

FORM 5.1: ASSESSMENT OF DAMAGE TO A CORAL REEF			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Mechanical Damage			
Smothering			
Impeding of Light			
"Fish Kills"			
Extraneous Matter			
		Effective Assessment	
Value of Asset Prior to Event			$
Damage Factor: (0 to 0.1 for a Low Effective Assessment, 0.1 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
		Full Economic Loss (asset value times damage factor)	$
Appropriate Responses:			
Restriction of Use:			
Corrective Action(s):			
Long-Term Measure(s):			
Other:			
		Remediation Cost	$

<table>
<tr><th colspan="4">FORM 5.2: ASSESSMENT OF DAMAGE TO A SEA GRASS BED</th></tr>
<tr><th>IMPACT</th><th>INTENSITY</th><th>SPATIAL EXTENT</th><th>DAMAGE RATING</th></tr>
<tr><td>Uprooting</td><td></td><td></td><td></td></tr>
<tr><td>Smothering</td><td></td><td></td><td></td></tr>
<tr><td>Impeding of Light</td><td></td><td></td><td></td></tr>
<tr><td>“Fish Kills”</td><td></td><td></td><td></td></tr>
<tr><td>Extraneous Matter</td><td></td><td></td><td></td></tr>
<tr><td colspan="3" align="right">Effective Assessment</td><td></td></tr>
<tr><td colspan="3">Value of Asset Prior to Event</td><td>$</td></tr>
<tr><td colspan="3">Damage Factor: (0 to 0.1 for a Low Effective Assessment,
0.1 to 0.25 for a Moderate Effective Assessment,
0.25 to 0.66 for a High Effective Assessment, and
0.66 to 1.0 for an Extreme Effective Assessment)</td><td></td></tr>
<tr><td colspan="3" align="right">Full Economic Loss (asset value times damage factor)</td><td>$</td></tr>
<tr><td colspan="4" align="center">Appropriate Responses</td></tr>
<tr><td colspan="4">Restriction of Use:</td></tr>
<tr><td colspan="4">Corrective Action(s):</td></tr>
<tr><td colspan="4">Long-term Measure(s):</td></tr>
<tr><td colspan="4">Other:</td></tr>
<tr><td colspan="3" align="right">Remediation Cost</td><td>$</td></tr>
</table>

FORM 5.3: ASSESSMENT OF DAMAGE TO A FISHING GROUND			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Mechanical Damage			
Smothering			
Impeding of Light			
"Fish Kills"			
Extraneous Matter			
Effective Assessment			
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.2 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
Full Economic Loss (asset value times damage factor)			$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
Remediation Cost			$

FORM 5.4: ASSESSMENT OF DAMAGE TO A SANDY BEACH			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Loss of Beach Width			
Sand Migration			
Scouring			
Changed Composition			
Contamination			
Littering			
Effective Assessment			
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.3 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
Full Economic Loss (asset value times damage factor)			$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
Remediation Cost			$

FORM 5.5: ASSESSMENT OF DAMAGE TO A SALT POND			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Breached Berm			
Filling Up			
Contamination			
Littering			
Effective Assessment			
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.4 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
Full Economic Loss (asset value times damage factor)			$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
Remediation Cost			$

FORM 5.6: ASSESSMENT OF DAMAGE TO A FOREST			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Defoliation			
Broken Limbs			
Tree Fall/Clearing			
Landslide/Mudslide			
Fire Damage			
		Effective Assessment	
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.5 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
Full Economic Loss (asset value times damage factor)			$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
		Remediation Cost	$

FORM 5.7: ASSESSMENT OF DAMAGE TO A WETLAND			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Defoliation			
Broken Limbs			
Tree Fall/Clearing			
Impaired Drainage			
Filling Up			
Contamination			
Littering			
		Effective Assessment	
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.6 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
		Full Economic Loss (asset value times damage factor)	$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
		Remediation Cost	$

FORM 5.8: ASSESSMENT OF DAMAGE TO A SURFACE WATER BODY (RIVER, POND, OR STREAM)			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
"Fish Kills"			
Impaired Drainage			
Altered Channels			
Contamination			
Littering			
		Effective Assessment	
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.7 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
		Full Economic Loss (asset value times damage factor)	$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
		Remediation Cost	$

FORM 5.9: ASSESSMENT OF DAMAGE TO GROUND WATER			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Contamination			
Altered Drainage			
Deforestation			
Effective Assessment			
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Assessment,** 0.8 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
Full Economic Loss (asset value times damage factor)			$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
Remediation Cost			$

FORM 5.10: ASSESSMENT OF DAMAGE TO AN HISTORICAL/ARCHAEOLOGICAL SITE			
IMPACT	**INTENSITY**	**SPATIAL EXTENT**	**DAMAGE RATING**
Structural Damage			
Landslide			
Burial			
Littering			
Effective Assessment			
Value of Asset Prior to Event			**$**
Damage Factor: **(0 to 0.1 for a Low Effective Asse ssment,** 0.9 to 0.25 for a Moderate Effective Assessment, 0.25 to 0.66 for a High Effective Assessment, and 0.66 to 1.0 for an Extreme Effective Assessment)			
Full Economic Loss (asset value times damage factor)			$
Appropriate Responses			
Restriction of Use:			
Corrective Action(s):			
Long-term Measure(s):			
Other:			
Remediation Cost			$

FORM 6A.1 : ENVIRONMENTAL PROTECTION CHECKLIST FOR ESTABLISHING TEMPORARY STAGING AREAS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	APPLY TO SPECIFIED SITE	VERIFY ON COMPLETION
GENERAL															
								T				T	Use existing clear area for staging area, if available [G-6.2.1].		
		T						T		T		T	Use existing buildings and toilet facilities, if available and functional.		
								T					If it is necessary to clear a new area, avoid special ecosystems such as primary forest or habitat for rare or endangered species.		
T								T					If it is necessary to clear a new area, do not burn the vegetation. Windrow in a suitable area to decompose [G-6.2.2].		
												T	If it is necessary to clear a new area, avoid historical or archaeological sites.		
		T					T		T	T			If levelling is necessary, avoid pushing dirt, etc into rivers, wetlands, saltponds or the sea [G-6.2.3].		
											T		Avoid aquifer recharge areas.		
		T	T	T	T		T		T	T			Locate fuel and vector control chemicals away from watercourses, salt ponds, wetlands and the sea [G-6.2.4].		
T			T	T	T	T	T	T	T	T			Provide for temporary holding (for proper disposal or reuse) of garbage, packaging material, etc. Do not burn [G-6.2.2].		
								T					Site cooking areas away from dry vegetation and protect to prevent accidental fires.		
SPECIFIC TO RECOVERY															
						T							If sand is required, do not mine from beaches.		
		T								T			If existing toilet facilities are not available, deploy portable toilets or construct pit latrines.		
		T	T	T	T	T	T	T	T	T			Construct earthen dykes (bunds) around fuel and chemical storage areas to contain spills.		
		T	T	T	T	T	T	T	T	T	T		In the event of spills, contain contaminated soil for proper disposal (see Section 6.17).		

FORM 6A.2 : ENVIRONMENTAL PROTECTION CHECKLIST FOR BUILDING TEMPORARY JETTIES

LOCATION:

TO PROTECT: Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	ENVIRONMENTAL PROTECTION MEASURE	APPLY TO SPECIFIED SITE	VERIFY ON COMPLETION
GENERAL															
			T	T	T	T							To the extent practical, build the temporary jetty close to the previous jetty.		
						T							Avoid turtle nesting beaches.		
			T	T	T		T		T				Avoid smothering of corals, sea grass beds, salt ponds and wetlands.		
		T	T	T	T								Fuel and service powered equipment away from the sea to avoid spills into the sea.		
SPECIFIC TO RECOVERY															
		T	T	T	T								If a Acauseway@ type jetty is built, install riprap or geofabric to minimize washing of sand and silt from the causeway into the sea.		
		T				T							Remove temporary jetty as soon as possible when it is no longer needed.		

FORM 6A.3 : ENVIRONMENTAL PROTECTION CHECKLIST FOR BUILDING EMERGENCY HELIPADS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
GENERAL															
								T				T	Use an existing clear, level area (if available) [G-6.2.1].		
T		T								T			Use a paved or grassed area (if available) [G-6.2.1].		
								T					If it is necessary to clear a new area, avoid special ecosystems such as primary forest or habitat for rare or endangered species.		
												T	If it is necessary to clear a new area, avoid historical or archaeological sites.		
T								T					If it is necessary to clear a new area, do not burn the vegetation. Windrow in a suitable area to decompose [G-6.2.2].		
		T					T		T	T			If levelling is necessary, avoid pushing dirt, etc., into rivers, wetlands, salt ponds or the sea [G-6.2.3].		
SPECIFIC TO RECOVERY															
						T							If sand is required, do not mine from the beach		
T	T	T								T			Decommission emergency helipad as soon as possible when it is no longer needed.		

FORM 6A.4 : ENVIRONMENTAL PROTECTION CHECKLIST FOR REOPENING/REPAIRING ROADS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
GENERAL															
		T	T	T	T		T		T	T		T	Do not dispose of cleared soil and mud in locations where it can flow or be washed into watercourses, salt ponds, wetlands, the sea or historical/archaeological sites [G-6.2.3].		
		T	T	T	T		T		T	T		T	Do not dispose of debris in watercourses, salt ponds, wetlands, the sea or on historical/archaeological sites [G-6.2.3].		
T								T					Do not burn fallen trees and branches. Remove for proper disposal or windrow in suitable areas to decompose [G-6.2.2].		
							T	T	T			T	Avoid diverting the road into forested areas, or across wetlands or salt ponds or through historical/archaeological sites.		
SPECIFIC TO RECOVERY															
										T			If rivers or streams have been forded as an emergency measure, replace with suitably sized culverts as early as practical.		

FORM 6A.5 : ENVIRONMENTAL PROTECTION CHECKLIST FOR CLEARING/REOPENING RUNWAYS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
GENERAL															
		T	T	T	T		T		T	T		T	Do not dispose of cleared soil and mud in locations where it can flow or be washed into watercourses, salt ponds, wetlands, the sea or onto historical/archaeological sites [G-6.2.3].		
		T	T	T	T		T		T	T		T	Do not dispose of debris or construction rubble in watercourses, salt ponds, wetlands, in the sea or onto historical/archaeological sites [G-6.2.3].		
T								T					Do not burn fallen trees and branches. Remove for proper disposal or windrow in suitable areas to decompose [G-6.2.2].		
SPECIFIC TO RECOVERY															
										T			If underground fuel tanks have been flooded out, stockpile and cover contaminated soil for proper disposal (see Section 6.17) [G-6.2.4].		
		T	T	T	T					T	T		If underground fuel tanks have been flooded out, seal off the openings to the tank until the water/oil mixture can be properly disposed.		

FORM 6A.6 : ENVIRONMENTAL PROTECTION CHECKLIST FOR RESTORING ELECTRICITY/TELECOMMUNICATIONS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
GENERAL															
								T				T	To the extent practical, restore electricity and telephone transmission and distribution systems in their original alignment.		
		T	T	T	T		T		T	T		T	Do not dispose of debris or construction rubble in watercourses, salt ponds, wetlands, in the sea or on historical/archaeological sites [G-6.2.3].		
T								T					Do not burn wooden poles, or fallen trees and branches. Reuse, remove for proper disposal or windrow in suitable areas to decompose [G-6.2.2].		
SPECIFIC TO RECOVERY															
		T	T	T	T					T	T		If underground fuel tanks have been flooded out, seal off the openings to the tank until the water/oil mixture can be properly disposed.		
T		T								T	T		If underground fuel tanks have been flooded out, stockpile and cover contaminated soil for proper disposal (see Section 6.17)[G-6.2.4].		
T													Collect and contain any asbestos material (insulation, etc) for proper disposal (see Section 6.17).		
										T	T		Collect and contain any PCB-containing material (insulation, etc) for proper disposal (see Section 6.17).		

FORM 6A.7 : ENVIRONMENTAL PROTECTION CHECKLIST FOR RESTORING WATER SUPPLY

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
GENERAL															
								T				T	To the extent practical, restore water mains in their original alignment.		
		T	T	T	T		T		T	T		T	Do not dispose of debris or construction rubble in locations where it can flow or be washed into watercourses, salt ponds, wetlands or in the sea or over historical/archaeological sites [G-6.2.3].		
T								T					Do not burn packaging material. Reuse, remove for proper disposal [G-6.2.2].		
SPECIFIC TO RECOVERY															
T		T								T	T		If underground fuel tanks have been flooded out, stockpile and cover contaminated soil for proper disposal (see Section 6.17).		
		T	T	T	T					T	T		If underground fuel tanks have been flooded out, seal off the openings to the tank until the water/oil mixture can be properly disposed.		
T													Collect and contain any asbestos material (insulation, etc) for proper disposal (see Section 6.17).		
T		T								T			Collect and contain any unserviceable water treatment chemicals [G-6.2.5].		
		T								T	T		Collect and contain any PCB-containing material (insulation, etc) for proper disposal (see Section 6.17).		

FORM 6A.8: ENVIRONMENTAL PROTECTION CHECKLIST FOR BUILDING TEMPORARY ACCOMMODATION

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
													GENERAL		
								T		T	T	T	Use serviceable buildings for temporary shelter, especially if these have working toilet systems [G-6.2.1].		
T								T				T	Use existing clear areas for tents, if available [G-6.2.1].		
								T					If areas must be cleared for tents, avoid sensitive ecosystems like primary forest or habitat for rare or endangered species.		
												T	If areas must be cleared for tents, avoid historical or archaeological sites.		
T								T					If areas must be cleared for tents, do not burn felled vegetation. Windrow in a suitable area and leave to decompose [G-6.2.2].		
		T							T	T			If pit latrines must be dug, locate them where they will not be flooded out after heavy rains.		
											T		Avoid aquifer recharge areas.		
		T	T	T	T		T		T	T			Locate fuel and vector control chemicals away from watercourses, salt ponds, wetlands and the sea [G-6.2.4].		
T			T	T	T	T	T	T	T	T			Provide for temporary holding (for proper disposal or reuse) of garbage, packaging material, etc. Do not burn [G-6.2.2].		
								T					Site cooking areas away from dry vegetation and protect to prevent accidental fires.		

FORM 6A.8: ENVIRONMENTAL PROTECTION CHECKLIST FOR BUILDING TEMPORARY ACCOMMODATION

LOCATION:

TO PROTECT: Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	ENVIRONMENTAL PROTECTION MEASURE	APPLY TO SPECIFIED SITE	VERIFY ON COMPLETION
SPECIFIC TO RECOVERY															
						T							If sand is required, do not mine from the beach.		
													Dismantle tents as soon as practical when they are no longer needed.		
T										T	T		Remove sewage to an approved sewage treatment facility and fill in pit.		
T		T								T			Revegetate area as soon as practical.		

FORM 6A.9 : ENVIRONMENTAL PROTECTION CHECKLIST FOR CLEARING WATER COURSES

LOCATION:

TO PROTECT													ENVIRONMENTAL PROTECTION MEASURE	APPLY TO SPECIFIED SITE	VERIFY ON COMPLETION
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites			
		T	T	T	T		T		T	T			When clearing river intakes, do not dispose of the debris back to the stream nor in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea [G-6.2.3].		
		T	T	T	T		T		T	T		T	Do not dispose of silt or mud in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea or onto historical/archaeological sites [G-6.2.3].		
										T			Fuel and service powered equipment away from the watercourse to avoid spills into the water.		

FORM 6A.10 : ENVIRONMENTAL PROTECTION CHECKLIST FOR TEMPORARY STABILIZATION OF LANDSLIPS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
		T	T	T	T		T		T	T		T	Do not dispose of failed soil in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea or onto historical/archaeological sites [G-6.2.3].		
T		T								T			Regrass exposed surfaces as soon as practical.		
										T			Fuel and service powered equipment away from the watercourse to avoid spills into the water.		

FORM 6A.11 : ENVIRONMENTAL PROTECTION CHECKLIST FOR TEMPORARY STABILIZATION OF SHORELINES															
LOCATION:															
TO PROTECT													ENVIRONMENTAL PROTECTION MEASURE	APPLY TO SPECIFIED SITE	VERIFY ON COMPLETION
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites			
		T	T	T									Use Aclean@ rock (that is, with minimal adhering silt and clay) for riprap.		
			T									T	Only use rock from an approved source.		
						T							Preserve access for turtles to nesting beaches (do not cover with course material nor install physical barriers).		
										T			Fuel and service powered equipment away from the watercourse to avoid spills into the water.		

FORM 6A.12 : ENVIRONMENTAL PROTECTION CHECKLIST FOR CLEANING-UP BUILDINGS

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
T		T								T	T		Identify the presence of hazardous chemicals and make provision for appropriate collection and proper disposal (see Section 6.17).		
		T	T	T			T		T	T			Remove as much silt and debris as possible by Adry@ methods before the final washdown.		
		T	T	T	T		T		T	T			Do not dispose of silt and debris in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea or onto historical/archaeological sites [G-6.2.3].		
T		T								T	T		Use only environmentally friendly chemicals at the correct dosage for cleaning and sanitizing and only if necessary.		

FORM 6A.13 : ENVIRONMENTAL PROTECTION CHECKLIST FOR DEMOLITION & CLEARING OF DAMAGED STRUCTURES

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
T		T								T	T		Identify the presence of hazardous chemicals and make provision for appropriate collection and proper disposal (see Section 6.17).		
		T	T	T			T		T	T			If broken asbestos sheeting is removed, collect for proper disposal (see Section 6.17).		
		T	T	T	T		T		T	T			Consider the use of material from demolished building in other applications.		
		T	T	T	T		T		T	T		T	Do not dispose of silt and debris in locations where it can flow or be washed into water courses, salt ponds, wetlands or the sea or where historical/archaeological sites can become buried [G-6.2.3].		
	T												Time demolition activity for daylight hours, when the noise will be less disruptive.		

FORM 6A.14 : ENVIRONMENTAL PROTECTION CHECKLIST FOR VECTOR CONTROL

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
		T	T		T				T	T	T		Use environmentally friendly chemicals (biodegradable, non bio accumulating, and non-toxic to aquatic species).		
		T	T		T				T	T	T		Do not use broad range insecticides.		
		T			T	T	T		T	T	T		Site storage area for chemicals away from waterways, salt ponds, wetlands, the sea and above the flood line [G-6.2.4].		
T		T							T	T	T		Store chemicals in appropriate containers within a covered and secured area [G-6.2.4].		

