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SECTOR ENVIRONMENTAL GUIDELINES

WATER SUPPLY AND SANITATION

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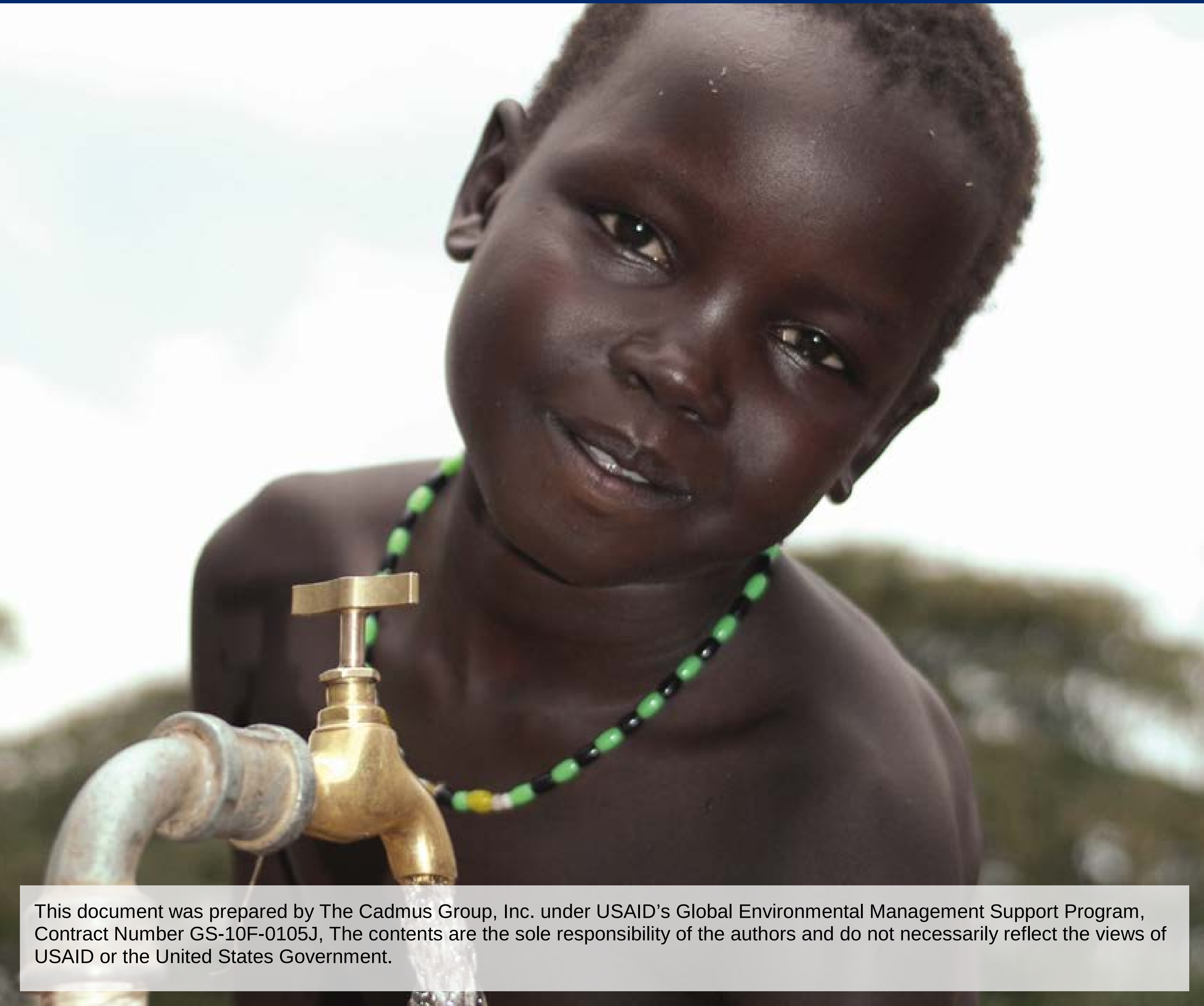


Cover Photo: A child fetches water at an improved water source in Kimatong, Eastern Equatoria, and Southern Sudan. The closer proximity of water resources has enabled families to invest more time in food security and livelihoods. Earlier, limited access to water resources created tensions and led to conflict in Upper Nile and other areas of the South. In response, USAID has funded a variety of initiatives designed to reduce the competition over water and increase access to nearby water points. Photo credit: Pact South Sudan

About this document and the *Sector Environmental Guidelines*

This document presents one sector of the *Sector Environmental Guidelines* prepared for USAID under the Agency's Global Environmental Management Support Project (GEMS). All sectors are accessible at www.usaidgems.org/bestPractice.htm.

Purpose. The purpose of this document and the *Sector Environmental Guidelines* overall is to support environmentally sound design and management (ESDM) of common USAID sectoral development activities by providing concise, plain-language information regarding:

- the typical, potential adverse impacts of activities in these sectors;
- how to prevent or otherwise mitigate these impacts, both in the form of general activity design guidance and specific design, construction and operating measures;
- how to minimize vulnerability of activities to climate change; and
- more detailed resources for further exploration of these issues.

Environmental Compliance Applications. USAID's mandatory life-of-project environmental procedures require that the potential adverse impacts of USAID-funded and managed activities be assessed prior to implementation via the Environmental Impact Assessment (EIA) process defined by 22 CFR 216 (Reg. 216). They also require that the environmental management/mitigation measures ("conditions") identified by this process be written into award documents, implemented over life of project, and monitored for compliance and sufficiency.

The procedures are USAID's principal mechanism to assure ESDM of USAID-funded Activities—and thus to protect environmental resources, ecosystems, and the health and livelihoods of beneficiaries and other groups. They strengthen development outcomes and help safeguard the good name and reputation of USAID.

The Sector Environmental Guidelines directly support environmental compliance by providing: information essential to assessing the potential impacts of activities, and to the identification and detailed design of appropriate mitigation and monitoring measures.

However, the Sector Environmental Guidelines *are **not** specific to USAID's environmental procedures. They are generally written, and are intended to support ESDM of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that apply, if any.*

Region-Specific Guidelines Superseded. The *Sector Environmental Guidelines* replace the following region-specific guidance: (1) *Environmental Guidelines for Small Scale Activities in Africa* ; (2) *Environmental Guidelines for Development Activities in Latin America and the Caribbean*; and (3) Asia/Middle East: *Sectoral Environmental Guidelines.* With the exception of some more recent Africa sectors, all were developed over 1999–2004.

Development Process & Limitations. In developing this document, regional-specific content in these predecessor guidelines has been retained. Statistics have been updated, and references verified and some new references added. However, this document is not the result of a comprehensive technical update.

Further, *The Guidelines* are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

Comments and corrections. Each sector of these guidelines is a work in progress. Comments, corrections, and suggested additions are welcome. Email: gems@cadmusgroup.com.

Advisory. *The Guidelines are advisory only. They are not official USAID regulatory guidance or policy. Following the practices and approaches outlined in the Guidelines does not necessarily assure compliance with USAID Environmental Procedures or host country environmental requirements.*

CONTENTS

WATER SUPPLY AND SANITATION

Good sanitation and hygiene practices are key to preventing contamination of water resources.

At the same time, good facilities and practices provide few health benefits if the water resource remains contaminated.

Therefore, water supply and sanitation projects and hygiene promotion should be viewed as interdependent activities.

USAID's Environmental Services Program (ESP) has helped local activists to provide clean water, recycling and proper sanitation services to Indonesian communities. Photographer: Roman Woronowycz

BRIEF DESCRIPTION OF THE SECTOR

ADEQUATE, SAFE WATER: A BASIC NEED

To remain healthy, human beings need an adequate, year-round supply of good quality water. Many debilitating or even fatal illnesses are spread by contamination of the water supply by human fecal matter containing disease-causing viruses, bacteria, and parasites. Unfortunately, nearly 2.5 billion people, over one-third of the world's population, have inadequate access to sanitation and approximately 800 million people do not have access to enough drinking water.[1] These conditions, combined with poor hygiene, are largely responsible for the fact that 50 percent of the world's population suffers from debilitating diarrheal diseases (e.g., typhoid, cholera, dysentery) at any given time. Of those affected, over 2 million die each year.[2]

Each year polluted water affects the health of 1.2 billion people and contributes to the death of 1.5 million children under age five every year. Vector-borne diseases, such as malaria, kill another 1 to 3 million people per year, with inadequate water management a key cause of such diseases.[3] In Africa alone, over 300 million people lack either sanitation or adequate water, and frequently both, and the Asia-Pacific region is by no means exempt from this problem. Indeed, of the global population without access to improved sanitation or water supply, most live in Asia.

[1] UNICEF. Clean Water Campaign. 2013. http://www.unicefusa.org/work/water/

[2] WHO. Water-Related Diseases. 2013. http://www.who.int/water_sanitation_health/diseases/diarrhoea/en/

[3] The Carter Center. Disease considered as candidates for global eradication by the International Task Force for Disease. Updated 2008. http://www.cartercenter.org/resources/pdfs/news/health_publications/itfde/updated_disease_candidate_table.pdf

In West Asia, water-borne diseases, especially diarrhea, are second only to respiratory diseases as a cause of mortality and morbidity in the region.

Women and children bear much of the brunt of unsafe water and water shortages. Children are the group most likely to become ill from poor water, and women are the primary caregivers for ill family members. Women and girls also carry out most water collection, often spending long hours doing so. Involving women as well as the community as a whole in small-scale water supply and sanitation improvement projects can lead to more sustainable sanitation systems (see The YACUPAJ Project below).

