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UPDATE

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Guidelines for Marine Outfalls and Alternative Disposal and Reuse Options

Increasingly, large metropolitan areas along coastlines are having to re-evaluate the current approach to treatment and disposal of sewage. This is due primarily to deteriorating quality of coastal waters and its impact on the health of the natural system and livelihood of coastal inhabitants.

This EA Sourcebook Update focuses on assessing the potential environmental impacts of proposed sewage outfalls on coastal waters and estuaries. It is intended to assist those involved in managing coastal wastewater discharges and planning appropriate levels of pollution control. It complements Environmental Sourcebook Updates nos. 2, 7 and 10 concerned respectively with environmental screening, coastal zone management and international environmental agreements. This Update is not a design manual, nor is it a definitive statement on the international or regional agreements governing discharges to the oceans. It expands on pp. 231-236, Vol. II, of the EA Sourcebook.

Background

With the exception of Mexico City and Beijing, 13 of the 15 largest population centers in the world are sited next to coastal waters. In addition, more than half of the world's population currently lives within 60 km of the coastline; it is anticipated that coastal inhabitants will constitute 75 percent of the global population by the year 2020. The projected coastal population growth is likely to be accompanied by an increase in sewage and an increased likelihood of health problems if coastal wastewater discharges are not adequately controlled.

It is not appropriate to decide questions of wastewater treatment and ocean disposal on the basis of cost or expediency alone. For example, coastal areas often embrace a substantial portion of a country's agricultural, industrial and mineral resources, the future water needs of which must be considered when deciding on the disposal of the treated wastewater. The growing demands for water spurred by urbanization, agricultural intensification and critical needs for sanitation require the use of cost-efficient technology as part of an area-wide sustainable water management plan. Anticipated urban spread also necessitates planning and possible early acquisition of available land for future expansion of wastewater treatment facilities. These facilities are often constructed in phases, with higher degrees of treatment and associated sludge management often requiring more land than initial phases.

Since the publication of the Bank's *Environmental Assessment Sourcebook* in 1991, numerous questions have arisen over the environmental aspects of coastal wastewater projects. Questions relate to the necessity for a full EA, its timing, requirements for minimal levels of treatment prior to discharge, the reuse of the wastewater, the location and size of the outfall structure, applicable water quality standards and possible impact upon existing and future water uses.

This *Update* covers only the discharge of sewage from municipal sewerage systems through submerged outfalls to coastal waters, estuaries or major rivers likely to impact coastal waters. It does not provide detailed guidance on waste discharges from industries or on dumping of sewage sludge and other materials into the sea or estuaries. It identifies the various policies, procedures and requirements of the World Bank that must be applied in order to achieve sustainable wastewater management.

Task Managers and personnel of the borrowing country's implementing agency will benefit from an understanding of the issues involved in planning the discharge of wastewater into the marine environment. While not an engineering design manual with formulae and models for calculating an outfall's physical requirements, this *Update* should assist design engineers in identifying and using the data needed to evaluate and monitor project proposals.

Box 1: Reuse without sea outfalls

The project area for the Southeast Coast Sewerage and Drainage Project in Cyprus accommodates half of all tourists staying on the island. Larnaca, with a population of about 55,000 is the third largest urban area. Ayia Napa and Paralimni are smaller coastal towns with resident populations of about 1,400 and 10,000 respectively, and high influxes of summer tourists. In all three areas, sewage disposal was unsatisfactory, contributing to groundwater and sea water pollution.

Due to the scarcity of water resources, the Government of Cyprus in 1978 adopted a policy of reusing treated sewage effluents, thus ruling out consideration of sea outfalls. A 1984 Bank sponsored study of wastewater disposal options determined the least cost solution to include a treatment plant and sea outfall, with future provisions for land disposal schemes. However, approval of new sewer rates was one of the preconditions for negotiations; the rates were not obtained due to lack of support from hoteliers, and the project languished for a few years.

After extensive consultations with stakeholders in Larnaca on the environmental and financial consequences of further delays, the Sewerage Board retained consultants in 1990 to update the feasibility studies. These concluded that a sea outfall would not be necessary and identified a reuse scheme for treated effluent.