FORM 6A.15 : ENVIRONMENTAL PROTECTION CHECKLIST FOR CONTAINMENT & COLLECTION OF CONTAMINANTS ON LAND

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
		T	T	T	T	T	T		T	T	T		Use absorbent material to capture spills.		
		T	T	T	T	T	T		T	T			Construct bunds around spills.		
		T	T	T	T	T	T		T	T			Segregate contaminated material, store in appropriate containers, and label correctly and completely [G-6.2.4].		
T	T	T	T	T	T	T	T		T	T			Use well-maintained and appropriate equipment.		
		T	T	T	T	T	T		T	T		T	Site temporary storage areas away from rivers, salt ponds, wetlands, the sea and historical/archaeological sites.		
T											T		Remove soil showing visible signs of contamination.		
		T	T	T	T	T	T		T	T	T		Use waterproof material to cover contaminated soil which cannot be removed immediately.		

FORM 6A.16 : ENVIRONMENTAL PROTECTION CHECKLIST FOR CONTAINMENT & COLLECTION OF CONTAMINANTS IN WATER

LOCATION:

TO PROTECT															
Air Quality	Ambient Noise	Sea Water Quality	Coral Communities	Sea Grass Beds	Fishing Grounds	Sandy Beaches & Turtle Nesting	Salt Ponds	Forests & Special Land Habitats	Wetlands	Rivers, Ponds & Streams	Ground Water	Historical & Archaeological Sites	**ENVIRONMENTAL PROTECTION MEASURE**	**APPLY TO SPECIFIED SITE**	**VERIFY ON COMPLETION**
		T	T	T	T	T	T		T	T			Install booms across rivers and streams to prevent spills from spreading.		
		T	T	T	T	T	T		T	T	T		Use appropriate absorbent material to capture spills.		
		T	T	T	T	T	T		T	T			Construct bunds around spills.		
		T	T	T	T	T	T		T	T			Collect spilled material in suitable containment vessels.		
T	T	T	T	T	T	T	T		T	T			Use well-maintained and appropriate equipment.		
		T	T	T	T	T	T		T	T		T	Site temporary storage areas away from rivers, salt ponds, wetlands, the sea and historical/archaeological sites [G-6.2.4].		
T											T		Remove soil showing visible signs of contamination.		
		T	T	T	T	T	T		T	T	T		Use waterproof material to cover contaminated soil which cannot be removed immediately.		

FORM 6B.1		
FUNCTION:	**CLEARING OF VEGETATION**	
GENERAL APPROACH:	Clear only when essential. Clear minimum of vegetation. Replanting where possible. No burning.	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Do not burn vegetation. Windrow in suitable area for decomposition. Re-use where possible. Do not burn solid waste, garbage etc.	
AMBIENT NOISE	Use well-maintained and appropriate equipment.	
SEA WATER QUALITY	Fuel and service powered equipment away from the sea to avoid spills entering the sea. Replant vegetation as soon as possible.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	---	
FISHING GROUNDS	---	
SALT PONDS	Do not place cut vegetation in salt ponds.	
FORESTS AND SPECIAL LAND HABITATS	Avoid clearing these areas. Replant where possible.	
GROUND WATER	---	
WETLANDS	Avoid clearing wetlands. Replant where possible.	
RIVERS, PONDS, STREAMS	Avoid dumping cleared material in waterways.	
HISTORIC AND ARCHAEOLOGICAL SITES	Avoid clearing if possible.	
VERIFIED BY:	DATE:	

FORM 6B.2		
FUNCTION:	**DEBRIS REMOVAL AND DISPOSAL**	
GENERAL APPROACH:	No burning. Prevention of hazardous materials spills. Disposal in approved sites.	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Do not burn fallen trees, branches, and poles. Remove for proper disposal or windrow for decomposition.	
AMBIENT NOISE	Use well-maintained and appropriate equipment.	
SEA WATER QUALITY	Fuel and service powered equipment away from the sea to avoid spills entering the sea. Do not dump debris in the sea. Move to approved site.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	Avoid placing debris in these areas.	
FISHING GROUNDS	---	
SALT PONDS	Do not dispose of debris in salt ponds. Fuel and service powered equipment away from ponds.	
FORESTS AND SPECIAL LAND HABITATS	Do not dispose of waste, debris in these areas.	
GROUND WATER	---	
WETLANDS	Do not dispose of debris in wetlands	
RIVERS, PONDS, STREAMS	Do not dispose of debris in waterways.	
HISTORIC AND ARCHAEOLOGICAL SITES	Avoid dumping in these areas.	
VERIFIED BY:	**DATE:**	

FORM 6B.3		
FUNCTION:	**CONSTRUCTION OF TEMPORARY FACILITIES**	
GENERAL APPROACH:	Use existing facilities where possible. Minimise clearing.	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Use a paved or grassed area if available. Use existing clear areas if possible. Do not burn waste, vegetation. Windrow vegetation for decomposing. Use well-maintained and appropriate equipment.	
AMBIENT NOISE	Decommission temporary facilities as soon as possible when no longer needed.	
SEA WATER QUALITY	Fuel and service powered equipment away from the sea to avoid spills entering the sea.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	Avoid operating heavy equipment in these areas. Avoid nesting areas. Remove temporary jetties as soon as possible when no longer needed. Do not mine beach sand.	
FISHING GROUNDS	For jetties build close to old site. Avoid smothering seagrass beds, corals.	
SALT PONDS	Avoid building in salt ponds.	
FORESTS AND SPECIAL LAND HABITATS	Avoid forests for construction. Use existing facilities where possible. If clearing is necessary, avoid special ecosystems such as primary forest or habitat for rare species. Use serviceable buildings for temporary shelter if these have toilet facilities.	
GROUND WATER	Use serviceable buildings for temporary shelter if these have toilet facilities. Avoid aquifer recharge areas.	
WETLANDS	Avoid construction and material disposal in wetlands.	
RIVERS, PONDS, STREAMS	If leveling necessary, avoid pushing material into waterways. Use serviceable buildings for temporary shelter if these have toilet facilities.	
HISTORIC AND ARCHAEOLOGICAL SITES	Use serviceable buildings for temporary shelter if these have toilet facilities.	
VERIFIED BY:	**DATE:**	

FORM 6B.4		
FUNCTION:	**CLEARING WATER COURSES**	
GENERAL APPROACH:	Proper storage, disposal of debris, mud	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	---	
AMBIENT NOISE	---	
SEA WATER QUALITY	When clearing river intakes, do not dispose of debris back into streams nor in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	---	
FISHING GROUNDS	When clearing river intakes, do not dispose of debris back into streams nor in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea.	
SALT PONDS		
FORESTS AND SPECIAL LAND HABITATS	---	
GROUND WATER	---	
WETLANDS	When clearing river intakes, do not dispose of debris back into streams nor in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea.	
RIVERS, PONDS, STREAMS	Fuel and service powered equipment away from watercourses. When clearing river intakes, do not dispose of debris back into streams nor in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea.	
HISTORIC AND ARCHAEOLOGICAL SITES	Do not dispose of silt or mud in locations where it can flow or be washed into watercourses, salt ponds, wetlands or the sea or onto historic or archaeological sites.	
VERIFIED BY:	**DATE:**	

FORM 6B.5

FUNCTION: **DEMOLITION AND CLEARING OF STRUCTURES**

GENERAL APPROACH: Identification and containment of hazardous substances, proper disposal of all waste and debris.

<table>
<tr><th>ASSET AT RISK</th><th>PROTECTION MEASURE</th><th>CHECK IF APPLICABLE</th></tr>
<tr><td>AIR QUALITY</td><td>Identify presence of hazardous chemicals and make provision for appropriate collection and disposal including asbestos sheeting.</td><td></td></tr>
<tr><td>AMBIENT NOISE</td><td>Demolish during the daytime when noise is less disturbing.</td><td></td></tr>
<tr><td>SEA WATER QUALITY</td><td rowspan="3">Identify presence of hazardous chemicals and make provision for appropriate collection and disposal including asbestos sheeting.
Collect broken asbestos sheeting for proper disposal.
Do not dispose of silt and debris in locations where it can get into waterways, salt ponds, wetlands or the sea.</td><td></td></tr>
<tr><td>CORAL COMMUNITIES</td><td></td></tr>
<tr><td>SEAGRASS BEDS</td><td></td></tr>
<tr><td>SANDY BEACHES AND TURTLE NESTING</td><td>---</td><td></td></tr>
<tr><td>FISHING GROUNDS</td><td>Consider use of material from demolished building in other applications.</td><td></td></tr>
<tr><td>SALT PONDS</td><td>Identify presence of hazardous chemicals and make provision for appropriate collection and disposal including asbestos sheeting.
Do not dispose of silt and debris in locations where it can get into waterways, salt ponds, wetlands or the sea.</td><td></td></tr>
<tr><td>FORESTS AND SPECIAL LAND HABITATS</td><td>---</td><td></td></tr>
<tr><td>GROUND WATER</td><td>Identify presence of hazardous chemicals and make provision for appropriate collection and proper disposal (See Section 6.17).</td><td></td></tr>
<tr><td>WETLANDS</td><td>Identify presence of hazardous chemicals and make provision for appropriate collection and disposal including asbestos sheeting.
Do not dispose of silt and debris in locations where it can get into waterways, salt ponds, wetlands or the sea.</td><td></td></tr>
</table>

FORM 6B.5		
FUNCTION: **DEMOLITION AND CLEARING OF STRUCTURES**		
GENERAL APPROACH: Identification and containment of hazardous substances, proper disposal of all waste and debris.		
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
RIVERS, PONDS, STREAMS	Identify presence of hazardous chemicals and make provision for appropriate collection and disposal including asbestos sheeting. Do not dispose of silt and debris in locations where it can get into waterways, salt ponds, wetlands or the sea.	
HISTORIC AND ARCHAEOLOGICAL SITES	Do not dispose of silt and debris in locations where it can get into waterways, salt ponds, wetlands or the sea.	
VERIFIED BY:	**DATE:**	

FORM 6B.6		
FUNCTION:	**VECTOR CONTROL**	
GENERAL APPROACH:	Use of environmentally friendly chemicals. Proper storage.	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Store chemicals in appropriate containers within covered, secure areas.	
AMBIENT NOISE	---	
SEA WATER QUALITY	Use environmentally friendly chemicals, biodegradable, non-bioaccumulating and non-toxic to aquatic species.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING		
FISHING GROUNDS		
SALT PONDS		
FORESTS AND SPECIAL LAND HABITATS	---	
GROUND WATER	Use environmentally friendly chemicals, biodegradable, non-bioaccumulating and non-toxic to aquatic species.	
WETLANDS		
RIVERS, PONDS, STREAMS		
HISTORIC AND ARCHAEOLOGICAL SITES	---	
VERIFIED BY:	**DATE:**	

FORM 6B.7

FUNCTION: CONTAINMENT AND COLLECTION OF HAZARDOUS MATERIALS

GENERAL APPROACH: Identification, containment, collection and disposal in approved manner.

ASSET AT RISK	PROTECTION MEASURE	CHECK IF APPLICABLE
AIR QUALITY	Use well-maintained and appropriate equipment. Remove soil showing visible signs of contamination.	
AMBIENT NOISE	Use well-maintained and appropriate equipment.	
SEA WATER QUALITY	Bund spills on land, boom spills on water. Use sorbent pads, other absorbent material to absorb spills. Collect contaminated material, store in containers, label appropriately. Site temporary storage areas away from rivers, salt ponds, wetlands, the sea and historical/ archaeological sites. Use waterproof material to cover contaminated soil which cannot be removed immediately.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	---	
FISHING GROUNDS	Bund spills on land, boom spills on water. Use sorbents pads, other absorbent material to absorb spills. Collect contaminated material, store in containers, label appropriately. Site temporary storage areas away from rivers, salt ponds, wetlands, the sea and historical/ archaeological sites. Use waterproof material to cover contaminated soil which cannot be removed immediately.	
SALT PONDS		
FORESTS AND SPECIAL LAND HABITATS	---	
GROUND WATER	Remove soil showing visible signs of contamination. Use waterproof material to cover contaminated soil showing visible signs of contamination.	
WETLANDS	Bund spills on land, boom spills on water. Use sorbents pads, other absorbent material to absorb spills. Collect contaminated material, store in containers, label appropriately. Site temporary storage areas away from rivers, salt ponds, wetlands, the sea and historical/ archaeological sites. Use waterproof material to cover contaminated soil which cannot be removed immediately.	
RIVERS, PONDS, STREAMS		
HISTORIC AND ARCHAEOLOGICAL SITES	Site temporary storage areas away from rivers, salt ponds, wetlands, sea and historical and archaeological sites.	

VERIFIED BY:	**DATE:**

FORM 6B.8		
FUNCTION:	**RESTORATION OF UTILITIES**	
GENERAL APPROACH: Use of original alignment where possible. Containment, collection and proper disposal of hazardous materials.		
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Do not burn fallen poles, packing material. Reuse or remove for proper disposal. If underground fuel tanks are flooded out, stockpile and cover contaminated soil for proper disposal or seal tank for future disposal of contents. Collect and contain asbestos material for proper disposal. Collect and contain any unserviceable water treatment chemicals.	
AMBIENT NOISE	---	
SEA WATER QUALITY	Do not dispose of debris where it can flow into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. Do not burn fallen poles, packing material. Reuse or remove for proper disposal. If underground fuel tanks are flooded out, stockpile and cover contaminated soil for proper disposal or seal tank for future disposal of contents. Collect and contain asbestos material for proper disposal. Collect and contain any unserviceable water treatment chemicals.	
CORAL COMMUNITIES	Do not dispose of debris where it can flow into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. If underground fuel tanks are flooded out, stockpile and cover contaminated soil for proper disposal or seal tank for future disposal of contents.	
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	Keep heavy equipment off sandy beaches and away from nesting areas.	
FISHING GROUNDS	Do not dispose of debris where it can flow into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. If underground fuel tanks are flooded out, stockpile and cover contaminated soil for proper disposal or seal tank for future disposal of contents.	
SALT PONDS	Do not dispose of debris where it can flow into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites.	
FORESTS AND SPECIAL LAND HABITATS	Do not burn (anything) in forested areas. Where possible, restore utilities using original alignment.	

FORM 6B.8		
FUNCTION:	**RESTORATION OF UTILITIES**	
GENERAL APPROACH: Use of original alignment where possible. Containment, collection and proper disposal of hazardous materials.		
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
GROUND WATER	If underground fuel tanks are flooded out, stockpile and cover contaminated soil for proper disposal or seal tank for future disposal of contents. Contain and collect any PCB-containing material for proper disposal. See Section 6.17.	
WETLANDS	Do not dispose of debris where it can flow into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites.	
RIVERS, PONDS, STREAMS		
HISTORIC AND ARCHAEOLOGICAL SITES	Where possible restore utilities using original alignment. Do not dispose of debris in watercourses, sea, salt ponds, wetlands, historic/ archaeological sites.	
VERIFIED BY:	**DATE:**	

FORM 6B.9		
FUNCTION:	**RESTORATION ACCESS**	
GENERAL APPROACH:	Use original alignments where possible	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Do not burn material. Dispose of properly.	
AMBIENT NOISE	Restrict heavy equipment use to daylight hours to reduce disruption.	
SEA WATER QUALITY	Do not dispose of debris, soil or mud in locations where it can be transported into watercourses, sea, salt ponds, wetlands, historic/ archaeological sites.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	Do not operate heavy equipment on sandy beaches or in nesting areas.	
FISHING GROUNDS	Do not dispose of debris, soil or mud in locations where it can be transported into watercourses, sea, salt ponds, wetlands, historic/ archaeological sites.	
SALT PONDS	Do not dispose of debris, soil or mud in locations where it can be transported into watercourses, sea, salt ponds, wetlands, historic/ archaeological sites. Avoid diverting the road into forested areas or across wetlands or salt ponds or through historical/ archaeological sites.	
FORESTS AND SPECIAL LAND HABITATS	Do not burn branches, fallen trees, and vegetation. Dispose of properly or windrow for decomposition. Avoid diverting roads through forests, and special habitats.	
GROUND WATER	---	
WETLANDS	Do not dispose of debris, soil or mud in locations where it can be transported into watercourses, sea, salt ponds, wetlands, historic/ archaeological sites. Avoid diverting the road into forested areas or across wetlands or salt ponds or through historical/ archaeological sites.	
RIVERS, PONDS, STREAMS	Do not dispose of debris, soil or mud in locations where it can be transported into watercourses, sea, salt ponds, wetlands, historic/ archaeological sites. If rivers or streams have been forded, replace with suitably sized culverts as early as practical.	
HISTORIC AND ARCHAEOLOGICAL SITES	No debris disposal at these sites. Avoid diverting roads through historic/ archaeological sites.	
VERIFIED BY:	**DATE:**	

FORM 6B.10		
FUNCTION:	**SLOPE STABILISATION**	
GENERAL APPROACH:	Revegetation, proper disposal techniques.	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	Revegetate exposed surfaces as soon as possible.	
AMBIENT NOISE	---	
SEA WATER QUALITY	Do not dispose of rocks, soil, mud, and debris in locations where it can be transported into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. Regrass exposed surfaces as soon as possible.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	Do not operate heavy equipment on sandy beaches or in nesting areas.	
FISHING GROUNDS	Do not dispose of rocks, soil, mud, and debris in locations where it can be transported into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. Regrass exposed surfaces as soon as possible.	
SALT PONDS	Do not dispose of rocks, soil, mud, and debris in locations where it can be transported into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites.	
FORESTS AND SPECIAL LAND HABITATS	Minimise temporary road cutting in these areas.	
GROUND WATER	---	
WETLANDS	Do not dispose of rocks, soil, mud, and debris in locations where it can be transported into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites.	
RIVERS, PONDS, STREAMS	Do not dispose of rocks, soil, mud, and debris in locations where it can be transported into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. Fuel and service powered equipment away from watercourses, to avoid spills in water.Regrass exposed surfaces as soon as possible.	
HISTORIC AND ARCHAEOLOGICAL SITES	Do not dispose of rocks, soil, mud, and debris in locations where it can be transported into watercourses, sea, salt ponds, wetlands, and historic/ archaeological sites. Avoid cutting roads through these areas.	
VERIFIED BY:	**DATE:**	

FORM 6B.11		
FUNCTION:	**SHORE STABILISATION**	
GENERAL APPROACH:	Use of clean rock. Preservation of habitats.	
ASSET AT RISK	**PROTECTION MEASURE**	**CHECK IF APPLICABLE**
AIR QUALITY	---	
AMBIENT NOISE	---	
SEA WATER QUALITY	Use clean rock with minimum adhering mud, clay for riprap.	
CORAL COMMUNITIES		
SEAGRASS BEDS	Use clean rock with minimum adhering mud, clay for riprap. Use only rock from approved sources.	
SANDY BEACHES AND TURTLE NESTING	Preserve access for turtles to nesting beaches. Do not cover with coarse material nor install physical barriers. Do not operate heavy equipment on sandy beaches.	
FISHING GROUNDS	Use clean rock with minimum adhering mud, clay for riprap. Use only rock from approved sources.	
SALT PONDS	---	
FORESTS AND SPECIAL LAND HABITATS	---	
GROUND WATER	---	
WETLANDS	---	
RIVERS, PONDS, STREAMS	Fuel powered vehicles away from waterways to avoid contamination.	
HISTORIC AND ARCHAEOLOGICAL SITES	Use rock only from approved source.	
VERIFIED BY:	**DATE:**	

FORM 6B.12

FUNCTION: **WASTE MANAGEMENT**

GENERAL APPROACH: Provide for temporary holding of garbage, packing material etc if approved site not available. Minimise waste generation.