The YACUPAJ project: community participation promotes sanitation

The YACUPAJ project in Bolivia (1991–94), which focused on small-scale water supply and sanitation improvements, integrated many of the features analysts have found in successful sustainable projects:

- **Respond to demand.** To participate in the project, communities had to ask to participate. The first stage of the project in every community was to strengthen and expand this demand through a coordinated education and demonstration program.
- **Community management.** Community members took part in managing the entire project. They defined their needs, set the level of participation, chose the project type, and shared costs.
- **Involve women.** Steps were taken to engage women as active participants in every stage of the project.
- **Install appropriate technology.** Facilities were simple, low-cost, and easily maintained by users.
- **Local construction and maintenance.** Family or community personnel constructed household latrines. Local masons were trained in latrine construction and as hygiene promoters.
- **Promote hygiene.** Hygiene was promoted through education and training. Promotion was identified as a key activity for ensuring effective and sustained use of the services.
- **Monitor sustainability.** State and private institutions remained involved after the project ended to monitor sustainability.

The results. Communities provided over 50% of the funding, even though they were the poorest in the country. A sustainability study of the community in 1995 showed 82% of latrines still in use. Trained masons continue to build latrines with direct responsibility to client families and no external support. Attitudes toward latrine use have improved dramatically.

See Soto (1998).

Representative small-scale water and sanitation activities/technologies

Water sources

- Pond and spring improvements
- Hand-dug wells
- Small-diameter boreholes
- Wells with hand pumps
- Roof rainwater catchments
- Small dams and seasonal impoundments
- Rivers and streams

Water distribution

- Simple spring-fed gravity feed water distribution systems
- Well or surface water source pump with storage tank and piped distribution to standposts or individual yard taps or connections,
- Extensions of existing urban water lines into unserved or under-served peri-urban zones

Water use points

- Showers
- Clothes-washing basins
- Cattle troughs
- Hand washing taps

Individual or community latrines

- Ventilated improved pit (VIP)
- Composting latrines
- Dehydrating latrines
- Pour-flush latrines
- Simple pit with or without cover

Sewerage

- Small-scale septic and leach field systems
- Settled and simplified sewers
- Water stabilization ponds
- Constructed wetlands
- Water borne sewage to primary/secondary treatment
- Ecological sanitation (urine diverting toilets, arborloo latrines)

WATER SUPPLY, SANITATION AND HYGIENE ARE CLOSELY RELATED

Good sanitation and hygiene practices are essential to preventing contamination of water resources. At the same time, good hygiene practices and sanitation facilities provide few health benefits if water resources remain contaminated. Therefore, water supply and sanitation projects and hygiene promotion should be viewed as interdependent activities. Implementing them at together leads to the greatest health benefit and is considered a best practice in the sector.

Over the past three decades, experience has shown that water and sanitation activities are most effective and sustainable when they adopt a participatory approach that (1) acts in response to genuine demand, (2) builds capacity for operation and maintenance and sharing of costs, (3) involves community members directly in all key decisions, (4) cultivates a sense of communal ownership of the project, and (5) uses appropriate technology that can be maintained at the village level. Also important are educational and participatory efforts to encourage sustainable behavioral practices.

CLIMATE CHANGE

Many communities are stressed by changes in temperatures, rainfall patterns, and extreme weather events that may be further exacerbated by global climate change. It is becoming more difficult to predict future climate based on historical baseline conditions or trends. This uncertainty is increasing project design risks and community vulnerabilities. In response, project designers also include a focus on climate change adaptation — defined as adjustment to natural or human systems in response to actual or expected climate change effects. Successful water and sanitation projects include efforts to moderate climate-related risks and vulnerabilities and to take advantage of potential benefits to improve the likelihood of long-term project success. This Guideline provides information on the relationship between climate change and water and sanitation activities. At the same time, project design should assess the potential contribution of a proposed project to greenhouse gas emissions, and reduce contributions by selecting from cost-effective strategies and actions that minimize these emissions. Taken individually, impacts of small activities may appear minimal, but collectively, their scale and magnitude can have far reaching effects on human health and life-sustaining natural systems.

When making use of climate change scenarios, those involved in water and sanitation projects need to take adequate account of the associated uncertainties around climate change and plan for robustness through adaptive management. Risk management frameworks can be used to understand the implications of uncertainties about climate change impacts when informing planning, investment and operation decisions.

POTENTIAL ENVIRONMENTAL IMPACTS OF WATER AND SANITATION ACTIVITIES AND THEIR CAUSES

While water and sanitation projects are intended to improve environmental and public health (and provide numerous other benefits), when managed ineffectively they may cause adverse impacts that can offset or eliminate these intended benefits. Below is a discussion of potential adverse impacts from mismanaged projects.

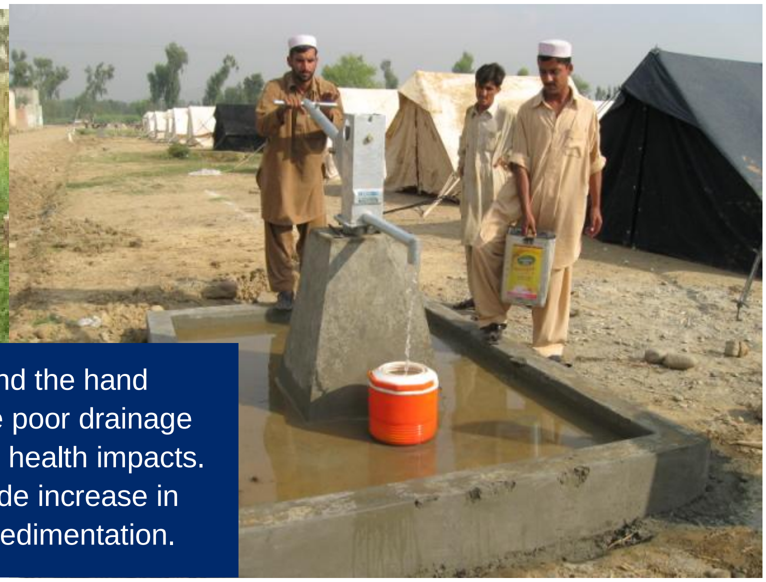
MORBIDITY AND MORTALITY

Water supply and sanitation projects may cause increased incidence of infectious water-borne diseases such as cholera, non-infectious disease such as arsenic poisoning, and water-enabled diseases such as malaria, schistosomiasis[4] or bilharzia.[5]

- Contamination of surface and groundwater supplies with infectious organisms from human excreta is especially serious. Contamination may be caused by poorly designed, operated or maintained sanitation facilities.
- Infectious diseases may also be spread by improper use of wastewater to grow food crops.
- Failure to test new sources of water, especially groundwater, for possible natural or industrial chemical contaminants, such as arsenic, mercury, fluoride and nitrate, can lead to serious health problems.

[4] An infection acquired from water infested with larval forms of parasitic blood flukes, or schistosomes http://www.who.int/schistosomiasis/en/

[5] A parasitic infection by flatworm or fluke larvae that penetrate the human skill and cause inflammation http://www.bbc.co.uk/health/physical_health/conditions/bilharzia1.shtml



The well near Tamale, Ghana (above) and the hand pump well in Pakistan (above right) have poor drainage and thus significant potential for adverse health impacts. Possible impacts of stagnant water include increase in vector-borne diseases and soil erosion/sedimentation.

DEGRADATION TO ECOSYSTEMS

Adverse impacts to ecosystems can arise from water diversion, construction or decommissioning activities in or near a watercourse, or from fecal contamination of water. Numerous impacts on ecosystems are possible:

- Construction of facilities in sensitive areas (wetlands, estuaries, etc.) can destroy flora or fauna or their habitats, leading to loss of biodiversity, reduction of economic productivity and loss of aesthetics and recreational value.
- Improperly designed water-supply projects can also deplete fresh water, erode soil from pipe leakage, or create poor drainage at taps. Increased consumption of water can reduce water flows and cause loss of habitat, wetlands and wildlife downstream. Soil erosion may cause sedimentation in receiving waters, which may reduce the capacity of ponds and reservoirs, increase flooding, or substantially alter aquatic ecosystems by changing streambed, lakebed and estuary conditions.
- Contamination of receiving waters with human excreta or animal manure can cause nutrient enrichment, depletion of dissolved oxygen and other changes that disturb natural ecosystems and reduce the vigor, abundance, and/or diversity of plants and animals that live in water or on land. Disease-causing microorganisms from excreta and manure may also contaminate fish or shellfish, creating health hazards.

FRESH WATER RESOURCES DEPLETED

Depletion of fresh water sources can occur when projects do not adequately assess the quantity of available surface and groundwater (including typical seasonal and annual variations.) Other causes include poor mechanisms for regulating withdrawals and use of water, and insufficient monitoring and maintenance of leaks.

- Depletion of surface water sources damages aquatic life, reduces economic productivity, diminishes downstream use, and curtails recreational possibilities.

- Overdrawing wells and boreholes can alter groundwater flows, reduce groundwater levels, or cause aquifers in coastal or island areas to experience salt-water intrusion, potentially leading to loss of drinking water sources locally or in downstream or down-hillhill locations. These losses of source water availability and quality may lead to increased costs if alternative supplies need to be located or if additional treatment is required. Aquifer depletion and falling water tables can also lead to land subsidence (sinking of the land's surface).

Both situations increase the cost of future water supply systems and may strike urban and rural areas. Increased population densities and the lack of facilities can increase the impact in peri-urban areas. In addition, depletion of water resources may lead to poorer water quality, health impacts, and elevated costs of potable water supplies in downstream or down-hill locations.

INCREASED DISEASE TRANSMISSION FROM STANDING, STAGNANT WATER

Poor design, operation and/or maintenance of water supply improvements can lead to pools of stagnant water near water taps, water pipes and storage tanks. Improper or ineffective practices for disposing of excreta and solid waste can exacerbate this problem.

Stagnant water pools form an excellent breeding place for disease vectors (mosquitoes that carry malaria, etc.). They can also increase transmission of water-related diseases, especially when the wet spots are clogged or contaminated with solid waste or excreta.

