Environmental Issues and Best Practices for Small-Scale Infrastructure

A. Construction

Brief Description of the Sector

Nearly all small-scale development activities--housing, sanitation, water supply, healthcare, schools--involve some amount of construction. Construction includes one or more of several diverse activities: demolition, site-clearing, excavation, pipe laying, equipment installation, structure erection, and soil grading, leveling, and compacting.

Every construction project has its own unique issues, but the activities in general share many common features and potentially adverse environmental impacts. This chapter covers small-scale projects and is only intended to identify key issues and illustrate potential mitigation measures. Detailed guidelines for the specific type of project should be consulted.

Potential Environmental Impacts

Adverse environmental impacts of construction can be direct and indirect. Although direct impacts often receive more attention, indirect effects can be equally significant, gradually inducing changes in the environment, population, and use of land by, for example, causing in-migration of a population to take advantage of new infrastructure or spreading disease from insects breeding in flooded and abandoned quarries and borrow pits. Construction can also have significant effects on public health. Roads--and construction workers themselves--can be pathways for the spread of AIDS and other communicable diseases.

Direct and indirect impacts of associated or ancillary activities can also result. Construction of a small-scale irrigation system may require a new road to be built or an existing road to be improved so materials and equipment can reach the project site--a separate project with its own set of environmental impacts.

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All potential impacts should be considered and mitigated, with the most significant impacts addressed first. As in any project, the best way to accomplish this is by careful planning and incorporation of mitigation measures during the planning and design phase of a project. Environmental impacts of special concern include:

All potential impacts should be considered and mitigated, with the most significant impacts addressed first.

Damage to sensitive or valuable land. Construction in wetlands, estuaries, or other sensitive ecosystems may destroy or significantly damage exceptional natural resources and the services they provide. This damage may reduce economic productivity, impair essential ecosystem services (such as flood control or breeding habitat for food fish), or degrade the recreational value of these resources. Compacting the soil and grading the site may alter drainage patterns and water tables, changing the accessibility and quality of water resources. Extracting construction materials such as wood, stone, gravel, or clay may damage terrestrial ecosystems.

Sedimentation of surface waters. Land clearing, excavation, extraction of materials, and other construction-related activities can result in soil erosion, which, in turn, can lead to sedimentation in receiving waters. Sedimentation may reduce capacity of ponds and reservoirs, increasing flood potential, or substantially alter aquatic ecosystems by changing streambed, lakebed, and estuary conditions.

Contamination of ground and surface water supplies. Toxic materials are often used in construction--solvents, paints, vehicle maintenance fluids, fuels. If these are dumped or wash into streams they may contaminate ground or surface water supplies, harming the health of the local community and populations living downstream. Aquatic and terrestrial ecosystems may also be damaged. Where inadequate sanitary facilities are provided for construction crews, human waste may contaminate water resources.

Construction may displace local inhabitants or reduce their access to environmental resources.

Adverse social impacts. Construction may displace local inhabitants or reduce their access to environmental resources. Construction on or near culturally important sites--cemeteries, meeting places, sacred sites--may generate conflict or resentment with the community, as would use of non-local labor. If the new facility provides a valuable service not available elsewhere it may cause migration to the area. Noise and dirt from the site may disturb neighbors.

Spread of disease. An influx of construction workers from other regions or construction of a new road may introduce new diseases to the local population or increase the incidence of local infection. This is a particular concern with sexually transmitted diseases, such as HIV. Certain facilities, such as those for healthcare, sanitation, and solid waste, can also increase the presence of diseases.

Aesthetic damage. If a structure is too large, inconsistent with local architectural customs, or sited with inadequate attention to existing aesthetics, the facility may harm the visual quality of the area.

Program Design--Some Specific Guidance

Apply best practices. The best practices discussed in chapter 1 of these guidelines apply to the construction dimension of projects, including using an adaptive management process, engaging the local population (including women) in planning, implementation, construction, and decision-making related to operation, ownership, and maintenance.

When planning a construction project and evaluating various options, project developers must examine all classes of impacts direct, indirect, ancillary, cumulative, and socio-cultural.

Consider the full range of impacts. When planning a construction project and evaluating various options, project developers must examine all classes of impacts--direct, indirect, ancillary, cumulative, and socio-cultural. Assessment of indirect effects is especially important for large infrastructure development projects. Ancillary, cumulative, and socio-cultural impacts can occur at any scale, and their strength is likely to be proportional to the size of the project.

The following checklist can be used to identify environmental effects of small-scale construction activities.[1]

[1] This list incorporates questions included in Checklist #2 of the Canadian International Development Agency's Handbook on Environmental Assessment.

Site Selection

- What are the current uses and activities at the proposed project site?
- What are the existing infrastructures?
- What is the traffic rate of the site?
- How close are neighboring residences? How close are the intended users?
- What are the expectations of the local population?
- Could the project lead to:

  Displacements of the population (immigration, migration, or transfer and resettlement)?

  Changes in ways of life or loss of territory for indigenous peoples?

  Accentuated social inequalities (for example, due to control by industrial entrepreneurs)?

  Incompatible uses (industrial area versus residential area, sacred land, and so on) or social and value conflicts between the possible land and building uses (for example, if the proposed uses are in conflict with cultural and traditional characteristics)?

  Problems in supplying water, energy, fuelwood, materials, and other resources and services such as sanitation facilities and electrical equipment?

  A decrease or an improvement in the quality of life?

  Greater awareness of the importance of a healthy environment?

  Better, more abundant, and more accessible goods and services (education, medical care, community services, industry)?
- What types of environment, landscape, flora, and fauna are present?

  Are there any species of particular biological, medicinal, cultural, historical, social, or commercial value?

  What is their specific importance?

  Could the project damage them?
- Is the site of cultural, archeological, historical, or social value?
- Are there any bodies of water, wooded areas, slopes, wetlands, or other vulnerable sites nearby?
- Is the site prone to landslides, flooding, heavy rainfall, earthquakes, or other disasters?

  Is the site steeply sloped?

  Is the soil sufficiently stable?

  What are its thickness, texture, drainage, and topographical features?
- Are anti-erosion measures and protective measures against flooding and heavy rainfall necessary to avoid damage to the building and its structures?
- Is there historical data on precipitation, surface water flows, and climatic conditions?
- Can the extent and quality of groundwater supplies be determined?
- What are the various activities associated with site preparation and construction?

  Will there be demolition, excavation, levelling, clearing, soil denudation, filling, backfilling or wetland reclamation?

Planning and Design

- What are the local zoning, building, and permitting requirements?
- Is the proposed design constructed of material appropriate to the climate and site?
- Are erosion and flood protection measures incorporated?
- Is this a small, isolated project or one of many similar projects?
- Will ancillary or associated infrastructure development be necessary?

  What indirect effects are possible--will a new road encourage illegal logging and poaching?
- What are the types, quantities, and sources of construction materials?
- Where will workers sleep? What preparations for water supply, sanitation, and solid waste disposal have been made? Have steps been taken to ensure that these services are provided in an environmentally sound manner? What kind of public health education will construction workers receive?
- What kind of healthcare facilities will be constructed, and how will gray water from bathing and washing of bedding be disposed of? What system of human waste disposal will be provided that will not create health risks? How will water be provided to the facility in a way that minimizes contamination risk for patients and nearby communities?
- If the facility will generate solid waste, does the design include space and features for separation of recyclables and organic waste?
- If hazardous materials will be produced, does the design include proper storage, handling, and disposal facilities?
- If cooling waters or water containing suspended matter are generated, does the design include elements for treatment, storage, and discharge?
- Could the project lead to social conflict or conflict over ownership rights or land use?
- Could the project lead to unplanned and spontaneous settlements
- Will there be a greater demand for natural, financial, energy, and agricultural resources as a result of the project?

Construction

- What activities will be carried out during the operational phase? What site preparation and construction activities will be carried out?
- How will construction and demolition debris be disposed of?
- How will the materials be conveyed to the site and stored?
- What toxic materials will be used during construction? Are non-toxic substitutes available? Are measures in place for disposal of toxic materials?
- What measures for monitoring environmental impacts and adhering to environmental guidelines are in place?
- From where will construction crews be recruited? Will the schedule compete with local crop harvesting or other seasonal labor requirements?