Supplementary studies were also carried out in Ayia Napa and Paralimni which recommended wastewater reuse in favor of sea disposal. The completed project consists of sewage collection systems and facilities for treating, storing, and distributing the effluent to the tourist areas for irrigation of lawns, etc.

Conformance with Bank policies

It is essential that Bank policies be considered in wastewater projects, thus helping to ensure the application of sound environmental practice throughout project preparation, implementation and supervision.

Environmental assessment

The Bank's requirements for environmental assessment are contained in Operational Directive 4.01 of 1991, soon to be reissued as OP / BP / GP 4.01. This policy provides for classification of projects according to the nature and extent of anticipated impacts. It provides guidance on public consultation and disclosure of information and requires the Borrower to assess impacts, evaluate alternative actions as appropriate, and to develop mitigation responses.

In the case of marine outfalls, the timing of the EA should permit a joint examination of treatment technologies and the method of final disposal, which may or may not be through a submerged marine outfall. The alternatives to be considered must address the issues outlined in the section below on 'Factors influencing selection of wastewater disposal schemes'. The Bank has prepared projects where outfalls have been rejected in favor of other disposal methods based on the outcome of the environmental assessment (see box 1).

Water resources management

The Bank's Water Resources Management Policy (OP 4.07) of 1993 identifies water as an economic good of increasing value as population centers grow and compete for investments in water supply, sanitation, irrigation, industry, hydropower, and flood control. However, at the core of the Bank's policy is the examination of water in a comprehensive way with respect to economics and pricing, delivery, reuse, disposal, institutional capabilities, stakeholder participation in decisions and environmental dimensions.

The Bank's policy is consistent with the Dublin Statement (1992) from the International Conference on Water and the Environment, as well as with Agenda 21 from the 1992 United Nations Conference on Environment and Development.

International waterways

The Bank's Operational Policy 7.50 of 1994 recognizes the rights of riparians in the utilization and protection of international waterways. The OP requires notification by the Borrower of all parties of a project's potential impact on riparians and identifies actions required to be taken should there be objections to the notification of the project. The Operational Policy is supported by the Bank Procedure, BP 7.50, also of 1994.

International environmental law

In analyzing a project's legal framework in accordance with OD 4.01, assistance should be given to the Borrower in determining if the project may violate relevant international environmental conventions. This is increasingly important as agreements are being ratified by a growing number of coastal states (see box 2). The Convention for the Protection of the Marine Environment of the North-East Atlantic and United Nations Convention on the Law of the Sea both make specific reference to prevention and control of land based pollution. Project teams are also required to take into account domestic legislation pertaining to discharge or reuse of treated wastewater.

As national plans are formulated to address sources of land based pollution, there will be a tendency to adopt concepts such as the "precautionary principle" which found prominence in the Rio declaration of 1992, and is a guiding principle of the Helsinki Convention of 1992 (which updates the original 1974 Convention). This requires that preventive measures be taken when there is reason to assume that substances or energy introduced into the marine environment may create hazards to human health, harm marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship. Accordingly, conventions citing the precautionary principle are obliged to implement protective measures at an early stage even if conclusive analyses are not yet available.

EA and the project cycle

The integration of EA into the core of coastal wastewater management projects is essential if environmental issues are to receive due consideration during decision making. The linkages between stages in the assessment process and the project cycle are described below.

The value of EA as a decision making tool can be improved by:

- preparing detailed TORs for the EA and feasibility study;
- using appropriate expertise in the screening and scoping process;
- incorporating environmental mitigation or management requirements in the project, including cost estimates and budgets; and
- maintaining close interaction between the EA team and planners, engineers, etc. throughout project preparation.

Complementary activities may be factored into the project as a result of discussing the EA and realistic alternatives with stakeholders. Other Bank wastewater projects have been modified to include low-cost sanitation components, monitoring of induced phased improvements and institutional strengthening.

