

**Excerpts from Chapter 16: Water Supply and Sanitation**

**Table 1: Impacts and mitigation measures for specific water and sanitation activities and technologies**

<b>Activity/ Technology</b>	<b>Potential Impacts</b> <i>The activity or technology may. . .</i>	<b>Mitigation measures</b> <i>Note: Measures apply to the project phase specified: planning and design (P&amp;D), construction (C), or operation and maintenance (O&amp;M).</i>
<b>General</b>		
<b>Site selection (P&amp;D)</b>	Damage sensitive ecosystems or endangered species (P&D)	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)
<b>Construction of buildings and structures (C)</b>	Damage sensitive ecosystems or endangered species (C) Cause erosion and sedimentation (C)	Follow guideline on Construction in this manual (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)
<b>Soakways and drains</b>	Cause erosion (O&M) Alter the natural flow of rainwater runoff (O&M) Create pools of stagnant water (O&M)	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)
<b>Water Supply Improvements</b>		
<b>Hand-dug wells, seasonal ponds, improved springs, ground-level</b>	Contaminate water with human pathogens (O&M)	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)

<b>Activity/ Technology</b>	<b>Potential Impacts</b> <i>The activity or technology may. . .</i>	<b>Mitigation measures</b> <i>Note: Measures apply to the project phase specified: planning and design (P&amp;D), construction (C), or operation and maintenance (O&amp;M).</i>
<b>catchment and similar structures</b>	<p>Contaminate water with animal manure (O&amp;M)</p> <p>Create pools of stagnant water (O&amp;M)</p> <p>Exhaust water supply (not applicable to improved springs or hand-dug wells) (O&amp;M)</p>	<p>Use fencing or equivalent that will keep live stock from grazing uphill or up gradient of the water supply improvement (P&amp;D) (C)</p> <p>Do not allow animals to drink directly from the water source (O&amp;M)</p> <p>Monitor drains and soakways and keep them clear of debris (see entry on soakways and drains above for more detail) (O&amp;M)</p> <p>Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&amp;M)</p> <p>Put in place a system for regulating use, such as a local warden or appropriate pricing (P&amp;D)</p> <p>Give the community training in operating the improvement (P&amp;D) (O&amp;M)</p> <p>Monitor water levels in wells or impoundment structures to detect overdrawn (O&amp;M)</p>
<b>Wells</b>	<p>Provide water contaminated with nutrients and bacteria from animal waste (O&amp;M)</p> <p>Create pools of stagnant water (O&amp;M)</p> <p>Change groundwater flow (O&amp;M)</p> <p>Create saltwater intrusions (O&amp;M)</p> <p>Deplete aquifer (groundwater) (O&amp;M)</p> <p>Cause land subsidence (impact from many wells) (O&amp;M)</p>	<p>Don't let animals graze or be watered up-gradient from wellhead (P&amp;D) (O&amp;M)</p> <p>Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures (O&amp;M)</p> <p>On islands and coastal areas, keep withdrawals within safe yield limits to avoid overdrawn, possible salt water intrusion and contamination of the well (P&amp;D)</p> <p>Put in place a system for regulating use, such as a local warden or appropriate pricing (P&amp;D)</p> <p>Include a focus on proper use and maintenance of the improvement as part of the behavior change and education program (O&amp;M)</p> <p>Monitor water levels (O&amp;M)</p>
<b>Standpipes</b>	<p>Create pools of stagnant water (O&amp;M) (This problem can be more severe when water table is high, clay soils are present, or population/tap density is high)</p>	<p>Ensure that spilled water and rainwater drain to a soakway or equivalent structure and do not accumulate and create stagnant standing water (C)</p> <p>Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves and similar structures</p>
<b>Treatment systems</b>		
<b>Pit latrine</b>	<p>Increase transmission of vector-borne diseases (O)</p> <p>Contaminate groundwater supply with pathogens (O)</p>	<p>Devote adequate attention to identifying and addressing social barriers to using latrine (P&amp;D)</p> <p>Use the ventilated improved pit latrine design that traps insect vectors (P&amp;D)</p> <p>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</p>

<b>Activity/ Technology</b>	<b>Potential Impacts</b> <i>The activity or technology may. . .</i>	<b>Mitigation measures</b> <i>Note: Measures apply to the project phase specified: planning and design (P&amp;D), construction (C), or operation and maintenance (O&amp;M).</i>
	<p>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 (O)</p> <p>Cause injury to people or animals</p>	<p>composition of the overlying deposits make groundwater or an aquifer vulnerable to contamination (P&amp;D)</p> <p>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, <i>Small Pit-Empty-ing Machine: An Appropriate Solution in Nairobi Slum</i>, for more details) (O&amp;M)</p> <p>Ensure that collected material is adequately treated and not directly applied to fields or otherwise disposed of improperly (O&amp;M)</p> <p>Properly decommission pit latrines. Do not leave pits open. Fill in unused capacity with rocks or soil.</p>
<b>Composting toilets</b>	<p>Increase transmission of vector-borne diseases (O)</p> <p>Contaminate groundwater supply with pathogens (O)</p> <p>Cause disease transmission to field workers and consumers of agricultural products (O)</p>	<p>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&amp;M)</p> <p>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&amp;M)</p> <p>Test samples from active chamber and mature chamber after fallow period for <i>Ascaris</i> eggs and fecal coliforms (O&amp;M)</p> <p>Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&amp;M)</p> <p>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&amp;M)</p>
<b>Dry toilets</b>	<p>Increase transmission of vector-borne diseases (O)</p> <p>Cause disease transmission to field workers and consumers of agricultural products (O)</p>	<p>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&amp;M). Generous applications of ashes will help ensure that pathogens are destroyed. pH is the most important factor for sterilization (O&amp;M)</p> <p>Construct sealed vaults to hold dehydrating and curing material (C)</p> <p>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&amp;M)</p> <p>Test samples from active chamber and mature chamber after fallow period for <i>Ascaris</i> eggs and fecal coliforms to assess level of sterilization (O&amp;M)</p> <p>Allow sufficient residence time in mature chamber. This may vary from 6 months in warm climates to 18 months in cooler climates (O&amp;M)</p>

