RECOMMENDATIONS FOR DISASTER PREPAREDNESS OF WATER AND SANITATION SYSTEMS IN PACIFIC SMALL ISLAND DEVELOPING STATES

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INTRODUCTION

The purpose of these paper is to assist water utilities in Pacific Small Island Developing States (SIDS) to develop emergency contingency plans to deal with the effects of natural and man-made disasters to water and wastewater facilities. It is universally recognised that in the aftermath of a disaster it is essential that water supply and sanitation systems are operational as soon as possible to minimise the outbreak of disease that may exacerbate a disaster.

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BACKGROUND

The natural environment throughout the Pacific SIDS is extremely fragile and is highly vulnerable to both natural and human-induced disasters. In the past decade, changing climate patterns, rapidly growing populations and increasing pressures on limited natural resources in many countries have produced a crisis of damage to, and depletion of these resources most necessary for basic life support, especially freshwater. The economic and public health implications of the crisis have provoked an urgent need for greatly improved management, planning, operation, and maintenance in the water supply and sanitation sector, associated environmental protection, and conservation of both surface and groundwater resources along with disaster mitigation and management planning.

Natural hazards like cyclones, earthquakes and tsunamis may strike at any time and at most places within the Pacific region causing disaster. The most recent disaster (July 1998) being the tsunami that devastated several villages on the northeast coast of Papua New Guinea killing over 2000 people. Also severe droughts caused by the 1997/98 El Nino, have also made life difficult for many tens of thousands of people in many Pacific SIDS, and resulted in states of emergency being declared on several islands.

Little can be done to prevent natural hazards (ie cyclones, earthquakes and tsunamis) but steps can be taken to reduce and minimise the effects on water sector facilities through mitigation works, preparedness and knowing responsive planning.

The principal motivation for this project came from a recommendation made at the 4th Global Forum of the Water Supply and Sanitation Collaborative Council (WSSCC) held in Manila in

November 1997, to draft guidelines for disaster preparedness in SIDS. The WSSCC recognised that water supply and sanitation systems in SIDS are particularly vulnerable to natural and man-made disasters thus requiring disaster management planning.

PRINCIPLES OF DISASTER MANAGEMENT

Three basic principles of disaster management are:

- **Mitigation**: to reduce the effects of events by risk and vulnerability assessment resulting in measures to prevent or avoid disasters.
- **Preparedness**: to be warned and ready for disasters to minimise potential damage.
- **Response**: to provide appropriate disaster relief to return to normal.

The recommendations will use these principles to focus on disaster mitigation, preparedness and response by water utilities to a disaster event.

TYPES OF HAZARDS

Various types of hazards may result national and/or regional disasters. The severity of a disaster depends on the magnitude of the hazard plus the vulnerability of the area subject to the hazard. An example of this would be in a densely populated area such as South Tarawa which would be affected more by the same hazard than the less-densely populated area of North Tarawa. Thus the risk of a national disaster is greater in South Tarawa compared to North Tarawa.

The equation risk = hazard x vulnerability indicates the relationship between risk, hazard and vulnerability.

Natural Hazards

Geological and meteorological hazards are the two general categories of natural hazards as shown below that will be considered here:

Geological hazards

- Earthquakes
- Tsunamis
- Volcanoes
- Landslides

Meteorological hazards

- Tropical cyclones
- Floods
- Droughts

Note that hazards may be linked to one another causing one or more to occur. Earthquakes, volcanoes or landslides may generate tsunamis, while tropical cyclones may trigger landslides and flooding.

Man-made Hazards (Technological)

Man is also good at producing technological hazards that include the following:

- Power loss
- Fire
- Terrorism
- War
- Chemical spillages from mining and other activities
- Pollution of water resources

Natural hazards can produce technological hazards by earthquakes causing electrical and gas fires as well as petroleum and chemical spills.

Man-made hazards are becoming more frequent, especially with regards to waste disposal and pollution that threatens already limited natural resources such as freshwater. However these recommendations concentrate on disasters caused by natural hazards.