ASSET AT RISK	PROTECTION MEASURE	CHECK IF APPLICABLE
AIR QUALITY	Do not burn waste. Dispose of properly.	
AMBIENT NOISE	---	
SEA WATER QUALITY	Dispose of waste in approved landfills if not hazardous materials.	
CORAL COMMUNITIES		
SEAGRASS BEDS		
SANDY BEACHES AND TURTLE NESTING	---	
FISHING GROUNDS	Dispose of waste in approved landfills if not hazardous materials.	
SALT PONDS	Do not place waste in salt ponds.	
FORESTS AND SPECIAL LAND HABITATS	Do not dispose of waste in these areas. Use approved landfills.	
GROUND WATER	---	
WETLANDS	Do not dispose of waste in these areas. Use approved landfills.	
RIVERS, PONDS, STREAMS	Do not dispose of waste in waterways.	
HISTORIC AND ARCHAEOLOGICAL SITES	Do not dispose of waste in these areas. Use approved landfills.	

VERIFIED BY:	**DATE:**

PART II

GUIDELINES

TABLE OF CONTENTS

GUIDELINES

These guidelines supplement the Technical Manual for Post Disaster Rapid Environmental Assessment (Volume 1). For ease of reference, each major section of the guidelines is aligned to the corresponding chapter in the manual; that is, Section G-1 contains information relevant to Chapter 1, etc. Each section therefore bears the name of the corresponding chapter.

G-1 AMENDMENT OF POLICIES AND PROCEDURES

During the interviews in the OECS which formed part of this assignment, Ecoengineering encountered to determine existing disaster response practices, a strong level of support was expressed for the concept of addressing environmental concerns during disaster response in the OECS. However, as noted in the main text of the Manual, successful implementation of the Post Disaster REA will depend on how well it is integrated into the existing Disaster Management System. This section discusses three aspects of that integration:

i. Policy,

ii. Programmes, and

iii. Training.

G-1.1 Policy

At the time of writing, there are no written policies with regard to the application of environmental controls to disaster response activities in OECS Member Countries. It is important that such policies be developed as early as possible, as a precursor to the full implementation of the this Manual and Guidelines. The following are some of the key issues which must be considered in developing the policy.

G-1.1.1 Achievable

Appropriate levels of resources must be made available to ensure that the policy can be implemented. For example, if the policy states that disposal of hazardous waste should be in engineered sites, then these sites must be available at the time of the disaster adverse event.

G-1.1.2 Window of Opportunity

Disasters present a window of opportunity for improvement which should not be missed. The policy should be so framedclearly state that prevention and mitigation measures are must be systematically and automatically integrated into recovery and rebuilding activities. This will avoid, for example, the rebuilding of settlements in flood-prone areas.

G-1.1.3 Standing Rules

Each country has a menu of standing environmental rules (laws, standards and guidelines) which apply in "normal" circumstances. The question which arises is whether these rules will continue to apply in times of disaster response; or if not, which would be exempted. While some rules may be exempted for expediency (for example, the need for a full-blown EIA during the Response Phase), there are others which must remain in force. For example, exemption of rules pertaining to drinking water quality or waste management could lead to the outbreak of disease thus exacerbating the crisis situation.

In the cases where exemptions are granted (that is, less rigorous environmental standards are applied temporarily in the immediate response), it is important to set time limits on the application of these exemptions. The danger here is that these "temporary" solutions can become long-term or even permanent. The policy must also ensure that Cclear responsibility must beis assigned for monitoring the application of the less-rigorous standards, and for ensuring that they are discontinued at the appropriate time.

G-1.1.4 The Rebuilding Phase

The recommendation in the Manual is that the REA should be used primarily during the Response and Rehabilitation Phases. Once the Rebuilding Phase commences, the results of the REA may inform the design of particular elements, but the intention is that "normal" environmental management procedures will be followed (specifically, Environmental Scoping and – if required – Environmental Impact Assessment). The duration of the emergency response phase will depend on a number of variables, such as severity of impact, resources available, size of displaced population and access to the affected area. The decision on timing should be made after consultation between the disaster management practitioners and the environmental management community. The policy should be flexible on this point.

G-1.2 Disaster Management Programmes

Although the REA is intended primarily as a preparedness and response tool, environmental management methods can be made relevant to all phases of the disaster management cycle. Examples are given below.

G-1.2.1 Preparedness and Prevention

Hazard and vulnerability assessments of environmental assets can be used to inform the siting of chemical plants and other hazardous material facilities. For example, they will allow the avoidance of siting such facilities in areas that are at risk from natural hazards or hazards from other land uses. The vulnerability mapping prepared for the REA would assist in this by recording and establishing databases on assets at risk. Beyond this, the design of such facilities should also take natural hazards into account (for example, structural designs should include appropriate earthquake and wind force loadings for the specific location).

In addition to the foregoing, such facilities should be sited in such a way as to mininize environmental impacts of accidental emissions. The mapping of environmental assets undertaken in the REA can assist in such siting decisions.

G-1.2.2 Mitigation

Several of the measures listed in the Manual may be generally applied for the mitigation of environmental impacts for example:

- Storage tanks surrounded by bunds, with the volume of the bunded area able to accommodate the full contents of the tank in the event of failure.
- Siting of facilities, as discussed in Section G.1.2.1, above.
- Factoring of economic value of assets into cost-benefit calculations.

G-1.2.3 Rebuilding

The results of the REA can inform the design of elements which have to be replacesreplaced. This would include considerations such as:

- appropriate locations for specific facilities,
- appropriate design codes for structures, and
- appropriate mitigation measures to be incorporated into the rebuilt facilities.

G-1.3 Training

Because Post-Disaster REA is a new technology being introduced in the OECS, training of personnel is a vital requisite for success. The following sub-sections address the range of personnel who should be trained, and the use of simulation exercises in training.

G-1.3.1 Personnel to be Trained

It is highly recommended that members of the National Disaster Management Organization other than environmental workers should be exposed to REA Concepts. This will ensure that all relevant personnel understand the potential and application of REA, and come to view it as another available tool for disaster management. The table overleaf suggests the range of personnel to receive different levels of REA training.

LEVEL OF TRAINING	SUGGESTED PARTICIPATION
OVERVIEW OF REA: Objectives and Application (2-hour Presentation)	National Disaster Committee, Heads of Environmental Authority
INTRODUCTION TO REA: Objectives Methods and Uses (1-day Seminar)	NEOC Director, National Disaster Co-ordinator, Damage Assessment Team, Emergency Response Personnel, Environmental Officers, Other Personnel using REA
APPLICATION OF REA (3- to 5-day Workshop)	Environmental Officers, Agricultural Extension Officers, Public Health Officers, Forestry Officers, Fisheries Officers, Other Personnel using REA

G-1.3.2 Simulation Exercises

Simulation exercises represent a valuable training tool, providing an opportunity for actors to become more familiar with plans, to rehearse their roles, and to become part of the crisis management team. As the REA will be a new tool, each country using it should organize simulation exercises as part of the training of the teams. During initial training, a table-top exercise may be organized. It would be useful if environmental management personnel are part of the scripting team. Scenarios should be as realistic as possible, and should be based on knowledge of the country, its environmental assets, and hazards faced.

Once the REA Methodology has been adopted, opportunities for its use should be written into any disaster response simulation exercises being planned. That is, the REA Team should be involved in disaster response simulation exercises in the same why way that they will be involved in the response to an actual disaster event.

G-2 MAPPING AND DESCRIBING ENVIRONMENTAL ASSETS

G-2.1 Describing Assets

G-2.1.1 Corals

Survey methods for describing the health of coral ecosystems are recommended by the Caribbean Coastal Marine Productivity (CARICOMP) Program. These methods include chain transects (very similar to chain transects used in forestry) and photo quadrants. It should be noted that the CARICOMP methods are detailed, designed for long term monitoring and may have to be simplified by the respective agencies. Table G-2.1 outlines the specific data which may be collected during a survey.

TABLE G-2.1: REEF DATA TO BE COLLECTED

COMPONENT	DATA
Stony Coral	i Growth, ii Diversity, and iii Abundance
Soft Coral	i Growth, ii Diversity, and iii Abundance
Fish	i Abundance ii Size, and iii Diversity
Macro-Invertebrates	i Abundance ii Size, and iii Diversity However this may concentrate on the more visible species such as urchins and spiny lobsters.
Coral Damage/Disease	i Live coral, dead coral and sand measurements (estimates of cover). ii Diseases on corals, and iii Algal cover.

G-2.1.2 Sea Grass Beds

The survey methods recommended in this section for describing the health of seagrass beds are also summarized from the recommendations of the Caribbean Coastal Marine Productivity (CARICOMP) Program. The methods include:

- Biomass and community composition of seagrass beds from core samples,
- Growth measurements of *Thalassia testudinum*, and
- Leaf area index and chemical composition.

Typically while standing crop and biomass are calculated on the representative community growth and productivity, measurements will only be made from *Thalassia* since it is the competitively dominant and "climax" seagrass species in the Caribbean. *Thalassia* contributes more to total seagrass production than *Syringodium filiforme*, *Halodule wrightii* and *Halophilia* spp.

G-2.1.3 Sandy Beaches

The following are the terms used in Engineering and Geology practice to describe soil and rock based on individual particle sizes:

TERM	PARTICLE SIZE RANGE
Boulder	greater than 200 mm
Cobble	100 mm to 200 mm
Gravel	2 mm to 100 mm
Coarse Sand	1 mm to 2 mm
Fine Sand	0.1 mm to 1 mm

G-2.1.4 Forests

Standard forestry methods such as strip transects and plot-less point quarter methods can provide a description of the composition of forests and as such will reflect the health of the system. Standard forestry methods regularly define a tree as > 10 cm diameter at breast height (dbh). Using such methods, estimates of biomass may even be calculated from the surveys.

G-2.1.5 Wetlands

As with coral communities and seagrass beds, survey methods for wetlands are recommended by the Caribbean Coastal Marine Productivity (CARICOMP) Program. These are detailed methods, designed for long term monitoring. The parameters to be surveyed include:

- Community Composition,
- Interstitial Water,
- Biomass, and
- Productivity.

G-2.2 Uses and Economic Values

G-2.2.1 Corals

Coral reefs have the highest species diversity and are considered the marine equivalent of tropical forests. They are popular with tourists and divers and are important as a feeding ground for fish. Coral reefs also play a role in coastal protection, often serving as natural break-waters which protect the shoreline from wave action. Coral reefs are integrated into the cultural, economic and social aspects of Caribbean life and as such uses and economic value should be used as an additional criteria for ranking coral reefs. The following list identifies some of these:

- Aesthetic value,
- Traditional uses (subsistence fishing, sand mining),
- Fisheries and tourism,
- Sand Mining (from reef edge), and
- Recreation/leisure.

G-2.2.2 Sea Grass Beds

Seagrass beds perform the following important functions and their uses and economic value can be assessed based on these:

- Provide shelter for many species, including juveniles of commercially important species such as queen conch and spiny lobster;
- Provide food for herbivores, including rays and marine turtles;
- Provide a substrate for epiphytic plants upon which other species may graze;
- Help retard coastal erosion by stabilizing loose substrates and reducing current flow through the drag provided by the seagrass leaves;

- Keep sea water clean by filtering and trapping large amounts of fine sediment;
- Bind the sand on the sea bed and prevent the sand from being carried away by water currents; and
- Provide opportunities for recreation and leisure activities such as diving and snorkeling.

Calcareous algae are often interspersed with seagrasses and are important sand sources.

G-2.2.3 Fishing Grounds

Fishing grounds are particularly important to commercial fishing and for recreation. Their uses and economic value can be assessed by considering:

- Traditional uses,
- Commercial catch,
- Sport fishing, and
- Employment generation.

G-2.2.4 Sandy Beaches

Sandy beaches provide the following important functions and their uses and economic value can be assessed based on these:

- For tourism and leisure;
- As habitats for burrowing species such as crabs, coquina (chip-chip), worms, and plants which are especially adapted for the stress;
- For nesting by marine turtles;
- As feeding grounds for shore birds;
- Sand overwash areas behind the beach serve as nesting sites for shore birds; and
- Dunes serve as storage areas for sand to replace that eroded by waves or torn away by storms and thus to provide long-term stability to the shorefront.

G-2.2.5 Salt Ponds

Salt ponds host specialized ecosystems, which have become far less common as increasing numbers of salt ponds are converted to other uses. They are of special interest to the scientific community and to naturalists. The economic value and use of salt ponds may be assessed based on their importance to:

- Commercial extraction of salt, and
- Scientific/educational interest.

G-2.2.6 Forests

Forests serve the following important functions and their economic value and uses can be assessed based on these:

- On a large scale, they contribute to the cycle of rainfall and transpiration;
- Forest cover helps protect watersheds by preserving the stability of slopes, inhibiting soil erosion, regulating water flows and controlling downstream deposition and siltation;
- Forests nourish the soil in various ways;
- Forests contain important species diversity which is potentially a rich source of genetic material for pharmaceuticals/medical products, other products and pest control methods for agriculture;
- Forests provide a source of hardwood and other products such as essential oils, resins, medical substances, rattan, rubber, flowers, bamboo, tannin, gums, honey, beeswax, etc;
- Stands of forest harbor plants, birds, insects and other forms of life that interact with neighbouring agricultural systems; and
- Forests provide recreational opportunities for locals and visitors.

G-2.2.7 Wetlands

Wetlands are diverse and complex ecological systems that serve the following important functions which can be used to assess their economic value and uses:

- Protect the land from erosion and help to build and consolidate silt (so extending coastal areas);
- Purify water through natural filtration and the trapping of silt;
- Are a rich source of food for fish and are favoured breeding grounds for certain

fish and shellfish.

< Provide a habitat for wild life (canopy, roots, mud, associated lagoons and mudflats);

< Are important seasonal habitat for migratory birds, fish, etc;

< Regulate water flows;

< Assimilate organic wastes;

< Have the ability to trap heavy metals or pesticides that would otherwise flow toward the sea, degrading the quality of coastal waters;

< Offer a wide variety of plant and animal products; and

< Offer recreational opportunities to residents and tourist.

G-2.2.8 Rivers, Ponds and Streams

The economic value and uses of rivers, ponds and streams can be assessed based on the following important functions they serve:

< Habitat for aquatic species,
< Drainage,
< Sources of potable water, and water for irrigation, and
< Opportunities for recreation and leisure.

In specific locations, they also provide:

< Sources of food, and
< Transportation corridors.

G-2.2.9 Ground Water

The use and economic value of aquifers is largely as a potable water source. The categories of users (agriculture, domestic, industrial) and the numbers who depend on the water from each groundwater resource should be identified.

G-2.2.10 Historical and Archaeological Sites

The economic value and uses of historical and archaeological sites can be assessed based on their following importance:

< Provide physical evidence of past indigenous cultures and peoples which have helped shape present-day life;
< Form an important part of the cultural heritage; and

< Provide opportunities for study, recreation and tourism.

G-2.3 Threats

G-2.3.1 Corals

Corals are susceptible to changes in temperature and salinity, reduction in light penetration, excessive nutrient loading in the water, and toxic chemicals. They are also structurally fragile and easily damaged by mechanical forces. The threats to coral reefs in the Caribbean and worldwide are varied and extensive. Many of the threats are well known and have been researched in detail while new threats are continuously being discovered. The following list, while not intended to be comprehensive, presents the threats to Caribbean reefs:

< General urban encroachment,
< Pollution from sewage, agricultural and industrial wastes,
< Siltation, sedimentation and erosion related to construction activities (including marine construction),
< Large freshwater inputs,
< Oil Pollution,
< Physical damage from anchors, divers and coral collection,
< Storm damage,
< Disease such as blackband and whiteband,
< Overfishing (spear, trap and cage), and
< Ship groundings.

G-2.3.2 Sea Grass Beds

The threats to seagrass beds are very similar to coral reefs and include:

< General urban encroachment,
< Pollution from sewage, agricultural and industrial wastes,
< Siltation, sedimentation and erosion related to construction activities (including marine construction),
< Large freshwater inputs,
< Oil Pollution,
< Physical damage from anchors and propellers,
< Storm damage, and
< Ship groundings

G-2.3.3 Fishing Grounds

Worldwide two of the major threats to fishing grounds are overfishing and destructive fishing practices. Many countries have recorded declines in fish landings which have been attributed to overfishing and the degradation of fishing grounds by the use of destructive fishing practices such as trawling. In addition, threats to fishing grounds reflect many of the same threats which are likely to affect coral reefs and seagrass beds (see Sections G-2.3.1 and G-2.3.2).

G-2.3.4 Sandy Beaches

Sandy beaches may be threatened by anything that may disrupt the transport and distribution of sand along the beach. Consequently, this may lead to erosion and deposition along the beach or adjacent beaches.