Environmental Mitigation and Monitoring Issues

Table 2.1 Environmental Mitigation and Monitoring Issues for Construction

Issue or aspect of activity	Impact *The activity may. . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Site Selection		
Site occupied or used by local residents	• Displace untenured residents or reduce farmers , herders', gatherers' lands	• Find alternative location. If not possible, provide equivalent land, accommodations, or fair monetary compensation, provided these are accepted voluntarily and without coercion (SS)
Dwellings located close by	• Disturb neighbors, with construction creating noise and dust	• Build as far as practical from neighbors • Concentrate noisiest work and take measures to keep dust to a minimum • Wet ground if water is abundant, and leave natural cover intact as long as possible • Screen facility with trees or fencing to control noise (P&D) (SS) (C)
Site has historic, cultural, or social importance	• Offend local population or damage social fabric	• Find alternative site (SS)
Difficult for intended users to reach (steep climb or decent, distant location)	• Result in unused or underused facility	• Find alternative site or find some way of making access easier, for example by providing bicycle cart shuttle service to health clinic (SS) (O&M)
Site would require road improvement or new road construction	• Adverse environmental impacts typical of roads, including erosion, changing water tables, or providing access for illegal mining, logging, or poaching	• Find alternative site or evaluate whether a footpath would suffice • Follow guidance on design, construction, operation and maintenance described in Chapter 3: Rural Roads in this manual (SS) (O&M)
Site contains habitat for important ecosystems, plants, or animals	• Destroy or harm important ecologically, culturally, or economically important ecosystems, plants, or animals	• Find alternative location. If not possible, design facility so that it will create least impact, minimize disturbance of native flora, remove large plants and turf where possible, and replant recovered plants and other flora from local ecosystem after construction (C) (SS) (P&D)
Site has important scenic, archeological, cultural, or historical features	• Destroy or harm sites with exceptional resource values	• Find alternative location. If not possible, design facility so that it will create least impact, minimize site disturbance, remove important artifacts, and provide worker incentives for discovery and safe removal of archeological, cultural, or historical material (SS) (C) (P&D)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Site Selection		
Site is wetland or abuts water body	• Destroy or harm valuable and sensitive ecosystems and organisms	• Find alternative site. Wetlands and riparian ecosystems are extremely sensitive. Wetlands provide important environmental services such as filtering toxins and nutrients from runoff. If no alternative, set the facility as far back as possible from the water body or wetland to minimize the amount of wetland destroyed by facility footprint and construction activity • Revegetate as soon as possible • If facility will include sanitation facility find alternative site (SS) (P&D) (C)
Site is steeply sloped	• Cause erosion and damage to terrestrial and aquatic ecosystems in construction or use	• Find alternative site. If not possible, design facility and apply construction practices that minimize risk, for instance, use hay bales to control erosion during construction. Pay particular attention to potential erosion and redirection of water flows during design and construction • Revegetate as soon as possible • Maintain design features (O&M) (SS) (P&D) (C)
Area is heavily wooded	• Degrade forest • Contribute to flooding potential	• Find alternative location if area is old growth or relatively undegraded forest. If not possible, design to minimize the number of trees that must be cut down • Avoid destroying rare or unique trees • Consult with local populations about current use of trees and preferences for preservation (SS) (P&D) (C)
Site prone to flooding	• Destroy site or subject workers and inhabitants are to risk of injury or death • Environmentally damage site from accidental release of toxic, infectious, or otherwise harmful material during flooding • Contaminate drinking water	• Find alternative site or design facility that is raised above flood plain • Design facility to minimize risk, designing with proper grading and drainage. Maintain design features such as drainage structures • Avoid constructing sanitation or other facilities that will use and store such materials at flood prone sites. If not possible, design storage area so hazardous materials are above the ground or in waterproof containers with locking lids that are kept closed, and ensure that facility operators follow these practices. Choose dry sanitation options, such as dehydrating toilets, instead of wet ones, such as septic tanks or detention ponds (P&D) (SS) (O&M)

Issue or aspect of activity	Impact: *The activity may. . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Site Selection		
Site prone to landslides	• Destroy site or subject workers and inhabitants to risk of injury or death • Environmentally damage site from accidental release of toxic, infectious, or otherwise harmful material during flooding • Contaminate drinking water	• Find alternative site on stable ground. If not possible, design facility to minimize risk, for example, by planting trees all around facility. Maintain design features • Avoid constructing sanitation or other facilities that will use and store hazardous materials at landslide-prone sites. If not possible, design storage area so that hazardous materials are stored in durable leak-proof containers with locking lids that are kept closed. Choose dry sanitation options, such as dehydrating toilets, instead of wet ones, such as septic tanks
Planning and Design		
Area experiences heavy rainfall, earthquakes	• Destroy site or subject workers and inhabitants to risk of injury or death • Environmentally damage site from accidental release of toxic, infectious, or otherwise harmful material during flooding • Contaminate drinking water	• Design facility to minimize risk, for instance, in earthquake prone areas, build structures with wood frames instead of concrete or brick. Maintain design features • Use material appropriate to the climate, such as stucco instead of adobe in areas with heavy rainfall • Design storage areas with hazardous materials above the ground or in waterproof containers. Ensure that facility operators follow these practices. Choose dry sanitation options, such as dehydrating toilets, instead of wet ones, such as septic tanks or detention ponds (P&D) (O&M) (C)
Facility is or will include a water supply improvement	• Deplete ground or surface water resources and damage local ecosystems or downstream communities • Poison users from natural or human-made chemical contaminants such as arsenic • Spread disease by pathogenic contaminants • Contaminate groundwater	• Determine safe yield and establish system for regulating use • Test seasonal water quality and examine historical water quality data before building facility • Incorporate siting, design features, and operation and maintenance practices that minimize environmental impacts described in Section B Water Supply and Sanitation in this chapter. Include practices such as community participation, fee for service pricing, preventing livestock grazing near water supply, and the like (SS) (P&D) (C) (O&M)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Planning and Design		
Facility is or will include a sanitation improvement	◆ Discharge untreated or insufficiently treated sewage that contaminates drinking water (ground and surface), spreads diseases, and degrades aquatic ecosystems	◆ Do not site in wetland or next to stream, river, lake, or well or up-gradient from a drinking water source ◆ Do not site where water table is high or underlying geology makes contamination of groundwater likely ◆ Choose dry sanitation options, such as dehydrating toilets, instead of wet ones, such as septic tanks or detention ponds ◆ Incorporate design features, education/social marketing programs, construction and O&M practices (see Section B Water and Sanitation in this chapter) such as community participation, sanitation promotion focusing on women and children, and use of appropriate natural treatment systems (SS) (P&D) (C) (O&M)
Facility will provide healthcare services	◆ Spread disease via failure to sterilize infectious waste or prevent access by waste pickers or disease vectors ◆ Expose local community to health risks via unsafe disposal of toxic, carcinogenic, and teratogenic materials ◆ Contaminate drinking water (ground and/or surface) via improper land disposal (May also damage local ecosystems, animals, or plants)	◆ Do not site in wetland or next to stream, river, lake, or well ◆ Incorporate design features and operation and maintenance procedures (see Chapter 5: Section B Medical Waste in this manual) ◆ Include elements such as hand washing facilities, a waste storage room, an incinerator (if rural), a space for encapsulation, and a plastic/clay lined pit for safe burial. ◆ If waste will be buried on site, do not site pit up-gradient from drinking water source such as a well. Do not site pit where water table is high or underlying geology makes groundwater contamination likely. If no alternative site is available, ensure that pit is lined with impermeable material such as clay or polyethylene ◆ Provide for safe disposal of gray water from bathing and washing of bedding ◆ Ensure that human waste disposal minimizes health risks ◆ Ensure that water is provided to the facility in a way that minimizes risk of contamination for patients and nearby communities (O&M) (SS) (P&D) (C)
Facility will generate solid waste	◆ Spread disease ◆ Contaminate drinking water (ground and surface) ◆ Degrade aquatic ecosystems ◆ Increase greenhouse gases	◆ Include space and features for source separation of recyclables and organic waste ◆ Consider including space and/or constructing a compost bin or wormbox if facility will produce organic waste (see Chapter 5: Solid Waste Management in this manual) (P&D) (C) (O&M)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Planning and Design		
Facility will house automotive, laboratory, or other industrial activities	• Expose workers or population to toxic, carcinogenic, and teratogenic materials • Contaminate drinking water (ground and surface) • Damage local ecosystems, animals, or plants	• Do not site near wetlands or bodies of water • Design with proper storage, handling, and treatment facilities (see Chapter 4: Microfinance Institutions and Micro and Small Enterprises in this manual) (SS) (P&D) (C) (O&M)
Facility will generate cooling waters, soaking waters, or water containing suspended organic mater, mercury, lead, or soaps	• Expose workers or population to toxic, carcinogenic, and teratogenic materials • Contaminate drinking water (ground and surface) • Damage local ecosystems, animals, or plants	• Incorporate cleaner production technologies into design, operation, and maintenance (see Chapter 4: Microfinance Institutions and Micro and Small Enterprises in this manual) • Design with elements for storage, treatment, and discharge of wastewater (P&D) (O&M) (SS) (C)
Indirect effects	• Damage or destroy natural resources • Increase in-migration • Damage local social and cultural integrity • Spread disease to both people and animals	• Research indirect effects that may be associated with the particular type of facility being built and evaluate other possible impacts of this type. If the project falls into one of the sectors in this volume, the relevant sector briefing and the resources listed therein are excellent starting points for this research (SS) (P&D) (C) (O&M)
Cumulative effects of one development project over time or many small developments built in a short time period	• Cause excessive extraction of building materials, multiply impacts associated with logging un-degraded forest, quarrying and borrowing (see below for more detail)	• Develop logging, quarrying, and borrowing plans that take into account cumulative effects and include reclamation plans. Monitor adherence to plans and impacts of extraction practices. Modify as necessary (C) (O&M) (P&D)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Construction		
Construction crews and camps	• Damage local habitat and compact and erode soil due to building and occupation of construction camps • Contaminate surface water and spread of disease through solid waste generated by camps • Spread communicable diseases including malaria, tuberculosis, and HIV/AIDS from construction crews from outside the region • Introduce alcohol or other socially destructive substances via construction crews • Deplete local animals and plants (especially game and fuelwood) via poaching and collection by the construction crew	• Explore off-site accommodation for crew. Keep camp size to a minimum. • Require that crew preserve as much vegetation as possible, for example, by creating defined foot paths • Provide temporary sanitation on site, such as pit latrines (assuming the water table is low enough and soil and geology of appropriate composition) • Use local or regional labor • Screen potential crew members for HIV and tuberculosis. • Provide education and enforce guidelines on contact with local residents • Set guidelines prohibiting poaching and collection of plants and wood with meaningful consequences for violation, such as termination of employment • Provide adequate quantities and good quality food and cooking fuel (C) (P&D)
Use of heavy equipment and hazardous materials	• Cause erosion due to machinery tracks • Compact soil, changing surface and groundwater flows, and hurting future use for agriculture • Contaminate ground or surface water when hazardous construction materials or mechanical fluids are spilled or dumped • Place workers at risk for exposure to hazardous materials	• Minimize use of heavy machinery • Set protocols for vehicle maintenance, such as requiring that repairs and fueling occur elsewhere or over impervious surface such as plastic sheeting • Prevent dumping of hazardous materials • Burn waste materials that are not readily reusable or recyclable, do not contain heavy metals, and are flammable. Investigate and use less toxic alternative products (P&D) (C)