POTENTIAL IMPACTS OF WATER SUPPLY AND SANITATION PROJECTS

PROBLEMS	POSSIBLE IMPACTS	POSSIBLE CAUSES
WATER SUPPLY PROJECTS		
Depletion of fresh water resources (surface and groundwater)	• Destruction of the natural resource • Destruction of aquatic life • Loss of economic productivity • Loss of recreation areas • Land subsidence • Increased cost of water supplies in the future or in down-hill locations	• Overestimation of water supplies • Underestimation of water demand • Over-pumping of water resources • Increase in impermeable area • Lack of information on resource yields • Waste and leakage of potable water (inefficient use) • Poor water pricing policies and practices, leading to excessive use, waste and leakage
Chemical degradation of the quality of potable water sources (surface and groundwater)	• Concentration of pollution in surface water sources • Salt water intrusion • Impaired water quality, with associated health problems • Increased water treatment costs in the future or in down-hill locations	• Depletion of surface and groundwater resources • Reduced stream flows • Runoff/drainage from improper solid and liquid waste or excreta disposal •
Creation of stagnant	• Increase in vector-borne	• Drainage systems lacking or poorly

PROBLEMS	POSSIBLE IMPACTS	POSSIBLE CAUSES
(standing) water	diseases • Contamination of standing water with fecal matter, solid waste, etc., leading to health problems • Soil erosion/sedimentation	designed • Leakage from pipes/wastage from taps • Lack of user/operator concern for stagnant water
Degradation of terrestrial, aquatic, and coastal habitats	• Alteration of ecosystem structure & function and loss of biodiversity • Loss of economic productivity • Loss of natural beauty • Loss of recreational values • Soil erosion/sedimentation	• Improper siting of facilities (within wetlands or other sensitive habitats, etc.) • Poor construction practice • Leakage/wastage from pipes and taps • Increased population density/agricultural activity because of new water systems • Eutrophication caused by over-application of fertilizers during agricultural production
Supply of contaminated water	• Arsenic poisoning • Mercury poisoning • Water-related infectious diseases	• Failure to test water quality before developing the water resource • Lack of ongoing water quality monitoring • Inadequate protection of wells and water supply points • Biological nitrite/nitrate and / or pesticide contamination
SANITATION PROJECTS		
Contamination of surface water, groundwater, soil, and food by excreta, chemicals and pathogens	• Increased disease transmission associated with excreta (diarrheal, parasitic, etc.) • Malnutrition caused by above diseases • Higher infant mortality • Reduced economic productivity • Health problems from use of chemically contaminated water • Increased cost of down-hill water treatment for domestic and industrial uses	• Failure to use sanitation facilities • Disposal of excreta or wastewater directly on land or into surface water without adequate treatment • Improper siting of sanitation facilities near water supplies • Inadequate protection of groundwater • Improper operation of sanitation facilities • Failure of sanitation facilities due to lack of maintenance • Improper handling of wastewater from food production
Degradation of stream, lake, estuarine and marine water quality and degradation of land habitats	• Health problems from contact with contaminated water • Fish or shellfish contamination (health hazards, lost economic productivity)	• Failure to use sanitation facilities • Disposal of excreta or wastewater directly into sensitive areas without adequate treatment • Improper operation of sanitation

PROBLEMS	POSSIBLE IMPACTS	POSSIBLE CAUSES
	• Nutrient contamination (eutrophication) • Alteration of ecosystem structure and function; loss of biodiversity • Reduced economic productivity • Soil erosion and sedimentation	facilities • Failure of sanitation facilities due to lack of maintenance • Improper siting of facilities (within wetlands or other sensitive habitats, etc.) • Poor construction practice

Source: Adapted from Alan Wyatt, William Hogrewe and Eugene Brantly (1992). Environmental Guidelines for: Potable Water and Sanitation Projects. Water and Sanitation for Health Project, USAID.

A low cost alternative to a hand pump — a privately owned shallow well with a trap door cover near Segou, Mali.

Note that water retrieved from pumps and wells may require treatment to achieve desired quality according to end use.

CLIMATE CHANGE

PLANNING FOR A CHANGING CLIMATE

Sea level rise, shifting temperatures and precipitation patterns are climatic changes to baseline conditions that affect water and sanitation—and especially the people that rely on these services. Project design, construction and operation must also take into account the frequency, intensity, and duration of extreme events, including droughts, floods, high winds, and tropical storms, which may result in contaminated drinking water, spread of disease, and water scarcity. Therefore, projects need to be designed to withstand exposure to an altered climate and be resilient to deviations from historical conditions. Elements of water and sanitation project design, construction and use sensitive to weather need greater attention to risk analysis and climate change probabilities than in the past, to help ensure that appropriate materials and designs are selected and the long-term success of projects is achieved. Specifically aspects of collection and sanitation systems sensitive to weather (e.g., materials, location) need to be examined to ensure that they are appropriate.

Thirty-eight percent of population growth now occurs in slums or shanty towns, which are more likely to be located in hazard-prone areas, and where existing lack of sanitation and safe drinking water may be exacerbated by climate change events such as drought, flooding, heavy rainfalls, or high winds. Sanitation systems that have been improperly or poorly constructed are one of the greatest risks associated with climate hazards, leaving inhabitants highly vulnerable.

ADAPTING TO CLIMATE CHANGE BY MINIMIZING VULNERABILITY THROUGH PROJECT DESIGN

Adapting planning, design, and project execution to climate change involves ensuring that new water and sanitation infrastructure is able to withstand variations in climatic conditions and especially extreme weather events. This involves incorporating both the function of the system as well as the vulnerability of users (e.g., children, elderly, or ill) into design.

Designers and project managers now include a focus on incorporating information on climate from past baseline trends, as well as near-term projection scenarios (e.g., the next 25-50 years, where feasible). In many cases managing for greater uncertainty and risk associated with potential extreme conditions rather than past historical trends emphasizes the **precautionary principle** over "**business as usual**." This type of focus on risk analysis and management is commonly applied by the financial and insurance industries and can also be used in assessing potential development activities.

For example, design and siting for water and sanitation projects should take into account projected sea level rises and storm surges—and potential salt water intrusion to drinking water sources. The same principle applies to residences located in or near flood plains, rivers and wetlands. Construction in these areas should be avoided whenever possible. In locations where drought conditions are becoming more frequent, project designs should ensure that a reliable source of water can be sustained to supply water sources and sanitation systems. Ultimately, more robust water and sanitation infrastructure will ensure resilience to climate change.

In the practice of EIA, mitigation is the implementation of measures designed to eliminate, reduce or offset the potential adverse effects of a proposed action on the environment.

In the practice of climate change, mitigation is an intervention to reduce GHG sources and emissions or to enhance the sequestration of GHG's by natural means (e.g., uptake by trees, vegetative cover, algae) or the use of technology (e.g., underground carbon storage) to limit the magnitude and/or

Climate change adaptation also includes integrating renewable and/or back up energy systems to maintain water and sanitation collection, distribution, and treatment in the event of sudden or intermittent flooding or fuel shortages. Extreme events may displace entire communities. It is essential to communicate early warning systems, evacuation plans, and temporary housing locations to residents in preparation for such events.

From a **risk management** perspective, it is less costly to design for the potential direct and indirect impacts of climate change on water and sanitation management projects, than to risk major losses or damage to water and sanitation infrastructure or for residents to face loss of service in the future.

For example, design and siting for water and sanitation projects near the sea should take into account potential changes in daily sea levels, projected sea level rise, and storm surges. The same principle applies to water and sanitation projects near flood plains, rivers and wetlands.. Climate change adaptation for construction also includes integrating renewable and/or back up energy systems to maintain buildings in the event of sudden or intermittent electrical outages or fuel shortages. In locations prone to drought, supplies of fresh water may be diminished. Project managers should implement procedures to closely monitor water use, repair leaking pipes, and install water efficient appliances. In some locations, harvesting rainwater for use during dry periods and recycling gray water for non-drinking purposes, such as irrigation of grounds should be applied.

Water supply projects must take into account projected surface water flow and ground water levels given changes from climate change. Minimum stream flow levels should be allowed to remain to ensure aquatic ecosystem integrity in streams and rivers.

MINIMIZING GREENHOUSE GAS (GHG) EMISSIONS AND MAXIMIZING SEQUESTRATION

GHG contributions from human waste management are mostly composed of methane. Coupled with emissions from the solid waste management sector, these make up less than 5 percent of total anthropogenic GHGs. Although minor levels of emissions are released through waste treatment and disposal, practices such as capturing methane can reduce emissions. Improved infrastructure for waste management in developing countries can also mitigate GHG emissions.

Energy efficiency can be achieved for water and waste sanitation facilities through green building design, efficient lighting technology, heat reflective walls and roofs, and insulation. Vehicles that transport waste or potable water can reduce greenhouse gas emissions by decreasing fuel use, reducing idling times, regular maintenance, and driver training to improve energy efficient driving practices.

Waste water treatment systems that mimic natural ecosystems, such as constructed wetlands, should be considered for areas that lack sufficient electrical power to operate a mechanized facility, and where sufficient land area is available.

ESDM OF ACTIVITIES & PROGRAMS: BEST PRACTICES

Water and sanitation activities and achieving ESDM in this sector requires a **participatory approach** to activity/program design and management. Strong technical design of the projects is also critical.

This section provides an overview of best practices drawn from lessons learned in the field over more than 30 years with both participatory approaches and technical design.

BEST PRACTICES APPLICABLE TO BOTH WATER SUPPLY AND SANITATION PROJECTS

Take advantage of the experience of others. A number of excellent and detailed guidelines, manuals, sourcebooks, and checklists provide clear and concise guidance on developing water supply and sanitation projects. In most cases these are available via the Internet. Some of these resources, most with affiliate URLs, can be found in the Resources and References section at the end of these guidelines.