Box 2: International agreements which may influence marine discharges

Among the international agreements which may influence projects involving marine discharges are the following:

- Convention Concerning the Protection of the World Cultural and Natural Heritage
- Convention on Biological Diversity
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)
- Convention for the Protection of the Marine Environment of the North-East Atlantic (Oslo and Paris Convention)
- Convention on the Protection and Use of Transboundary Watercourses and International Lakes
- Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention)
- United Nations Convention on the Law of the Sea (Montego Bay Convention)
  UNEP Regional Seas Programme which established conventions for the Black Sea; Mediterranean; Wider Caribbean; West and Central Africa; East Africa, Red Sea and Gulf of Aden; South-East Pacific; South Pacific; and the Kuwait Action Plan.

The implementing agency needs to examine treaty texts and subsidiary agreements which may contain detailed provisions. An example would be the Convention for the Protection of the Mediterranean Sea Against Pollution (1976) and its four Protocols for: Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft (1976); Cooperation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency (1976); Protection of the Mediterranean Sea Against Pollution from Land-based Sources (1980); and Protocol Concerning Mediterranean Specially Protected Areas (1983).

A more thorough discussion on international agreements is contained in *Update* no. 10.

Project identification

The institutional and regulatory structure, and overall environmental conditions are established during this phase of the project. The condition of existing wastewater collection, treatment and disposal infrastructure is also confirmed. At this stage of the project, dialogue with the implementing agency will help to clarify the:

- project categorization (EA category A or B);
- institutional framework, status of decision making and competing interests;
- willingness to consider alternative treatment / disposal options and phased project execution;
- status of international treaties, coastal zone management plans, and water quality objectives / standards;
- availability of water for all present and future uses;
- data available or required to support decisions for sustainability; and
- time frame for conducting the analyses, consulting the affected stakeholders, and designing and implementing the project.

Despite the environmental improvement focus of coastal wastewater management projects, the scale and complexity of the potential environmental impacts associated with construction and operation are such that an EA category A rating would normally apply. Bank projects in this category require a full EA (see OD 4.01 and *Update* No. 2 on environmental screening). An A categorization should apply to: all new outfalls (or treatment alternatives) from primary or secondary cities (i.e. cities having a population in excess of 100,000); projects that may significantly affect any protected areas or other important natural habitats (see OP 4.04: Natural Habitats); projects involving significant modifications to existing systems; and projects with substantial industrial wastewater contributions. In the latter instance, pretreatment is essential where there are significant quantities of metals and other bioaccumulative toxics.

Projects involving moderate upgrades or extension, or rehabilitation, of existing wastewater infrastructure are usually assigned a category B rating. For such projects an environmental audit looking at the existing environmental conditions will often meet the Bank's EA requirements and most effectively address the key environmental issues (see *Update* no. 11: *Environmental Auditing*).

Task Managers and Borrowers should collaboratively generate realistic wastewater management alternatives at an early stage of project identification. The comparative evaluation and assessment of alternatives should be an integral part of the TOR for the EA, prefeasibility and feasibility studies. The analysis of alternatives should encompass alternative technologies, strategies and locations for treatment plants, outfalls and / or reuse facilities. For example, technological alternatives to outfalls may include land application (with varying degrees of pretreatment), industrial reuse or aquifer recharge. Siting issues are important in the location of treatment facilities, landfall and discharge points for outfalls, and pipeline routes. Guidance on the generation and analysis of realistic project alternatives will be covered in a forthcoming *Update.*

If an outfall proposal might result in significant cumulative impacts (see box 3) arising from multiple pressures within a coastal area, a Regional EA (REA) is strongly recommended. An *Update* on regional EA is forthcoming.

Project preparation and detailed design

During project preparation, the EA should be integrated with the project feasibility studies. In the context of outfall projects, the following aspects should be addressed:

- legal and institutional factors including the existence of national water or environmental strategies, the implications of international or regional agreements to which the borrowing county is a party;
- the affected area's future water needs or resources, and the significance of reuse alternatives in this context;
- projected population growth (both medium and long term);
- characteristics of wastewater, i.e. domestic, storm water and industrial contributions;
- the need for an industrial pretreatment program;
- availability and costs of land for construction or expansion of wastewater treatment facilities;
- significance of climatic and meteorological factors in terms of seasonality of wastewater generation or water availability;
- the influence of water quality criteria or standards on the pretreatment and treatment of wastewater, discharge location (including outfall length and depth), diffuser design, or choice of alternative technology, e.g. land application;
- dispersion characteristics and assimilative capacity at alternative locations including the diurnal and seasonal effects of currents and meteorological factors;
- timing and extent of public involvement and degree to which stakeholders may influence project components;
- economic and technical evaluation of realistic alternatives; and
- pricing mechanisms and incentives.