Issue or aspect of activity	Impact *The activity may. . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Construction		
Demolition of existing structures	• Bother or endanger neighbors due to noise, dust, and debris • Contaminate soil or ground or surface water from demolition waste containing residual amounts of toxic materials, such as leaded paint	• Recover all reusable material (this may be the standard procedure in many developing countries). Determine whether toxic materials are present. If so, dispose of waste in lined landfill; otherwise, explore options for reuse in areas where potential for contamination of surface and ground water are small, such as for roadbed material (P&D) (C)
Site clearing or leveling	• Damage or destroy sensitive terrestrial ecosystems in the course of site clearing or preparation • Cause erosion, siltation, changes in natural water flow, or damage to aquatic ecosystems	• Design facility to create least impact • Minimize disturbance of native flora during construction. Remove without destroying large plants and turf. Use erosion control measures such as hay bales. Replant recovered plants and other appropriate local flora as soon as possible (C) (P&D)
Excavation	• Cause erosion, siltation, changes in natural water flow, or damage to aquatic ecosystems when excavated soil is piled inappropriately • Expose inhabitants and crew to risk of injuries in excavation pits • Deprive down-gradient populations and ecosystems of water if higher regions are blocked	• Cover pile with plastic sheeting, prevent run-off with hay bales, or similar measures • Place fence around excavation site • Investigate shallower excavation or no-excavation alternatives (P&D) (C)
Filling	• Block water courses if fill is inappropriately placed • Destroy valuable ecosystems if fill is inappropriately placed • Cause land subsidence or landslides if fill is inappropriately placed, causing injuries or damage	• Do not fill the flow-line of a watershed • Be aware that in arid areas, occasional rains may create strong water flows in channels. A culvert may not supply adequate capacity for rare high-volume events. Design so filling will not be necessary • Transplant as much vegetation and turf as possible. • Use good engineering practices. For example, do not use soil alone; first lay a bed of rock and gravel (P&D) (C) (SS)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Construction		
Road improvement/new road construction	• Cause erosion and changes to water quality and natural water flows via poor road construction practices and maintenance • Increase access for mining, logging, poaching, settlement, or other development that destroys natural resources or harms local populations • Spread human or livestock disease	• Find alternative site • Evaluate whether an alternative mode of transport would suffice, such as rail, water, or footpath • Adhere to specifications for road design and maintenance that keep water off road surfaces • Follow best practices for design, construction, and operation and maintenance (see Chapter 3: Rural Roads in this manual), including developing quarry and borrow pit plans, following the contour line, using camber and turnout drains, training operations and maintenance personnel, and so on (SS) (P&D) (C) (O&M)
Source of building materials	• Damage aquatic ecosystems through erosion and siltation • Harm terrestrial ecosystems via harvesting of timber or other natural products • Spread vector-borne diseases when stagnant water accumulates in active or abandoned quarries or borrow pits and breeds insect vectors	• Identify the most environmentally sound source of materials that is within budget • Develop logging, quarrying, and borrowing plans that take into account cumulative effects • Monitor adherence to plans and impacts of extraction practices; modify as necessary • Fill quarries and pits before abandoning • Control run-off into pit (C) (P&D) (O&M)

Reference

CIDA (Canadian International Development Agency). 1997. Checklist #2: Building Construction. In *Handbook on Environmental Assessment of Non-Governmental Organizations and Institutions Programs and Practices.* CIDA: Quebec.

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B. Water and Sanitation Activities

Brief Description of the Sector

In Latin America and the Caribbean, 128 million people lack access to adequate sanitation and 92 million lack sufficient water supply.

Worldwide, 2.5 billion people lack access to adequate sanitation and more than 1 billion lack sufficient safe water. In Latin America and the Caribbean, 128 million people lack access to adequate sanitation and 92 million lack sufficient water supply (UN Economic and Social Council 2000). Polluted water harms the health of 1.2 billion people and contributes to the deaths of 15 million children under five every year. Poor sanitation and water management often promote transmission of vector-borne diseases, such as malaria, which kill another 1.5 2.7 million people annually. In certain areas, large numbers of people have been poisoned by groundwater contaminated with naturally occurring toxins, such as arsenic, or pre-industrial and industrial pollutants, such as mercury and pesticides (UNEP 2000).

Disease and mortality are not the only consequences of polluted and scarce water. There is also a high opportunity cost--and women and children bear most of it. Women and girls spend hours a day collecting most household water, hours that could be spent more productively on education or food production. Also, children are more likely to become sick from contaminated water, and women are likely to be their caregivers, making both unable to carry out other tasks.

Women and girls spend hours a day collecting most household water, hours that could be spent more productively on education or food production.

Water resources are generally poorly managed in the developing world. Many urban areas in developing countries lose more than half of the distributed water from leaking pipes. Rural people and the rapidly growing urban and peri-urban poor are disproportionately underserved. Good sanitation and hygiene are key to preventing contamination and improving health--but good sanitation facilities have little benefit if the water remains contaminated. Therefore, water supply and sanitation projects must be viewed as interdependent. Concurrent implementation that incorporates hygiene promotion as a key component creates the greatest benefits. However, this approach is not yet widely practiced.

Over the past three decades, experience has also shown that water and sanitation activities are most effective and sustainable when they use a participatory approach that responds to genuine demand; builds capacity for operation, maintenance, and cost sharing; involves the community directly in all key decisions; cultivates a sense of communal ownership; and uses appropriate technology that can be maintained at the village level. Also important are educational and participatory efforts to change hygiene behaviors.

These guidelines are designed to apply to small-scale rural and urban water supply technologies and sanitation systems. Large-scale water projects are not considered here. Water supply technologies covered by these guidelines include:

- Pond and spring improvements, hand-dug wells, small-diameter boreholes, wells with hand pumps, roof rainwater catchments, small dams, seasonal impoundments
- Showers, clothes-washing basins, cattle troughs
- Spring-fed, gravity water distribution systems
- Complex systems--well or surface water pumps, storage tanks and standpost distribution, yard taps or connections, extensions of urban water lines into underserved peri-urban areas

Water supply and sanitation projects must be viewed as interdependent.

Sanitation systems covered by these guidelines include:

- Individual latrines--composting, dehydrating, pour-flush and community latrines
- Small-scale septic and leachfield systems
- Settled and simplified sewers
- Water stabilization ponds
- Constructed wetlands
- Water-borne sewage with disposal to surface waters

Experience has also shown that water and sanitation activities are most effective and sustainable when they use a participatory approach.

Potential Environmental Impacts[2]

Water Supply

Depletion of fresh water. Fresh water sources, including groundwater and surface water, can be depleted as a result of unplanned uses or insufficient source yields. This usually occurs when water extraction exceeds safe yields as a result of underestimating the capacity of the source or the demand. Depleting surface waters destroys the resource, affects aquatic life, reduces economic productivity, and diminishes downstream uses and recreational possibilities. Exhaustion of groundwater can lead to land subsistence, altered flow in other locations, and loss of economic productivity. These impacts also lead to poorer water quality, health impacts, and higher costs of potable water supplies downstream.

[2] This section is taken from *Environmental Guidelines for PVOs and NGOs: Potable Water and Sanitation Projects.*

Chemical degradation of the quality of potable water sources. Water quality can be affected as a result of resource depletion or contamination by wastewater or runoff, which contains silt, solid waste, or agricultural and industrial pollutants. Surface waters tend to become more polluted as normal contaminant loadings become concentrated in reduced flow situations, and groundwater can be altered in coastal or island areas due to saltwater intrusion. Both of these situations affect health and water treatment costs.

Construction of facilities in sensitive areas (wetlands, estuaries, protected areas) can destroy flora, fauna or their habitats leading to loss of biodiversity.

Standing water. Pools of stagnant water can collect near water taps as a result of poorly designed drainage systems, or leaking taps, pipes and storage tanks. This problem can be exacerbated by improper or ineffective wastewater or solid waste disposal practices. Stagnant water provides a breeding ground for mosquitos, can increase transmission of water related diseases, and can lead to increase erosion and siltation problems, if not properly drained.

Degradation of terrestrial, aquatic, and coastal habitats. Habitats can be damaged during the construction of water systems. Construction of facilities in sensitive areas (wetlands, estuaries, protected areas) can destroy flora, fauna or their habitats leading to loss of biodiversity, reduction of productivity, and loss of aesthetic and recreational areas. Soil erosion resulting from poor construction practices, leakage or lack of adequate drainage, is the principle impact on land resources. This in turn can lead to siltation in receiving waters. If the construction of water facilities leads to an unplanned increase in population or resource based economic activity, this then has secondary effects on habitat and biodiversity.