NATURAL HAZARDS FREQUENCY

The following information was taken from the AGSO/Australian IDNDR publication Natural Hazards: Their Potential in the Pacific Southwest. It is recommended that every Pacific water utility obtain a copy of this informative publication.

Globally, tropical cyclones, floods and earthquakes are shown to be the most frequent types of disasters with earthquakes and tropical cyclones the most deadly regarding human life. Also meteorological hazards (cyclones, floods and droughts) occur much more frequently than geological hazards (earthquakes, volcanoes and tsunamis) worldwide.

Table 1 below lists natural disasters that occurred in Pacific SIDS between 1900 to 1994:

Country	Number of Disasters	Number of Dead
Tonga	54	14
Fiji	46	603
Papua New Guinea	39	7486
Vanuatu	33	213
Solomon Islands	25	407
New Caledonia	16	18
Cook Islands	8	6
Samoa	7	281
American Samoa	6	115
Tokelau	5	0
Tuvalu	5	6
Guam	5	20
Wallis and Futuna	4	6
Niue	4	0
Kiribati	1	3

Note: Data from the EMDAT database on disasters from Centre of Research on the Epidemiology of Disasters (CRED), University Catholiquede Louvain, Brussels, Belgium. Data shown are for natural disasters only. No claim is made that the data are definitive. Disasters in the CRED database are those that required relief assistance at the national or international level, or caused at least 10 deaths, or affected at least 100 people.

The above figures indicate the number of natural disasters that occurred (according to the CRED definition of disaster) in Pacific SIDS in the 94-year period from 1990 to 1994. There does not appear to be any correlation between the number of events to deaths.

However based on the uncertain statistics available, the following general conclusions can be made:

- floods, tropical cyclones and earthquakes are the natural hazards that produce disasters most frequently;
- earthquakes, tropical cyclones, and floods produce most deaths;
- meteorological hazards and disasters are more common and produce more deaths than geological hazards and disasters;
- large economic losses are associated most commonly with earthquakes and tropical cyclones, although the available data are very incomplete;
- natural disasters in small countries tend to produce higher costs per capita then those in countries having large populations.

NATURAL HAZARDS POTENTIAL

Hazard potential depends on the location of each country in relation to the hazard source, especially in regards to geological hazards. High island countries located near the high-energy interactions between the Pacific Plate and the Indo-Australian Plate have a higher potential for earthquakes, volcanoes and tsunamis than atoll countries. Meteorological hazards are more "mobile" and may strike more randomly thus location is not a limiting factor.

Again the AGSO/Australian IDNDR publication Natural Hazards: Their Potential in the Pacific Southwest contains maps that show information on natural hazard potential indicating future distribution and intensity of various hazards.

An attempt has been made to simplify the rating of natural hazard potentials for selected Pacific SIDS. The following table is based on a similar table presented in the UNDP/UNDHA publication Natural Disaster Mitigation in Pacific Island Countries. The potential of the occurrence of various natural hazards for each SIDS is given a ranking of low, medium or high. However each country should prepare its own ranking based on local information.

Water utilities are encouraged to obtain copies of both the above-mentioned useful publication.

Table 2. Estimated Natural Hazard Potentials in Pacific SIDS.

Country/State	cyclones	droughts	Flooding	earthquakes	volcanoes	tsunamis	land slides
Cooks Islands	H	H	M	L	L	M	M
Kosrae	M	H	M	L	L	M	M
Pohnpei	M	H	M	L	L	M	M
Chuuk	M	H	M	L	L	M	M
Yap	M	H	M	M	L	M	M
Palau	M	H	M	M	L	M	M
Fiji	H	H	H	H	H	M	H
French Polynesia	H	H	M	L	M	M	H
Guam	M	H	M	M	L	M	M
Kiribati	L	H	L	L	L	M	L
Marshall Islands	M	H	L	L	L	M	L
New Caledonia	M	M	M	H	M	L	M
Niue	H	M	L	M	L	L	L
Nauru	M	H	L	L	L	L	L
Papua New Guinea	H	H	H	H	H	H	H
Solomon Islands	H	H	H	H	H	H	H
Samoa	H	H	H	H	H	M	H
American Samoa	H	H	L	H	H	M	H
Tonga	H	H	L	H	H	M	L
Tuvalu	H	H	L	L	L	M	L
Vanuatu	H	H	M	H	H	H	H

L = low M = medium H = high

RECOMMENDATIONS

Since each water utility is unique, a specific plan is required that reflects the strategies needed for mitigation and coping with natural disasters. Thus, the following recommendations have been developed to assist each water utility to prepare it's own personalised plan by providing the basic information.