A more thorough discussion of the factors which influence the selection of wastewater disposal schemes is included in the final main section of this *Update.*

EA documentation is disclosed locally and through the Bank's Public Information Center prior to IBRD's appraisal in accordance with OD 4.01 and Bank procedures on disclosure of information (BP 17.50). For "programmatic" operations for which sub-project

Box 3: Bombay sewage disposal project

Currently less than 2 percent of wastewaters generated by Bombay's population of 12 million undergo treatment before disposal to creeks and adjoining coastal areas. The project includes construction of two sea outfalls and aerated lagoons; improvements to five sewage pumping stations and conveyance systems; a slum sanitation program to serve 1 million people; and technical assistance for operation of the system. Upon completion, some 45 percent of the population will be connected to a sewage collection, treatment and disposal system, with anticipated improvements in health and quality of life. Furthermore, coastal water quality in and around Bombay should improve significantly.

The EA not only addressed questions concerning the direct environmental impacts of the project, but also analyzed the project's ability to attain proposed environmental goals. This approach made the EA central to the design of the project and focused attention on potential cumulative impacts. A key component of the EA was hydrodynamic and water quality modeling to predict water quality changes resulting from alternative project configurations. In situ dispersion studies and bacterial die-off studies were also conducted. The analysis incorporated projected changes in population growth, land use, land issues in relation to resettlement, and assessment of cumulative and interdependent impacts of water pollution.

The EA demonstrated that the impact of the project would be highly dependent on pollution control in upstream urban and industrial areas outside the legal boundaries of Bombay. It also recommended that a system of aerated lagoons along a creek surrounded by dense populations, be dropped, as the assimilative capacity of the creek was insufficient to achieve the agreed water quality target, due in part to the large number of additional sources of pollution. Studies are ongoing to determine the final level of treatment and outfall configuration.

details are unknown during appraisal, EA documentation is disclosed as it becomes available.

Appraisal and negotiation

During appraisal, Task Managers should seek the assistance of legal and technical staff in reviewing decisions reached by the Borrower based on the feasibility study, EA and associated studies. Discussions need to address the extent to which the EA satisfies the Bank's requirements and the need for environmental loan conditionality to guide implementation of the project and associated environmental management (mitigation and monitoring) plans. For example, where industrial toxics are a problem, pretreatment should be a condition of the loan or dated covenant. The basic factors to consider include required activities and timing, assignment of responsibilities, and inclusion of appropriate funding and reporting arrangements. Additional complementary activities to help the sustainability of the project or strengthen the capacity of the implementing agency should also be examined. Whether the project is in category A or B, the results of the EA process should always be summarized in the Staff Appraisal Report as indicated in box 4.

Monitoring and supervision

The TOR for the EA should reflect the importance of preparing a monitoring plan, as part of or separate from an Environmental Management Plan (EMP). The content and level of detail will vary depending on the scale and complexity of the wastewater project. However, in all cases the plan should demonstrate that monitoring activities (including indicators and benchmarks) will effectively address all major impacts identified in the EA.

The monitoring plan should define monitoring objectives which clearly identify the questions to be answered by measurement activities. It should include a description of monitoring to be performed and linkages to impacts and mitigation measures identified in the EA. The parameters to be measured, sampling locations, methods to be employed, frequency of measurements, detection limits (where appropriate) and definition of thresholds that will trigger remedial actions should also be specified.

The basic framework within which supervision occurs is project conditionality. It is vital to link measures in the EMP to the project legal agreement in the form of environmental conditions and covenants the Borrower and Bank agree on. To reinforce the legal documents it is recommended that a monitoring summary be prepared that is linked to the project's legal agreements. Detailed guidance on monitoring and supervision of projects is contained in a forthcoming *Update.*

Public involvement

Given the sensitivities associated with wastewater collection, treatment and disposal, the effective involvement of stakeholders is essential to the EA process. The challenge for Task Managers is to assist Borrowers to understand Bank policies and encourage the adoption of a comprehensive decision making approach. This will help ensure the identification of groups likely to be impacted by the project initially, for example those engaged in fisheries or tourism, or in the long term such as outlying unsewered communities. For assistance, Task Managers should review *Update* no. 5 on the public's involvement in the environmental assessment process.