Sanitation

Improper siting and design of latrines, soakaways, or leach fields increases the probability of contamination.

Contamination of surface water, groundwater, and soil. Improperly designed or unused sanitation facilities can contaminate soil and water by pathogens from human excreta or decomposing wastes. Nitrate contamination is especially common. Contamination of soil and water can result in increased incidences of diseases associated with poor sanitation--diarrheal diseases, dysenteries, and enteric fevers and viruses.

Surface water inflow can contaminate groundwater resources that are inadequately protected. Improper siting and design of latrines, soakaways, or leach fields increases the probability of contamination. Contamination can also occur if sanitation facilities are not properly operated and maintained, reinforcing the fact that appropriate training and health education are key to preventing contamination.

Degradation of aquatic and terrestrial habitats. Streams, lakes, estuaries, and ecosystems can be contaminated with organic nutrients and solids from poorly designed or operated sanitation facilities. Improper site selection and poor construction practices can also create adverse effects. Polluted waters can negatively affect health, as can fish and shellfish that are contaminated with pathogens. Polluted receiving waters can become eutrophic and lose their aesthetic and economic value. Land can become contaminated if wastewater, septic tank sludge, or raw wastes are disposed of improperly by land application.

Table 2.2 Impacts of Water Supply Projects

Problem	Possible Impacts	Possible Causes
Depletion of fresh water resources	• Destruction of natural resources • Destruction of aquatic life • Loss of economic productivity • Loss of recreation areas • Increased cost of water supplies	• Overestimated water supplies • Underestimated water demand • Over-pumping water resources • Lack of information on resource yields • Waste and leakage of potable water • Poor pricing policies and practices, leading to excessive use, waste, and leakage
Chemical degradation of the quality of potable water sources	• Concentrated pollution in surface water • Salt water intrusion • Poorer quality water and associated health impacts • Increased water treatment costs	• Depleted surface and groundwater resources • Reduced stream flows • Runoff from improper solid and liquid waste or excreta disposal
Creation of standing water	• Increase in vector-borne diseases • Standing water contaminated with solid waste and associated health impacts • Soil erosion or sedimentation	• Lack of, or inadequately designed, drainage systems • Leakage or waste from pipes and taps • Lack of operator concern for stagnant water
Degraded terrestrial, aquatic, and costal habitats	• Altered ecosystem structure, function • Loss of biodiversity • Loss of economic productivity • Loss of aesthetics and recreational value • Soil erosion or sedimentation	• Improperly sited facilities (in wetlands or other sensitive habitats) • Poor construction practice • Leakage or waste from pipes and taps • Increased population and agricultural activity
Increased human health risks	• 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 supplies • Biological contamination

Source: Wyatt, Hogrewe, and Brantly 1992.

Program Design--Some Specific Guidance

As with other program and project development activities, potentially adverse environmental impacts need to be addressed early in the design process to avoid possible costly mistakes or project failure. Generally, the same design questions outlined in Section A of this chapter apply to the design of small-scale water and sanitation activities. Many adverse environmental, social, and cultural impacts of water supply and sanitation projects occur when the improvements are not used, used improperly, or not maintained--or if the users do not adopt necessary complementary behaviors, such as washing their hands after defecating. There are many lessons from water supply and sanitation projects over the past 30 years, a few of which are summarized below.

Table 2.3 Impacts of Sanitation Projects

Problem	Possible Impact	Possible Cause
Increased human health risk from contamination of surface water, groundwater, soil, and food by excreta, chemicals, and pathogens	• Increased disease transmission associated with excreta (diarrhea, parasites) • Malnutrition caused by diseases • Higher infant mortality • Reduced economic productivity • Poor-quality surface and groundwater • Health impacts associated with use of chemically contaminated water • Increased cost of water treatment for domestic and industrial uses	• Failure to use sanitation facilities • Disposal of excreta or wastewater on land or into surface water without adequate treatment • Improperly sited sanitation facilities near water supplies • Inadequately protected groundwater • Improper operation of sanitation facilities • Lack of maintenance on sanitation facilities • Improper use of wastewater in food production
Ecological harm from degraded stream, lake, estuary and marine water quality and terrestrial habitats	• Health impacts associated with contaminated water • Fish or shellfish contamination and associated health risks • Nutrient contamination (eutrophication) • Alteration of ecosystem structure and function and loss of biodiversity • Reduced economic productivity • Soil erosion and sedimentation	• Failure to use sanitation facilities • Disposal of excreta or wastewater directly into sensitive areas without adequate treatment • Improperly operated sanitation facilities • Lack of maintenance on sanitation facilities • Improperly sited facilities (in wetlands or other sensitive habitats) • Poor construction practice

Source: Wyatt, Hogrewe, and Brantly 1992.

Best practices for water supply and sanitation projects

Take advantage of the experience of others. There are many detailed manuals, source books, and checklists that provide clear and concise guidance on developing water supply and sanitation projects. In most cases these are available electronically, and a number of these resources can be found in the reference section of this chapter.

Potentially adverse environmental impacts need to be addressed early in the design process to avoid possible costly mistakes or project failure.

Concentrate on the human component of the project. Use a demand-focused approach. Projects will be welcomed and supported by the local community only when they fulfill a need. At a minimum, the community must commit to share the costs of the operation and maintenance of systems before project development. Such commitment grows out of genuine household demand and an interest in adopting hygienic behaviors.

Hygiene promotion must accompany infrastructure development. Community participation and understanding are essential to water supply and sanitation projects. Cultivating a focus on improved hygiene requires sensitivity to the community s cultural and social norms. This process must also be approached with realism--it may take years for a community to adjust to new practices.

Projects will be welcomed and supported by the local community only when they fulfill a need.

Improved public health and welfare are the true goals of any water and sanitation project. And those that fail to improve hygiene practices generally result in little or no improvement in public health. Trying to reach school children is often an effective strategy, but efforts to bring about behavior change must focus on other family members as well. Traditional sanitation practices for infants, preschool children, the elderly, the sick, and the disabled generally contribute more to the contamination of water supplies and transmission of disease than those of healthy adults.

Cultivating a focus on improved hygiene requires sensitivity to the community s cultural and social norms.

Understanding local hygiene behaviors and socio-cultural beliefs on hygiene practices is an essential first step in project design. In some cultures sanitation facilities for men and women must be strictly segregated, even at the family level--making a single latrine per family inadequate. In other cases there may be beliefs forbidding defecation in roofed structures. Materials have been developed to help promote the adoption of better hygiene behaviors. See Sanitation Promotion (Simpson-Hébert and Wood 1998), *PHAST Step-by-Step Guide: A Participatory Approach for the Control of Diarrheal Disease* (Sawyer et al. 1998), and *Towards Better Programming: A Sanitation Handbook* (UNICEF 1997).

Use a participatory approach. Actively engage the community in all stages of the project, including planning and development of management systems,

USAID/EL SALVADOR, AGUA: A NEGATIVE THRESHOLD DETERMINATION WITH CONDITIONS

Recently USAID/El Salvador submitted an amended Initial Environmental Examination to incorporate specific environmental conditions for the new well drilling component of the AGUA (Acesso, Gestion y Uso Racional de Agua) Project, 519-0443. Working closely with the implementing partner, the Mission developed a detailed plan of environmental considerations that were to be incorporated in every community water activity that required well drilling. The recommended threshold decision for this amended IEE was a Negative Determination with Conditions for well drilling. The IEE includes guidelines for planning well drilling activities and specific conditions that are to be followed included the following mitigation activities.

Guidelines for Well Drilling. The IEE recommended that in addition to national guidelines for well drilling, the contractor would conduct a hydro-geological study. The study addresses aspects such as the geology and geological history of the site, soil permeability, groundwater availability, climate, rainfall, drainage, and evapotranspiration and infiltration rates.

Watershed Study and Environmental Mitigation Measures. The contractor will also prepare a diagnostic study for each watershed in which wells will be drilled. These studies will identify environmental mitigation measures that include the delimitation of infiltration areas; soil protection measures, reforestation activities, environmental education and watershed conservation activities.

Specific Conditions Associated with Negative Determination.

Design

1. Hydro-geological studies will be conducted at each well site
2. The design will be in compliance with the appropriate watershed management plan

Construction

1. Soil materials excavated during well drilling activities (barrow) should be deposited in pits to avoid sedimentation and fugitive dust.
2. Cut areas should be protected by safe slopes; revegetation and other appropriate techniques to avoid soil erosion and slides.
3. Waste drilling materials (composed of bentonite and other drilling products) must be stored and kept moist to prevent fugitive dust and must be buried at the end of the drilling activity.

   Special care must be exercised with the use and handling of MAX GEL (crystalline silica) to ensure that the dust is not inhaled or does not come in contact with skin.

   Care should be taken to avoid any contamination of the well area with petroleum, combustibles, or lubricants.

USAID and the contractor monitor the implementation and effectiveness of these guidelines and will use this experience to improve environmental guidelines for future well drilling operations.

Source: USAID Document Approving the Amended IEE for Project No. 519-0443. March 17, 2000 establishment of user fees, choice of technology, construction, operation and maintenance, and future decommissioning. Participation will result in more appropriate design, enhance adoption of new behaviors, and help generate the community commitment and support necessary for the proper project maintenance.

