Journal of Civil Engineering
The Institution of Engineers, Bangladesh
Vol. CE 25, No. 2 , 1997

ENVIRONMENTAL PLANNING OF BRIDGE-ENDS AND RESETTLEMENT SITES OF JAMUNA MULTIPURPOSE BRIDGE

Md. Delwar Hossain[1] and A. B. M. Badruzzaman[2]

Abstract: With a view to provide a permanent link between the north-western and eastern parts of Bangladesh, which has been severely restricted by the formidable natural barrier, the Jamuna River, in late 1994 construction of a 4.8 km long multipurpose bridge has begun. Considerable land has been acquired on the both ends of the proposed bridge to develop the area in a planned and organized manner. However, the population displaced from their homesteads needs to be resettled in an orderly and environmentally sound manner. Also, for safe and efficient construction of the bridge and to provide smooth operation and maintenance of the bridge following the construction, it is essential that the bridge-ends also be developed. This paper is an attempt to address the issues related to environmentally sound and sustainable development of the bridge-ends and the resettlement sites of the Jamuna Multipurpose Bridge Project.

KEYWORDS: Jamuna Multipurpose Bridge, Bridge-Ends, Resettlement Sites, Environmental Planning

INTRODUCTION

Under the supervision of World Bank, local and foreign experts a 4.8 km long multipurpose bridge is under construction over the Jamuna River near Bhuapur (Fig. 1). The north-western and eastern parts of Bangladesh has long been world apart due the physical presence of this formidable natural barrier. With a total estimated cost of US $ 900 million the largest development project is aimed at creating a permanent link between these two parts and providing smooth transfer of vehicle, gas and energy, telecommunication and railway. During the construction and subsequent operation of the Jamuna multipurpose bridge, it is required to generate development at the bridge ends and resettlement sites. Generated development is the one that depends on those facilities necessary for the construction and operation of the bridge, i.e.,

i. the space and facilities required to ensure safe and efficient construction of the bridge.
ii. the space and facilities required to accommodate the road, rail and power lines, and to ensure their safe operation.
iii. Jamuna Multipurpose Bridge Authority (JMBA) offices and facilities, and operational services. Moreover, emergency

[1] Department of Civil Engineering, BUET, Dhaka 1000, Bangladesh.
[2] Department of Civil Engineering, BUET, Dhaka 1000, Bangladesh.

services, roadside services and other facilities (shops, restaurants, postal and telecommunication services, etc.) are to be generated at the bridge ends in order to allow the bridge to function safely and properly.