The Will

Water utility managers and staff must have the will and determination to undertake and prepare a disaster response contingency plan. Not only will the plan be a valuable document during times of emergency but also the entire exercise will be useful in learning more about existing water facilities and how they operate and perform.

Water utility managers should consult and work closely with National Disaster Management Offices (civil defence or equivalent organisation) in each SIDS during the development of the plan. During any national disaster this office has the main response coordination responsibility. By having a water utility contingency plan already prepared, the coordination role of the National Disaster Management Offices would be assisted immensely in the event of a disaster. Maintaining water supply and sanitation facilities during and after a disaster is vital for a quick and complete recovery from a disaster.

Assess Potential Natural Hazards

Each water utility should determine which hazards their facilities are most susceptible to. As an example is, Kiribati does not need to consider river flooding but the possibility of drought conditions is very real. Information on hazard potentials can be obtained from the following publications: Natural Hazards: Their Potential in the Pacific Southwest and Natural Disaster Mitigation in Pacific Island Countries. National Disaster Management Offices should also be able to assist in providing hazard assessment information. Table 2 should also give a good general indication of estimated natural hazard potentials for each country.

Survey of Existing Water Facilities

Before any planning can proceed a survey of all water facilities must be undertaken. This process could be as simple as studying existing as-built drawings or as thorough as implementing a complete ground survey for each facility. However, very few Pacific water utilities are likely to have updated as-built drawings readily available for use, thus ground surveys are recommended. During recent demand management fieldwork in Honiara, it was found that several distribution valves that were always thought to be open were actually closed. This is a common occurrence and is compounded by the existence of counter clockwise closing (left-handed threads) valves that are used throughout the Pacific region. The resulting survey of each facility should describe water systems, noting component age, sizes, lengths, valves (noting right or left handed), pumps, materials, locations, specifications, etc. This survey could easily be extended into an asset register of facilities and would be a valuable document in itself. Note that this may present a good opportunity for a water utility to review it’s plan record system (ie. the storing and retrieval of plans, specifications and other information). A utility may want to upgrade it’s existing system, to use the latest GIS and GPS methods to store, retrieve and print water facility systems. Once water systems are recorded in a GIS system, reticulation networks can easily be modelled thus giving the utility another tool to better managing reticulation systems.

Identify Vulnerability of Water Facilities

Knowing the potential types of natural hazards that may affect the operation of a water utility and having surveyed existing water utility facilities (i.e. water supply and wastewater disposal systems), areas of vulnerability or weakness may be identified, for example, a flood or earthquake may damage a major pipeline that crosses over a river. However by relocating the pipeline or constructing it under the river possible damage could be avoided resulting in an uninterrupted service throughout a disaster. Damage to electric power supplies by a natural disaster may cut off freshwater supplies that rely on pumping, or cause sewerage to overflow at pumping stations thus compounding the disaster further. By installing underground cables or stand-by generators a more secure operational and failsafe system would result.

One of the objects of this exercise is to motivate utilities into thinking about the occurrence of disasters, how these may affect water and wastewater facilities and how to "disaster proof" various facilities through appropriate mitigation works.

Appendix 1 provides a list of water supply and wastewater disposal components that should be considered when identifying areas of vulnerability. Following sections comment on various components.