Best practices for water and sanitation projects

- Learn from effective projects
- Concentrate on the human component
- Use a promotional program, especially for sanitation, to build demand

Selected water quality standards for human health

- Arsenic < 0.01 mg/L
- Total Coliforms = not detectable in any 100mL sample
- Lead < 0.01 mg/L
- Copper < 2 mg/L
- Nitrate (as NO3-) < 50 mg/L
- Nitrite (as NO2-) < 0.2 mg/L for long-term exposure
- Fluoride < 1.5 mg/l

Reference: WHO, *Guidelines for Drinking-Water Quality (3rd Edition)*, 2004. http://www.who.int/water_sanitation_health/dwq/gdwq3/en/index.html

Concentrate first on preparing and developing the human component of the project and use a demand-focused approach. Projects will be welcomed and supported by the local community only when they perceive a need. Cost sharing, especially for operation and maintenance, should be encouraged because of the positive effects it has on ownership, community support, and long-term sustainability. However, there may be some instances where cost-sharing may not be possible. Cost sharing can be in-kind, such as community clean up days for drainage ditches, or a community supplying locally available materials (sand, wood, etc).

Promotional program/social marketing must accompany infrastructure development. Water supply and sanitation projects that fail to improve hygiene behaviors generally achieve little or no improvement in public health. Community participation (discussed below) and awareness are essential to achieving these changes. Improving hygiene practices requires sensitivity to the community's cultural and social preferences. Realism must be applied in this process—it may take years for the community to adjust to new practices.

Reaching school children is often an effective strategy, but efforts to bring about behavior change must focus on other family members as well. Family members who are able must ensure that sanitation practices for infants, pre-school age children, and elderly do not contaminate water supplies or spread diseases to healthy children or adults.

Understanding local hygiene behaviors and social-cultural beliefs that affect supply and sanitation options is an essential first step in design. For example, in some cultures sanitation facilities for men and women must be strictly segregated even at the family level, so that a single latrine per family is inadequate. In other cases the culture may forbid defecation in roofed structures.

Resources exist to help design programs to improve hygiene behavior. See *Sanitation Promotion* (Simpson-Hébert and Wood, 1998), *PHAST step-by-step guide: a participatory approach for the control of diarrhoeal disease* (Sawyer et al., 1998), and *Sanitation and Hygiene Promotion Programming Guidance* (WHO, 2005). The Resources and References section at the end of this guideline provides a summary description and access information for each document.

Use a participatory approach, including choice of technology that actively engages the community in all stages of the project, including: planning and development of management systems; establishment of user fees, construction, operation and maintenance; and possible future decommissioning. This will help lead to appropriate design, enhance adoption of new behaviors and help generate the levels of community commitment and support needed for proper maintenance of the project. The field of Participatory Rural Appraisal for example, has developed an array of tools to engage or benefit from the perspective of stakeholders regarding potential project activity.

An essential part of the participatory process is to give families and communities a selection of generally appropriate technology and design options to choose from, instead of beginning the project with a predetermined technology.

For instance, offer technology alternatives that can be operated and maintained locally/at the village level. In addition, confirm that spare parts and necessary expertise are readily available. For example, village operation and maintenance is widely used to bring the long-term responsibility for the continued use of communal hand pumps down to the level of the users, but it must be part of a well-established system of community management, training, and technical support when repairs require outside expertise.

Use some form of cost sharing to minimize subsidies. When households share the cost of building latrines they feel a sense of ownership and responsibility for the project. This can reduce overall costs.

Integrate water supply, sanitation and hygiene promotion. If these elements are treated individually, the fecal-oral route of disease transmission will not be broken and public health benefits from infrastructure investments will be limited. If it is not possible to implement an integrated program, the first priority should be increasing water quantity, with improving infrastructure for water quality of secondary importance. When programs are implemented independently, those that focus on improved sanitation, including the adoption of good hygiene behaviors, show the greatest reduction in disease transmission. Those focused exclusively on improving water quantity show the next best performance and those focused only on improved water quality give the least benefit.

Draw upon existing community organizations instead of starting new ones. In many communities there may be established groups or leadership that can be called upon to help guide the proposed project or activity. Project teams can work with these existing groups to engage key stakeholders and gather objective opinions and information in support of the water and sanitation activity.

Design the program so that it will be economically self-sustaining. Generally, this requires cost recovery mechanisms such as user fees, taxes or levies to finance operations, monitoring, maintenance and repairs, along with a sustainable management structure for collecting these monies and overseeing their use. This can be a challenge and should be approached with considerable planning that is supported by research, common sense and a constant dialogue with the community regarding what might be feasible.

Include a system for sustaining operation and maintenance as part of overall program design. The failure to ensure ongoing operation and maintenance is one of the most common reasons projects fail. The system should include a mechanism for training local residents to operate, monitor, maintain and repair the project and to keep up institutional memory; for example, maintaining a pool of community members trained in operation and maintenance.

BEST PRACTICES FOR WATER SUPPLY PROJECTS

- **Calculate yield and extraction rates** in relation to other area water uses and available supply. This is necessary to avoid depleting the resource or adversely affecting aquatic ecosystems and/or communities downstream/downhill.
- These calculations should take into account historic and projected upstream/up-hill and downstream/down-hill supply and demand for water. Projects tapping groundwater should also consider depth to water table and groundwater hydrology.
- **Design improvements with an appropriate scale and capacity.** Estimate current and projected water quantity and availability based on current water sources and existing uses, baseline measurements on quantity of water available (including seasonal fluctuations), current and historic use data (household, agricultural, and institutional), population data and forecasts, current and projected demand up and down stream/up and down hill, and actual water use for similar projects in the past.
- If possible, data on typical water leakage rates in other existing water schemes should be examined. Demand projections should take into account the likelihood that the project will attract additional users.
- **Assess water quality** to determine if water is safe to drink and to establish a baseline so that any future degradation can be detected.
- Ideally tests should be performed on the chemical, biological and physical quality of the proposed water source. At a minimum arsenic and fecal coliform tests should be conducted. *USAID requires testing for arsenic for all USAID-funded water supply projects, as there is currently no way to determine which locations may contain natural arsenic deposits.*
- **Maintain periodic testing.** Ongoing testing is the only way to determine if a water supply is or has become contaminated (other than by observing dramatic and sustained increases in water-borne disease).
- **Minimize downstream/down-hill effects of intervention,** perhaps by establishing some form of communication with downstream parties.

Best practices – water supply

- Calculate yields and extraction rates
- Appropriate scale and capacity
- Assess water quality
- Periodic testing
- Minimize downstream impacts
- Promote improved hygiene behaviors

Best practices – sanitation

- Promotion of sanitation to create demand
- Match demand, customs, preferences and ecosystem
- Assess local water quality
- Minimize downstream impacts
- Consider natural treatment before mechanical options
- Promote improved hygiene

BEST PRACTICES FOR SANITATION PROJECTS

- **Develop a hygiene promotion strategy** that takes into account the current hygiene behavior (hand washing, latrine use, water collection, transport, and storage) of all users, = as well as any social/cultural religious factors that may hinder changing behavior.
- Design improvements to match demand, user customs and preferences, climate, and abundance of water.
- **Test water quality downstream/downhill** from the proposed site before construction of infrastructure to establish a baseline. Testing after completion of project will provide necessary information for mitigation purposes.
  - Elements to test for include fecal coliform, total suspended solids (TSS), biological oxygen demand (BOD) and nutrients. Maintain ongoing testing to monitor for contamination.
- Minimize downstream/down-hill effects of intervention. See box below on Sanitation and Hydrology.
- **Consider appropriate natural treatment systems instead of mechanical systems.** Natural treatment systems tend to be preferable for small-scale activities as they generally cost less, do not require highly skilled labor, and can frequently be manufactured locally. Also, supplies for maintenance and repair are likely to be more readily available.
  - There are many proven natural treatment options. Examples include double-vault batch composting toilets, double-vault batch dry toilets, upflow anaerobic filters,[6] biogas reactors, confined-space constructed wetlands, subsurface wetlands, floating aquatic macrophytes,[7] stabilization ponds and ecological sanitation (urine diversion and arborloo systems).

COMMUNITY-LED TOTAL SANITATION (CLTS) AND COMMUNITY APPROACHES TO TOTAL SANITATION (CATS)

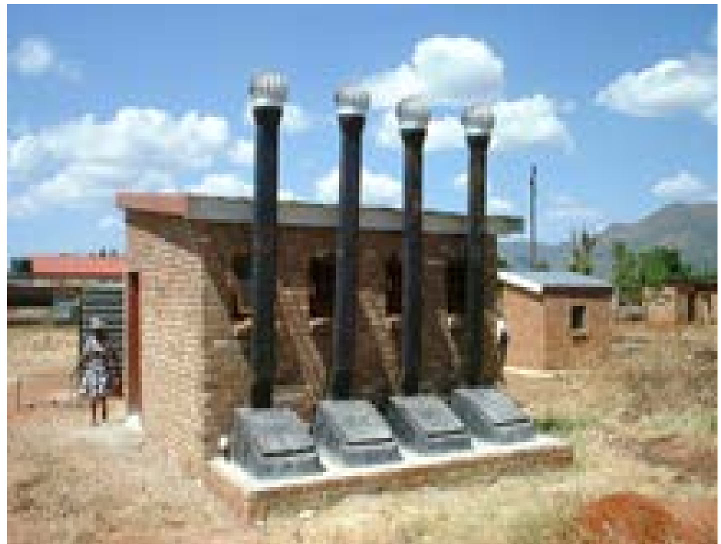
CLTS/CATS represent the efficacy and importance of taking a participatory approach to sanitation projects. Instead of relying exclusively on external incentives and provisions – such as subsidies or construction of toilets – to promote improved sanitary practices, CLTS/CATS rely on creating community awareness about the health impacts of open-defecation and allowing the community to fuel the effort toward ending open-defecation. The technical aspects and specifications regarding infrastructure take a back seat until a process of engagement and awareness raising has been satisfactorily completed.

CLTS began in late 1999, innovated by Dr. Kamal Kar, then serving on a mission for the UK NGO WaterAid. Dr. Kar observed that WaterAid's subsidized latrine-construction projects resulted in more toilets but did not coincide with increased use of latrines. Instead, it was through the collective decision of a pilot community to cease the practice of open-defecation that led to CLTS.

[6] The reference to upflow anaerobic filters and biogas reactors both require pumping, so they are not truly "natural treatment systems".