Box 4: Coverage of environmental aspects in the Staff Appraisal Report (SAR)

SARs for wastewater projects which involve the use of outfalls should include an annex covering the following:

- Borrower's requirements for EA
- Current problems needing attention
- The basis for design of wastewater facilities:
  - Population trends and future water needs
  - Pollution sources
  - Quantity and quality of wastes
  - Industrial sources of wastes
  - Receiving water standards
  - Existence of coastal zone plans
  - National or local pollution laws
  - International agreements
- Alternatives examined:
  - Technologies / strategies
  - Site locations—treatment and disposal
  - Reuse of treated wastewater
- Impacts predicted:
  - Receiving waters
  - Ground water
  - Air quality (odor and drift of aerosols from treatment plants)
  - Flora / fauna
  - Cultural heritage sites
  - Construction impacts
  - Disposal of sludges and screenings
  - Involuntary resettlement
- Consultation:
  - Stakeholders included
  - Forms and process of consultations
  - Records of comments
  - Proposed measures
- Management (mitigation and monitoring) plans:
  - Proposed measures
  - Timetable and costs

Data collection

As noted under the identification phase of the project, it will be necessary to work with the Borrower's implementing agency during the pre-feasibility stage to assemble information on any applicable national or international laws and water quality or sediment criteria. If project specific data collection has not commenced (depths, currents and water quality), arrangements should be made to ensure sufficient data are available to model the dispersion of the buoyant plume from various discharge locations, depths, and changing current patterns. Seasonal studies are required for an all-season model to determine the most suitable option for management of the wastes; this may necessitate sampling over a 12 month period.

The seasonal bottom profile in the vicinity of a proposed outfall and the seismic history of the area must also be known to ensure appropriate design and placement of the outfall structure (see box 5). Data collected during monitoring and supervision of projects can be used to refine subsequent decisions relating to treatment and disposal or reuse of wastewater from currently unsewered areas.

Institutional strengthening

In the context of IBRD's lending operations, it is important to address the needs for institutional strengthening and long range planning for wastewater projects. In many cases, the Borrower will have prepared a National Environmental Action Plan (NEAP) or an equivalent program. Specific wastewater projects may present opportunities for initiating regional or basin-wide water management or coastal zone management (CZM) plans. Other opportunities to consider include:

- updating fee structures for water and waste services;
- upgrading use of monitoring data in waste water treatment plant operations;
- expanding measures to reduce leakage and wastage of water;
- a program of low-cost sanitation for unsewered areas;
- developing incentive programs for industrial wastes;
- supporting public education and awareness programs concerning water conservation and proper use of sewage systems; and
- establishment of coastal reserves or enhancement of barrier reefs or mangrove forests.

It is also imperative that operation and maintenance capacity be assessed and strengthened if necessary. In the absence of the requisite skills, experience and equipment to operate and maintain wastewater infrastructure, the potential for system failure is high.

Wastewater management alternatives

Alternative waste treatment / disposal / dispersion systems that will meet established water quality objectives must be examined in the EA. Treatment levels and disposal options will be determined by the Borrower in concert with the implementing agency. These range from primary treatment of the domestic waste discharging through a long (3-5 km) outfall to deep stratified water with significant year-around currents to higher degrees of treatment and subsequent reuse of the waste water or disposal through shorter, appropriately designed marine outfalls. The EA will weigh the economics of each alternative against projected population and commercial growth, water scarcity, available land for treatment facilities, public health and many other criteria. Benefits as well as negative impacts of each option will be subjected to discussion both within the country and in the Bank.