Sources

Water supply sources such as surface catchments (rivers and streams) and groundwater recharge areas (wells, galleries and springs) should be protected from land developments and other activities that may adversely affect both water quantity and quality. It is a well-known fact that clearing or developing catchment areas result in increased and more rapid runoff, lower river-base flows and poorer-quality water. Also the development of catchment and recharge areas normally results in greater potential for pollution and erosion. Ideally legislation should be enacted to protect all existing and potential water source areas for sustainable water resources now and for future generations.

Sources may be affected by the lack of rain (droughts) or by too much rain (cyclones). Associated with drought is the depletion of available water resources. This is especially critical with groundwater lenses on atolls and coastal aquifers, where saltwater intrusion may occur due to a combination of reduced recharge and over abstraction. Groundwater lenses may also be affected by surface saltwater intrusion from prolonged sea sprays and coastal flooding (seawater) inundation caused by tropical cyclones and tsunamis. Careful monitoring of lens thickness and groundwater abstraction rates is required. Tropical cyclones are known for their heavy rainfalls and high winds that can saturate, strip and erode catchments and cause landslides. River channels may be blocked or dammed by landslide debris caused by rain and/or earthquakes.

After cyclones and earthquakes water resource catchments should be inspected for any major changes. Eroded areas should be replanted or other appropriate soil conservation measures used to stop further erosion occurring.

Cyclones and earthquakes may damage artificial catchments such as rooftops and aircraft runways (e.g. Majuro). Volcanic ash showers are known to deposit ash material on catchment surfaces and in open storage reservoirs. Artificial catchments are also subject to seawater spray (increased during cyclones) that may find its way into reservoirs thus contaminating stored freshwater.

Protection of water catchments is most important to ensure the sustainability of water supply sources, especially the exclusion of human development settlement that usually results in the reduction of water quantity and increased pollution potential.

The collection of rainwater from both individual homes and public buildings should be encouraged by utilities as a “drought proofing” measure. In most cases this would provide some relief for utilities with limited water resources.

Intakes

Structural damage to in-stream water supply intakes may be caused by flooding, earthquakes and volcanoes. Intake structures should be designed to standards that consider damage by extreme natural forces. Also, intake headworks may become blocked and filled with silt and debris due to flooding, landslides and erosion. Silt traps constructed upstream from water supply intakes are useful. Properly constructed infiltration galleries installed in-stream or adjacent to alluvial streams may be unaffected by flooding and debris caused by natural disasters but still require maintenance to remove surplus deposits of silts and debris.

Ground movements following earthquakes may affect groundwater wells, boreholes and galleries causing them to collapse, damage pipe work and change alignment. Changes to water quantity and quality may result and these should be closely monitored.

Storage

Earthquakes may cause structural damage to storage facilities that may result in either failure or leakage. Dams and concrete structures should be checked as soon as possible to ensure their integrity. Large uncovered reservoirs (such as those used in Majuro) are subject to contamination by salt spray and losses through high evaporation rates. Where possible storage tanks should be covered to protect freshwater from contamination and evaporation.

It is good practice to monitor storage levels or volumes to account for changes. For example a broken water main or damage to the reservoir may cause a sudden unexpected decrease.

The ability to isolate a storage facility is also desirable during and/or after a natural disaster to save water that may be lost or wasted through damage to the reticulation system. Outlets from storage facilities should be closed after an event to save wastage of stored water through leaks and broken pipes. Once it is known that major distribution faults are under control then the storage facilities can be opened, resulting in minimisation of water wastage. However, if fire is a factor then a decision must be made on whether to provide reticulated water to assist fire fighting.

Note that access to storage facilities should be controlled and restricted to authorised personnel thus avoiding possible man-made disasters.

Construction of additional storage is an ideal method to assist in “drought proofing” a utility, assuming that there is enough water to fill the extra storage.

Distribution Systems

The extensive nature of distribution systems increases their risk to natural hazards such as earthquakes, floods, cyclones, landslides and volcanic activity. Pipeline failures and leakages are common results of natural hazards. Thus water is wasted and does not reach the areas where it is required. The same is true for wastewater pipelines however broken pipes may lead to environmental hazards such as pollution of freshwater resources (both surface and groundwater) and coastal marine waters.