[7] Sooknah, R. D. and A. C. Wilkie. Nutrient removal by floating aquatic macrophytes cultured in anaerobically digested flushed dairy manure wastewater. 2004. Ecological Engineering 22: 27-42. http://dairy.ifas.ufl.edu/other/files/Sooknah-and-Wilkie-EcolEng-22_1_-2004.pdf

UNICEF developed its similar CATS approach, which is broadly outlined in the organization`s 2008 publication, “Community Approaches to Total Sanitation: Based on case studies from India, Nepal, Sierra Leone, Zambia.” Below is a broad overview of the CATS approach taken directly from the aforementioned document and which in many ways mirrors the objectives and process of the CLTS approach:



An "enviroloo" (dry composting toilets) mandated by the Department of Public Works in the Northern Province of the Republic of South Africa (2002)

- “CATS aim to achieve 100 per cent open defecation free (ODF) communities through affordable, appropriate technology and behavior change. The emphasis of CATS is the sustainable use of sanitation facilities rather than the construction of infrastructure. The safe disposal of infant and young children’s feces in toilets is essential to achieving ODF status.
- CATS depend on broad engagement with diverse members of the community, including households, schools, health centers and traditional leadership structures.
- Communities lead the change process and use their own capacities to attain their objectives. Their role is central in planning and implementing improved sanitation, taking into account the needs of diverse community members, including vulnerable groups, people with disabilities, and women and girls.
- Subsidies – whether funds, hardware or other forms – should not be given directly to households. Community rewards, subsidies and incentives are acceptable only where they encourage collective action in support of total sanitation and where they facilitate the sustainable use of sanitation facilities.
- CATS support communities to determine for themselves what design and materials work best for sanitation infrastructure rather than imposing standards. External agencies provide guidance rather than regulation. Thus, households build toilets based on locally available materials using the skills of local technicians and artisans.
- CATS focus on building local capacities to enable sustainability. This includes the training of community facilitators and local artisans, and the encouragement of local champions for community-led programs.
- Government participation from the outset – at the local and national levels – ensures the effectiveness of CATS and the potential for scaling up.
- CATS have the greatest impact when they integrate hygiene promotion into programme design. The definition, scope and sequencing of hygiene components should always be based on the local context.
- CATS are an entry point for social change and a potential catalyst for wider community mobilization.”

Project managers should consider the viability of employing CLTS/CATS model to WATSAN activity as a means to avoid many of challenges related to the social dimensions that can undermine activity in the sector.

PROCESS FOR EVALUATING POTENTIAL ENVIRONMENTAL IMPACTS

Potential environmental impacts of a project should be evaluated with public involvement concurrently as the PVO/NGO and community define the project's objective, the types and extent of services, and the types of facilities that will provide the desired services in a way that fits the physical, social, and economic conditions of the community.

Appropriate options should be identified for each "component" of the system. For a water supply system these would include the water source, storage facilities, the distribution system, and possibly treatment facilities. For a sanitation system they would include facilities for excreta, as well as collecting, transporting, treating, and disposal or reuse of excreta or wastewater.

As the set of appropriate options is being defined, a project proponent (e.g., PVO or NGO) can work with the community to evaluate the potential environmental impacts of each option and identify appropriate mitigation measures.

Factors to consider for siting wells

Location:

- Locate the well at the highest point on the property. This makes protecting the wellhead easier.
- Avoid positioning down slope from potential sources of contamination, including surface water flows and flooding conditions.
- Locate the well in a site easily accessible for maintenance.
- Define a sanitary protective area around the wellhead that is kept in its natural state.

Potential Contaminants:

- Yield and quality of water supply will depend on soil type (which determines filtering capability and transmissivity Not sure how many generalists would understand this term).
- Course gravel, limestone, and disintegrated rock can allow contaminants to travel quickly with little opportunity for natural purification.
- Distance to nearest point of potential contamination is site and aquifer specific. The following MINIMUM distances from potential sources of contamination are best practice for sites with sand-like filtering capabilities:
  - 45.7 m (150 ft) from a preparation area or storage area of spray materials, commercial fertilizers, or chemicals that may cause contamination of the soil or groundwater.
  - 30.5 m (100 ft) from a below-grade manure storage area.
  - 22.9 m (75 ft) from cesspools, leaching pits, and dry wells.
  - 15.2 m (50 ft) from a buried sewer, septic tank, subsurface disposal field, grave animal or poultry yard or building, privy, or other contaminants that may drain into the soil.
  - The distance between a septic tank leach field and a down-hill well should be greater than 30.5 m (100 ft) if the soil is coarser than fine sand and the groundwater flow rate is greater than 0.03 ft/day (0.01 m/day).

Source: Driscoll, Groundwater and Wells, Second Edition.

ESDM OF ACTIVITIES AND PROGRAMS: SPECIFIC MITIGATION AND MONITORING MEASURES

The table in this section matches impacts and mitigation measures to specific water and sanitation activities/technologies.

Achieving ESDM requires that these impacts are considered and the corresponding mitigation measures adopted when the impacts are potentially significant. Note that in many cases, the mitigation measures are good practices.

In general, USAID IEEs or subproject review documents should note and assess the potential impacts listed here and specify corresponding, appropriate mitigation measures.

Sanitation and hydrology

Preventing microbial contamination of groundwater sources depends on several factors:

- Type of latrine – the rate of flow of pathogen-containing liquid from latrine pits to the soil beneath is proportional to the quantity of liquid in the pit (static head). Dry latrines present the smallest risk of groundwater contamination.
- Water table – a latrine pit must be above the water table during all seasons. 1.5m below the surface is the minimum depth necessary to ensure the pit contents remain dry. The greater the distance between the base of the pit and the water table, the more time is required for pathogens to seep from the pit into the groundwater, thus allowing more pathogens to die-off naturally.
- Soil type – Clay, silt, and fine sand soil types all have grain sizes small enough to act as natural filters for microbial contaminants (<0.2mm). Certain clay soils can also absorb viruses.
- Distance to nearest water source – the risk of contamination of a surface or groundwater source by a latrine depends on the distance to the source, the direction and velocity of the flow of water in the soil (hydraulic hill), and the soil/rock permeability. 30m is considered the minimum separation for most soil types.

Balancing these factors to determine the best combination of siting and sanitation technology should involve input from engineers and/or hydrologists. For more information, see S. Sugden, *WELL Factsheet: The Microbiological Contamination of Water Supplies*, 2004. http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/Contamination.htm

IMPACTS AND MITIGATION MEASURES FOR SPECIFIC WATER AND SANITATION ACTIVITIES AND TECHNOLOGIES

ACTIVITY/ TECHNOLOGY	POTENTIAL IMPACTS	MITIGATION MEASURES *Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)*
GENERAL		
Site selection	• Damage sensitive ecosystems or endangered species	• Survey for, and avoid, wetlands, estuaries or other ecologically sensitive sites in the project area. Identify nearby areas that contain endangered species and get professional assessment of species' sensitivity to construction at site (P&D)
Construction of buildings and structures	• Damage sensitive ecosystems or endangered species • Cause erosion and sedimentation	• Follow guideline on Construction in this guideline series (P&D) (C) • Train and monitor workers on best practices in construction of buildings and structures (P&D) (C) • Gather data on soil type, slope and topography to determine the potential for significant erosion (P&D) • Use silt screens, straw bales or similar erosion control measures (C) • Avoid damaging vegetation (C) • Revegetate areas damaged during construction. Do not remove erosion control measures until revegetation is complete (C) • Use proper bedding materials for pipes (P&D) (C) • Create a community-based operations and maintenance plan that takes into account associated long-term costs (O&M)
Soakways and drains	• Cause erosion • Alter the natural flow of rainwater runoff • Create pools of stagnant water	• Use riprap (cobbled stone), gravel or concrete as needed to prevent erosion of drainage structures (P&D) (C) • Monitor and keep drains and soakways clear (O&M)

<table>
<tr><th>ACTIVITY/ TECHNOLOGY</th><th>POTENTIAL IMPACTS</th><th>MITIGATION MEASURES
Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)</th></tr>
<tr><td colspan="3">WATER SUPPLY IMPROVEMENTS</td></tr>
<tr><td rowspan="2">Hand-dug wells, seasonal ponds, improved springs, ground-level catchment and similar structures</td><td>• Contaminate water with human pathogens</td><td>• Include focus on proper use and maintenance of the improvement as part of behavior change and education program (P&D)
• Construct spigot or similar system that prevents people from touching impounded water with their hands or mouths (P&D) (C)</td></tr>
<tr><td>• Contaminate water with animal manure
• Create pools of stagnant water
• Exhaust water supply (not applicable to improved springs or hand-dug wells)</td><td>• Use fencing or equivalent that will keep live stock from grazing uphill or uphill of the water supply improvement (P&D) (C)
• Do not allow animals to drink directly from the water source (O&M)
• Monitor drains and soakways and keep them clear of debris (see entry on soakways and drains above for more detail) (O&M)
• Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M)
• Put in place a system for regulating use, such as a local warden or appropriate pricing (P&D)
• Give the community training in operating the improvement (P&D) (O&M)
• Monitor water levels in wells or impoundment structures to detect overdrawing (O&M)</td></tr>
<tr><td>Wells</td><td>• Provide water contaminated with nutrients and bacteria from animal waste
• Create pools of stagnant water
• Change groundwater flow
• Create saltwater intrusions
• Deplete aquifer (groundwater)
• Cause land subsidence (impact from many wells)</td><td>• Don’t let animals graze or be watered up-hill from wellhead (P&D) (O&M)
• Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M)
• On islands and coastal areas, keep withdrawals within safe yield limits to avoid overdrawing, possible salt water intrusion and contamination of the well (P&D)
• Put in place a system for regulating use, such as a local warden or appropriate pricing (P&D)
• Include a focus on proper use and maintenance of the improvement as part of the behavior change and education program (O&M)
• Monitor water levels (O&M)</td></tr>
</table>