An essential element of the participatory process is allowing families and communities to select the appropriate technology and design, instead of beginning the project with a predetermined technology. Appropriate technologies fulfill the criteria for true village-level operation and maintenance, including ready availability of spare parts and necessary expertise. Often one or more of these essential factors is missing. For example, communal hand pump schemes rarely succeed. If other options are preferred by the community, these should be pursued.

An essential element of the participatory process is allowing families and communities to select the appropriate technology and design, instead of beginning the project with a predetermined technology.

Employ some form of cost sharing. When households share the outlay for building latrines, overall costs to the project sponsor drop, the sense of ownership and responsibility increases, usage is greater, and maintenance improves.

Draw on existing community organizations instead of starting new ones.

Integrate water supply, sanitation, and hygiene promotion. If these elements are treated individually, the route of disease transmission will not be broken and public health benefits will be limited. But if it is not possible to implement an integrated program, the first priority should be to improve hygiene behavior and provide sanitation improvements, the next to increase water quantity, and the last to improve water quality. 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 have the least benefit.

Design the program to be economically self-sustaining. Necessary features for economic sustainability include cost recovery mechanisms such as user fees, taxes, or levies. These mechanisms finance operations, monitoring, maintenance, and repairs, as well as the management structure for collecting the funds and overseeing their use.

Include a system for sustaining operation and maintenance as part of overall program design. Failure to do this is one of the most common causes of project failure. The system should include a mechanism for training local residents to operate, monitor, maintain, and repair the improvements. The system must also maintain institutional memory. For example, a pool of community members should be trained in operation and maintenance, not just one individual.

Necessary features for economic sustainability include cost recovery mechanisms such as user fees, taxes, or levies.

Best practices for water supply projects

Calculate yield and extraction rates in relation to other area water uses to avoid depletion of the resource or damage to aquatic ecosystems or communities downstream. These calculations should take into account historic and projected upstream and downstream supply and demand for water. Projects tapping groundwater should consider depth to water table and groundwater hydrology, to the extent data is available.

Design improvements with an appropriate scale and capacity. Estimate current and projected water quantity and availability based on current water sources and preferences, baseline measurements on quantity of water available including seasonal fluctuations, current and historic use data (household, agricultural, institutional), population data and forecasts, current and projected demand upstream and downstream, and actual water use in similar projects conducted in the past. 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 generate additional users.

Assess water quality to determine if it is safe to drink and 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 arsenic testing in all USAID-funded water supply projects because there is currently no way to determine which locations may contain natural arsenic deposits. (For international water quality standards on virtually any parameter see WHO 1997).

Ongoing testing is the only way to determine if a water supply is or has become contaminated.

Periodically test as part of the operation and maintenance program. 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 effects of intervention, perhaps by establishing some form of communication with downstream parties.

Best practices for sanitation projects

Develop a hygiene promotion strategy that takes into account the current hygiene behavior of all users, including women, infants, children, the elderly, and the infirm and any social, cultural, or religious factors that may hinder changing behavior.

USAID requires arsenic testing in all USAID-funded water supply projects.

Design improvements to match demand, user customs and preferences, climate, and water abundance.

Minimize downstream effects of intervention. Test water quality downstream of the proposed site for fecal coliform, total suspended solids (TSS), biological oxygen demand (BOD), and nutrients before construction of infrastructure. Maintain ongoing testing to monitor for contamination, as appropriate.

Consider appropriate natural treatment systems instead of mechanical systems. These tend to be preferable for small-scale activities as they generally cost less, do not require highly skilled labor, and can frequently be constructed locally. Also, supplies for repair and maintenance are likely to be more readily available. There are many proven natural treatment options, including double vault batch composing and dry toilets, upflow anaerobic filters, biogas reactors, confined space constructed wetlands, subsurface wetlands, floating aquatic macrophytes, and stabilization ponds.

Develop a hygiene promotion strategy that takes into account the current hygiene behavior of all users, including women, infants, children, the elderly, and the infirm and any social, cultural, or religious factors.

Process for evaluating potential environmental impacts

Potential environmental impacts of a project should be evaluated after the PVO/NGO and community have defined the project's objective, the type and extent of services, and the type of facility that will provide the services in a manner appropriate to the physical, social, and economic conditions of the community.

Appropriate options should have been 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, collecting, transporting, treating, and disposal or reuse of excreta or wastewater.

Once a set of appropriate options for the components of the system has been defined, a PVO or NGO can evaluate the potential environmental impacts of each option and identify appropriate mitigation measures.

Environmental Mitigation and Monitoring Issues

Table 2.4 Environmental Mitigation and Monitoring Issues

Activity/ Technology	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases: site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
General		
Site selection	• Damage sensitive ecosystems or endangered species	• Survey for wetlands, estuaries, or other ecologically sensitive sites, and avoid siting the project in or near them • Identify nearby areas that contain endangered species and get professional assessment of sensitivity of species to construction at site (P&D)
Construction of buildings and structures	• Damage sensitive ecosystems or endangered species • Cause erosion and sedimentation	• Train and monitor workers (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 (See also Section A Construction in this chapter) (P&D) (C)
Soakways and drainage structures	• Cause erosion • Alter the natural flow of rainwater runoff • Create pools of stagnant water	• Use riprap (cobbled stone), gravel, or concrete to prevent erosion of drainage structures (P&D) (C) • Monitor and keep drains and soakways clear (O&M)
Water Supply Improvements		
Hand-dug wells, seasonal ponds, improved springs, ground-level catchment and similar structures	• Contaminate water with human or animal excrement and pathogens • Create pools of stagnant water· • Exhaust water supply (not applicable to improved springs or hand-dug wells)	• Focus on proper use and maintenance 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) • Use fencing that will keep live stock from grazing up-gradient of the water supply improvement (P&D) (C) • Do not allow animals to drink directly from water source (O&M) • Monitor drains and soakways and clear debris (O&M) Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves, and similar structures (O&M) • Establish a system for regulating use, such as a local warden or pricing structures (P&D) • Provide operational training to the community (P&D) (O&M) • Monitor water levels in wells or impoundment structures to detect overdrawing (O&M)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases: site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Water Supply Improvements		
Wells	◆ Contaminate water with animal waste ◆ Create pools of stagnant water ◆ Change groundwater flow ◆ Create saltwater intrusions ◆ Deplete aquifer ◆ Cause land subsidence (impact from many wells)	◆ Do not allow animals to graze or be watered up-gradient of the well-head (P&D) (O&M) ◆ Monitor and repair leaks from cracked containment structures, broken pipes, faulty valves, and similar structures (O&M) ◆ On islands and in coastal areas, maintain withdrawals within safe yield limits to avoid overdrawing, possible salt water intrusion, and contamination of the well (P&D) ◆ Establish a system for regulating use, such as a local warden or pricing structures (P&D) ◆ Focus on proper use and maintenance as part of behavior change and education program (O&M) ◆ Monitor water levels (O&M)
Standpipes	◆ Create pools of stagnant water (This problem can be more severe when water table is high, clay soils are present, or population/tap density is high)	◆ Ensure 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
Sanitation Systems		
Pit latrine	◆ Increase transmission of vector borne diseases ◆ Contaminate water supplies, damage water quality 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 latrine use (P&D) ◆ Use ventilated improved pit latrine design that traps insect vectors (P&D) ◆ Evaluate depth of 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 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 that relies on an engine driven vacuum pump (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 unused capacity with rocks or soil

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases: site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Sanitation Systems		
Composting toilets	• Increase transmission of vector borne diseases (O) • Contaminate groundwater supply with pathogens (O) • Cause disease transmission to field workers and consumers of agricultural products (O)	• Maintain humidity of composting material above 60% and supplement excreta with generous quantities of carboniferous material (dry leaves, straw), keeping the pile aerobic, odor free, and insect free. This will require proper training of the owners or maintenance staff (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 and mature chambers after fallow period for Ascaris eggs and fecal coliform (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 the soil amendment taken out after treatment is truly sanitized (O&M)
Dry toilets	• Increase transmission of vector-borne diseases (O) • Cause disease transmission to field workers and consumers of agricultural products (O)	• Maintain humidity of composting material below 20% and supplement excreta with alkaline material (ash or lime), keeping the pile odor free and insect free. Generous applications of ash will help ensure that pathogens are destroyed. Establishing and maintaining a high 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 the soil amendment taken out after treatment is truly sanitized (O&M) • Test samples from active and mature chambers after fallow period for Ascaris eggs and fecal coliform 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)
Septic tanks	• Contaminate groundwater with pathogens • Contaminate surface water with nutrients, biological oxygen demand, suspended solids, and pathogens. (Septic tank effluent generally contains relatively high concentrations of these) • Contaminate water supplies, damage water quality and transmit disease to other locations if waste is not properly handled and treated during or after servicing	• Evaluate depth of water table, including seasonal fluctuations and groundwater hydrology. If water table is too high line tank with clay, plastic sheeting, or other impermeable material to prevent leakage (P&D) (C) • Avoid directly discharging effluent to waterways. Discharging to waterways with sufficient volume and flow to assimilate waste may be acceptable, but secondary treatment is preferred passing effluent through an anaerobic filter followed by discharge to an absorption field or, better, a constructed wetland (P&D) • Ensure that a reliable system for safely removing sludge and transporting it 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)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases: site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Sanitatin Systems		
Upflow anaerobic filters	• Damage ecosystems and degrade surface water quality (Sludge contains high concentrations of nutrients, biological oxygen demand, and solids, and it may still contain pathogens) • Transmit diseases to field workers and consumers of agricultural products	• Treat sludge before secondary use. Do not dispose in or near bodies of water (O&M) • Provide workers that are exposed to sludge appropriate protective clothing including rubber gloves, at a minimum. Train workers to wash hands and faces frequently with soap and warm water (See "Sludge management" and "Wastewater use" 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, for example, 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)
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 bodies of water (O&M) • Follow national or international guidelines for use of wastewater sludge in agriculture and aquaculture (See "Sludge management" and "Wastewater use" below) (P&D) (O&M)
Wastewater stabilization ponds(aerobic, anaerobic, facultative)	• 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 unavoidable, construct hydrograph-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) (P&D) • Restrict uses for agriculture and aquaculture of effluent from all but five pond systems (O&M)
Reed bed filter, subsurface wetland	• Contaminate ground or surface water	• Evaluate depth of water table, including seasonal fluctuations and groundwater hydrology. If water table is too high line tank with clay, plastic sheeting, or other impermeable material to prevent leakage (P&D) (C)