A feature of many Pacific SIDS is their sandy soils that suits pipe laying but makes it very difficult to locate broken and leaking pipes buried in the highly permeable soils. In recent volcanic areas (e.g. Samoa), pipelines (often PVC) are laid exposed above lava rock making them vulnerable not only to natural hazards but man-made hazards as well. The installation and monitoring of bulk water meters at various locations throughout water supply systems is an excellent way to assess areas of high water usage that may relate to damaged pipelines.

The use of an appropriate pipe material can minimise breakages. PVC pipes should always be buried while steel pipes are most suited for out-of-ground use.

Power failures may also disrupt both water and wastewater reticulation systems when pumps fail to operate. Where this may cause a major problem, stand-by emergency power supplies should be considered.

Often the refilling of water pipelines is a problem due to air getting trapped in high sections preventing the flow of water. Air valves installed at high locations along the pipeline will expel trapped air while refilling the system. Periodic maintenance of all types of valves is important for the efficient operation of a water supply system.

Sewerage outfall structures and pipelines are susceptible to natural hazards and should be examined after major events to ensure their integrity.

Treatment Plants

Structural damage and operational failure may occur from natural disasters resulting in the buildup and overflow of untreated water and/or sewerage. Stand-by emergency power supplies to ensure continuous operation may be appropriate in some facilities that may cause environmental and health problems if the power failed. Water-treatment plants should be provided with by-pass facilities to enable untreated water to be supplied in case of prolonged treatment plant problems. In the aftermath of a disaster, untreated water is better than no water at all. In those circumstances water utilities can issue instructions to the public to boil water used for drinking and cooking.

Damage to chemicals stored at treatment plants or other locations is another potential problem especially chlorine in its many forms (gas, granular and liquid). Special storage procedures recommended by manufacturers should be followed.

Access and Communication to Facilities

During and after a disaster, knowing the degree of damage caused by the event to a water facility is most important in order to assess the situation and respond accordingly. Often intake, storage and distribution systems are located in remote areas with difficult access at the best of times. An example is in Rarotonga where one major surface supply has 23 river crossings (road and pipeline) and requires a 4-wheel drive vehicle. During flood conditions access is very limited. The installation of bulk flow meters at accessible locations or the use of portable ultrasound flowmeters can give an indication if a pipeline is functioning properly or if there is a problem. This can save time by only checking facilities where problems exist.

Road access to major facilities should be maintained to provide reasonable access during extreme conditions. This may include road drainage control using water tables and culverts plus suitable stream crossing fords that may be constructed using gabion baskets and readily available material from the river beds.

Radio telemetric monitoring devices for water levels, rainfall, pipe flows, power failures and other functions are desirable not only for emergency purposes but also for normal operation and for recording system performance. Again, time can be saved by only checking facilities where problems exist.

A fleet of well-maintained and equipped vehicles is most important especially during emergencies. Vehicles should all be equipped with communication devices and equipment in order to respond to an emergency quickly and efficiently. Field information on actual conditions must be communicated to those responsible for making decisions and implementing actions.

Both vehicles and communication devices must be 'emergency-ready' at all times including full fuel tanks, spare radios and battery charger plus other equipment (chainsaws, portable generators and pumps) in working order.

Spare Equipment and Materials

A well-equipped store is a valuable asset at any time but especially in times of emergency. Equipment and materials should be on-hand to repair or replace damaged pipes, valves, fittings, pumps and other gear as required. It is important to keep an up-to-date and accurate inventory of all equipment and materials available. Stores that may be required for a range of emergencies should be ordered as soon as possible.

Monitoring

Monitoring of systems (water levels, flow rates, water pressures, wastewater quality and rainfall) to assess potential changes to water quantity and quality can be a valuable tool in disaster management and mitigation. This is especially true in drought conditions, that develop gradually and can tend to catch water utilities off-guard. The first indication of a dry period is often an increase in demand (watering of grass and gardens) and a reduction in water resources (decreasing water levels in streams, rivers and aquifers) and of course below-normal rainfall. By monitoring these indicators, water utilities may warn consumers to reduce water usage and/or impose water restrictions and/or rationing, thus conserving water resources. Note that the enforcement of restrictions/rationing should be in place to ensure that they are observed.