ACTIVITY/ TECHNOLOGY	POTENTIAL IMPACTS	MITIGATION MEASURES *Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)*
Standpipes	• Create pools of stagnant water (This problem can be more severe when the water table is high, clay soils are present, or population/tap density is high)	• Ensure that spilled water and rainwater drain to a soakway or equivalent structure and do not accumulate and create stagnant standing water (C) • Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&M)
TREATMENT SYSTEMS		
Pit latrine	• Increase transmission of vector-borne diseases • Contaminate groundwater supply with pathogens • Contaminate water supplies, damage water quality and/or transmit disease at other locations if waste is not properly handled and treated during or after servicing • Cause injury to people or animals	• Devote adequate attention to identifying and addressing social barriers to using latrine (P&D) • Use the ventilated improved pit latrine design that traps insect vectors (P&D) • Evaluate depth to water table, including seasonal fluctuations and groundwater hydrology. The size and composition of the unsaturated zone determine the residence time of effluent from the latrine, which is the key factor in removal and elimination of pathogens. Pit latrines should not be installed where the water table is shallow or where the composition of the overlying deposits make groundwater or an aquifer vulnerable to contamination (P&D) • Ensure that a reliable system for safely emptying latrines and transporting the collected material off-site for treatment is used. This should include use of a small pit-emptying machine such as the vacutug that relies on an engine-driven vacuum pump. The vacutug was tested for UNCHS in low-income areas of Nairobi, Kenya, and was found to give workers much greater protection from disease than conventional methods. See Wegelin-Schuringa, Small Pit-Empty-ing Machine: An Appropriate Solution in Nairobi Slum, for more details) (O&M) • Ensure that collected material is adequately treated and not directly applied to fields or otherwise disposed of improperly (O&M) • Properly decommission pit latrines. Do not leave pits open. Fill in unused capacity with rocks or soil. (O&M)

ACTIVITY/ TECHNOLOGY	POTENTIAL IMPACTS	MITIGATION MEASURES *Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)*
Composting toilets	• Increase transmission of vector-borne diseases • Contaminate groundwater supply with pathogens • Cause disease transmission to field workers and consumers of agricultural products	• Maintain humidity of composting material above 60% and supplement excreta with generous quantities of carboniferous material (dry leaves, straw, etc.). The pile should then remain aerobic, odor-free and insect-free (O&M) • Construct sealed vaults to hold composting material if using fixed-batch systems. If using movable-batch systems check removable containers for leaks before installing (O&M) • Test samples from active chamber and mature chamber after fallow period for Ascaris eggs and fecal coliforms (O&M) • Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&M) • Ensure that the systems will be properly operated and maintained so that the soil amendment taken out after the treatment period is truly sanitized (O&M)
Dry toilets	• Increase transmission of vector-borne diseases • Cause disease transmission to field workers and consumers of agricultural products	• Maintain humidity of composting material below 20% and supplement excreta with alkaline material (ashes or lime). The pile should then remain both odor free and insect free (O&M). Generous applications of ashes will help ensure that pathogens are destroyed. pH is the most important factor for sterilization (O&M) • Construct sealed vaults to hold dehydrating and curing material (C) • Ensure that the systems will be properly operated and maintained so that the soil amendment taken out after the treatment period is truly sanitized (O&M) • Test samples from active chamber and mature chamber after fallow period for Ascaris eggs and fecal coliforms to assess level of sterilization (O&M) • Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&M)

ACTIVITY/ TECHNOLOGY	POTENTIAL IMPACTS	MITIGATION MEASURES *Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)*
Septic tanks	• Contaminate groundwater supply with pathogens • Contaminate surface water supplies with nutrients, biological oxygen demand (BOD), suspended solids (SS) and pathogens. (Septic tank effluent generally contains relatively high concentrations of pathogens, BOD, and SS) • Contaminate water supplies, damage water quality and/or transmit disease at other locations if waste is not properly handled and treated during or after servicing	• Evaluate depth to the water table, including seasonal fluctuations and groundwater hydrology. If water table is too high, line the tank with clay, plastic sheeting or some other impermeable material to prevent leakage (P&D) (C) • Avoid direct discharge of effluent to waterways if possible. Direct discharge to waterways with sufficient volume and flow to assimilate the waste may be acceptable. It is better to add a secondary treatment, such as passing effluent through an anaerobic filter, followed by discharge to an absorption field, or better yet, a constructed wetland (P&D) • Ensure that a reliable system for safely removing sludge and transporting the collected material off-site for treatment is available. This should include use of a mechanized (probably vacuum-based) removal system (P&D) (O&M) • Ensure that collected sludge is adequately treated and not directly applied to fields or otherwise improperly disposed of (See Sludge management below) (O&M)
Upflow anaerobic filters	• Damage ecosystems and degrade surface water quality. Sludge has high concentrations of nutrients, BOD, and solids • Cause disease transmission to field workers and consumers of agricultural products (Sludge may still contain pathogens)	• Treat sludge before secondary use (see Sludge management below). Do not allow disposal in or near water bodies (O&M) • Provide workers servicing, transporting, and otherwise exposed to sludge with appropriate protective clothing including, at a minimum, rubber gloves. Train workers to wash hands and faces frequently with soap and warm water and make both available. (See Wastewater and sludge use in agriculture and aquaculture below) (O&M)
Settled and simplified sewers	• Damage ecosystems and degrade surface water quality • Transmit diseases to field workers and consumers of agricultural products	• Ensure that collected sewage will be treated, e.g., in a wastewater stabilization pond, and not simply discharged to a river or stream or used directly in agriculture or aquaculture. This is especially important for simplified sewerage, since there is no interceptor tank (P&D) (O&M)

ACTIVITY/ TECHNOLOGY	POTENTIAL IMPACTS	MITIGATION MEASURES *Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)*
Biogas reactors	• Damage ecosystems and degrade surface water quality • Transmit diseases to field workers and consumers of agricultural products	• Do not allow disposal of digested slurry in or near water bodies (O&M) • Follow WHO or other national or international guidelines for use of sludge in wastewater in agriculture and aquaculture (see Sludge and wastewater reuse below) (P&D) (O&M)
Wastewater stabilization ponds (anaerobic, facultative, aerobic)	• Damage ecosystems and degrade surface water quality • Transmit diseases to field workers and consumers of agricultural products	• Avoid discharging single (facultative) pond systems directly into receiving waters. If this is unavoidable, construct hydrography-controlled release lagoons that discharge effluent only when stream conditions are adequate. Install secondary treatment such as a constructed wetland, if possible (P&D) (C) (O&M) • Use two-, three- or five-pond systems if possible (anaerobic, facultative, maturation). (P&D) • Allow only restricted uses for agriculture and aquaculture of effluent from all but five-pond systems (O&M)
Reed bed filter or Subsurface wetland	• Contaminate groundwater or surface water	• Evaluate depth to the water table, including seasonal fluctuations and groundwater hydrology. If water table is too high, line tank with clay, plastic sheeting or some other impermeable material to prevent leakage (P&D) (C)
Free water surface wetland; Floating aquatic macropytes	• Provide breeding ground for disease vectors • Introduce invasive non-native species	• Use plant and animal species that are native to the region. Avoid introducing water hyacinth, water milfoil, or salvinia, which have proven extremely invasive outside of their natural range (P&D) • If using water hyacinth, maintain dissolved oxygen at 1.0 mg/L, frequently harvest and thin plants and/or add mosquitofish (Gambusia affinis) to the wetland or use other plant species such as duckweed, water lettuce (Pistia stratiotes), water milfoil, or salvinia (Salvinia spp.) (O&M)
Slow-rate overland flow	• Contaminate groundwater or surface water	• Use where growing season is year round. Requires vegetation (P&D) (O&M) • Use only where soil textures are sandy loam to clay loam (P&D) (O&M) • Use where groundwater is >3 ft. below surface (P&D) (O&M)

ACTIVITY/ TECHNOLOGY	POTENTIAL IMPACTS	MITIGATION MEASURES *Note: Measures apply to specified project phase: planning and design (P&D), construction (C), or operation and maintenance (O&M)*
Slow-rate subsurface flow	• Contaminate groundwater or surface water	• Use only where soil textures are sand to clayey loam (P&D) • Use only where groundwater is >3 ft. below surface (P&D)
Rapid infiltration	• Contaminate groundwater or surface water	• Use only where soil textures are sandy to loam (P&D) • Use only where groundwater is >3 ft. below surface (P&D)
Sludge management	• Damage ecosystems and degrade surface water quality • Cause disease in handlers and processors	• If possible, choose treatment technologies that do not generate sludge, such as wastewater stabilization ponds (P&D) • Compost sludge, then use as soil amendment for agriculture (O&M) • Provide workers with appropriate protective clothing, including rubber gloves, boots, long-sleeved shirts and pants. Train workers to wash hands and faces frequently with soap and warm water and make both available (O&M)
Wastewater use in agriculture and aquaculture	• Cause disease in field workers and consumers of agricultural products	• WHO guidelines recommend (1) treat to reduce pathogen concentrations, (2) restrict use to crops that will be cooked, (3) use application methods that reduce contact with edible crops, and (4) minimize the exposure of workers, crop handlers, field workers and consumers to waste (P&D) (O&M) • Wastewater used in aquaculture should have <103 fecal coliforms per 100 ml to minimize risk to public health. (P&D) (O&M) See Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: Measures for Public Health Protection, 1989, WHO, Geneva http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf

RESOURCES AND REFERENCES

GUIDELINES FOR WATER SUPPLY AND SANITATION PROGRAMMES

- Guidelines for the Development of Small Scale rural Water Supply & Sanitation Projects In East Africa. Warner. D, Abate. C July 2005. http://www.encapafrica.org/documents/Wat0509_e.pdf

  In order to respond to the growing needs for safe drinking water and appropriate means of household sanitation, Catholic Relief Services is determined to provide the best possible technical, social and economic support to rural communities of East Africa. These guidelines are the result of the combined efforts of many individuals, both within CRS and other organizations, to assist in the planning and implementation of CRS country programs in water and sanitation in the region.