G-2.3.5 Salt Ponds

Some of the threats to salt ponds include:

- Freshwater influx,
- Siltation/Sedimentation of the pond,
- Pollution (solid waste, agrochemicals, industrial wastes, domestic waste, sewage), and
- Erosion of the berm which separates the salt pond from the sea.

G-2.3.6 Forests

The major threat to forests is deforestation caused by fires, over extraction of logs, clearing for agriculture and development.

G-2.3.7 Wetlands

Wetlands are vulnerable to anything which affect the flow characteristics and water quality. Some of the factors which are a threat to wetlands include:

- Siltation, sedimentation and erosion related to construction activities (including marine construction),
- Large freshwater inputs,
- Oil Pollution,
- Physical damage from anchors, propellers,
- Storm damage, and
- Diseases.

G-2.3.8 Rivers, Ponds and Streams

The following threats and others (where noted) should be identified for each surface water body:

- General urban encroachment,
- Pollution from domestic, agricultural and industrial wastes,
- Siltation/sedimentation of watercourses (including clogging due to debris), and
- Alteration/redirection of watercourses.

G-2.3.9 Ground Water

The following factors are a threat to ground water:

< Contamination from domestic, agricultural and industrial sources,
< Salt water intrusion (due to over extraction), and
< Watershed destruction (deforestation).

G-2.3.10 Historical and Archaeological Sites

Historical and archaeological sites are threatened by:

< Pilferage,
< Vandalism,
< Degradation and destruction due to land development, and
< Natural forces (wind, rain, coastal erosion, etc).

G-3 HUMAN-INDUCED HAZARDS

This section of the guidelines makes suggestions for storing information on human-induced hazards (sometimes called risk factors) and discusses the summary sheet which was suggested in Chapter 3 of the Manual.

G-3.1 Storage of Information

Given the level of technology which is presently available in the OECS Territories at the present time, it is very tempting to rely on computerized systems for information storage. While this trend is to be encouraged, it must also be noted that computerized systems may not always be available in the immediate post-disaster period. It is therefore recommended that information to be used by the disaster response team should be stored in two forms. The primary form of information storage may be computerized, but a back-up of paper copies is also necessary. This also requires that a system be implemented to make back-up paper copies every time the primary data-base is updated, and that old paper copies be promptly replaced (and discarded).

G-3.2 Summary Sheets

A typical summary sheet for recording risk factors is shown as Table 1 in the Technical Manual. This section of the Guidelines provides more details about the information that can be entered on this summary sheet, as well as an example of a filled-out summary. As noted in the manual, this format is provided only as an example. It should be modified (or replaced) as best suits the needs in any specific territory.

G-3.2.1 Identification

The first group of cells in the summary is simply intended to identify the facility.

Name of Facility: Use the name by which the facility is commonly known, if this is different from the legally-registered company name. The emergency response team is far more likely to recognize "XYZ Soap Factory" than "XYZ Holdings and Investments Limited".

Contact Person: The contact should be the person most likely to be available in the aftermath of a disaster. This may be the factory superintendent, rather than the chairman of the board of directors.

Location: Describe the location so that it can be found on the ground. Avoid administrative designations such as post office box numbers.

Phone or Radio Contact: List different means of contact (factory phone, mobile/cellular phone, personal phone, car radio, etc), as some may be out of service following a disaster.

Map Reference: If the location is shown on a map, give the map sheet reference.

G-3.2.2 Material of Concern

The second group of cells on the form provides information on the material of concern, and the way it was stored prior to the disaster. The objective here is to allow the emergency response team to identify whether any of the material has been released during the disaster, and to avoid further releases during disaster response activities. It is important to note that at any given facility there can be a wide range of materials stored, so the attention of the emergency response team should be drawn to those which are of particular environmental concern.

Material of Concern (Name and Description):

< the name of the material and general description (colour, odour, etc);

< classification (industrial chemical, fuel, pesticide, herbicide, explosive, fertilizer, insulation, other);

< physical state at room temperature and atmospheric pressure (liquid, gas, solid);

< hazardous properties (corrosive, flammable, explosive, toxic, infectious, asphyxiating, ecotoxic, volatile, or if there are any chronic health effects such as carcinogenesis, mutagenesis etc.); and

< reactivity parameters such as
  - Self Accelerating Decomposition Temperature (SADT), the temperature at which reactive compounds will sustain autoreactivity,
  - Chemical Incompatibility,
  - Water Reactive Chemicals,
  - Heat Sensitive Chemicals, and
  - Highly Reactive Chemicals.

Type of Storage:

< type of storage vessel (boxes, canisters, tanks, etc);

< whether above ground or underground (if confined space entry is required or may be required, this must be indicated); and

< volume or weight of material is stored in individual vessels, and estimated total volume of material stored (if available).

Secondary Containment:

< identify and describe any secondary containment around the storage containers; and

< indicate if the storage area open or enclosed (e.g. in bunkers, warehouses, etc).

G-3.2.3 Personal Safety

The third group of cells in the summary provides information relevant to the safety of the response team as well as the general public in the area. As noted in the manual, this information is not intended to replace the efforts of safety specialists such as the Health Department and the Fire Service. Instead, it is provided as a back-up to the work of those primary protective agencies.

Health Effects:

< type of contact (Ingestion, Eye Contact, Skin Contact and Inhalation) which may result in acute health effects.

Exposure:

< provide exposure criteria, such as
- Time Weighted Average (TWA), that is, a time weighted average concentration of a contaminant gas in air to which it is believed that nearly all workers may be repeatedly exposed day after day, without adverse effect. TWAs are often averaged over for a conventional 8-hour workday and a 40-hour work week. However, in emergency situations, the response team may work longer hours than this. Therefore, adjustments may have to be made in shift lengths if a hazardous material is present.

- Threshold Limit Value (TLV), that is, the concentration that should not be exceeded during any part of the working exposure.

Handling Requirements and Personal Protective Equipment:

< list such requirements and equipment.

Flammability/Explosivity:

< with regard to flammability, provide information such as
- Flash Point (the lowest temperature at which liquid will release sufficient vapour to ignite),
- Boiling Point (the temperature at which a liquid becomes a vapour),
- Auto-ignition temperature (the minimum temperature at which self-sustained combustion will take place), and

  (liquids with low Boiling Points and Flash Points are exceptionally flammable).

< with regard to explosivity, provide information such as
- Lower Explosive Limit (LEL), that is, the minimum concentrations at which a gas/vapour will ignite;
- Upper Explosive Limit (UEL), that is, the maximum concentrations at which a gas/vapour will ignite; and

  (increasing temperatures will increase the range between the LEL and UEL of a gas/vapour)

Fire Fighting Information:

< Flame Temperature (the temperature of the flames when the material is burning), and

< Extinguishing Media (the appropriate extinguishing media to be used for combating fires in the material of concern).

First Aid Requirements:

< provide information on first aid response for the acute health effects identified above.

G-3.2.4 Environmental Concerns

The final group of cells in the summary sheet provide information on the potential impacts of the release of the material of concern into the natural environment.

Environmental Concerns:

< identify what sort of effects on the environment can be expected due to release of the material (smothering effect on watercourses, fish toxicity, bioaccumulation, eutrophication); and

< if available, include the following
- LD50 (this value is the amount of a solid or liquid material that it takes to kill 50% of teat animals in one dose),
- LC50 (this value is the concentration of a material in air that will kill 50% of test subjects when administered as a single exposure of typically 1 or 4 hours).

Sensitive Receptors:

< Using information collected in Chapter 2 of the Manual, list any components of the environment which may be particularly sensitive to releases of the material of concern.

Spill Containment and Recovery Methods:

< Identify appropriate methods for containing and recovering spills of the material of concern, such as the following

- procedures for containment/collection of the spilled material,
- suitable absorbents for the material,
- appropriate containment booms (suitability to spill, non-degrading),
- types of collection vessels required (material of construction, appropriate sizes, etc),
- ventilation requirements,
- special requirements for handling, and
- special requirements for labeling.

G-3.2.5 Example of a Completed Summary Sheet

Table G-3.1 is an example of a completed Summary Sheet (for Diesel).

TABLE G-3.1: RISK FACTOR SUMMARY SHEET FOR DIESEL	
NAME OF FACILITY:	CONTACT PERSON:
LOCATION:	PHONE OR RADIO CONTACT: MAP REFERENCE:
MATERIAL OF CONCERN (NAME AND DESCRIPTION): Diesel Odour - gasoline -like Colourless Physical State - Liquid Boiling Point 180 - 360ºC (Test Method: ASTM D 86) Vapour pressure <0.1 kPa (Test Method: ASTM D 23) Density 840 kg/m3 @ 15ºC (Test Method: ASTM D 1298)	
TYPE OF STORAGE: 2-above ground steel tanks each of 1000L capacity.	
SECONDARY CONTAINMENT: Open storage area surrounded by a concrete berm to create an area of volume 1200L.	
HEALTH EFFECTS: Hazardous if swallowed Aspiration hazard Material may contain significant quantities of polycyclic aromatic hydrocarbons (PCAs) some of which have been shown by experimental studies to induce skin cancer. Repeated exposure may cause skin dryness or cracking.	PERSONAL EXPOSURE LIMITS: There is no appropriate occupational limit for this material. If vapour mists or fumes are generated their concentration in the workplace air should be controlled to the lowest reasonable practicable level. A recommended exposure standard of 5 mg/m^3 for oil mist for an 8 hour time period.

TABLE G-3.1: RISK FACTOR SUMMARY SHEET FOR DIESEL

HANDLING REQUIREMENTS AND PERSONAL PROTECTIVE EQUIPMENT:

Avoid as far as practicable inhalation of vapour mists or fumes generated during use. Avoid contact with eyes. If splashing is likely to occur wear a full-face mask or chemical goggles as appropriate. Do not siphon product by mouth. Do not drink or smoke while using the product. Wash hands thoroughly after contact. Use disposable cloths and discard when soiled. Do not put soiled cloths into pockets. Take all necessary precautions against accidental spillage into soil or water. If operations are such that exposure to vapour mist or fumes may be anticipated then suitable approved respiratory equipment should be worn. Wear face visor or goggles in circumstances where eye contact can accidentally occur.

FLAMMABILITY LIMITS	FIRE FIGHTING INFORMATION
Flash Point:>61.5ºC (PMC) Test Method: ASTM D 93 Upper Explosive Limit: 5.0% Lower Explosive Limit: 0.7%	Flame Temperature: 61.5ºC (PMC) Extinguishing media: Use foam dry powder or water fog. Do not use water jets.

FIRST AID REQUIREMENTS:

Inhalation - If inhalation of mists/fumes or vapour causes irritation to the nose or throat or coughing, remove to fresh air. If symptoms persist obtain medical advice.

Ingestion - If contamination of the mouth, occurs wash out thoroughly with water. Except as a deliberate act, the ingestion of large amounts of product is unlikely. If it should occur do not induce vomiting and obtain medical advice.

Skin -Wash skin thoroughly with soap and water as soon as reasonably practicable. Remove heavily contaminated clothing and wash underlying skin.

Eye - Wash eye thoroughly with copious quantities of water ensuring eyelids are held open. Obtain medical advice if any pain or redness develops or persists.

Product can be aspirated on swallowing or following regurgitation of stomach contents and can cause severe and potentially fatal chemical pneumonitis which will require urgent treatment. Because of the risk of aspiration, induction of vomiting and gastric lavage should be avoided. Gastric lavage should be undertaken only after endotracheal intubation.

Monitor for cardiac dysrhythmias.

Note: High Pressure Applications Injections through the skin resulting from contact with the product at high pressure constitute a major medical emergency. Injuries may not appear serious at first but within a few hours tissue becomes swollen, discoloured and extremely painful with extensive subcutaneous necrosis. Surgical exploration should be undertaken without delay. Thorough and extensive debridement of the wound and underlying tissue is necessary to minimise tissue loss and prevent or limit permanent damage. Note that high pressure may force the product considerable distances along tissue planes.

<table>
<tr><th colspan="2">TABLE G-3.1: RISK FACTOR SUMMARY SHEET FOR DIESEL</th></tr>
<tr><td>ENVIRONMENTAL CONCERNS:

Spills may penetrate into the soil causing ground water contamination.

This material may accumulate in sediments.

This product is inherently biodegradable.

Harmful to aquatic organism and may cause long term effect in the aquatic environment.

Spills may form a film on water surfaces causing physical damage to organisms.

Oxygen transfer is also impaired</td><td>SENSITIVE RECEPTORS:</td></tr>
<tr><td colspan="2">SPILL CONTAINMENT AND RECOVERY METHODS:

Any spills should be regarded as a potential fire risk. In the event of spillage remove all sources of ignition and ensure good ventilation. Clean up spilled material immediately. Contain and recover spilled material using sand or other suitable inert absorbent material. Recovery of large spills should be effected by specialist personnel. Large and uncontained spills should be smothered with foam to reduce the risk of ignition. In case of spillage on water, prevent the spread of the material by the use of suitable barrier equipment. Recover product from the surface. In the case of spillage at sea, approved dispersants may be used here authorized by the appropriate government/regulatory authorities.</td></tr>
</table>

G-4 SAFETY FIRST!

G-4.1 Role of the Environmental Officer

A key finding in the Task 1 Report is that the Environmental Departments in the OECS Territories are not presently well-integrated into the disaster response system. In fact, in some territories the role of the environmental department in disaster response is limited to lending 4-wheel drive vehicles to the disaster response team. This manual assumes that the disaster response organizations will take steps to better integrate the Environmental Departments into disaster response activities.

G-4.2 Management of Emergency Response

All of the OECS Territories now have public service officers who are designated to manage emergency response following disasters. This manual assumes that the Environmental Departments will report to these managers during emergency response.

G-5 ASSESSMENT OF DAMAGE TO ENVIRONMENTAL ASSETS

G-5.1 Corals

Corals and associated reefs are very slow growers and the following are the likely types of damage to corals in the context of natural disasters. Examples of a low damage rating may include turbid waters after a storm which may impede light while an example of a high damage rating may include an abundance of broken and dislodged corals over the entire reef system.

Mechanical Damage can arise from dredging, dragging of anchors or grounding of ships and unusually heavy wave action. Mechanical damage includes broken and/or dislodged corals.

Smothering is related to the marine disposal of dirt and construction rubble, releases of silt-laden water (possibly due to heavy rains) or the construction of temporary groynes or jetties. This appears as a layer of coarse or fine particles burying the corals (see Impeding of Light). Corals have the ability to rid themselves of particles by the movement of the polyps and cilia but this is an energy consuming task. Numerous studies have indicated that corals are unable to withstand cover by particles for periods longer than one or two days. A large quantity of particles will fill in cavities and bury other reef species that are integral to the functioning of the ecosystem. Another type of smothering to be considered is the covering of corals by lava flows and this may additionally affect corals via elevated water temperature.

Mossing can occur as a result of nutrient rich and or highly organic waste entering the sea (eutrophication). Mossing is not likely to be noticed immediately after a natural disaster but may occur with the passage of time. However, eutrophication and reduction in the dissolved oxygen content of the water may occur more rapidly, and result in the death of marine organisms including fish, corals and other invertebrates.

Impeding of Light is closely related to smothering by particles and may also be due to oil spills and algal blooms due to hypernutrification. These activities can all reduce the level of incident light reaching the corals and thus reduce photosynthetic productivity and the overall productivity of the reef. The sedimentation/fallout of suspended particles leads to smothering. In addition to impeding light, suspended particles also affect the respiration and/or feeding of most marine organisms adapted to life on a reef.

"Fish Kills" occur if toxic chemicals are released into the marine environment. These can directly or indirectly kill fishes, corals and other invertebrates or impair their functioning. Attention must be paid to the potential human consumption of contaminated reef life.

G-5.2 Seagrass Beds

The following are the likely types of damage to seagrass beds in the context of natural disasters. Examples of a low damage rating may include turbid waters after a storm which may impede light while an example of a high damage rating may include extensive mechanical damage, which may cover most of the seagrass bed.

Mechanical Damage can arise from dredging, dragging of anchors, grounding of ships, unusually heavy wave action and boat traffic over shallow seagrass flats. Although seagrasses themselves are quite flexible when compared to most corals, the blades can be broken and the plants can also be dislodged or uprooted. Studies have shown that when plants have become dislodged (e.g. from dragging of anchors), and the rhizosphere is disturbed, the resulting scars may remain bare for more than a year.

Smothering: as with corals, seagrasses are also susceptible to smothering, which can be related to the disposal of dirt and silt-laden water, dredging or the temporary building of groynes or jetties. When suspended solids settle from within the water column they accumulate on the photosynthetic surfaces and block the incident light. Further to this fine sediment can often create an unstable substrate in which the grasses are unable to securely anchor their roots.

Impeding of Light affects seagrasses in essentially the same manner as corals. Boat traffic over shallow grass flats can not only cut the grasses but additionally stir up sediments leading to an increase in turbidity and hence light impediment and possibly smothering.

"Fish Kills": as with corals, if toxic chemicals are released to the marine environment these can directly or indirectly kill fishes, invertebrates, seagrasses and other plants or impair their functioning. Attention must be paid to the potential human consumption of contaminated sea grass life.

G-5.3 Fishing Grounds

Since coral reefs and seagrass beds are also marine environments and are often closely associated to fishing grounds, fishing grounds are likely to suffer the same types of damages due to natural disasters. Examples of damage ratings are similar to those for corals and seagrass beds.

Mechanical Damage can arise from dredging, dragging of anchors, grounding of ships, unusually heavy wave action and boat traffic over shallow seagrass flats. Mechanical damage can include broken and/or dislodged corals, broken seagrass blades and dislodged/uprooted plants.

Smothering: as with corals and seagrasses, fishing grounds are also susceptible to smothering, which can be related to the disposal of dirt and silt laden water, dredging or the temporary building of groynes or jetties. Smothering can result in a reduction in the net primary productivity of an area.

Impeding of Light, seagrasses are affected in essentially the same manner as corals. Boat traffic over shallow grass flats can not only cut the grasses but additionally stir up sediments leading to an increase in turbidity and hence light impediment and possibly smothering.

"Fish Kills": as with corals and seagrasses, if toxic chemicals are released to the marine environment these can directly or indirectly kill fish, corals and other invertebrates, seagrasses and other plants or impair their functioning. Attention must be paid to the potential human consumption of contaminated fish from the area.