SOPAC is currently developing a drought index that is based on monthly rainfall data. An example is in Rarotonga where routine monitoring of drought conditions is now being undertaken by the Water Works Department in an effort to develop effective drought management strategies. This monitoring should provide a more objective measurement of drought severity and should assist in increasing public and political awareness of the nature of Rarotonga's water supply and the need for conservation. In the future it may provide a basis for management intervention to control specified types of water use during periods of severe drought. This approach may be used in most Pacific SIDS. SOPAC is available to assist it's member country water utilities develop a drought monitoring strategy.

Monitoring the thickness of freshwater lenses is the only way to determine the amount of groundwater available. Abstraction rates can then be adjusted accordingly. Increased pumping rates to meet increased demand during drought conditions may result in saltwater intrusion, by shrinking the thickness of the freshwater lens that is situated above more saline groundwater.

Comparing water usage against water produced, gives a good indication of unaccounted for water. However, this requires water metering, which in some countries is resisted by both the public and politicians. With unaccounted-for water losses (usually leakage) commonly over 50% in most Pacific island countries, effective demand management practices are highly recommended to reduce water losses. Fixing leaks and reducing water demand is an effective alternative to the costly construction of new intakes, dams and wells that themselves may only increase the stress on already limited water resources.

Early Warning Predictions

A water utility should make use of disaster information and warning centres as part of its disaster mitigation policy. The following warning and prediction services are useful and are recommended to be used:

- ENSO (El Nino Southern Oscillations) predictions, Pacific ENCO Application Center, Hawaii
- Regional weather forecasts
- Guam Joint Typhoon Warning Center
- Development of drought index using local rainfall data, SOPAC Water Resources Unit
- Tsunami Warnings, National Weather Service, Pacific Tsunami Warning Center, 91-270 Fort Weaver Road, East Beach, Hawaii 96706, Fax: +1 808 689 4543

DEVELOPING A UTILITY EMERGENCY RESPONSE PLAN

The objective of an emergency response plan is to provide a framework that will be followed by utility staff in a coordinated response to a national disaster. This will result in the quick assessment of damage and reinstatement of the service as soon as possible.

It is important that the development of the plan includes input from Utility staff in order to ensure a sense of ownership. Many staff will be able to make valuable contributions to the plan with their first hand knowledge of the facilities. Also, it would be beneficial to involve the national disaster management office to assist with the emergency response plan. A list of Pacific SIDS disaster management contacts appears in Appendix 2.

Response Phases

After a disaster there are normally response and recovery phases as follows:

- Immediate response
- Partial service recovery
- Full service restoration

The immediate response phase would focus on the impact of the event and on system stabilisation. A quick and accurate assessment of any damage is essential in recovery operations. However, not all utility staff would be available immediately to assist because they may have to tend to their family needs first. This should be allowed for in the plan. Non-technical staff may be used to carry out some tasks, allowing technical staff to be free for more important activities.

Recovery to the partial service phase involves getting the damaged system operational as soon as possible even if temporary measures are employed. At this time strategic decisions need to be made on whether to repair or replace various system components depending on the degree of damaged, and remaining usefulness. For example, if a section of old pipeline was damaged it may be better to replace the whole pipeline for full service restoration while temporary repairs are adequate for regaining operational service. All too often temporary repairs become permanent repairs if no follow-up action is taken.

At all times after an emergency the affected utility should be consulting and working with the national disaster management office or it's equivalent (see Appendix 2).

Key Features

An operational plan must define the roles and responsibilities of Utility staff members so that everyone automatically knows what he/she should do following an emergency. Management staff would normally coordinate tasks. Engineering and operational staff would check on the security of each system assessing any damage to system's intake or headworks, treatment and storage facilities plus the distribution systems more or less in the above order. Accurate and concise field assessments (with alternative solutions) must be conveyed to the Emergency Operation Centre (see below) as soon as possible.