- DFID Guidance Manual On Water Supply and Sanitation Programmes (2007). United Kingdom Department for International Development (DFID). http://www.lboro.ac.uk/well/resources/Publications/guidance-manual/guidance-manual.htm

  An excellent general resource designed to assist DFID staff and partners in developing effective and sustainable water supply and sanitation programs. Comprising three chapters and appendices, it takes the reader from an overview of the sector, through specific development perspectives, to detailed recommendations for each stage of the project cycle.

- Standard Methods for the Examination Of Water and Wastewater, 22nd Ed. (2012). Washington, D.C.: APHA. http://www.standardmethods.org/

  This comprehensive reference covers all aspects of water and wastewater analysis techniques. Standard Methods is a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF).

- Assessing Demand for Water Supply and Sanitation Projects. (2005). Sarah Parry-Jones. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  An exploration of the issues surrounding a demand-responsive approach to water and sanitation service provision, with a discussion of the relative merits of the most commonly used demand assessment tools.

- On-Site Sanitation In Areas With a High Groundwater Table. (2005). Sarah Parry-Jones http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/lcsahgt.htm

  In areas that experience a seasonally high groundwater table or that are prone to flooding, constructing affordable on-site sanitation facilities can be very problematic. It is a challenge that affects many countries worldwide. This technical brief provides practical guidance on some sanitation options in such conditions. More details on each option outlined can be found in the references in the further reading section.

- Private Sector Participation In the Water and Sanitation Sector: Public-Private Partnership and the Poor (1999). Mike Webster and Kevin Sansom.

http://www.lboro.ac.uk/well/resources/well-studies/full-reports-pdf/task0164.pdf or http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

A review of existing work examining the impact of Public-Private Partnerships (PPP) in the water and sanitation sectors on service delivery to the poor. Important gaps in current knowledge are also identified.

- Environmental guidelines for PVOs and NGOs: potable water and sanitation projects (1992). Alan Wyatt, William Hogrewe and Eugene Brantly. Water Sanitation for Health Project, USAID.

  A guideline designed to assist project proponents (e.g., PVOs and NGOs) in identifying and mitigating environmental impacts of water supply and sanitation projects. The guideline outlines a process for conduction an environmental evaluation of proposed projects.

WEBSITES

- WELL - Research Centre Network for Water, Sanitation and Environmental Health. http://www.lboro.ac.uk/well/

  The Water and Environmental Health at London and Loughborough (WELL) website is a focal point of information about water, sanitation and environmental health and related issues in developing and transitional countries. They publish a wide-variety of guidance documents, including factsheets, studies and technical briefs in response to specific requests from the British Government Department for International Development (DFID) staff. WELL also supports development of technical manuals and guidance notes designed to reduce short-and-long-term problems through better documentation and dissemination of existing knowledge and understanding. WELL offers technical assistance and support to representatives of developing countries, UN agencies and UK non-governmental organizations.

- IRC International Water and Sanitation Centre. http://www.irc.nl/

  Since its foundation in 1968, the IRC International Water and Sanitation Centre (IRC) has facilitated the sharing, promotion and use of knowledge so that governments, professionals and organisations can better support poor men, women and children in developing countries to obtain water and sanitation services they will use and maintain. The website contains a vast array of references, training courses and documents. Of particular interest is the interWater Guide to Organizations available at http://www.irc.nl/page/126.

- Water Supply and Sanitation Collaborative Council. http://www.wsscc.org/

  Established in 1990 at the end of the International Drinking Water Supply and Sanitation Decade. Its purpose is to maintain the momentum of the Decade, by providing a regular way for water and sanitation sector professionals to exchange views and experiences and develop approaches to foster more rapid achievement of the goal of universal coverage

- NETWAS: Network for Water and Sanitation. Hosting the International Training Network for Water and Waste Management (ITN - Africa). http://www.netwas.org/

A network of regional and international training institutions, launched in 1984 by the World Bank's Water and Sanitation Program to support training in low-cost water supply and sanitation. ITN Centers provide training, disseminate information and promote local applied sector research on low-cost water supply and sanitation options. The Network links affiliated institutions serving Asia and Africa in Ouagadougou, Burkina Faso (serving countries in francophone West Africa); Kumasi, Ghana (Ghana); Harare, Zimbabwe (Zimbabwe); Nairobi, Kenya (Ethiopia, Kenya, Tanzania, and Uganda); Dhaka, Bangladesh; Calcutta, India (India); and Manila, Philippines (Philippines). New centers are under development.

- All Vision 21 Thematic Papers: http://www.wsscc.org/vision21/docs/index.html

- WHO catalogue 1991-2000. http://www.who.int/dsa/cat98/zcon.htm. See: http://www.who.int/dsa/cat95/zhow.htm

- Water and Sanitation Program Knowledge Network http://www.wsp.org/

  The Water and Sanitation Program (WSP) is an international partnership of the world's leading development agencies concerned with improving sector policies, practices and capacities to serve poor people. Administered by the World Bank, WSP provides targeted support to national and local governments, local communities, and their support organizations.

- United Nations Water. http://www.unwater.org/ or http://www.unwater.org/statistics_KWIP.html

- Community-Led Total Sanitation. http://www.communityledtotalsanitation.org/page/clts-approach

DISEASE PREVENTION AND CONTROL

- Cholera and Other Epidemic Diarrhoeal Diseases Control (1996). Prepared by the Robens Institute, University of Surrey, UK. Geneva: WHO. http://apps.who.int/iris/handle/10665/66334

- PHAST Step-By-Step Guide: A Participatory Approach for the Control of Diarrhoeal Disease (1998). R. Sawyer, M. Simpson-Hébert and S. Wood. Geneva: WHO. English: http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.3.pdf. French: Available for purchase at http://www.who.int/bookorders/francais/detart2.jsp?sesslan=2&codlan=1&codcol=93&codcch=131

- Sanitation Promotion (1998). Mayling Simpson-Hébert and Sara Wood, eds. Water Supply and Sanitation Collaborative Council (WSSCC) Working Group on Promotion of Sanitation. Geneva: World Health Organization (WHO). http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp1-140.pdf and http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp141-277.pdf

  A valuable resource consisting of a number of short sections that can be used independently. A "Checklists" section (pp. 141-153) includes checklists for planning better sanitation projects, sanitation in emergency situations, hygiene behavior-change, and suggestions for addressing gender issues. Other sections focus on building political will and partnerships and on conducting promotional programs including subsections on principles and guidelines, empowerment, checklists, and promotion through innovation.

- Promoting Change in Environmental Health Behaviour (1999). Ben Cave and Valerie Curtis. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A literature review focusing on the potential effectiveness of approaches to environmental health promotion in developing countries, and appropriate expectations and targets for change in health behavior.

- *Drinking water and disease: what healthcare providers should know* (2000). Physicians for Social Responsibility. Washington, D.C. http://www.psr.org/dwprimer.pdf

PROVISION OF DRINKING WATER

- WHO Guidelines for Drinking Water Quality: Training Pack. (2000). World Health Organization, Protection of the Human Environment. Geneva: WHO. http://www.who.int/water_sanitation_health/dwq/dwqtraining/en/index.html

  These training materials cover a wide range of topics and include 23 sessions - both presentations and practical sessions. Each presentation in the materials includes a session plan, a background paper and overhead transparencies. Each practical session provides guidance as to how such sessions might be delivered and the materials required.

- On-Line Bore-Well and Hand-Pump Installation Tutorial. Lifewater Canada. http://www.lifewater.ca/ndexdril.htm

- Water Quality Assessments: A Guide to The Use Of Biota, Sediments And Water In Environmental Monitoring, 2nd edition (1996). Deborah Chapman, ed. Published on behalf of UNESCO, WHO and UNEP. London: E & FN Spon. http://www.who.int/water_sanitation_health/resourcesquality/wqa/en/index.html

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- John Kalbermatten, Richard Middleton and Roland Schertenleib. Household-Centered Environmental Sanitation. (1999). Vision 21. http://www.tempest.eawag.ch/organisation/abteilungen/sandec/publikationen/publications_sesp/downloads_sesp/Paper_Description_HCES_July99.pdf

  An amplification of the HCES Model, developed following the Wageningen Meeting. It includes more detailed descriptions of the "zones" and the decision-making processes in different circumstances. Likely to be the model for environmental sanitation planning and implementation in the coming years.

- Guidelines for Wastewater Reuse In Agriculture And Aquaculture: Recommended Revisions Based On New Research Evidence (1999). Ursula Blumenthal, Anne Peasey, Guillermo Ruiz-Palacios and Duncan Mara. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  The implications of some new studies for the setting of international guidelines for using wastewater in agriculture and aquaculture are considered, along with the wastewater treatment and other health protection measures needed to achieve these guidelines.

- A Guide to the Development Of On-Site Sanitation (1992). R. Franceys et al. Geneva: WHO. http://www.who.int/water_sanitation_health/hygiene/envsan/onsitesan.pdf

- Community-Based Technologies for Domestic Wastewater Treatment And Reuse: Options For Urban Agriculture (1999). G.D. Rose. International Development Research Centre (IDRC). http://www.p2pays.org/ref/03/02008.htm

  This document provides information on urban wastewater management. It specifically discussed issues involved in wastewater resrouce recovery, wastewater management, project planning and implementation. It also includes a good discussion of wastewater treatment technologies such as on-site treatment, anaerobic treatment systems, water-based treatments, and sludge management.

- Operation and maintenance of rural water supply and sanitation systems: a training package for managers and planners (2000). Prepared by Francois Brikke. WSSCC Operation and Maintenace Network and IRC International Water and Sanitation Centre. Geneva: http://www.who.int/water_sanitation_health/wss/O_M/Rural.htm

- Sanitation for all (2000). UNICEF. http://www.unicef.org/sanitation/sanitation.pdf

  Good overview of key issues. Offers a short set of recommendations for better programming.