In many developed countries, coastal cities are required to employ at least secondary treatment of wastes prior to discharge through submerged ocean outfalls. This is often dictated by official policy or legislation establishing uniform requirements rather than on the basis of site specific technical decisions. The United States goes beyond the minimum treatment requirement and meeting of water quality standards by requiring that direct discharges to ocean waters be assessed through an ecological risk analysis that must demonstrate no unreasonable degradation of the marine environment.

In developing countries, where much of the wastes are untreated and discharged to urban ditches and creeks with little regard for the public's health, there is merit in evaluating each situation and looking to phased construction as conditions and available financing dictate.

In many instances, the resulting analysis of options will favor the use of preliminary treatment with a properly designed submerged outfall (see box 6). While the ocean outfall may be the most capital intensive option for wastewater disposal, its lifetime costs will be considerably less than secondary treatment with disinfection and on shore disposal.

The Borrower should encourage periodic discussions on the alternative approaches to disposal with representatives of various governmental agencies, NGOs and the public, especially those likely to be directly affected.

Box 5: Tunneling for seismic safety

Depending upon the type of pipe being used, outfalls have usually been constructed in place, pulled or floated into position and then sunk and anchored. However, where seismic activity is a design constraint, specific mitigation measures may be necessary to ensure structural integrity of the outfall if a seismic event were to occur.

In the case of the South Bay Ocean Outfall off the USA coast at the border with Mexico, an 11 ft diameter tunnel will be constructed some 150 ft below the ocean floor. It will extend 2.7 miles offshore, then a 9 ft diameter riser will convey the treated effluent to a 1 mile pipeline anchored to the ocean floor. Ultimately, two diffuser legs of 2000 ft will discharge the effluent in water up to 93 ft deep. The outfall system with a design capacity of 333 mgd will accommodate wastes from the South Bay International Wastewater Treatment Plant and the San Diego wastewater treatment facilities and eliminate pollution from the Tijuana River during storm events. Construction is expected to be completed by mid-1998.

Building a part of the outfall within bedrock avoids the impact construction would have on an environmentally sensitive estuary. It also helps overcome concerns of ocean floor placement which traverses several active fault zones. The sea floor pipeline will be engineered to provide stability in the event of an earthquake.

Factors influencing selection of wastewater disposal schemes

Future regional water needs

With the global demand for water doubling every 20 years, closer attention to the future needs for water in all sectors of the economy is required at the local, national and regional levels. Most countries with limited water are in the Middle East, North Africa, Central Asia and sub-Saharan Africa. Other regions facing water scarcity are northern China, southern India, western South America and large parts of Pakistan and Mexico.

The lack of water resources is frequently accompanied by rapid population growth. Treated wastewater may be an acceptable source of water for a range of restricted uses including irrigation, industrial processes, aquaculture, fire protection and direct recharge of aquifers. Reuse of treated wastewater should be carefully controlled and monitored. In some cultures, however, the potential for reuse may be limited. Thus a decision to dispose of wastewater should be reached only after careful examination of future water demands.

Wastewater characteristics

Sewerage systems frequently cover only a small percentage of the metropolitan area's population. On-site septic tanks using individual subsurface drainfields or periodic pumping and hauling to a point of discharge are often commonplace. Occasionally, sewers handle domestic waste, storm water runoff, and industrial wastes which frequently receive no pretreatment. In these cases, it is important to work with the implementing agency in the project's prefeasibility phase to incorporate proposed pretreatment measures for the project.

An effective system of user charges and fines, coupled with training and demonstration activities, provide powerful compliance incentives for industry.

Waste minimization by industrial operations can also result in considerable savings. In some developed countries, an industrial focus on core business has led to subcontracting of many non-core functions such as wastewater treatment. In many cases, wastewater service companies not only treat the industrial discharge but also return clean water and / or recovered constituents to the process, thereby adding value.

Climatic and meteorological factors

Climates of the world are divided into five major systems based on temperature and rainfall, an aspect that must be considered during selection of discharge options. Generally, the more arid regions require careful water management planning. Thus, additional emphasis is often given to reuse of collected and treated wastewater rather than disposal to the sea. Some 80 countries are currently experiencing water shortages serious enough to threaten agriculture; demand for water will grow as populations increase and urban centers spread.