G-5.4 Sandy Beaches

It should be noted that many Caribbean beaches are formed from coral derived sand. As a result, when corals are severely affected this can reduce the supply of sand to the beach. The following are the likely types of damage to sandy beaches in the context of natural disasters. Examples of a low damage rating may include the removal of small amounts of sand due to storm surges while an example of a high damage rating may include a disruption in the transport of sand (leading to erosion and deposition in different areas), due to the erection of a structure.

Excavation of beach sand to repair structures may occur in the aftermath of a natural disaster. The quantity of sand removed may vary from a few buckets to truckloads of material. The production and transportation of sand along a beach is a slow and gradual process. When large quantities of sand are removed the sand transport system is affected in two main ways (a) the wave refraction pattern is altered and sand from both sides of the excavation enters the gap, and (b) sand transported by littoral drift is trapped in the excavation. The net result is less sand is available for beach replenishment down the coast and the beach erodes. Numerous studies have indicated that the rate of recovery from sand mining is extremely slow, especially for coral sand beaches. Not only can beaches be affected by man's excavation but often after storms there are significant losses due to erosion of beach sand by large swells.

Erection of Structures, even those intended to protect the shoreline (e.g. groynes, jetties, and sea walls), can have adverse effects on beaches. Sandy beaches comprise a dynamic ecosystem with constant erosion, movement and deposition occurring and the erection of structures on the coast can interrupt these natural processes. These structures interrupt the movement of sand particles and cause an imbalance in the processes. Often this results in increased erosion along some parts of the beach and increased accretion in other areas.

Removal of Vegetation can lead to rapid erosion and loss of beach sand. Most natural beach vegetation are fast growers and form runners. Plants disrupt the flow of onshore winds and allow sand to settle. This vegetation network is adapted to withstand changes in wind and sand but not extreme situations nor human feet, grazing animals and vehicles. If this protective vegetative cover is removed sand may be lost at a rate at which it cannot be replaced.

Pollution from oil, sewage and industrial and agrochemical discharges may occur in the aftermath of natural disasters owing to the rupture of lines or storage containers etc. As with all other environments the release of toxic materials has the potential to be devastating. In the case of natural disasters which cause flooding, pollution may also take the form of large quantities of solid waste and/debris being deposited on the beach. Attention must be paid to the potential human consumption of contaminated organisms.

Volcanic Activity, especially lava flows, can cover and destroy sandy beaches which lie in their path.

Flooding, as with lava flows, can occur at sandy beaches due to their low topography. Associated with flooding are the accompanying silt, debris and garbage transported by the flood waters.

G-5.5 Salt Ponds

The following are the likely types of damage to seagrass beds in the context of natural disasters. Examples of a low damage rating may include a minor leak in the berm, leading to a slight lowering of salinity while a major damage rating may include the flooding of the pond by large quantities of freshwater and silt which may even be accompanied by breaching of the berm.

Berm Breach may be caused by intense wave action arising from storm surges, earthquakes and flows of lava or mud. Breach of the berm may result in sea water intrusion, thus altering the specialized ecology of the salt pond. Marine organisms may therefore enter and colonize the salt pond, replacing the specialised halophilic organisms, which previously inhabited the pond. In addition to the influx of seawater is the accompanying sand (see Siltation).

Flooding during periods of high rainfall can result in significant changes in the ecological character of salt ponds. As with berm breach, the salinity of the pond can be greatly reduced in a relatively short period, resulting in the mass death of halophilic organisms. Often, after flooding, ponds contain an abundance of dead halophilic algae which may result in an offensive odour. Similar to berm breach, siltation can also occur (see Siltation).

Siltation: inflows of freshwater and storm surges bring with them silt and sand respectively. This can be a significant load which will be deposited in the pond, decreasing its volume, covering the substrate and reducing or destroying its function as a catchment basin.

Pollution: since salt ponds often act as catchment basins it is reasonable to expect that the concentrations of most pollutants (as with salt) would be above background levels. As with all systems there are optimal levels and tolerance ranges. A significant increase in toxic substances can be detrimental or fatal to a salt pond ecosystem.

Escape of Hydrogen Sulphide can occur when the sediment of a salt pond is disturbed. The upper layers of salt pond sediment are rich in organic matter which is undergoing anaerobic decomposition. One of the products of anaerobic decomposition is Hydrogen Sulphide (H_2S). This noxious gas reduces the oxygen content of water. If hydrogen sulphide escapes from a pond it can lead to the death of organisms in the surrounding marine environment.

G-5.6 Forests

Forests are not only susceptible to deforestation but the trees themselves may be damaged. The following are the likely types of damage to forests in the context of natural disasters.

Defoliation: loss of foliage from trees may occur in the event of strong winds associated with hurricanes and storms. Defoliation can occur as the loss of a few leaves to an almost total loss of leaves on a tree. Generally, this type of damage is not expected to be long-term or detrimental to the life of the ecosystem since natural regeneration should be able to occur. However, in extreme cases of defoliation the recovery period may be much longer or recovery may not be possible.

Broken Limbs may also occur as a result of strong winds associated with hurricanes and storms. As with defoliation this type of damage is not likely to cause the death of trees. Their functioning may be impaired but natural regeneration is expected and broken limbs should not impair the functioning of the forest ecosystem.

Broken Trunks/Tree Fall: where tree trunks become broken or tree falls occur, the majority of these individuals die. Although these trees are not removed from the forest ecosystem, a large primary producer is lost. Loss of a few trees may not be significant but with the loss of a significant number of trees the ecological character of forests can be affected. In the aftermath of a natural disaster, trees may also be indiscriminately removed to create staging areas or for construction. The effect on the functioning of the ecosystem is directly related to the number of trees affected.

Mud Slides remove the topsoil as well as some or all of the trees. As with broken trunks/tree fall, the effect on the ecosystem will depend on the number of trees affected as well as the volume and nature of the soil removed during the mud slide. In severe cases of topsoil removal natural regeneration may not be possible.

Fires due to lightening or volcanic activity can occur. In extreme cases, all of the trees and plants may be burnt and destroyed. In less severe cases it may simply mean scorching of a few individuals or the burning and death of the smaller individuals or those closest to the source of ignition. Natural regeneration can be expected but this may range from total regeneration to a deflected climax which may even be grasses and not trees.

G-5.7 Mangrove

Forests are not only susceptible to deforestation but the trees themselves may be damaged. The following are the likely types of damage to forests in the context of natural disasters.

Deforestation due to natural disasters themselves or by man (for fuel or construction) after a disaster is likely. There may be loss of foliage, uprooting of plants and erosion. In the case of human action, mangroves are often exploited for timber or cleared to make way for ports and marinas. Some natural regeneration can be expected depending on the number of propagules present and the ability of some species to regenerate from stumps. However if the loss/damage is substantial, regeneration may not be likely, and the ecological character may be permanently altered.

Alteration of Water Courses, even minor alterations, have the potential to significantly affect mangrove ecosystems. Watercourses may be diverted by natural disasters or by man in the period following the disaster. Diversion of watercourses by man is among the leading causes of mangrove loss worldwide. Not only do watercourses provide water to mangroves they also provide sediment rich in valuable nutrients. The net primary productivity of mangroves are among the highest on earth and redirection of watercourses may result in a decreased inflow of water and nutrients causing a “die off” of the mangroves.

Siltation, by large quantities of sediment brought by flood waters, is possible even though mangroves are well known for their ability to act as silt traps. A sudden input of large quantities of sediment can exceed the assimilative capacity and has the potential to be detrimental. In such cases, the sediment may cover up the breathing roots which are associated with some mangroves and smother the trees. Losses may be extensive in these instances if the area of deposition is wide.

Chemicals/Wastes can affect mangroves although mangroves naturally act as filters for pollutants which may be brought in by rivers and streams that feed them. This may include pollution from industrial sources including organic wastes and heavy metals, agricultural sources including agrochemicals, as well as from urban sources including sewage effluent. Being a coastal system, mangroves may also be threatened from oil spills which may originate from offshore sources. It is extremely difficult to remove oil from mangroves once they have been penetrated and coated by oil. This can result in mass mortality of the trees and associated fauna. The residue of the waste may continue to impact the area for several years having become trapped in the sediment. Attention must be paid to the potential human consumption of contaminated reef life.

G-5.8 Freshwater Habitats

The following are the likely types of damage to freshwater habitats in the context of natural disasters.

Silt/Debris can clog freshwater habitats impairing their function as drainage systems or storage areas. Natural disasters tend to create a lot of debris due to very strong wind and rain action associated. Where flooding or high runoff occurs the debris often finds it way into watercourses and water bodies causing blockage and loss of the drainage function of this ecosystem. Similarly high wind and rain action accelerates rates of soil erosion causing large amounts of sediment to enter watercourses and water bodies. With the saturation of hillside areas, there may also be land, rock and mud slides, which may also add large quantities of material to watercourses. If the freshwater system is a source of potable water this poses an additional concern.

Chemicals/Wastes may enter freshwater systems due to damage of their containment vessels or pipelines. Freshwater habitats support a variety of fish and other species, which may be adversely affected by the contaminants washed into the water bodies. Dysfunction or death of these organisms may occur, and in the case of persistent chemicals, bioaccumulation in the tissues of freshwater organisms may also occur. Depending on the level of contamination, the system may no longer be able to be used for drinking water or may require additional treatment. Care should be taken to avoid the consumption of contaminated water or aquatic life.

Redirection/Alteration: due to the torrential rainfall associated with storms changes in the direction of flow of rivers and streams as well as the depth of the channel may occur. Meanders may become abandoned as the larger, more powerful water body gorges out a straight path or breaks free of its existing channel to flood nearby areas. Apart from redirection of a watercourse occurring as a direct result of a natural event, post-disaster mitigation measures, which seek to immediately address the effects of the natural disaster, may cause alteration of watercourses. The alteration of water courses often leads to adverse consequences such as flooding and/or the drying up of the downstream areas of the original course.

G-6 MEASURES TO MINIMIZE ENVIRONMENTAL DAMAGE

This section of the Guidelines discusses the use of the checklists, comments on specific measures contained therein, and provides information on collection and disposal of contaminated waste.

G-6.1 Use of the Checklists

In Chapter 6 of the Manual, a series of checklists of measures to minimize environmental damage is provided, each checklist relating to a different disaster response activity. It must be emphasized that none of these checklists represents an absolute list of actions to be taken on all occasions. Instead, each checklist is a menu of measures which may be useful if warranted by the specifics of the disaster at hand. Thus, a degree of reasoning is required before any specific measure is implemented. For example, if a measure is intended primarily to protect wetlands and there are no wetlands in the area, then the use of that measure is not justified.

G-6.2 Comments on Specific Measures

G-6.2.1 Use of Existing Facilities

Several of the measures are based on the use of existing facilities or existing clear areas where these are available. The rationale here is to avoid clearing and occupying new areas if this can be avoided. This has the potential to protect forested areas and the habitat contained therein, as well as historical or archaeological sites.

G-6.2.2 Burning of Rubbish

In many situations, burning of rubbish is considered to be a quick, easy means of disposing of waste. There are, however, certain concerns related to this:

- Untended fires can spread to adjacent forested or vegetated areas;
- Burning of plastics can release exotic contaminants to the air;
- Some of the containers and packaging material can be reused; and
- Much of the organic waste (tree cuttings, etc) will decompose naturally if simply windrowed and left in place.

In the circumstances, alternatives to burning (burial, composting/windrowing, reuse) should be actively considered. Where it is determined that burning is the best option (for example, to remove food waste as an attraction to vermin), this should be done in a controlled location, and the fire should be tended until it is completely burned out.

G-6.2.3 Keeping Water Courses Silt Free

A common mistake is the placement of silt or soil in areas where they can be washed into water courses after the next heavy rains. This is counter-productive, as it creates a second problem of water course blockage. Similarly, problems arise when cleared silt or soil is so positioned that they can be washed into the sea, wetlands or salt ponds after rainfall. The disposal site for cleared silt and soil should be chosen to prevent these problems of wash-off.

G-6.2.4 Handling of Waste Chemicals

The following guidelines apply to the collection of spilled or waste chemicals, and (to a lesser extent) to the collection of contaminated waste.

Use Proper Containers:

- As far as practicable, store liquid wastes in containers that originally held liquids and solids in containers that held solids.
- Make sure that all bottles are in good condition and have the original cap.
- Collect organic wastes in empty organic solvent containers.
- Collect inorganic (acid/base) wastes in empty inorganic containers.
- Secure lids tightly and store waste under a fume hood, in a inflammable cabinet or on shelves.
- Place containers on spill pads or in secondary containers.

Segregate Wastes:

- Whenever possible, keep different hazardous wastes separate so that disposal options are clearer and more cost effective. If this isn't possible, collect waste in compatible containers segregated into these categories:
  a. Halogenated solvents (i.e. methylene chloride, chloroform, carbon tetrachloride),
  b. Non-halogenated solvents (i.e. xylene, toluene, acetone, alcohols),
  c. Acids,
  d. Bases,
  e. Heavy Metals,
  f. Special Wastes (i.e. cyanide, sulfide, oxidizers, organic acids, explosives, peroxides), and
  g. Waste Oil: whenever possible do not mix with solvents, PCB's, etc.

Label Wastes Correctly and Completely

- Label waste containers with chemical content waste labels.
- Date & attach labels to containers as soon as you begin to collect waste.
- Write the complete name and description of each waste/chemical on the label.
- Make sure each label is completely filled out before waste is transported.

PART III

REFERENCE NOTES

TABLE OF CONTENTS

REFERENCE NOTES

These reference notes provide further information on specific topics in the Technical Manual for Post Disaster Rapid Environmental Assessment (Volume 1). As with the Guidelines, each major section of the reference notes is aligned to the corresponding chapter in the manual; that is, Section R -1 contains information relevant to Chapter 1, etc. Each section therefore bears the name of the corresponding chapter.

R-1 INTRODUCTION

R-1.1 Earlier Study

The preparation of this manual was based on the results of a survey to document current (2002) disaster response practices in the OECS, as well as practices in neighbouring CARICOM countries. The results of that survey are contained in the Task 1 Report for this assignment, dated May 03, 2002. The key findings and recommendations of that survey were:

i In 2002, environmental controls were being applied on a case-by-case basis in disaster response planning and implementation in the OECS and neighbouring countries. However, a specific tool was required which would facilitate systematically addressing environmental controls in response to disasters.

ii It was generally conceded that there is the potential for environmental damage during disaster response, but up to 2002 there had been very little post-auditing to investigate such damage.

iii For best results, the disaster cycle should be viewed as a whole. Response efforts (including environmental controls) must be integrated with disaster preparedness.

iv The Rapid Environmental Assessment tool should focus on the Emergency Response and Recovery stages of disaster response. Normal environmental controls should be applied during the rebuilding stage.

v Environmental Agencies should be more closely integrated into the disaster response process.

vi The design of the Rapid Environmental Assessment tool should be appropriate to the available environmental expertise in the OECS.

vii The Rapid Environmental Assessment tool should not disrupt the normal chain-of-command during disaster response.

R-1.2 Typical Durations of Stages in Disaster Response

During the survey which formed Task 1 of this assignment, disaster response agencies in various OECS territories were asked to indicate typical durations of the three stages in disaster response. Their replies are summarized as follows:

STAGE	TYPICAL DURATION
Emergency Response	10 days to 6 weeks. However, it depends on the nature of the disaster. Emergency response for a hurricane may be completed within 36 hours, but for a drought this stage may last for months.
Recovery	72 hours to 6 weeks.
Rebuilding	Several months to years.

R-2 SIGNIFICANT ENVIRONMENTAL ASSETS

This section of the Reference Notes provides additional information on some of the significant ecosystems found in the OECS Territories. A short reference list is placed at the end of each sub-section.

R-2.1 Coral Reefs

R-2.1.1 Background

Corals are tiny invertebrate animals called polyps which belong to the phylum Cnidaria. They can be divided into two large groups, soft corals and hard or stony corals. It is the stony or hermatypic corals which form coral reefs. The reef-building corals secrete calcium carbonate which forms the exo-skeleton of the coral and the framework of reefs. The result of this process is a continual growth of the coral reefs. There are over 700 species of hermatypic corals but only 65 species occur on the reefs found in the Caribbean. There are several types of coral reefs. These include, fringing reefs, platform or patch reefs, bank reefs, barrier reefs and atolls. The Caribbean Sea is home to all these types of reefs.

Corals have a symbiotic relationship with microscopic algae called zooxanthellae that live within each polyp. Zooxanthellae are photosynthetic and convert sunlight and carbon dioxide into oxygen and carbonates. This provides nutrients for the polyp, which in return provides a secure environment with access to sunlight for the zooxanthellae.

R-2.1.2 Growth Conditions

Corals generally have a narrow range of tolerance to many environmental variables. These limits vary, however, with species and with the local environmental conditions. Generally, coral reefs are found where the water temperature is between 18 EC and 30 EC and with an optimum salinity (for most species) of about 34 to 38 ppt. Specifically, the water temperature ideal for optimum development of tropical corals is between 23E - 25EC with a salinity below 25 ppt . Coral reefs grow at depths shallower than 100 m.

Coral reefs are susceptible to continued heavy siltation. Although corals have a limited ability to cleanse themselves (by means of ciliated cells on the upper epidermis of the animal), they may expend too much energy in eliminating non-nutritive particles or may be literally smothered. Siltation is closely related to turbidity or the presence of suspended particles in the water. Light penetration in turbid waters is considerably reduced. This adversely affects the symbiotic algae contained in the coral polyps since they require light for photosynthesis. Specific light requirements for corals are not known. It is reasonable to assume, however, that Caribbean reefs, accustomed to very clear waters, are very sensitive to light reduction.

R-2.1.3 Benefits of Coral Reefs

- Coral reefs provide vast fisheries that coastal communities depend upon for economic development, recreational tourism and employment.
- Coral reefs act as natural barriers that protect coastlines from tides, storms and hurricanes. They dissipate the wave energy and decrease the destructive stress upon the coast.
- Pharmaceuticals currently used in the treatment of heart disease and cancers were discovered on coral reefs, and new compounds isolated from corals show potential as powerful anti-microbial and antiviral agents to combat disease in the future. In addition, scientists have developed an extraordinarily potent pain-killing drug from the toxin of a reef-dwelling snail used for the treatment of severe pain in the terminally ill who are resistant to morphine. Even coral skeletons are utilized (as bone substitutes in reconstruction bone surgery).
- The diving and snorkeling industry has become a booming part of the tourism business and supports many coastal communities in the Caribbean, as well as, all over the world.