- PROSANEAR. People, poverty and pipes: a program of community participation and low-cost technology bringing water and sanitation to Brazil's urban poor (1998). Y. Katakura and A. Bakalian. UNDP-World Bank Water and Sanitation Program. www.wsp.org/pdfs/working_prosanear.pdf

- AQUA PLUS guidelist: appropriate technology for water supply and sanitation in the developing countries (2002). UNICEF Supply Division. Can be ordered at http://www.irc.nl/products/publications/descr/age.html

- Water for the world (1982). USAID Development Information Center. A series of 160 technical notes covering all aspects of rural water supply and sanitation. Out of print but available online through Lifewater International. http://www.lifewater.org/wfw/wfwindex.htm

- Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: measures for public health protection (executive summary) (1989). D. Maraand and S. Cairncross. Geneva: WHO. http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf

- Multi-stage filtration: an innovative water treatment technology (2000). Gerardo Galvis, Jorge Latorre and Jan Teun Visscher. Technical Paper no. 34. IRC International Water and Sanitation Centre.

- Engineering theme W4: executive summaries. DFID. Covering topics including water supply, water treatment, sanitation, wastewater, drainage, project cycle and others. http://www.lboro.ac.uk/well/themew4/contents.htm

- Environmental sanitation from eco-systems approach (1999). Steven Esrey and Ingvar Andersson. Vision 21. http://www.wsscc.org/vision21/docs/doc39.html

- Health Aspects Of Dry Sanitation With Waste Reuse (2000). Anne Peasey. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A review that collates current knowledge of health risks associated with dry sanitation technologies and the problems associated with their use and maintenance.

- Handbook on Community-Led Total Sanitation (2008). Kamal Kar and Robert Chambers. http://www.communityledtotalsanitation.org/resource/handbook-community-led-total-sanitation

- Community Approaches to Total Sanitation (2008). UNICEF Division of Policy and Practice, Programme Division. http://www.unicef.org/innovations/files/CATS_field_note.pdf

GUIDANCE FOR OPERATION AND MAINTENANCE

- *Operation and Maintenance of Rural Water Supply and Sanitation Systems: A Training Package for Managers and Planners* (2000). Prepared by François Brikké. WSSCC Operation and Maintenance Network and IRC International Water and Sanitation Centre. Geneva: http://www.irc.nl/redir/content/download/2548/26132/file/OME_OM_TrainingPackage.pdf

- See http://www.who.int/docstore/water_sanitation_health/wss/o_m.html for links to the following guides:

  Selected case studies on operation and maintenance of water supply and sanitation systems. These case studies describe different operation and maintenance (O&M) experiences in a variety of countries, in both rural and urban settings. They are a useful source of information for improving O&M practice.

  Tools for assessing operation and maintenance status of urban and rural water supply (2000). These comprehensive guidelines show how to assess O&M performance in both rural and urban areas.

  Operation and maintenance of urban water supply and sanitation systems: a guide for managers. This publication examines factors which may prevent existing urban water supply systems from working efficiently, and provides guidelines and solutions for optimization.

  Leakage control: source material for a training package. Materials trainers can adapt for use in local training courses, covering all aspects of leakage control, divided into individual modules for ease of use.

  Upgrading water treatment plants (2001). Summarizes many different field experiences with efforts to improve the quality of water and to upgrade the capacity of water treatment plants. It provides a practical approach to improving the performance of water treatment plants.

Management of operation and maintenance in rural drinking-water supply and sanitation: a resource training package. This package contains resource material for training courses aimed at improving the management of O&M in rural areas.

Models of management systems for the operation and maintenance of rural water supply and sanitation systems. This document evaluates the factors which influence the development of O&M management systems for rural facilities. It describes models in eight representative countries and offers guidance to planners and designers in selecting the best approach.

Linking technology choice with operation and maintenance. This document helps users make more appropriate technology choices by providing information on the O&M implications-particularly the costs-of selecting a specific technology.

- *Tecnologia manual de vaciado de pozos negros (manual pit latrine emptying technology (MAPET)),* Dar es Salaam (Tanzania). Habitat. United Nations Best Practices Database. In Spanish: http:habitat.aq.upm.es/bpn/bp271.html

- *Small pit emptying machine: an appropriate solution in Nairobi slum,* Madeleen Weglin-Schuringa, IRC International Water and Sanitation Centre, and Manus Coffey, Manus Coffey Associates (MCA) for UNCHS (Habitat). http://www.irc.nl/themes/sanitation/smallpit.html

CASE STUDIES

- Provision of Water and Sanitation Services to Small Towns (2000). Jeremy Colin and Joy Morgan. http://www.lboro.ac.uk/well/resources/well-studies/summaries-htm/%23brief323.htm

  This report describes and analyzes the findings of rapid investigations in two small towns in Uganda and two in the Southern Indian state of Kerala.

- Sanitation Programmes Revisited (1999). Darren Saywell and Caroline Hunt. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A comparative analysis of two notable African sanitation programs, focusing on a historical analysis (investigating how, when and why the programs developed in the way they did) and an understanding of critical issues common to each program, including demand assessment, sanitation promotion, community participation, responsibility for service provision, finance and cost recovery, and health aspects of promotion.

- Lessons Learned From Village-Level Operation and Maintenance (VLOM) (1999). Jeremy Colin. http://www.lboro.ac.uk/well/resources/well-studies/well-studies.htm

  A literature review of sector experience of the Village Level Operation and Maintenance Management (VLOM) approach to rural water supply.

- Learning What Works: A 20-Year Retrospective View on International Water And Sanitation Cooperation (1998). Maggie Black. World Bank. English:. http://www.un.org/esa/sustdev/sdissues/water/InternationalWaterDecade1981-1990_review.pdf

  A detailed history of water supply and sanitation programs and lessons learned.

CLIMATE CHANGE RESOURCES

Note: USAID's Global Climate Change (GCC) Office can provide support on the climate change aspects of this Guideline. To contact the GCC office, please email: climatechange@usaid.gov

- USAID. 2007. Adapting to Climate Variability and Change: A Guidance Manual for Development Planning. http://pdf.usaid.gov/pdf_docs/PNADJ990.pdf
- USAID. 2009. Adapting to Coastal Climate Change: A Guidebook for Development Planners. http://pdf.usaid.gov/pdf_docs/PNADO614.pdf

  The guidance provides information to assist planners and stakeholders as they cope with a changing climate throughout the project cycle.
- United Nations. Climate Change and the Human Rights to Water and Sanitation. Position Paper. http://www2.ohchr.org/english/issues/water/iexpert/docs/ClimateChange_HRtWS.pdf
- WHO. 2009. Vision 2030: The Resilience of Water Supply and Sanitation in the Face of Climate Change. http://www.who.int/water_sanitation_health/vision_2030_9789241598422.pdf
- WaterAid. 2012. Handbook on Climate Change and Disaster Resilient Water, Sanitation and Hygiene Practices. http://www.wateraidamerica.org/includes/documents/cm_docs/2013/h/handbook_on_climate_change_and_disaster_resilient_wash_practices.pdf
- Commonwealth Secretariat. 2009. Managing the Health Effects of Climate Change: 3. Water and Sanitation. http://www.thecommonwealth.org/files/206112/FileName/waterandsanitation.pdf
- Environmental Protection Agency. Sources of Greenhouse Gas Emissions. 2013. http://www.epa.gov/climatechange/ghgemissions/sources/commercialresidential.html

DOCUMENTS DISPONIBLES EN FRANÇAIS

- Manuel de l'Assainissement Total. Piloté par la Communauté. Kamal Kar et. Robert Chambers. Plan International 2008. http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/media/Manuel_ATPC.pdf
- Documents et outres resources du Site de IRC, http://www.fr.irc.nl/page/13567

  Directives environnementales, sanitaires et sécuritaires pour l'eau et l'assainissement. Société Financière Internationale Avril 2007. http://www1.ifc.org/wps/wcm/connect/c292fc00488658adb6c6f66a6515bb18/052_Water%2Band%2BSanitation.pdf?MOD=AJPERES&CACHEID=c292fc00488658adb6c6f66a6515bb18

  Manuel en environnement - Ressources complémentaires — Systèmes d'assainissement. Outils pour l'identification des effets environnementaux de secteurs d'activités spécifiques, des mesures d'atténuation appropriées et lignes directrices ACDI. 2007. http://www.acdi-cida.gc.ca/acdi-cida/acdi-cida.nsf/fra/REN-218123430-NML

Normes relatives à l'eau, l'assainissement et l'hygiène en milieu scolaire dans les environnements pauvres en ressources John Adams, Jamie Bartram, Yves Chartier, Jackie Sims. WH)O. 2010.
http://www.who.int/water_sanitation_health/publications/wsh_standards_school/fr/index.html

DOCUMENTOS DISPONIBLES EN ESPAÑOL

- Normas sobre agua, saneamiento e higiene para escuelas en contextos de escasos recursos. John Adams, Jamie Bartram, Yves Chartier, Jackie Sims. WHO. 2010.
  http://www.who.int/water_sanitation_health/publications/wsh_standards_school/es/index.html

- Manual sobre. Saneamiento. Total Liderado por la Comunidad. Kamal Kar con Robert Chambers. Preparado con el apoyo del Plan 2008.
  http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/media/Manual_sobre_saneamiento_total.pdf

- Saneamiento, aqua e higiene en escuela. Una prioridad para el desarrollo de la niñez Alianza para el mejoramiento de las condiciones de Agua, Saneamiento e Higiene en las Escuelas de América y el Caribe.
  http://www2.paho.org/hq/dmdocuments/2010/Nota%20Conceptual%20-%20WASH%20en%20escuelas_lowres.pdf

- Manual sobre saneamiento e higiene en la escuela UNICEF 2007.
  http://www.irc.nl/page/6521

- Guías sobre medio ambiente, salud y seguridad para agua y saneamiento Corporación Financiera Internacional. Abril 2007.
  http://www1.ifc.org/wps/wcm/connect/d594b60048855aba86dcd66a6515bb18/0000199659ESes%2BWater%2Band%2BSanitation%2Brev%2Bcc.pdf?MOD=AJPERES&CACHEID=d594b60048855aba86dcd66a6515bb18