<b>Activity/ Technology</b>	<b>Potential Impacts</b> <i>The activity or technology may. . .</i>	<b>Mitigation measures</b> <i>Note: Measures apply to the project phase specified: planning and design (P&amp;D), construction (C), or operation and maintenance (O&amp;M).</i>
<b>Septic tanks</b>	<p>Contaminate groundwater supply with pathogens (O&amp;M)</p> <p>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) (O&amp;M)</p> <p>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 (O&amp;M)</p>	<p>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&amp;D) (C)</p> <p>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&amp;D)</p> <p>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&amp;D) (O&amp;M)</p> <p>Ensure that collected sludge is adequately treated and not directly applied to fields or otherwise improperly disposed of (See Sludge management below) (O&amp;M)</p>
<b>Upflow anaerobic filters</b>	<p>Damage ecosystems and degrade surface water quality. Sludge has high concentrations of nutrients, BOD, and solids (O&amp;M)</p> <p>Cause disease transmission to field workers and consumers of agricultural products (Sludge may still contain pathogens) (O&amp;M)</p>	<p>Treat sludge before secondary use (see Sludge management below). Do not allow disposal in or near water bodies (O&amp;M)</p> <p>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&amp;M)</p>
<b>Settled and simplified sewers</b>	<p>Damage ecosystems and degrade surface water quality (O&amp;M)</p> <p>Transmit diseases to field workers and consumers of agricultural products (O&amp;M)</p>	<p>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&amp;D) (O&amp;M)</p>
<b>Biogas reactors</b>	<p>Damage ecosystems and degrade surface water quality (O&amp;M)</p> <p>Transmit diseases to field workers and consumers of agricultural products (O&amp;M)</p>	<p>Do not allow disposal of digested slurry in or near water bodies (O&amp;M)</p> <p>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&amp;D) (O&amp;M)</p>
<b>Wastewater stabilization ponds (anaerobic, facultative, aerobic)</b>	<p>Damage ecosystems and degrade surface water quality (O&amp;M)</p> <p>Transmit diseases to field workers and consumers of agricultural products (O&amp;M)</p>	<p>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&amp;D) (C) (O&amp;M)</p> <p>Use two-, three- or five-pond systems if possible (anaerobic, facultative, (maturation)) (P&amp;D)</p> <p>Allow only restricted uses for agriculture and aquaculture of effluent from all but five-pond systems (O&amp;M)</p>
<b>Reed bed filter</b>	<p>Contaminate groundwater or surface water (O&amp;M)</p>	<p>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</p>

<b>Activity/ Technology</b>	<b>Potential Impacts</b> <i>The activity or technology may. . .</i>	<b>Mitigation measures</b> <i>Note: Measures apply to the project phase specified: planning and design (P&amp;D), construction (C), or operation and maintenance (O&amp;M).</i>
		impermeable material to prevent leakage (P&D) (C)
<b>Subsurface wetland</b>	(See reed bed filter above)	
<b>Free water surface wetland</b> <b>Floating aquatic macrophytes</b>	Provide breeding ground for disease vectors (O&M) Introduce invasive non-native species (O&M)	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 ( <i>Gambusia affinis</i> ) to the wetland or use other plant species such as duckweed, water lettuce ( <i>Pistia stratiotes</i> ), water milfoil, or salvinia ( <i>Salvinia spp.</i> ) (O&M)
<b>Slow-rate overland flow</b>	Contaminate groundwater or surface water (O&M)	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)
<b>Slow-rate subsurface flow</b>	Contaminate groundwater or surface water (O&M)	Use only where soil textures are sand to clayey loam (P&D) Use only where groundwater is >3 ft. below surface (P&D)
<b>Rapid infiltration</b>	Contaminate groundwater or surface water (O&M)	Use only where soil textures are sandy to loam (P&D) Use only where groundwater is >3 ft. below surface (P&D)
<b>Sludge management</b>	Damage ecosystems and degrade surface water quality (O&M)  Cause disease in handlers and processors (O&M)	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)
<b>Wastewater use in agriculture and aquaculture</b>	Cause disease in field workers and consumers of agricultural products (O&M)	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 <10 <sup>3</sup> fecal coliforms per 100 ml to minimize risk to public health. (See <i>Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: Measures for Public Health Protection</i> , 1989, WHO, Geneva (P&D) (O&M) <a href="http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf">http://www.who.int/environmental_information/Information_resources/documents/wastreus.pdf</a>