R-2.1.4 Natural and Human Hazards

The following is a listing of some of the hazards to coral communities from natural and human sources:

Prolonged Heavy Rainfall - Excessive rainfall causes large amounts of fresh, silt laden water from the land to the sea. High turbidity as a result of this causes a reduction in the growth rate of the corals and low salinities may cause the polyps to eject their symbiotic partners.

Bioerosion - Several species of fish (butterflyfish, parrotfish and angelfish) nibble at the coral, while other organisms bore holes in the coral in search for food.

Diseases- There are two major diseases which affect corals. Both black band disease (which is caused by an algal infection) and whiteband disease affects soft coral tissue.

Bleaching - This phenomena causes the corals to expel their symbionts thereby losing their colour. Bleaching stops coral growth and other organisms compete against the corals and the corals die. The most common cause of bleaching is an increase in water temperature but it may also be caused by cyanide and other stressful conditions.

Thermal Pollution - Most tropical organisms exist near their upper temperature limits. Corals, made up of countless minute individual delicate polyps, have an extremely high surface to mass exposure. Heated effluents which elevate water temperature above 30EC will adversely affect many corals. Prolonged temperatures above 40EC will kill most corals. Prolonged exposure to hypersaline discharge which elevate salinities to above 40 ppt is also detrimental to reefs. Fresh water discharges lowering salinity below 30 ppt can also affect reef composition.

Chemical Pollution - Some of the most harmful substances are chemical insecticides and fertilizers used in growing crops. Sewage also causes harm to corals. The more obvious contributions of sewage are lower salinity, high oxygen demand, high nutrients, turbidity, sediment and toxic compounds. Enrichment of water in the vicinity of reefs may be beneficial up to a point. Corals are filter feeding animals and take fine digestible organic matter and small organisms from the water. Enriched water may increase the supply of these items but will also increase the growth of algae and other forms which can overgrow, smother and compete with the corals for food and oxygen.

Oil Pollution - Reefs are also exposed to oil pollution from offshore oil exploration and storage facilities, oil tanker accidents and from other vessels discharging their waste into the sea. When oil sticks on the corals, the corals react by secreting large amounts of mucus. This mucus attracts colonies of bacteria which decompose it and a black shiny mass forms.

Collectors - a small piece of coral removed from the reef may take hundreds of years to grow back to its original size.

Construction - Various types of construction works cause damage to coral reef systems, such as dredging, construction of highways and hotels along the coast. The sediment from these works fill the water and smothers the reef organisms. In addition, any construction work which requires either the digging up or the filling in of a coral reef would of course, be detrimental to the system.

Dynamite Fishing - Dynamite or blast fishing is a practice in which fishermen use explosives to kill and harvest fish. The explosion, which indiscriminately kills all fish within the blast radius also destroys living coral. An explosive the size of a coke bottle will shatter to pieces all stony corals within a three metre radius. Repetitive blasting in an area reduces coral to rubble, which cannot support marine life.

Cyanide Fishing - Cyanide fishing is used to capture fish live for aquariums as well as for "live fish" restaurants. Divers squirt a cyanide solution from bottles directly onto fish resting on corals, killing the corals and stunning the fish. The fish often escape into crevices and the divers have to break apart the coral to get to their paralyzed prey. The cyanide disrupts the zooxanthellae that live in their coral hosts and causes them to discharge out of the corals in a process known as coral bleaching. The coral polyps are unable to survive because of lack of nutrients. This method of fishing is not used in the Caribbean.

Fish Traps - This type of fishing uses a wire trap to capture fish. These traps capture both large and small fish and therefore disrupt the coral reef ecosystem.

Anchoring - Boat anchors dropped onto reefs damage the reef structure when they are dragged.

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R-2.2 Sea Grass Beds

R-2.2.1 Background

There are three types of seagrass found throughout the Caribbean. These are Turtle Grass (*Thalassia testudinum*), Manatee Grass (*Syringodium filiforme*) and Shoal Grass (*Halodule wrightii*). They are unlike the majority of marine plants, (which are algae), in that they are true flowering plants. Annually, they produce flowers and seeds. However, the prolific growth is mostly due to spreading via runners with emergent shoots. Seagrass requires sunlight for photosynthesis and is therefore most often found in shallow, clear waters. Seagrass beds are among the most productive marine habitats in the world, supporting a myriad of plants and animals, large and small.

There is a very close knit relationship between the plants and animals in this habitat, both spatially and physiologically. The plants usually do not exceed eight inches in height, and all but a few of the associated animals live within this zone or in the sediment. Thus, except for visiting foragers and predators, the majority of community energy cycling goes on in close quarters. Wastes from the animals are utilized by the plants which produce oxygen and forage.

R-2.2.2 Distribution

The distribution of sea grass beds is controlled by a number of factors: sediment quality and stability, depth, water clarity, currents, grazing by herbivorous animals, etc. They usually do not extend below 60-70 feet depth. Their growth is interrupted in channels or other areas with swift currents or in surge areas when the sediment is constantly tossed, for example, close to a beach.

Seagrass bed edges are grazed away near reefs or other solid objects by fishes and sea urchins. Thus, there is almost always a band of bare sand between a reef or rubble pile and the surrounding seagrass bed.

R-2.2.3 Function

Seagrass beds perform a variety of functions in the near shore environment. With a root system that can grow as deep as three feet into the sediment, turtle grass plays an important role in stabilizing sediments which otherwise would get washed away with the current. Their flat blades are able to trap sediments which may be floating in the water, thereby filtering the water and keeping it clear. This is not only important for the seagrass, but also for the nearby coral reefs which also require sunlight to grow.

Seagrass beds provide a safe haven and nursery for juvenile animals as well as food for these and larger animals including the Green Sea Turtle and the West Indian Manatee. A diverse group of animals live in the sand between the plants, and the bottom is often heaped into mounds marking the burrow entrances of large worms and shrimp.

Sea grass beds produce a significant amount of (some authorities say most of) the oxygen generated in inshore waters. On a bright day, dissolved oxygen over a healthy grass bed will exceed the saturation value, and small bubbles rise from the leaves to the surface. Seagrass beds also help to stabilize the sand. Where they front a beach, they act as a "footing" to retard seaward loss of sand from the beach.

R-2.2.4 Natural and Human Hazards

Seagrass beds are easily depleted, being especially vulnerable to pollution of all types including heat discharged from power plants and the turbidity induced by them. Turbidity from silt and eutrophication screens out light and prevent growth of grass. Fine sediment (mud) often creates an unstable bottom condition in which the grasses cannot anchor their roots. Boat traffic over grass flats may compound the problem by stirring up the sediments and ripping up the plants.

Small continuous sewage discharges can actually be beneficial to the seagrass beds by causing affected areas of grass to grow extremely rapidly and produce long leaves. Prolonged enrichment however, usually encourages atypical species of algae, indicative of pollution *(Ulva, Enteromorpha, Cladophora)*.

For unexplained reasons, patches of grass removed by various means (dredging, boat anchors) may not be replaced for years. In areas which have been dredged, the seagrass beds generally do not become re-established for many years. Even small swatches cut by an anchor, a dredge, or a boat's propeller, may remain bare for a year or longer.

REFERENCES ON SEA GRASS BEDS

Island Resources Foundation, Marine Environments of the Virgin Islands, Technical Supplement No. 1, prepared for the Office of the Governor, Virgin Islands Planning Office, Coastal Zone Management Program, August, 1977.

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R-2.3 Salt Ponds

R-2.3.1 Background

Most salt ponds are isolated former bays or parts of a bay. Over time, they have become closed by reef or mangrove growth across the bay. The closure may be accelerated by sand and other debris tossed up onto shallow banks during storms. These ponds are sometimes replenished by water from the neighbouring bay. Within these ponds, evaporation is very rapid so that the salinity increases and the pond, if not replenished from the sea or by rain water, will dry up completely leaving crystallized salt on the surface. This characteristic high salinity (ranging from 115 to 180 ppt) results from high evaporation of runoff waters which are then stirred by winds, keeping the sediments in suspension.

Occasionally, a pond berm will be breached by storm water from the land or sea. When this occurs, the pond can be re-invaded by marine animals, usually crabs and fishes. These will die off as the pond is again cut off from the bay and salinity increases again.

R-2.3.2 Diversity

The biota of a salt pond is very specialized and limited compared to that of the adjacent bay, but its ecology is complex and dynamic. Common animals are fiddler crabs and larger land crabs *(Cardisoma guanhumi)*. Several kinds of insects which prefer saline environments live or breed in these ponds, including a fly *(Salina gracilis)* and several kinds of midges. Mosquitoes may breed there during brief periods when heavy rains lower the salinity sufficiently.

Several kinds of microscopic algae float in the water sometimes giving it a green, pink, orange, brown, or red colour. Other micro-algae grow as mats on the shallow margins. A number of wading birds (stilts, sandpipers) feed along the edges of the ponds on crabs, insect larvae and other small animals. Ponds frequently contain large numbers of brine shrimp *(Artemia)* which is in great demand throughout the world as food for aquarium fish, aquaculture and research organisms. Thick blooms of *Artemia* can give the pond water a brownish-pink tinge.

At times when the pond banks are breached, it will contain fishes (sennets, small barracuda, mullet, tarpon, snook) and marine crabs. These are fed upon by king-fishers, herons and ospreys. Kingbirds, martins and swallows frequently feed on flying insects over the water.

R-2.3.3 Environmental Characteristics

Salt ponds may concentrate to more than three times that of sea water (over 100 parts per thousand), or may be depressed by heavy flooding to almost fresh water. Periodic changes of even one-third of this magnitude would cause significant changes in the types and numbers of organisms inhabiting the pond. Slow changes, as by evaporation concentrating the salt, would promote a gradual die-off of some forms and gradual invasion and development of others. There would be a constant, slow modification of the natural community in response to this change.

Sudden changes in salinity, as by flood waters, causes catastrophic changes in the biota. Masses of halophilic (salt-loving) forms are killed while other types, suited to the new, less saline environment, quickly invade the pond and become established. Following heavy flooding, many ponds contain great amount of dead halophilic algae, insects, etc. These often account for the occasionally bad odour of a pond.

Other environmental characteristics of salt ponds are high concentrations of hydrogen sulfide, especially in the sediments (from the decay of dead organic matter), high temperature (from isolation with lack of shade), low dissolved oxygen (from high temperature, salinity and BOD), and high turbidity (from large concentrations of land and pond-derived solids).

Although no specific data is available, it is safe to assume that ponds also contain higher concentrations of most pollutants than, for example, their adjacent associated bays. This is likely because of the natural ecosystem function of salt ponds as buffer zones and sumps. As they are located between the bay and its upland watershed, they receive and trap most of the runoff from the land, thus protecting the bay.

Because most of the upper layers of pond sediment are highly organic and being anaerobically decomposed, disturbing these sediments usually releases obnoxious sulfide odours. When these materials are dispersed, they use up the available oxygen rapidly. This can kill animals in the water. These ponds serve as sediment basins in collecting and filtering rainwater runoff which could severely damage ecosystems such as coral reefs and seagrass meadows in the nearshore waters.

REFERENCES ON SALT PONDS

Island Resources Foundation, Marine Environments of the Virgin Islands, Technical Supplement No. 1, prepared for the Office of the Governor, Virgin Islands Planning Office, Coastal Zone Management Program, August, 1977.

Lie, V., “Marine Ecosystems: Research and Management”, in Managing the Oceans (J. G. Richardson, Ed), Lomond Publications, Maryland, U. S. A., 1986.

Clarke J., Coastal Ecosystems, Ecological Considerations for Management of the Coastal Zone, The Conservation Foundation, 1974

R-2.4 Forests

R-2.4.1 Forest Types in the OECS

Despite the fact that the term "forest" is used generically (and the term "rain forest" has come to be used indiscriminately), there are, in fact, a number of different forest types in the OECS. These are introduced in Table R-2.1, at the end of this section. The differences between these forest types are important in the context of conservation.

R-2.4.2 Deforestation

In the tropics, the issues driving deforestation are very intense, because for hundreds of millions living in these countries the struggle is for survival. Growing rural populations invade the forests in search of land for their crops, fuel for cooking, and fodder for their animals. Governments impelled to raise foreign exchange earnings and employment, and to finance economic development programs, turn to the forests as a resource that can readily be exploited. Under this relentless assault, forests in the Third World are retreating. Every year more than 11 million hectares are cleared for other uses.

In the CARICOM Region, deforestation rates in the early 1990s were estimated (or "guestimated" as follows:

Country	Annual Rate of Deforestation	Deforestation per Year (Hectares)
Belize	0.6%	9,000
Jamaica	3.3%	15,000
St. Lucia	0.5%	33
St. Vincent and the Grenadines	--	175
Trinidad and Tobago	0.3%	1

These figures show only a fraction of the losses: the area completely cleared to make way for other uses. Forests and woodlands are also deteriorating in quality. Virgin forests are harvested, becoming "secondary" forest. Under prevailing practices, most of the mature stems of those few species with commercial value are removed (usually amounting to 10-20 percent of standing volume) but typically another 30-50 percent of the trees are destroyed or fatally damaged during logging, and the soil is sufficiently disturbed to impede regeneration, leaving a forest much diminished in quality.

Demands for tropical timber is not limited to subsistence needs in the developing countries, but springs in large part from rapidly growing demands in richer countries of the North for exotic tropical hardwoods. To supply European, Japanese, and American markets, countries exploit their mature forests for commercial species with little heed either for the pace or possibility of regeneration or for impairment of other forest functions and yields.

Tropical forests are slow to recover fully once disturbed, and although total primary productivity is high, the annual growth of the relatively few prized commercial species is relatively low in a heterogeneous stand. Although secondary tree species will quickly revegetate forest clearings unless soils have been severely depleted, canopy trees and large individuals emerging through the canopy may take a hundred years or more to mature, and the density of commercial stems will likely be lower than in the original stand.

R-2.4.3 Uses of Tropical Forests

Because of their biological richness, tropical forests are a potential source of a wide variety of sustainable products. A single hectare of tropical forest may contain 300 different trees, most of them represented by a single individual. The Amazon contains one-fifth of all bird species on earth, and at least eight times as many fish species as the Mississippi River system. A single tree in the Amazon was found to shelter 43 ant species from 26 genera, a greater diversity than exists in all the British Isles. (Current uses are only a very minor fraction of the potential benefits.) Tropical forests as a standing resource confer important ongoing benefits:

- A wide variety of nuts, berries, game, fish, honey and other foodstuffs are available for domestic use; as well as resins, essential oils, medicinal substances, rattan, flowers, and a wide variety of other products which may be exploited commercially.

- Genetic material for plant breeders that confers disease and pest resistance and other desirable properties to coffee, cocoa, bananas, pineapples, maize, rice and many other crops.

- Entirely new foods such as the mangosteen and the winged bean.

- Pyrethrins, rotenoids, other insecticides and insect repellants, and insect predators and parasites.

- Pharmaceutical products (including alkaloids such as quinine and others used in drugs to treat hypertension, childhood leukemia, and Hodgkin's disease; and plant steroids such as diosgenin, which comes from Mexican yams and West African calabar beans and is used in oral contraceptives).

Attempts to substitute monocultures, whether of annual or tree crops, typically encounter declining yields and invasion by pest and weed species. Plantation crops that are most successful in the tropics are those such as tea, cocoa and rubber that remove relatively little of the nutrient stock. Traditional long-fallow shifting cultivation systems also give the forest ecosystems ample time to recover, but most annual cropping efforts have proved to be economic as well as ecological failures. Agricultural settlement schemes and large-scale plantations have incurred economic losses and, if not covered by continuing government subsidies, have led to the eventual abandonment of large areas of degraded soils and impoverished biota.

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Caribbean Conservation Association, Country Report on the Environment: Antigua and Barbuda, 1991.

TABLE R-2.1: FOREST TYPES IN THE OECS TERRITORIES
RAINFOREST (*Dacryodes-Sloanea* Association) The dominant trees of this forest are Gommier (*Dacryodes excelsa*), Chataigne, and Mahoe. In both Antigua and Barbuda, the rainforest is not one of the principal natural vegetation types and in St Kitts there is a lack of well-developed rain forest. This primary rainforest generally lies over 1,000 feet where there is abundant precipitation. Species in the under-canopy include *Licania ternatensis* and *Tapura antillana*, in addition to a number of epiphytes and lianas. In Dominica, the "nature" island of the Caribbean, mature rainforest occurs toward the interior of the island, generally not below 1,000 feet and having few periods without precipitation. The canopy is dominated by *Dacryodes excelsa*, Slonea spp., and *Amanoa caribea*. Under-canopy species include *Licania ternatensis* and *Tapura antillana* and numerous epiphytes and lianas.
SECONDARY RAINFOREST This consists of areas once occupied by primary rainforest that have been disturbed by either natural occurrences or human activities. It is characterized by *Miconia* species, *Cecropia schreberiana*, and *Simaruba amara* (in smaller gaps). The prominent species however are the mountain cabbage palm (*Euterpe globosa*), gumlin (*Dacryodes excelsa*), and burrwood (*Slonea truncata*). Secondary forests occur in most islands within the Caribbean due to increased human activities and the effects of hurricanes.
DRY EVERGREEN FOREST This is classified as secondary forest occupying lands below rain forest. Dominant species of this forest are white cedar (*Tabebuia heterophylla*), black mast (*Diosyros ebenaster*) and loblolly (*Pisonia fragrans*).
PALM BRAKE This is generally found over heights ranging from 1,200 to 1,800 feet. It is dominated by palms (mainly the mountain cabbage palm, *Euterpe globosa*) and the remainder of the forest is made up of tree ferns (*Cyathea arborea*) and small trees. It is located on either very steep slopes or places which are exposed to high winds.