An Emergency Operation Centre and procedures need to be established to receive system impact assessment information, develop strategies and to act accordingly. The Centre will be the Utilities' focal point to respond to disasters, to communicate with national disaster offices, the public and other organisations required during the emergency. The location of the Centre should be in a secure structure, able to withstand cyclone conditions and be easily accessible. The Centre should be equipped with the necessary robust communication and emergency equipment to enable it to function uninterrupted, which may require stand-by power generators.

Once most of the damage assessment information is available, the coordination team can organise the resources required to regain partial or temporary services until a total recovery strategy can be developed and funded.

When a Utility Emergency Response Plan is established, government and donors may be more amenable to financing assistance not only to repair and/or replace damaged systems but also to implement other mitigation measures to protect the system from similar future events.

The main thrust of the Plan should be for immediate response followed by partial or temporary service until full service is available. Temporary service may include supplying water to the public through standpipes located at reservoirs or other sources and/or by water tanker deliveries to affected areas.

Developing a Plan

Consultants may be used to assist in the development of a response plan. However, using good common sense a utility may wish to develop the plan themselves using available resources. Regional organisations like the Pacific Water Association and SOPAC may be able to assist.

Once a utility has decided to develop a plan, a good way to start is to hold a workshop. Utility staff should be introduced to the concept of a response plan, instilling the sense of ownership with the staff. Many staff members may not realise the importance of the utility in providing water and/or disposing of wastewater services. The process of developing a plan should generate staff interest and pride in the services that they help provide to the community.

Presenting disaster scenarios during workshops is an excellent tool to develop response plans and procedures. It also gets staff involved and thinking in anticipation of disaster. By working through a mock disaster various alternatives and solutions would be discussed leading to the development of an operational plan and a set of procedures noting "who contacts who" and what are the roles and responsibilities of those involved. It may be useful to develop a flow chart noting possible actions to initiate, for example, "what if" there is a power failure and water and/or wastewater can not be pumped? Or, "what if" a water source is damaged and no water is entering the system? Flow chart responses can be thought through in anticipation of an emergency thus assisting responses if a similar event does occur.

Several workshops might be required to develop a plan and at least one training workshop to explain the plan and how it is used. Again, using various emergency scenarios is an excellent training tool where all participants gain from the exercise.

Plan Format

The plan should be as brief as possible using appendices to contain details such as contact lists, specific tasks and responsibilities. A suggested plan format follows:

- *Introduction*

This section should state the purpose of the plan, along with how the plan is to be used. Distribution of the plan documents should also be recorded. The plan should be flexible to allow for future modifications.

- *Response Phases*

This section is the heart of the plan noting actions and responsibilities for specific tasks of the three response phases (ie immediate, partial/temporary and full service restoration). It must be decided what triggers the plan into action or what event is necessary to activate the plan. In the case of a water supply it may be the loss of raw water intake or major damage to the distribution system or prolonged power failure.

Some utilities may wish to stage plan activation by issuing an alert or stand-by phase in anticipation of a forthcoming event like a tropical cyclone. Other events like an earthquake or tsunami may occur with little or no warning. Drought events tend to catch utilities off guard which is why it is important to monitor rainfall, water levels and other parameters to alert utilities of possible drought conditions. Note that the plan may also be used to deal with non-disaster-related events that could be triggered by operational problems or unexpected equipment failures.

Reporting and implementing procedures will have to be established. Specific utility staff roles and responsibilities must be determined for each response phase. For example, once the plan is activated, frontline operation and field staff would be contacted to initially check for any system changes and/or damage. They would report to the supervisor or engineer of observed damage with suggested solutions and required resources to deal with the problem. This information is relayed back to the Emergency Operation Centre along with reports from other utility sections. The Response Team would now assess the overall situation and set priorities to implement repairs and allocate available resources accordingly. Note that resources (human and materials) beyond those of the utility may be required to restore partial and full services. National Disaster Management Offices may be able to assist with obtaining additional resources.