Seasonal variations in temperature and precipitation may also have a profound effect on volumes of wastewater being generated or the preferred treatment option. For example, where rainfall is seasonal there may be a need for short term storage of stormwater and subsequent controlled treatment and / or discharge. Similarly, where reuse for irrigation is being considered, storage may be necessary due to cold weather or crop management issues.

Water quality considerations

Where effluents are discharged to the open ocean, only a few components of the waste are important. These are primarily microbiological quality associated with the protection of public health; floatable substances including oil and grease; and toxic persistent organic and inorganic pollutants. Toxic materials are not easily removed from municipal sewage and are better controlled through source identification and reduction.

Most other sewage constituents such as, biochemical oxygen demand (BOD), suspended solids, salinity and nutrients are of less significance when effluents are discharged to the open ocean through properly designed outfalls and diffuser systems. Persistent floatable material which can return to the shoreline and cause aesthetic damage should be removed through treatment.

If the discharge is to a river or poorly flushed coastline or embayment, nutrients and BOD assume greater significance due to their direct impact upon the dissolved oxygen content and quality of the receiving waters.

Box 6: Regional approach to land based sources of pollution

Sewage has been identified as one of the most significant coastal pollutants in the Wider Caribbean Region (WCR). In 1991, the Pan American Health Organization reported that only 10 percent of sewage generated in Central America and the Caribbean was properly treated. Only 25 percent of resort owned treatment plants were found to be in good operating condition by the United Nations Environment Programme (UNEP). Any increase in population or tourism exacerbates potential public health problems via primary contact with contaminated bathing waters or the consumption of contaminated fish or shellfish.

A Programme of Action for the Sustainable Development of Small Island Developing States adopted in 1994 is critical to ensuring the adequate treatment of sewage discharged to near-shore coastal waters. A precautionary approach has been recommended for individual national programs. The WCR's Land Based Sources of Pollution (LBSP) Protocol currently under consideration, requires application of the most effective and appropriate available technologies to point sources. Alternatives such as reuse of wastewater and various combinations of treatment and marine outfalls are to be evaluated on a site specific basis.

In Barbados for example, a Coastal Zone Management (CZM) plan includes the elimination of graywater from surface drains along the south coast through wastewater treatment. Coral reefs have been damaged to the extent they provide little protection from wave action. Data compiled over a one year period on currents, water uses and quality, sensitive coral reefs and tourism growth, led to recommendations for the treatment of collected wastes. Water quality criteria for bathing waters, shellfish areas, and an outfall mixing zone were developed. Taking advantage of strong unidirectional currents that sweep the coast, a system was selected that employs collection, fine screening, grit removal and discharge through a 1 km outfall designed to keep the waste plume below the 30 m contour.

Bacteriological contamination

In addition to data needed to model the coastal water quality under various conditions of discharge, bacterial decay coefficients obtained from laboratory or field measurements will be necessary for predicating conformance with water quality objectives. In many developing countries, national water quality standards for bacterial contamination in marine waters (either for bathing waters or shellfish harvesting) have been adopted from pre-1986 United States standards, those of the European Union (EU), or as adopted by the WHO and UNEP.

Bathing water and recreational usage

Where national standards are significantly more stringent than the above, e.g. Peru or Brazil, the Borrower should determine their basis, such as epidemiological investigations or other criteria. Compliance with stringent standards, by pretreatment of sewage or modifying outfall design can profoundly affect project costs. Hence, the benefits associated with incremental costs should be understood.

The most widely used indicator of the safety of bathing waters are coliform bacteria, which form the basis of the EU, WHO, or the USA (prior to 1986) bacteriological standards and guidelines. In 1986 the USA adopted a new criterion for marine recreational waters based on enterococci as the indicator organism with the best correlation for gastrointestinal symptoms attributed to fecal contamination. Given the widespread successful application of the total coliform index as indicators of bathing waters safety, regional organizations such as the Caribbean Environmental Programme and some countries have concluded it best to continue to use coliforms until sufficient information based on local epidemiological studies is available to support changing to other indicator organisms.