TABLE R-2.1: FOREST TYPES IN THE OECS TERRITORIES
ELFIN WOODLAND (*Didymopinax-Charianthus* Association) Elfin woodland is found above 2,000 feet elevation and is usually laden with mosses and epiphytes, and matted with lianas. The trees are generally short, gnarled and wind-deformed. It is characterized by *Clusia venosa* and *Lobelia cirsifolia*.
DRY SCRUB WOODLAND This vegetation type occurs down-slope of secondary rainforest. Present are many different species of Acacia and Cassia. Additionally, there are century plant (*Agave americana*), Prickly Pear Cactus (*Opuntia rubescens*), and Pope's Head or Barrel Cactus (*Euphorbia pulcherrima*). They generally are formerly forested areas.
SCRUB WOODLAND This vegetation type occurs at lower elevations, with a floral community dominated by a scrub layer and representing the most xeric (dry) conditions on some of the Caribbean islands. Characteristic species are *Lonchocarpus pentaphyllus*, *Pisonia fragrans, atoxylon campechianum*, *Myrsia atrifolia*, *Chrysophyllum argenteum* and *Erythroxylum ovatum*.
LITTORAL WOODLAND This vegetation type occurs along the coastline. The tree canopy is subjected to nearly constant onshore winds yielding asymmetrical tree growth shaped from the sea breezes. The species of this community are salt spray tolerant and are characterized by *Coccoloba uvifera*, *Chyrsobalanus icaco, terminalia cattapa* and *Tabebuia pallida*.
MONTANE THICKET (*Micropholis-Podocarpus* Association) This formation occurs at high elevations, about 3,500 feet. The species are characterized by *Richeria grandis*, *Byrsonima martinicensis* and *Podocarpus coriaceus*. Making up the understory are *Heliconia bihai*, the tree ferns *Cyathea imrayana* and *Hemitelia* spp., and razor grass *Scleria latifolia*. It does not occur in St Vincent.
LOWER MONTANE RAIN FOREST (*Licania-Oxythece* Association) This formation is found up-slope from the rainforest, however, it is below mountain peaks and ridges. The dominant trees include Corosol Marron, Dacryodes, Paletuvier, Balata Chien, Laurier Puant and Balata.
HUMID-VALLEY FOREST This exists is small areas and is dominated by the ciba tree (*Ceiba pentandra*). Other species include *Ficus* spp., *Delonix regia*, and wild fruit trees. There are no ferns and very few vines, epiphytes and palm trees. It is found in areas with well-drained soils and great water availability.
SEMI-EVERGREEN FOREST Classified as a transition vegetation zone in which the species have characteristics of both dry and rain forest.
FUMAROLE VEGETATION Plant communities are restricted to areas of geothermal activity. Characteristic species are various melastomes, particularly *Tibouchina ornata*. There are also some endemics which are prominent, notably *Pitcairnia micotrinensis*. This type of vegetation is well formed on the island of Dominica in the Valley of Desolation.

R-2.5 Mangroves

R-2.5.1 Background

The most characteristic feature of any mangrove system is the mangrove trees. These are flowering trees of a number of different species referred to by the common name "mangrove". They are tolerant of both salt and brackish water and are able to obtain moisture from the sea-water and nutrients from the sediments of shallow marine lagoons.

Mangrove forests within the Caribbean are made up of three types of mangrove trees, Red Mangrove *(Rhizophora mangle)*, White Mangrove (*Languncularia racemosa)* and Black Mangrove *(Avicenia nitida)*. *Rhizophora*, known as "the plant that makes land", is the most typically recognized species. It grows at the water's edge, and new seedlings become established seaward. These trees provide support, nesting sites and hiding places for a wide variety of marine animals. Mangrove plants have special adaptations that allow them to colonize their extreme environment such as exposed breathing roots, support roots and buttresses, salt excluding or secreting leaves and viviparous dispersal propagules.

The prop roots system of the plants traps sediments that accumulate from the plants or are washed down from the land. By this process, the shoreline is slowly extended. Once the sediment becomes rather firmly established, the red mangroves die off naturally and are succeeded by other plants, initially black and then white mangroves. This sequence of succession creates a pattern of zonation in which the pioneer red mangrove is at the water's edge, black mangroves occupy a zone behind and white mangroves are more inland, but still in sand soil. Mangroves, therefore, by their dense coverage and complex root structures at the shoreline, interrupt runoff from the land and help to trap fresh water, sediment and debris at the shoreline, thus protecting offshore marine areas from these pollutants.

R-2.5.2 Growth Conditions

Mangroves require certain conditions for establishment and sustenance and, in turn, modify the environment in a characteristic way which further favours their proliferation. Mangrove systems vary in their development, from scrub vegetation found as coastal fringe, to well developed stands with heights of up to 25 m found at river mouths. This variation depends on levels of rainfall and fresh water input from riverine and groundwater systems, the tidal range, salinity levels, degree of shoreline protection from high energy waves, the accumulation of fine-grained sediments and localized conditions in the various parts of the islands.

For example mangrove distribution is often restricted by the lack of large rivers, and they are primarily found in the low depositional areas of the coastline that have a constant flow of both tidal and fresh water. Mean rainfall varies throughout the region, ranging from 800 mm in parts of Jamaica to over 5,000 in parts of Puerto Rico. The mean tidal range also varies, but is in the vicinity of 0.34 m, the level found in Cuba, where springtides reach up to 0.90 m.

R-2.5.3 Productivity

Mangroves are characterized by high productivity, particularly due to a very rich supply of inorganic nutrients. These are in part imported from land or from the sea, but a major part of the nutrient requirements of the mangrove ecosystems is derived from regeneration within the ecosystems. All the mangrove ecosystems are effective sediment traps, organic material brought into the systems by drainage from the land or produced within the ecosystem (including the leaves of the mangrove trees) being deposited in the sediments on the bottom. This leads to a very active degradation of the organic matter by micro-organisms, and subsequent release of inorganic nutrients from the sediments to the water due to the turbulence created by river flow or tidal action.

The primary production of the mangrove ecosystem is high, and the waters of the mangrove systems are often characterized by high turbidity (oceanographers often refer to them as 'brown water systems' as distinct from the oceanic 'blue water systems'); and this prevents penetration of light and limits the growth of microalgae in the water masses. The major producers are therefore plants that have the ability to utilize the water and the nutrients of the aquatic environment, and the light above the surface of the water. The primary production of these plants is 300-1000 grams of carbon per square metre per year.
Each year red mangroves drop large quantities of leaves and seedlings, all of which do not survive to become new plants. The natural decomposition of these materials sustains a complex food web beginning with micro-organisms and scavengers and culminating in such higher trophic members as snappers, barracuda, lobsters and birds. The nutrients and other food energy supplied by plant litter decomposition account for the large numbers and wide variety of plants and animals which are found in climax mangrove communities.

R-2.5.4 Diversity

Because of the wide variety of environmental conditions and ecological niches in a rather small area, mangrove forests are characterized by an unusually wide variety of wildlife, particularly marine life and birds. Wildlife diversity in mangrove ecosystems is second only to the coral reefs in the Caribbean. The large numbers of fishes, birds, crustaceans and other animals that live in a mangrove area are dependent basically on the nutrients and vegetable matter produced from the leaves of mangroves and sea grasses. This material is eaten by vegetarian and omnivorous animals. Their excrement and the organic soup from rotting of other leaf litter provide food for plankton (single-celled plants, larval animals) and bacteria. These, in turn, are eaten by larger animals, including those harvested by man.

The upper parts of the tree, the branches and leaves, are parts of terrestrial ecosystems as they provide food and habitat for insects and birds, whereas the lower parts, the branched roots, are important features of the marine mangrove ecosystem. Dead leaves from the canopy are important sources of organic matter for the marine mangrove system.

Coastal mangroves together with coral reefs and seagrass beds are often interdependent and, together, form a highly diverse and structurally complex ecosystems in which the reef acts as a barrier that shelters seagrass beds and mangroves from high energy waves and strong coastal currents typical of the Caribbean environment.

R-2.5.5 Hazards

Predators can greatly affect the survival of propagules and seedlings in mangrove ecosystems. Crabs, snails, insects, monkeys and fish all may consume mangrove propagules.

Mangroves are also exploited for timber, fuel wood and charcoal, shrimp and lobster which may be exported and oyster and fish sold in domestic/international markets. Mangrove bark is also in demand for leather tanning.

Of particular concern in the Caribbean is the apparent increase in the frequency and intensity of tropical storms and hurricanes which damage mangroves.

REFERENCES ON MANGROVES

Island Resources Foundation, Marine Environments of the Virgin Islands, Technical Supplement No. 1, prepared for the Office of the Governor, Virgin Islands Planning Office, Coastal Zone Management Program, August, 1977.

Lie, V., “Marine Ecosystems: Research and Management”, in Managing the Oceans (J. G. Richardson, Ed), Lomond Publications, Maryland, U. S. A., 1986.

Clarke J., Coastal Ecosystems, Ecological Considerations for Management of the Coastal Zone, The Conservation Foundation, 1974

R-3 RISK FACTORS

R-3.1 MSD Sheets

Material Safety Data Sheets (MSDS) are now a standard document provided by chemical manufactures. These sheets list important information concerning health, safety and environmental aspects of the product being sold. MSD sheets are provided with shipments of materials, and are also available directly from the manufacturers (or local agents) or from selected web sites:

www.ilpi.com/msds/index.chtml

www.msdssearch.com/

www.phys.ksu.edu/area/jrm/Safety/msds.html

As an example, the MSDS for 5% Malathion is shown in Table R-3.1

TABLE R-3.1- MATERIAL SAFETY DATA SHEET FOR 5 % MALATHION

Manufacturer's Name & Address
Southern Agricultural Insecticides, Inc.
PO Box 218, Palmetto, Fla. 34220
Phone: 1-941-722-3285
Chemtrec: 1-800-424-9300

I NOMENCLATURE

Product Name:	5% MALATHION DUST EPA.Reg.No. 829-61
Chemical Name:	O,O-Dimethyl-S-(1,2-di(ethoxycarbonyl0-ethyl) Phosphorodithioate
Synonyms:	Common name: Malathion
Chemical Family:	Organophosphate

II INGREDIENTS:

	Nominal %	CAS#	OSHA PEL	ACGIH TLV
Malathion	5.4%	121-75-5	10 mg/m^3 X skin	10 mg/m^3
mixed clays	93.9% containing approximately the following			
Quartz	44%	14808-60-7	0.22 mg/m^3 (respirable)	0.1mg/m dust
Crystoballite	10%		5 mg/m^3 (respirable)	
Kaolin	6.5%	1332-58-7	15 mg/m^3	10 mg/m^3
Mica	17.0	12001-26-2	29 mppcf	3 mg/m^3

III PHYSICAL PROPERTIES * (value is for Technical Malathion)

Decomposes rapidly above 100ºC *
Vapour Pressure: 3.4 x 10-6mmHg *
Vapour Density: (air=1) N.A.
Reactivity in Water: slow hydrolysis
Solubility In Water: (Malathion)145 ppm @25 ºC
Appearance/Odour: Off-white, finely ground powder, with slight mercaptan odour.

Specific Gravity (h20=1):
Percent Volatile: (by volume)N.A.
Evaporation Rate: N.A.

IV FIRE AND EXPLOSION DATA

Flash Point: (technical malathion) 163ºC (Pensky-Martens closed tester)
Flammable Limits: N/A
Extinguishing Media: Water, foam, CO_2, dry chemical
Special Fire Fighting Procedures: Water fog to cool material. Firefighters should wear self contained breathing apparatus and full protective clothing
Unusual Fire & Explosion Hazards: Decomposition products from fire: Dimethyl sulfide, SO_2, CO_2, CO, and phosphorous pentoxide. Avoid breathing smoke and fumes. Malathion rapidly decomposes above 100ºC.

V FIRST AID

EYE Exposure: Flush eyes a gentle stream of clean water for at least 15 minutes. Hold eye lids apart to ensure washing underside of lids. Remove contact lenses while rinsing. Get medical attention.

SKIN Exposure: Wash contaminated areas with plenty of soap and water. Remove contaminated clothing and launder separately from household laundry before reuse. Seek medical attention if adverse symptoms occur.

For INHALATION: Remove person from contaminated area to fresh air. Resuscitate and/or administer oxygen as necessary. Seek immediate medical attention.

If SWALLOWED: Wash mouth out with water. Drink 1 or 2 glasses of water and induce vomiting by touching finger in back of throat. Do not induce vomiting or give anything to an unconscious person. Seek medical attention immediately.

SYMPTOMS of OVEREXPOSURE: Headaches, nausea, vomiting, cramps, weakness, blurred vision, tightness of chest, salivation, sweating, pin point eye pupils. Muscle spasms and coma.
Note to physician: Malathion is a cholinesterase inhibitor. ANTIDOTE: Administer atropine sulfate in large doses. Two to Four mg intravenously or intramuscularly as soon as cyanosis is overcome. Repeat at 5 to 10 minute intervals until signs of atropinization appear. 2-Pam chloride is a pharmacological antidote and may be administered as an adjunct to, but not a substitute for atropine. Do not give morphine or tranquilizers. At first sign of pulmonary edema, patient should be given supplemental oxygen and treated symptomatically. Continued absorption of Malathion may occur after initial improvement. Very close supervision of patient is indicated for at least 48 hours.

VI TOXICITY DATA

WARNING: This product contains the following substance that is considered a probable or suspected human carcinogen, Crystalline silica as quartz OSHA no IARC yes
NTP yes Crystalline silica as quartz, is a part of the naturally occurring mineral diluents. Respirable crystalline silica as quartz upon repeated or prolonged exposure can cause silicosis.

Route of Entry-
Ingestion: LD50 oral (rat) >5500 mg/kg
Skin: LD50 dermal (rat) > 2000 mg/kg
Inhalation: LC50 inhalation, rat, > 5.2 mg/l 4 hr
Irritancy: Slightly irritating to eyes & skin. Not a sensitizer to guinea pigs.
Carcinogenicity of Malathion IARC group 3 Not classifiable as to carcinogenicity for humans
Malathion Not listed as a carcinogen by OSHA, IARC, NTP

VII REACTIVITY

Stability:. Slow decomposition above 120ºF. Rapid decomposition above 100ºC Decomposition is dependent on time as well as temperature due to exothermic and autocatalyic reactions. The reactions involve rearrangements and polymerization releasing volatile and malodorous compounds such as dimethyl sulfide.. Inappropriate storage may induce the formation of the more toxic and synergistic isomalathion. Conditions to Avoid: Moisture and high temperatures. Materials to Avoid: Strong alkalis, amines, and strong oxidizers It can corrode iron, steel, tin plate, lead and copper. Hazardous Decomposition Products: Thermal decomposition see section IV.

VIII SPILL OR LEAK PROTECTION

Steps To Be Taken If Spilled: Clean up personnel should wear protective equipment as indicated in section VIII Contain and sweep up spilled material. Keep dust to minimum during clean up. Waste Disposal: Spilled product that can not be used according to labeled instructions must be disposed according to applicable local, State, and Federal procedures.

IX SPECIAL PROTECTION

Respiratory: Type/Conditions. Avoid breathing dust. Under dusty conditions and/or when indicated TWA values would be exceeded, wear a NIOSH approved respirator with pesticide cartridge.
Ventilation: General. Handle with good ventilation. Handle to produce a minimum of dust. Gloves: Wear chemical resistant gloves such as barrier laminate, butyl rubber, nitrile rubber or viton. Eye Protection: Safety Glasses. Other protective equipment: Clean freshly laundered, coveralls or long sleeved shirt long pants shoes plus socks. Do not wear contaminated clothing. Launder separately from household laundry.

X SPECIAL PRECAUTIONS

Handling Precautions: Avoid breathing dust. Wash thoroughly after handling.

Storing Precautions: Store in cool dry place. Do not contaminate feed or food. Do not store where temperatures would exceed 120ºF. Do not place damaged or leaking containers in inventory.

Other Precautions: Do not contaminate any body of water. KEEP OUT OF REACH OF CHILDREN.

XI TRANSPORTATION AND SELECTED REGULATIONS

5% Malathion is not regulated in the packing sizes offered.
Freight Classification Insecticides, solid, NOI O/T Poison NMFC 102120
SARA Title III section 313 not listed, Section 311/312 malathion CAS# 121-75-5-RQ 100 Lb

R-6 MEASURES TO MINIMIZE ENVIRONMENTAL DAMAGE

R-6.1 Containment of Oil Spilt on Water

The containment of hydrocarbons spilt on water (rivers, ponds or the sea) is of particular interest in the OECS Region. All of these territories import fuel and lubricants for domestic use, and the island chain is parallel to and downwind of a tanker route to the Gulf of Mexico. The following is a brief introduction to some of the methods which can be used to contain spills on water. It is not intended to be an operating manual on the subject, as that is outside the scope of these reference notes.

R-6.1.1 Sources of Information

The information in this section was summarised from the following sources:

1 US EPA Oil Program, "Response Techniques" [http://www.epa.gov/oilspill/oiltech.htm],
2 National Oceanic and Atmospheric Administration / National Ocean Service, "Spill Containment Methods" [http://response.restoration.noaa.gov/esi/exercise/contain.html], and
3 US Coast Guard, "Mechanical Containment and Recovery of Spilled Oil" [http://www.uscg.mil/d1/staff/m/rrt/mech.html]

R-6.1.2 Overview

During spill response, sensitive locations may be threatened by an advancing oil slick. A number of advanced response mechanisms are available for controlling spills and minimising their impacts on human health and the environment. The key to effectively combating spills is careful selection and proper use of the equipment and materials best suited to the type of oil and the conditions at the spill site.

Spill response equipment and materials are greatly affected by factors such as:

< conditions at sea,

< water currents, and

< wind.

Environmental impact may be reduced by timely and proper use of containment and recovery equipment. Mechanical containment or recovery is often the primary line of defence against oil spills, and is used to capture and store the spilled oil until it can be disposed of properly. Where feasible and effective, this technique is preferable to other methods, since spilled oil is removed from the environment to be recycled or disposed of at appropriate facilities.

Containment and recovery equipment include a variety of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials. Chemical and biological methods can be used in conjunction with mechanical means for containing and cleaning up oil spills. Dispersants and gelling agents used to help prevent oil from reaching shorelines and other sensitive habitats.

Biological agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, and wetlands. Physical methods are used to clean up shorelines. Natural processes such as evaporation, oxidation, and biodegradation can start the cleanup process, but are generally too slow to provide adequate environmental recovery. Physical methods, such as wiping with sorbent materials, pressure washing, and raking and bulldozing can be used to assist these natural processes. Scare tactics may be used to protect birds and animals by keeping them away from oil spill areas. Devices such as propane scare-cans, floating dummies, and helium-filled balloons are often used, particularly to keep away birds.