Specific procedure and inspection forms for each utility section (ie intakes, storage, treatment, reticulation, etc.) should be prepared and can be included in the plan as appendices. These individual appendices can then be given to those involved with specific tasks and kept handy for immediate reference when required.

Mitigation and Preparedness Measurements

Based on field surveys and potential hazards that may affect a utility, this section should list identified mitigation and preparedness measures required to “disaster proof” the utility. Work that can be funded through the normal utility budget should be scheduled and implemented. Where additional funding is required project proposals should be prepared and donor support sought. As mentioned earlier, donors may be more likely to fund longer-term mitigation works following a disaster rather than interim measures, that may fail during the next event.

Utilities may wish to include GIS/GPS and/or SCADA developments to upgrade ‘as-built’ records and operational control systems.

SUMMARY

Pacific SIDS (Small Island Developing States) are vulnerable to an array of natural hazards that have caused many deaths, destruction and hardship throughout the Pacific region.

These recommendations have been prepared to assist water utilities (boards, authorities and government departments) to “disaster proof” water and wastewater facilities by developing emergency response plans. These plans also include mitigation and preparedness works to eliminate or minimise adverse effects caused by natural disasters.

Utilities will find that the process of developing an emergency response plan will be a very valuable exercise that will not only result in a useful plan but also increase staff members’ knowledge in the operation and physical location of water sector systems. Through field surveys and workshops, staff will also take pride and ownership of the plan that should be beneficial to the utility. This will result in a better and more reliable service for the community at all times.

REFERENCES CITED OR CONSULTED

1 Brunsden, D.R., I.S McIntosh, Developing a Utility Emergency Response Plan: Proceeding from the New Zealand Water and Wastes Association 1998 Conference, Wellington, New Zealand, 1998

2 Hamnett M.P., Natural Disaster Mitigation in Pacific Island Countries: A Policy Guide for Planners and Decision Makers: UNDP/UNDHA South Pacific Disaster Reduction Programme, 1995

3 House S, B Reed, Emergency Water Sources: Guideline for Selection and Treatment: Water, Engineering and Development Centre (WEDC) Loughborogh University, UK, 1997

4 Johnson R.W., R.J. Blong, and C.J. Ryan (compilers). National Hazards: Their Potential in the Pacific Southwest. Canberra: Australian Government Publishing Service for the Australian Geological Survey and Australian Co-ordination Committee for the International Decade for National Disaster Reduction,1995

APPENDIX 1

Water Supply Systems

Sources
- Rainfall
- Surface
- Groundwater
- Seawater

Intakes
- Artificial catchments (roof tops, runway surfaces)
- Structures in rivers and streams (dams, diversions)
- Spring captures
- Shallow wells (mainly for individual use)
- Boreholes
- Galleries (both groundwater and river/stream)
- Desalination

Storage
- Large impoundments
- Reservoir tanks (all sizes, shapes, materials, in-ground, elevated)

Distribution systems
- Gravity
- Pumped (power required)
- Combination (gravity plus pumping)
- Pipelines (all sizes, materials, pressure rating, in-ground, above-ground)
- Control valves
- Crossings (rivers, streams, etc)

Treatment systems
- None
- Chlorination only
- Sedimentation
- Full treatment

Access to facilities
- By foot
- By road (all weather, four wheel drive, stream crossings)

System control and monitoring
- Manual
- Automatic
- Semi-automatic

Wastewater Systems

Sources
- Domestic
- Industrial

Distribution systems
- Gravity
- Pumped (power required)
- Combination (gravity plus pumping)
- Combined with stormwater
- Pipelines (all sizes, materials, in-ground, above-ground)

- Control valves
- Crossings (rivers, streams, etc)

Treatment systems
- None
- Septic tank (individual system)
- Primary
- Secondary
- Full treatment
- Sludge disposal

Effluent Disposal method
- River or stream
- Ocean or lagoon
- Ground (surface and sub-surface)

Access to facilities
- By foot
- By road (all weather, four wheel drive, stream crossings)

System control and monitoring
- Manual
- Automatic
- Semi-automatic

APPENDIX 2

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