Shellfish harvesting waters

The most stringent bacteriological and toxicant criteria are reserved for receiving waters used for shellfish harvesting. This is due to the ability of certain shellfish such as oysters and mussels to accumulate contaminants and transmit a wide range of diseases, including paratyphoid fever, cholera, viral hepatitis and many other gastro-enteric conditions. The indicator organism is fecal coliform and the generally accepted levels are those of the World Health Organization (WHO) and the United Nations Environment Program (UNEP). These state that 80 percent of samples from shellfish harvesting waters should have less than 10 fecal coliforms per 100 ml and all samples should have less than 100 fecal coliforms per 100 ml. It is recognized, however, that water quality criteria do not determine the acceptability of shellfish for direct human consumption; this needs to be determined on the basis of sanitary procedures and food safety regulations of each country.

Characteristics of receiving waters

Proposals to discharge into tidal lagoons, bays, and estuaries are common. However, because of the characteristics of these water bodies (including shallow depths and vertical mixing, low current velocities, restricted flushing rates, high rates of sedimentation) and multiple uses, such proposals require greater attention and design data than discharge proposals to coastal waters off the continental shelf. One region prone to the impacts of pollution from coastal communities is the system of interconnecting and highly productive coastal lagoons extending some 760 km along the west coast of Africa from Cote d'Ivoire to eastern Nigeria (see box 7).

While estuaries generally are important areas for the propagation, movement and harvesting of marine and freshwater fish, the existence of any protected areas or critical ecosystems or habitats designated by an international body that could be impacted by the location of an outfall brings an added dimension to deciding the suitability of marine outfalls. For detailed worldwide information on marine protected areas, regional institutions, participation in international conventions, ocean currents, coastal features and more, see the Bank's *Global Representative System of Marine Protected Areas*, 1995.

Box 7: Sewage disposal and coastal lagoons: Abidjan, Cote d'Ivoire

The Bank participated in two sewage disposal projects in Abidjan (1974 and 1989) which highlight the importance of EA and post-project evaluation. Both projects predate the Bank's Operational Directive on EA. The first assisted the formation of the government's 10 year sewerage and storm water drainage development program. A sewage outfall constructed as part of this project discharged to the shallow Ebrié lagoon (mean depth of 3 m). This resulted in pollution problems within the lagoon due to the effects of municipal, industrial and storm water discharges. Following the 1974 project, Abidjan experienced rapid growth which outpaced development of the metropolitan plan, leading to unplanned increases in wastewater volumes. The loss of the Ebrié lagoon, one of the country's most attractive coastal features, was at stake.

The second project was aimed at overcoming these problems. Three alternative options were considered: secondary treatment with continued discharge to the lagoon; the use of the lagoon as an oxidation pond; and primary treatment combined with extending the outfall into the open ocean. The latter was selected and implemented. The outfall constructed during the initial project was extended to the ocean shoreline, and an additional 1.5 km of submerged outfall added. A monitoring program was required as part of the loan agreement.

Conclusions

Adequate control of coastal wastewater discharges is imperative given projected coastal population growth. As international agreements affect increasingly large numbers of coastal areas, it is important to determine the influence of such agreements on specific projects.

The integration of EA into the early stages of coastal wastewater projects is essential to ensure sufficient consideration of potential impacts. This should include, for example, generation of realistic alternatives during project identification

Despite the environmental improvement focus of wastewater projects, the scale and complexity of potential environmental impacts normally merit an A categorization.

Future regional water needs and projected population growth are examples of several important factors influencing the selection of wastewater disposal schemes. All such factors should be thoroughly evaluated prior to determining an optimal wastewater disposal strategy.

For further information:

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This *Update* was prepared by Albert Printz and Aidan Davy. Based on Bank policy and procedures on Environmental Assessment (EA) (Operational Directive 4.01), the *EA SOURCEBOOK UPDATE* provides up-to-date guidance for conducting EAs of proposed projects. This publication should be used as a supplement to the *Environmental Assessment Sourcebook.* Please address comments and inquiries to Olav Kjørven and Aidan Davy, Managing Editors, EA Sourcebook Update, ENVLW, The World Bank, 1818 H St. NW, Washington, D.C., 20433, Room No. S-5139, (202) 473- 1297. The Bank is thankful for the Government of Norway for financing the production of the *EA Sourcebook Update.*