R.6.1.3 Containment Booms

Containment booms are used to control the spread of oil to reduce the possibility of polluting shorelines and other resources, as well as to concentrate oil in thicker surface layers, making recovery easier. Additionally, booms may be used to divert and channel oil slicks along desired paths, making them easier to remove from the surface of the water. They may be fixed to a structure, such as a pier, or towed behind or alongside one or more vessels. All boom types are greatly affected by the conditions on the water; the higher the waves swell, the less effective booms become. Mechanical problems and improper mooring can also cause a boom to fail.

When a spill occurs and no containment equipment is available, barriers can be improvised from whatever materials are at hand. These improvised booms may be made from common materials as wood, plastic pipe, inflated fire hoses, automobile tires, and empty oil drums. They can be as simple as a board placed across the surface of a slow-moving stream, or a berm built by bulldozers pushing a wall of sand out from the beach to divert oil from a sensitive section of shoreline.

Although they are most often used as temporary measures to hold or divert oil until more sophisticated equipment arrives, improvised booms can be an effective way to deal with oil spills, particularly in calm water such as streams, slow-moving rivers, or sheltered bays and inlets.

R-6.1.4 Oil Skimmers

An oil skimmer is a device for recovering spilled oil from the water's surface. Vessel-based skimming systems are used to remove oil from open water, while vacuum trucks are often used to remove oil that has collected near the shoreline. The efficiency of skimmers is highly dependent upon conditions at sea. In moderately rough or choppy water, skimmers tend to recover more water than oil.

The main benefits of skimmers are that they physically remove oil from the environment, allow recycling or proper disposal of recovered oil and minimises direct environmental impacts in open water areas. Three of the main types of skimmers are weir, oleophilic and suction. Each type offers advantages and drawbacks depending on the type of oil being recovered, the sea conditions during cleanup efforts, and the presence of ice or debris in the water.

Weir Skimmers use a dam or enclosure positioned at the oil/water interface. Oil floating on top of the water will spill over the dam and be trapped in a well inside, bringing with it as little water as possible. The trapped oil and water mixture can then be pumped out through a pipe or hose to a storage tank for recycling or disposal. These skimmers are prone to becoming jammed and clogged by floating debris.

Oleophilic ("oil-attracting") Skimmers use belts, disks, or continuous mop chains of oleophilic materials to blot the oil from the water surface. The oil is then squeezed out or scraped off into a recovery tank. Oleophilic skimmers have the advantage of flexibility, allowing them to be used effectively on spills of any thickness. Some types, such as the chain or "rope-mop" skimmer, work well on water that is choked with debris.

Suction Skimmers operate similarly to a household vacuum cleaner. Oil is sucked up through wide floating heads and pumped into storage tanks. Although suction skimmers are generally very efficient, they are vulnerable to becoming clogged by debris and require constant skilled observation. Suction skimmers operate best on smooth water, where oil has collected against a boom or barrier.

R-6.1.5 Sorbents

Sorbents are materials that soak up liquids. They can be used to recover oil through the mechanisms of absorption, adsorption, or both. Absorbents allow oil to penetrate into pore spaces in the material they are made of, while adsorbents attract oil to their surfaces but do not allow it to penetrate into the material. Although they may be used as the sole cleanup method in small spills, sorbents are most often used to remove final traces of oil, or in areas that cannot be reached by skimmers.

Once sorbents have been used to recover oil, they must be removed from the water and properly disposed of or cleaned for re-use. Any oil that is removed from sorbent materials must also be properly disposed of or recycled.

Sorbents can be divided into three basic categories: natural organic, natural inorganic, and synthetic. Natural organic sorbents include peat moss, straw, hay, sawdust, ground corncobs, feathers, and other readily available carbon-based products. They are relatively inexpensive and usually readily available. Organic sorbents can soak up between 3 and 15 times their weight in oil, but they do present some disadvantages. Some organic sorbents tend to soak up water as well as oil, causing them to sink. Many organic sorbents are loose particles such as sawdust, and are difficult to collect after they are spread on the water. Adding flotation devices, such as empty drums attached to sorbent bales of hay, can help to overcome the sinking problem, and wrapping loose particles in mesh will aid in collection.

Natural inorganic sorbents include clay, perlite, vermiculite, glass wool, sand, or volcanic ash. They can absorb from 4 to 20 times their weight in oil. Inorganic substances, like organic substances, are inexpensive and readily available in large quantities. Synthetic sorbents include man-made materials that are similar to plastics, such as polyurethane, polyethylene, and nylon fibres. Most synthetic sorbents can absorb as much as 70 times their weight in oil, and some types can be cleaned and re-used several times. Synthetic sorbents that cannot be cleaned after they are used can present difficulties because arrangements must be made for their temporary storage prior to disposal.

R-6.1.6 Dispersing Agents

Dispersing agents, also called dispersants, are chemicals that contain surfactants, or compounds that act to break liquid substances such as oil into small droplets. In an oil spill, these droplets disperse into the water column where they are subjected to natural processes (wind, waves, and currents) that help to break them down further. This helps to clear oil from the water surface, making it less likely that the oil slick will reach the shoreline.

Heavy crude oils do not disperse as well as light to medium-weight oils. Dispersants are most effective when applied immediately following a spill, before the lightest materials in the oil have evaporated. The effectiveness of dispersants depends on environmental factors including water salinity and temperature and conditions at sea, and is often favourable when frequently rough or choppy conditions at sea make mechanical containment and cleanup difficult. However, difficulties with application coupled with disagreement about their effectiveness as well as concerns regarding their toxicity has limited their application. These problems are now being overcome as new technologies that improve the application of dispersants are being designed.

R-6.1.7 Gelling Agents

Gelling agents, also known as solidifiers, are chemicals that react with oil to form rubber-like solids. With small spills, these chemicals can be applied by hand and left to mix on their own. For treating larger spills, the chemicals are applied to the oil, then mixed in by the force of high-pressure water streams. The gelled oil is removed from the water using nets, suction equipment, or skimmers, and is sometimes reused after being mixed with fuel oil. Gelling agents can be used in calm to moderately rough seas, since the mixing energy provided by waves increases the contact between the chemicals and the oil, resulting in greater solidification.

There is one drawback to the use of gelling agents. Large quantities of the material must often be applied, as much as three times the volume of the spill. For oil spills of millions of gallons it is impractical to store, move, and apply such large quantities of material.

R-6.1.8 Biological Agents

Biological agents are chemicals or organisms that increase the rate at which natural biodegradation occurs. Biodegradation is a process by which microorganisms such as bacteria, fungi, and yeast break down complex compounds into simpler products to obtain energy and nutrients. Biodegradation of oil is a natural process that slowly (sometimes over the course of several years) removes oil from the aquatic environment. However, rapid removal of spilled oil from shorelines and wetlands is necessary in order to minimize potential environmental damage to these sensitive habitats.

Bioremediation technologies can help biodegradation processes work faster. Bioremediation refers to the act of adding materials to the environment, such as fertilizers or microorganisms, that will increase the rate at which natural biodegradation occurs. Two bioremediation technologies, fertilisation and seeding, are often used to increase the population of microorganisms that can biodegrade the spilled oil.

Fertilisation (nutrient enrichment) is the method of adding nutrients such as phosphorus and nitrogen to a contaminated environment to stimulate the growth of the microorganisms capable of biodegradation. Seeding is the addition of microorganisms to the existing native oil-degrading population.

R-6.2 Treatment and Disposal of Oil-Contaminated Soil

The following discussion is a brief introduction to some of the methods which can be used to treat oil-contaminated soil in the OECS Territories. It is not intended to be an operating manual on the subject, which is outside the scope of these guidelines. The techniques addressed are:

<	Bioremediation	-	Land Farming,
		-	Biopiles,
<	Thermal Desorption	-	Indirect,
		-	Direct, and
<	Fixing.		

R-6.2.1 Bioremediation

Land farming and biocells are both forms of bioremediation, which is the process by which naturally occurring microorganisms and microbial processes transform chemical contaminants into less harmful compounds.

Microbial processes can be broadly divided into two types. Aerobic metabolic processes take place in the presence of oxygen and, in fact, require oxygen to be an electron acceptor in an oxidation-reduction reaction. Anaerobic metabolism, on the other hand, occurs only in the absence of molecular oxygen and these processes use compounds other than oxygen as electron acceptors. Petroleum hydrocarbons have been remediated under aerobic conditions. Both above-ground technologies (ex-situ applications) and below-ground systems (typically in-situ applications) are available for remediation.

Bioremediation of soils containing hydrocarbons is typically carried out either by land farming or by construction of a biopile. Both techniques utilize identical principles and techniques to achieve the remedial objectives; they only differ in terms of the thickness of the soil column being remediated and the amount of maintenance required during the treatment process.

Finally, it must be accepted that biodegradation will not reduce the concentrations of all contaminants. It is not effective in treating metals, nor is it very effective in treating polycyclic hydrocarbons containing four or more rings. While these latter compounds will degrade, the time required for a significant reduction in concentration may be considerable.

R-6.2.2 Land Farming

Land farming has come to mean a process in which the contaminated material is spread on the ground surface in a thin layer and the contaminants are allowed to degrade under the action of the naturally occurring microbes in the underlying soil. The contaminated media may be tilled into the underlying soil and nutrients (typically nitrogen- and phosphorous-rich fertilizer) may be added. Land farming is a combined method of treating and disposing of contaminated soil, since the remediated material is generally not removed after treatment.

Traditional land farming techniques generally require that the land be left fallow for several years before it can be returned to agricultural use after the treatment process. Vegetation will grow on the site in a shorter time, but the human health/domestic animal health implications of eating crops grown on the site relatively soon after land farming are not properly understood. In addition, crop production may be hindered because of increased salinity in the soil, particularly if a specific area is used repeatedly. Land farm sites may ultimately be used for built development, provided that adequate testing is done to verify that contaminants have been reduced to an acceptable level.

R-6.2.3 Biopiles

A biopile (in contrast to a land farm) is a contained cell constructed at, or close to, the ground surface in which the contaminated material is deposited as a pile. The pile may be several feet high and aeration and moisture conditioning pipes may be incorporated into the pile.

The contaminants in the soil are allowed to biodegrade under aerobic conditions, and conditions within the pile are monitored by sampling soil gases within the pile and measurement of indicator parameters such as the oxygen content, moisture content, temperature, and total petroleum hydrocarbon concentration. Other parameters, such as methane content, may also be monitored.

The advantage of a biopile over traditional land farming methods is that a biopile generally requires much less space for its operation. This is a decided advantage where land values are at a premium. However, the pile must be carefully engineered and controlled to prevent the development of anaerobic conditions. While the hydrocarbons in the soil will degrade under anaerobic conditions, the degradation rate will typically be much slower and the time required to achieve the same degree of contaminant reduction will be longer. As well, anaerobic degradation is generally accompanied by unpleasant odours. To avoid the development of such conditions, the pile may require aeration by tilling or by circulating air through the soil mass via perforated pipes inserted into the pile.

Moisture conditioning to maintain an optimum moisture content and nutrient addition are also more likely to be necessary in a biopile than in the case of a more traditional land farming operation. All of these maintenance requirements generally result in higher operating costs for a biopile. However, these costs may be far outweighed by the saving realized by the lower land requirement.

Unlike land farming, the biopile is solely a treatment facility. The remediated soil will be removed after treatment and can be put to a final use or disposed. This allows the reuse of the biopile repeatedly over time, allowing the initial cost of set-up to be amortized over a much larger volume of contaminated material.

R-6.2.4 Direct Thermal Desorption

Desorption systems can be subdivided into direct and indirect systems. In the direct system, thermal energy is applied directly to the contaminated material in a rotary desorption chamber, similar to a rotary kiln. The contents of the chamber are heated to a temperature in the range of 150°C to 250°C and the contaminants are vaporized and transported as off-gas. The off-gas is filtered to remove dust and is then treated before discharge into the atmosphere. Treatment processes can include thermal oxidation (incineration), scrubbing, adsorption by activated carbon, catalytic conversion, and acid neutralization. For off-gases containing petroleum hydrocarbons, the most common treatments are incineration and adsorption. The treated soil is cooled and can then be used for a variety of purposes, depending on its physical characteristics.

The major disadvantage to the use of direct thermal treatment is the fact that the off-gases require treatment before disposal and cannot be recycled. Such treatment can be expensive, especially if stringent air emission regulations have to be satisfied. When incineration is used, temperatures in the thermal oxidizer may be as high as 1100°C to ensure a destruction efficiency in the vicinity of 99 percent. The consequent energy costs can be high and cannot be offset by cost savings associated with recycling and reuse of the chemical compounds.

This is particularly relevant in the case of materials containing hydrocarbons and oleaginous compounds, such as drill cuttings. The recovered compounds can be reused in drilling mud and the hydrocarbons can be used as fuel supplements.

R-6.2.5 Indirect Thermal Desorption

Indirect thermal desorption overcomes these disadvantages. In this process, the contaminated media are indirectly heated to between 150°C to 250°C by hot gases flowing around an enclosed chamber containing the media. The contaminants are vaporized and are transferred with an inert carrier gas to an off-gas treatment system for condensation and recovery. A portion of the treated off-gas is returned to the chamber containing the contaminated media as the carrier gas, while the rest is vented to atmosphere. Since neither the contaminated solids nor the separated contaminants contact the burner's flue gas, the flue gas can be vented directly to the atmosphere without treatment. The pressure within the treatment system is kept slightly negative (below atmospheric pressure) to prevent unwanted emissions.

Because the heating is indirect, the process is less efficient and the residence time required to achieve the desired level of contaminant removal is typically longer than for direct thermal desorption systems. Consequently, the feed rate is typically lower for indirect systems, resulting in higher treatment costs and extended project schedules. Feed rates for direct systems can be as high as 80 to100 tonnes per hour, while most indirect systems operate at a maximum feed rate of 10 to15 tonnes per hour with most systems being in the range of 2 to 5 tonnes per hour. In this context, it should be noted that feed rates are highly dependent on the physical characteristics of the material and the moisture content. Feed rates as low as a few tons per day have been reported for wet drilling mud. High capacity indirect systems capable of feed rates comparable to the direct systems are being developed and are currently being used in North America.

Because the temperature of the contaminated media can be varied over a large range, thermal desorption will treat a wider range of constituents than will biodegradation, reportedly including some volatile metallic compounds such as mercury. Thus, for example, materials containing a significant quantity of multi-ringed polycyclic hydrocarbons will be more easily remediated by thermal treatment than in a biopile.

R-6.2.6 Fixing

The term 'fixing' is used to describe processes by which physical and chemical processes are used to bind contaminants firmly to the matrix, so as to prevent separation (especially by leaching). Perhaps the most commonly-used agent for fixing is ordinary portland cement (OPC), but other agents like fly-ash are sometimes used. Fixing is used frequently for inorganic contaminants such as metals, but may be ineffective with some organic contaminants.

The procedure for fixing usually includes the following steps:

1. Pretreatment, for example adjusting the water content or removal of excessive concentrations of petroleum hydrocarbons.

2. Mixing, to ensure that the entire bulk of the contaminated soil is exposed to the fixing agent.

3. Densification of the mix (for example, into a brickette).

4. Leachate testing to verify the success of the fixing.

R-6.3 Treatment and Disposal of other Hazardous Material

This section discusses options for the treatment and disposal of other hazardous/contaminated material: asbestos, PCBs and other chemicals. As before, it is not intended to be an operating manual on the subject, which is outside the scope of these guidelines. Instead, it is intended only to be a brief introduction.

R-6.3.1 Asbestos

The following are some general guidelines for handling and disposal of asbestos containing materials (ACM).

1. Only personnel trained in the handling and disposal of asbestos containing material should be allowed to lead any ACM removal.

2. A combination of approved respiratory protection and wet methods should be used to prevent employees' exposure to airborne asbestos above the permissible limits.

3. Where airborne asbestos concentration limits are exceeded, special clothing must be provided.

4. Friable asbestos-containing materials should be removed before any wrecking or dismantling takes place.

5. Friable asbestos-containing materials should be adequately wetted to prevent emissions to the outside air.

6. After wetting, while wet, all ACM must be sealed in leak-tight packaging comprised of multiple layers and should be labeled for proper disposal.

7. In the Caribbean, final disposal of asbestos is usually by “encryption”. The material is buried in its leak-tight packaging at an approved location, at a depth of at least 2 m below ground level. The buried material is capped with a 100 mm thick layer of concrete, and the site is marked as “Asbestos Buried Here, Do Not Excavate”.

R-6.3.2 PCBs

Because there is no facility for the disposal of PCBs in the West Indies, there are only two options available: export out of the region for treatment, or long-term storage. The latter is not a disposal option at all, but rather a holding system until a proper means of disposal becomes available. When considering the export of PCBs for treatment and disposal abroad, the requirements of the Basel Convention on the Transboundary Movement of Hazardous Waste must be adhered to.

Anecdotal information suggests that efforts have been made to “fix” (see Section R-6.5.3, below) small quantities of suspected PCB contaminated soil for encryption (see Section R-6.5.1, above), but this raises concerns about the slow leaching of the PCBs through the soil into ground water. A full discussion of this method of disposal is outside the scope of these Guidelines.

R-6.3.3 Other Chemicals

The use of “fixing” to treat oil-contaminated soil was discussed in Section R-6.4.6, above. This technique can be used on soil with other types of contaminants. The following is a description of a proprietary fixing product which is available in the West Indies:

1. The product contains an inert adsorbent medium which enables easy handling of liquid or semi-liquid waste.

2. A clay mineral constituent in the product allows for further adsorption at the micro (molecular) level and preliminary fixing of mobile ions in the waste materials.

3. A pozzolanic fixing ingredient precipitates and fixes heavy metals and salts.

4. A hydrophobic absorbent for hydrocarbons and oil based residues.

5. A chemical buffer is included in the product, for pH stabilization.

This product in particular was designed as a general use formulation for hazardous chemical wastes. However, specific identified chemical wastes may require further or alternative treatment in order to detoxify or remove toxic characteristics. For example, when treating used Mercury-containing Fluorescent Tubes, in addition to the product, an alkaline solution of sodium sulphide is added to the crushed material. The resulting precipitate is solidified in an ordinary portland cement matrix along with the crushed glass. Many similar applications may be applied to facilitate pozzolanic treatment with the product followed by microencapsulation in ordinary portland cement.