Issue or aspect of activity	Impact *The activity may . . .*	Mitigation *Note: Mitigations apply to specific project phases: site selection (SS); planning and design (P&D), construction (C), operation and maintenance (O&M)*
Sanitation System		
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 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 ground 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 only where groundwater is more than 3 feet below surface (P&D) (O&M)
Slow-rate subsurface flow	• Contaminate ground or surface water	• Use only where soil texture is sand to clay loam (P&D) • Use only where groundwater is more than 3 feet below surface (P&D) (O&M)
Rapid infiltration	• Contaminate ground or surface water	• Use only where soil textures are sandy to loam (P&D) • Use only where groundwater is more than 3 feet below surface (P&D) (O&M)
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 and use as soil amendment for agriculture (O&M) • Provide workers with 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 in agriculture and aquaculture	• Cause disease in field workers and consumers of agricultural products	• WHO guidelines recommend treatment to reduce pathogen concentrations, restriction to use on crops that will be cooked, application methods that reduce contact with edible crops, and minimization of worker and consumer exposure to waste (P&D) (O&M) • Wastewater used in aquaculture should have less than 103 fecal coliform per 100 ml to minimize public health risk. (P&D) (O&M) • See WHO 1989, *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture*

References

Reports

Brikké, François. 2000. *Operation and Maintenance of Rural Water Supply and Sanitation Systems: A Training Package for Managers and Planners.* WSSCC Operation and Maintenance Network and IRC International Water and Sanitation Centre, Geneva.

The site contains links to an excellent set of technical guidelines. Online: www.who.int/water_sanitation_health/wss/O_M/Rural.htm. (Digital copy included.)

DFID (Department for International Development). 1998. *DFID Guidance Manual on Water Supply and Sanitation Programmes.* United Kingdom: DFID.

An excellent general resource designed to assist DFID staff and partners in developing effective and sustainable water supply and sanitation programs. Three chapters and appendices take the reader from an overview of the sector through specific development perspectives to detailed recommendations for each stage of the project cycle. Online: www.lboro.ac.uk/well/resources/books-and-manuals/guidance-manual/guidance-manual.htm. (Digital copy included: Acronyms; Overview; Preliminaries; 1 Introduction; 2.1 Principles and practices; 2.2 Social development perspectives; 2.3 Health aspects; 2.4 Environmental sustainability; 2.5 Economic and financial perspectives; 2.6 Institutional perspectives; 2.7 Technical aspects; 2.8 A social marketing approach to hygiene promotion and sanitation promotion; 2.9 Maximizing benefits of interventions; 3 Water supply and sanitation in the DFID programme and project cycle; Table–Sample logical frameworks; References; Index.)

Environmental Health Project. 1999. *Environmental Sanitation Policies, Lessons Learned.* Camp Dresser &McKee International (USAID Contract No. HRN-C-00-93-00036-11)

Online: www.wsp.org/pdfs/working_prosanear.pdf.

Katakura, Y., and A. Bakalian. 1998. *PROSANEAR: People, Poverty and Pipes–A Program of Community Participation and Low-Cost Technology Bringing Water and Sanitation to Brazil s Urban Poor.* United Nations Development Programme-World Bank Water and Sanitation Program.

A description of a water supply and sanitation project in the urban slums of Brazil. Includes participation strategies, design costs, and listings of different technologies. A good discussion of solutions to specific urban problems, such as the condominial sewage system that created shared access to sewers for clusters of closely located houses. Online: www.wsp.org/pdfs/working_prosanear.pdf. (Digital copy included.)

Rose, G.D. 1999. *Community-Based Technologies for Domestic Wastewater Treatment and Reuse: Options for Urban Agriculture.* International Development Research Centre (IDRC).

This document provides information on urban wastewater management. It specifically discusses issues involved in wastewater resource recovery, wastewater management, project planning and implementation. It also includes a discussion of wastewater treatment technologies, such as on-site treatment, anaerobic treatment systems, water-based treatments, and sludge management. Online: www.idrc.ca/cfp/rep27_e.html. (Digital copy included.)

Simpson-Hébert, Mayling, and Sara Wood, eds. 1998. *Sanitation Promotion.* Water Supply and Sanitation Collaborative Council Working Group on Promotion of Sanitation, Geneva, World Health Organization.

A valuable resource consisting of a number of sections that can be used independently. A checklist section includes 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 promotional programs, including subsections on principles and guidelines, empowerment, and promotion through innovation. Online: http://whqlibdoc.who.int/hq/1998/WHO_EOS_98.5_pp1-140.pdf. (Digital copy included.)

UNICEF (United Nations Children's Fund). 1999. *Hacia una mejor programación: Manual sobre Saneamiento,* No.3. *Hacia una mejor programación: Manual sobre el agua,* No.2. *Hacia una mejor programación: Manual sobre comunicación en materia de agua, medio ambiente y saneamiento,* No.7.

This technical series of manuals, developed in collaboration with the USAID Environmental Health Project (EHP) provides guidelines for planning, designing and implementing community level water and sanitation projects using a systematic approach which emphasizes capacity building, community participation. Topics covered in the guidelines include key design issues, community participation, technology options, financing and institution building, and operation and maintenance among others. Online: www.unicef.org/programme/wes/pubs/glines. (Digital copy included.)

WHO (World Health Organization). 1997. *Guidelines for Drinking-Water Quality,* Volumes 1, 2, and 3. Geneva, WHO.

Volume 1 sets out guideline values for a large number of water contaminants. Volume 2 reviews and interprets the extensive toxicological, epidemiological, and clinical evidence that shaped the determination of guideline values for drinking-water quality. Volume 3 offers a comprehensive guide to all practical procedures and technical measures required to ensure the safety of water supplies in small and peri-urban areas of developing countries. Online: www.who.int/water_sanitation_health/GDWQ/index.html. (Digital copy of Volume 3 included.)

Web Sites

WELL Studies.

Links to a wide range of practical studies on water supply, sanitation, solid waste disposal studies and related issues in the developing world. Online: www.lboro.ac.uk/orgs/well/resources/publications.htm.

WSSCC (Water Supply and Sanitation Collaborative Council).

Organization providing forums for water and sanitation sector professions to exchange view and information towards the goal of universal coverage. Maintains collection of fact sheets describing past and present projects. Online: www.wsscc.org/index.html.

C. Housing Reconstruction

The urban poor are disproportionately affected by any natural disaster because they tend to occupy poor-quality housing in high-risk areas (flood plains, steep slopes).

This section focuses on reconstructing housing after natural disasters--situations where time is of the essence and where pursuing integrated approaches are particularly difficult. The section does not address technical standards for construction of housing units, provision of utilities, or other services. Instead, its purpose is to convey the range of environmental and health issues associated with housing and provide a guided framework for considering these issues in siting, designing, and implementing housing reconstruction projects in post-disaster and risk-prone areas.

Readers should also review other sector briefings in this volume, including water and sanitation, solid waste, rural roads, and small-scale construction.

Brief Description of the Sector

Much of Latin America and the Caribbean is highly susceptible to hurricanes, extreme rainfall, earthquakes, and volcanic eruptions. Natural disasters can have disastrous effects on dwellings, while causing enormous casualties and hardships for displaced persons. This was demonstrated dramatically by the devastation caused by Hurricane Mitch in 1998, the Mexico City earthquake in 1985, and the Venezuela mudslides in 1999. In 1999 alone, the region endured four tropical storms and eight hurricanes, five of which reached Category 4 status.

Failure to address rural post-disaster housing and infrastructure needs can only further encourage out-migration from rural areas to already overcrowded urban areas.

Since Latin America is 75 percent urban, natural disasters in densely populated urban areas can be particularly devastating. Typically, the urban poor are disproportionately affected by any natural disaster--because they tend to occupy poor-quality housing in high-risk areas (flood plains, steep slopes), which are, even in the best of times, poorly served by municipal services and because they lack the resources to rebuild (including the political connections often needed to obtain assistance from external sources).

Reconstructing rural housing after a natural disaster is also a time-sensitive issue--and assessing reconstruction needs in rural areas is often much more difficult than it is in urban areas. Failure to address rural post-disaster housing and infrastructure needs can only further encourage out-migration from rural areas to already overcrowded urban areas.

Potential Environmental Impacts

A fundamental issue facing post-disaster reconstruction efforts is whether to rebuild and repair or develop a new site altogether. In densely populated urban areas, there may be little choice but to rebuild. Well-designed and implemented reconstruction programs have far fewer negative impacts--and result in healthier populations--than unplanned or poorly planned programs. In the case of a new settlement, housing construction will cause some impact. But its other impacts may be much more significant. A settlement tends to attract both economic activity and additional settlement, causing the environmental and health impacts of the original project to be amplified.

Potential impacts arising from land development and the introduction of human waste streams and resource demands include:

- Destruction of important ecological, archeological, or historical areas. This may be caused by clearing land for construction, associated infrastructure, or agriculture and by subsequent exploitation of land and other resources, including over-harvesting of fuelwood for domestic use or small-scale charcoal production.
- Contamination of soil and water from sewage and solid waste (see Section B--Water and Sanitation in this chapter) and creation of breeding grounds for animal and insect disease vectors.
- Erosion caused by house and road construction, resulting in destruction of agricultural land, sedimentation of waterways, and particulate pollution.

Poorly planned and constructed housing or settlements can create poor environmental health conditions.

Construction. The consequences of construction persist after the process is complete--eroded land does not regain its fertility, contaminated waterways recover only slowly.

The built environment. Housing activities change the natural environment. But housing also creates a built environment for its inhabitants. Poorly planned and constructed housing or settlements can create poor environmental health conditions, and impose severe consequences on the existing population, as well as new inhabitants. Environmental issues include:

- Health hazards due to inadequate or absent sanitation facilities (water, sewage and solid waste disposal), leading to a higher incidence of fecal-oral disease transmission, and diseases borne by insect and animal vectors (mosquitoes, rats).
- Risk to residents due to possible natural dangers (landslides, flooding).

Table 2.5 Construction Impacts and Their Causes

Impact	Cause
Erosion	◆ Earth is left barren after the site is cleared, leveled, filled in, and compacted, making it susceptible to water or wind erosion aggravated by sloping terrain ◆ May also be associated with access roads or quarry or borrow areas that provide construction material
Water contamination	◆ Dumping of demolition debris or excess soil from land-leveling into watercourses ◆ On-site machinery maintenance affecting surface and groundwater supplies ◆ Lack of on-site sanitary facilities for construction workers
Air contamination	◆ Removal of groundcover from access roads, quarries, borrow pits, and construction sites, creating conditions for airborne dust and particulates
Resource depletion and destruction	◆ Use of local natural resources-sand and rock from riverbeds, quarries, or borrow areas ◆ Extraction of wood from neighboring forests for construction or firing brick
Landslides and slupping	◆ Loss of hillside stability due to removal of vegetation cover ◆ Water saturation due to altered drainage ◆ Poorly designed quarries and borrow pits
Disease vectors	◆ Demolition rubble creating breeding grounds for rats, standing water creating breeding grounds for insect and harboring water-borne diseases
Visual contamination	◆ Improperly disposed construction and demolition waste ◆ Scarring associated with quarries and borrow pits for construction materials

The alternative to planned reconstruction may be unplanned and ad hoc resettlement ... that ... worsens preexisting public health hazards and poor construction practices.

- Risks to residents due to ongoing human activity near the site or past use of the site (highly polluting industrial, mining or agricultural operations, military operations).
- Creation of standing water due to poorly constructed drainage systems or abandoned borrow pits, with associated increase in vector-borne disease.
- Unhealthy living conditions due to improper house design or construction materials, given local climate and anticipated use (interior conditions that are either too hot or too cold, improper ventilation for heating or cooking).

Environmental resources. Particularly in rural areas, creation of a housing settlement can affect the environmental resources available to the existing population in the area, including:

- Increased competition with new residents for water supply, forest resources (fuelwood and game), and agricultural land.
- Loss of access to resources or agriculture land altogether, as a result of land clearance for the project itself, changes in land tenure, etc.
- Degradation of land and--particularly downstream--water resources.
- Increased pressure on available resources (overloaded transportation systems, power and water supplies, schools, health centers).

Assessing environmental impacts of a housing project requires knowledge of the baseline situation--that is, impacts of a proposed project must be assessed against what would happen in the absence of the project. Assessing the baseline of housing projects can be a particularly difficult proposition. The alternative to planned reconstruction may be unplanned and ad hoc resettlement of the site that reproduces--or even worsens--preexisting public health hazards and poor construction practices that contributed to the disaster in the first place.

An absolute necessity for any project is resolution of outstanding land tenure issues.

Program Design--Some Specific Guidance

Land Tenure

An absolute necessity for any project is resolution of outstanding land tenure issues--with obvious importance to the general viability of the project. In addition, others can counteract any environmental health protections put in place by the project with legal claim on the land. Resolving land tenure is rarely straightforward; for poor urban populations in Latin America the issues are often unclear or highly informal.

Governance and Maintenance

Ongoing mitigation of environmental health impacts--and benefits and services individuals derive from the built environment--are contingent on proper maintenance and community governance. In some cases, reconstruction will occur in communities with effective, pre-existing governance systems. In other cases, a new community must be established. Large scale or new-community reconstruction should include a complete community development plan that includes the following elements:

- ***Administration and maintenance of services.*** This should include potable water, sanitation, solid waste disposal, transportation, cooking, educational, and health facilities.
- ***Provision of social services.*** Community counseling in aspects such as adapting to change and how to live in a community (especially important for resettlement/disaster relief-related housing); aid in the formation of communal organization services (patronatos, water boards); educational services oriented toward the construction, use and maintenance of latrines, water storage systems, and fuel efficient stoves; and job assessment programs that include training and placement.
- ***Participation and management.*** It is imperative that a functional group be established with the technical, organizational, and administrative capacity to execute the development plan. Ideally, the group should include representatives from all relevant stakeholder groups.
- ***Supervision and monitoring.*** Regular on-site visits, surveys, and quality testing of facilities and services are needed to ensure proper functioning.

The Design Process

Because housing activities are highly integrated, and because their impacts depend in large part on the social and economic behaviors of affected stakeholder populations, those designing and implementing activities must develop as complete a baseline as possible that describes existing and historical environmental and social conditions.

Two baseline surveys are highly recommended: (1) a social survey, to be administered both to future occupants (if known) and the existing local population, and (2) an environmental baseline survey of the project site.

Following the baseline surveys, a preliminary project profile is developed. The profile contains basic information about the preliminary design of the housing project, and should be filled out in advance of any construction and before the project plan is finalized. A template profile is also included as Attachment 3 to this chapter.

Using the preliminary design and baseline data to identify environmental concerns. Taken together, the baseline surveys and the project profile allow the most critical questions about the project's impacts to be answered. The checklists identify the most likely adverse impacts from a proposed project or program and point to needed mitigation measures.

If adjustments to project design are not made in response to identified concerns, then the entire environmental assessment process is meaningless.

Note that the surveys and the project design assume construction of new housing units, rather than repair of existing structures.

Key Questions: Site and Design

These checklists should be answered using information from the baseline surveys and the project profile. If the answer is no, further action is not needed. For each significant adverse impact, a mitigation measure is mandatory. For each moderate adverse impact, mitigation should be considered.

Table 2.6 Checklist: Site and Design

	Yes		No	Not Applicable
	Significant Impact (with no mitigation actions)	**Moderate Impact** (with no mitigation actions)		
Will the project have reasonably foreseeable impacts on endangered or endemic species?	____	____	____	____
Are any hazardous or highly polluting activities foreseen or currently taking place in the surrounding areas?	____	____	____	____
Could previous land use put the future population at risk?	____	____	____	____
Did the environmental survey identify any proximity issues?	____	____	____	____
Is the site at risk from natural hazards?	____	____	____	____
Does the site slope exceed 20%?	____	____	____	____
Associated construction:				
Will there be a need to create or rehabilitate an access road?	____	____	____	____
Will there be a need to construct electricity infrastructure?	____	____	____	____
Will there be a need to construct water infrastructure?	____	____	____	____
Does the proposed potable water system meet estimated water requirements for the present and future population?	____	____	____	____
If no, are complementary water sources available?				
Does the potable water quality meet national or funding agency standards?	____	____	____	____
Has the lighting source and distribution system been taken into account in the design and layout of the project?	____	____	____	____
Is the availability of cooking fuel in proportion to the demands of the community?	____	____	____	____
Has a solid waste disposal system been designed for the site?	____	____	____	____

	Yes: Significant Impact (with no mitigation actions)	Yes: Moderate Impact (with no mitigation actions)	No	Not Applicable
Will the solid waste disposal meet relevant standards and will it be designed with future growth in mind?	___	___	___	___
Has a sewage or gray water disposal system been included in the design?	___	___	___	___
Will the effluent from the water disposal system meet national or funding agency standards	___	___	___	___
Are the building materials adequate for the average weather conditions?	___	___	___	___
Does construction embody appropriate earthquake resistance?	___	___	___	___
Have provisions been made to ensure adequate occupant comfort in hot and cold seasons?	___	___	___	___
Has the predominant wind direction been considered in the design of the project houses?	___	___	___	___
In the design of the waste disposal and sewage systems?	___	___	___	
Do the design and layout include the elements of type and quantity that meet relevant standards	___	___	___	___
Internal roads?	___	___	___	___
Green areas?	___	___	___	___
Social and recreational areas?	___	___	___	___
Prevention of fire hazards?	___	___	___	___
Transportation needs?	___	___	___	___
Does the design accommodate future expansion? (population growth, home expansion, and utility service connections)	___	___	___	___
Is house design consistent with that of other housing in the area?	___	___	___	___

Key Questions: Construction Management

These checklists should be answered using information from the baseline surveys and the project profile. If the answer is no, further action is not needed. For each significant adverse impact, a mitigation measure is mandatory. For each moderate adverse impact, mitigation should be considered.

Table 2.7 Checklist: Construction Management

	Yes		No
	Significant Impact (with no mitigation actions)	**Moderate Impact** (with no mitigation actions)	
Will construction activities likely produce significant:			
Erosion?	___________	___________	___________
Water contamination?	___________	___________	___________
Air contamination (particulate dust)?	___________	___________	___________
Deforestation?	___________	___________	___________
Loss of habitat or biodiversity?	___________	___________	___________
Effects on threatened or endangered species?	___________	___________	___________
Hillside instability/Landslide risk?	___________	___________	___________
Noise?	___________	___________	___________
Obstruction to roads or other existing transportation?	___________	___________	___________
Construction or demolition waste?	___________	___________	___________
Will on-site water resources be used to satisfy construction needs?	___________	___________	___________
Will potentially hazardous construction techniques be employed with serious risk to worker safety? (felling trees, blasting, large-scale excavation, constructing bridges and towers.)	___________	___________	___________
Will laborers brought into the area require food and housing?	___________	___________	___________

Key Questions: Post-construction Management and Community Governance

Following the completion of housing reconstruction long-term impacts (beneficial or adverse) will develop for the inhabitants, surrounding communities and the environment. Careful thought must be given to ensure that the project will have a lasting positive effect in the area. Mark the answer that will best fit the project characteristics. For every no a clearly defined plan should be designed and ready to implement before the houses are officially transferred to the new inhabitants.

Table 2.8 Checklist: Post-construction Management and Community Governance

	Yes	No
Will a management structure for the community be established before the houses are occupied?	______________	______________
Will the basic facilities latrines, potable water, gray water and solid waste disposal be ready for use by the time the houses are inhabited?	______________	______________
Will there be any training for the inhabitants in the use of the sanitary facilities?	______________	______________
Have the responsible parties for the operation and maintenance of the facilities been identified and trained?	______________ ______________	______________ ______________
Is there an established basic service billing system?	______________	______________
Has the responsible party for the billing system been identified and trained?	______________	______________

Environmental Mitigation and Monitoring Issues

Table 2.9 Environmental Mitigation and Monitoring Issues

Impact *The activity may*	Mitigation Measures
Site and design	
Change land use pattern	• Ensure that present land use at project site is not critical and the activities can be carried out on nearby land before the site is selected.
Destroy important ecological, archeological, or historical areas	• Evaluate to verify that endangered or endemic species and critical ecosystems will not be adversely affected. • An alternative site should be used if the affects are identified as critical.
Contaminate soil and water from sewage and solid waste	• Site human waste and solid waste disposal systems to avoid contamination of surface and groundwater, taking into account soil characteristics and historical groundwater and surface water conditions. • Install adequate, appropriate sewage and solid waste disposal systems. For example, use above-ground compost latrines in areas with high water tables.
Create risks for residents due to possible natural dangers	• Ensure that project site is not located in areas: subject to landslides, fires, or flooding; with slopes over 20%; or below areas likely to undergo significant deforestation or land clearing. • If the site is in an area subject to these natural dangers, an alternate site should be used or appropriate mitigation measures taken to minimize risk in areas where unavoidable. Measures may include construction of firebreaks, slope stabilization, drainage construction, or elevating housing units on pilings.
Create risks for residents due to human activity near site	• Ensure that project will not be located within the area of influence (1 km) of pollution sources or hazards, including factories, mines, and military bases· Ensure that project is not downwind of contamination source • If groundwater is to be used for drinking, test for chemical and microbial contamination • Identify sources of noise pollution • Select alternate site if risk to residents is high
Put excessive pressure on existing facilities (schools, health centers)	• Include the expansion or construction of necessary infrastructure in the layout and design of the project
Cause deforestation	• If forest is dense or is part of a critical habitat, an alternative site must be found • For each tree cut in a sparsely treed area, plant 20 no later than 6 months after the residents have moved in
Initiate excessive use of fuelwood as an energy source	• Encourage alternative energy sources, such as gas, electric, and solar • Require all residents to use improved stoves if they cook with fuelwood • If fuelwood is the dominant energy source, include the planting of fuelwood plots using local species in the project layout and design

Impact *The activity may*	Mitigation Measures
Site and design	
Create housing that is inadequate for local climatic conditions	• Ensure that the design, construction materials, and placement of windows and doors take into account local conditions in cool and hot seasons and seasonal variation in precipitation and winds • Use local materials
Install inadequate ventilation	• Design houses to ensure adequate ventilation matched to the heating and cooking sources to be used within the home. Take advantage of wind direction
Pay inadequate attention to type and location of solid waste disposal	• Prepare and implement a solid waste disposal management plan, including technology and funding for system maintenance and disposal, effects on groundwater, and wind direction, before resident occupancy
Create health hazards due to lack of sanitation facilities (water, sewage, solid waste disposal)	• Sanitation facilities *must* be included in the project design • Ensure that all sanitation facilities are installed and running by the time the occupants move in
Make potable water supplies unsafe	• Ensure siting of supply systems and choice of supply technologies minimize health hazards • Conduct seasonal testing of water quality, particularly for coliform bacteria and arsenic. Assess historical and seasonal shifts in water quantity and quality
Cause hazards due to inadequate earthquake resistance or inappropriate materials	• Assure that construction meets appropriate standards. Follow or exceed official design criteria. Use locally available materials, and assure quality
Cause social impacts in and around the project site	• Conduct a social diagnosis of the beneficiaries of and communities around the proposed site before the project is designed. If the social conflict is too significant, an alternative site must be selected • Implement development programs in each community before or during the construction process
Lack in its compliance with mitigation measures	• Create binding agreements between the organizations collaborating on the project before it begins • Each implementing organization must have an environmental management plan to ensure compliance with the mitigation measures. Conduct an independent evaluation of the plan annually
Construction	
Risk injury to construction workers and local inhabitants	• Ensure that workers have proper protective equipment and follow sound safety practices, including use of safety ropes, proper blasting safety, noise and dust protection, boots, and gloves • Insure that pits are covered or access impeded during construction • Excavate and rebury trenches quickly • Manage quarry slopes to avoid cave-ins

Impact *The activity may*	Mitigation Measures
Construction	
Interrupt local transportation	• Schedule construction for low-traffic days or hours; phase construction to distribute the impacts of road closure. Conduct work to permit at least alternating one-way (half-width) road passage
Cause noise	• Use less noisy construction techniques, including making a work schedule that to minimizes impact
Create dust or mud	• Spread water to keep dust down. Drain areas prone to mud· Schedule land-clearing, excavation, and similar activities to avoid extremely dry and extremely wet conditions
Create breeding grounds for disease vectors (standing water in borrow pits, demolition debris)	• Excavate and rebury trenches quickly and arrange for proper permanent disposal of construction or demolition debris, away from watercourses. Fill borrow pits or assure drainage • Use shallow wells or streams for construction water, rather than diverting natural flows to the construction site
Cause erosion	• Soil conservation measures must be included in the design and implemented during construction. The exact measure will depend on the site and the severity of the impact. Install checks and barriers berms, hay bales, or other vegetation to trap sediment runoff • Re-vegetate disturbed areas
Lack in its compliance with mitigation measures	• Create binding agreements between the organizations collaborating on the project before it begins • Each implementing organization must have an environmental management plan to ensure compliance with the mitigation measures. Conduct an independent evaluation of the plan annually
Habitation	
Improperly use environmental and sanitary resources	• If applicable, the implementing organization must provide environmental and sanitary training for all residents before they move in, including: environmental education for children, care for domestic animals, reforestation of green areas, proper use and maintenance of latrines, social interactions in housing projects, proper use and conservation of water, construction and use of improved stoves, etc.

References

Coordination Center for Natural Disaster Prevention in Central America.

Online: www.cepredenac.org.

Costa Rica National Risk Prevention and Emergency Commission.

Online: www.cne.go.cr.

CRID (Regional Disaster Information Center).

CRID offers a gateway to an extensive technical library in English and Spanish, accessed via database search. Sponsored by six organizations that joined efforts to compile and disseminate disaster-related information in Latin America and the Caribbean, all of the constituent bodies may offer resources of interest to those engaging in post-disaster recovery efforts, including housing reconstruction. Online: www.crid.or.cr.

Doctors Without Borders.

Online: www.msf.org.

International Federation of Red Cross and Red Crescent Societies.

Online: www.ifrc.org.

International Strategy for Disaster Reduction, Regional Unit for Latin America and the Caribbean.

Online: www.unisdr.org.

ITDG (Intermediate Technology Development Group).

This site offers online technical guidance on appropriate and disaster-resistant housing. The online Development Bookshop service serves as a single point-of-search for this and other technical, development-related subjects. Online: www.itdg.org.

Pan American Health Organization (A regional office of the World Health Organization).

Online: http://www.paho.org.

UNCHS (UN Commission on Human Settlements) and the Together Foundation.

This partnership maintains free documentation of disaster reconstruction efforts in the Best Practices Database. Online: www.bestpractices.org.