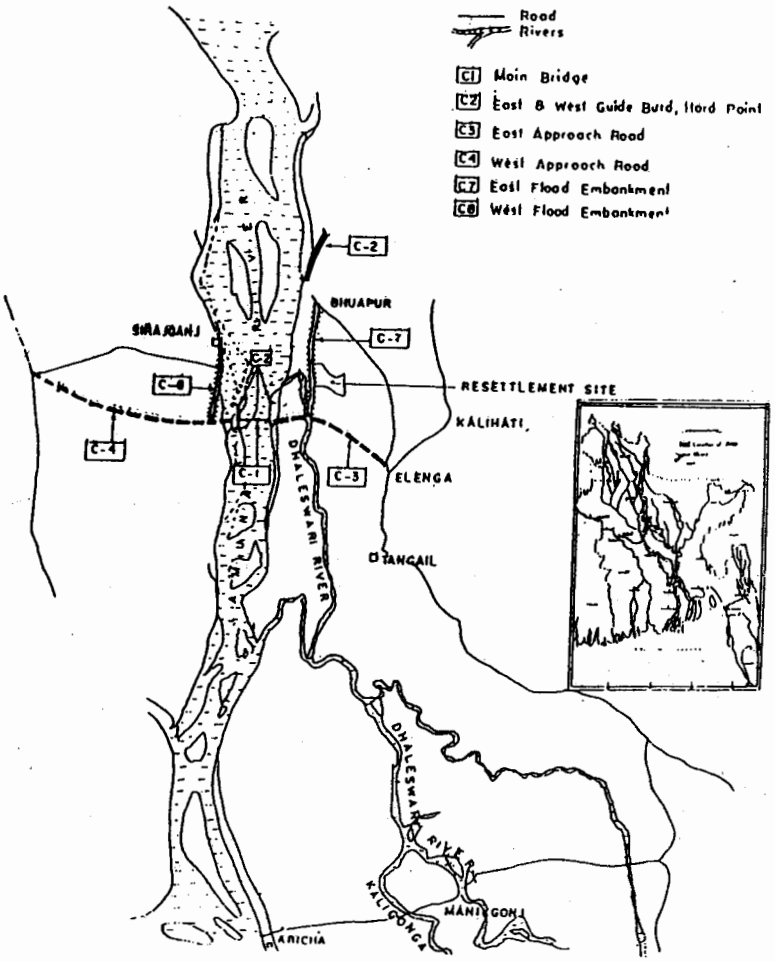

Fig. 1 Location of the Jamuna Multipurpose Bridge.

Since a residential population is required to operate the bridge, housing is necessary at both the bridge-ends. Unplanned residential

development may either pose a security risk or may promote disorderly development and thus needs to be restricted.

There are provisions of settlement of Project Affected Persons (PAPs) at developed resettlement sites and around the approach roads in the vicinity of their lost homesteads (JMBA-EU, 1993). Presently a resettlement site about 3 km north of the east bridge end has been acquired for development. The other PAPs are expected to settle in scattered homesteads. It is necessary to maintain proper environmental conditions for the dwellers of bridge ends and settlement sites. To understand the environmental constraints of bridge-ends and resettlement sites following issues need to be addressed which will facilitate proper environmental planning.

ENVIRONMENTAL PLANNING COMPONENTS

The JMBA has the responsibility to ensure that development at the bridge ends, growth of the resettlement sites and all the activities around construction and resettlement sites are environmentally acceptable (Ahmed et al, 1995). The objectives of the environmental planning components will be:

- to make provision for all service facilities in the bridge ends and resettlement sites to maintain a better living environment.
- to deliver effective health education package to all temporary and permanent residents in the area and to the people involved in various activities at the bridge ends.

To achieve environmentally sound and sustainable development following components need to be addressed:

(i) Environmental Planning of Bridge-ends and Resettlement Sites
(ii) Environmental Health Education Campaign.

ENVIRONMENTAL PLANNING OF BRIDGE-END FACILITIES

Bridge-end Facility Requirements

The contractor's facilities have been concentrated on the east bridge-end. Apart from the yard, storage facilities and labor camp the contractor's office and related staff quarters have also occupied the same corner of the bridge-end site. About 2000 people are being employed, as estimated by the consultants, during the construction of the bridge (GHK/MRM, 1992).

It is expected that operational facilities would be split between both bridge ends. The proposed facilities required to operate the bridge

includes - toll collection, security facilities, police facilities. fire/ambulance stations, vehicle inspection areas, holding areas, maintenance facilities, etc. Moreover, facilities will be required for commercial social activities and for rail operation at both bridge-ends. During construction and after opening the bridge for road traffic, it is expected that one township will gradually develop at each bridge ends. Population at east-end township is expected to be higher than that in the west end town. The ultimate design population of the east-end town is planned to be 20,000 which is expected to grow incrementally as shown in Table 1. The industrial expansion is expected to follow a similar pattern, while the commercial growth may lag behind by one year. Size of west-end township and the population of resettlements are not yet finalized.

Table 1. Incremental Population Growth at East Bridge-End (GHK/MRM, 1992).

Increment (Year)	Population	Percent of Total
1	2,000	10
2	6,000	20
3	10,000	20
4	15,000	25
5	20,000	25

Water Supply

The relatively high standard of housing proposed for the east-end area and the need to encourage industrial development indicate that a piped connection would be the preferred option for the whole township. The feasibility study suggests that drinking water for the contractor's site could be taken either from the river or be pumped from underground (RPT-NEDECO-BCL, 1991). The water in the river Jamuna has fluctuating high turbidity, suspended solids and high fecal count which require expensive biological and/or chemical as well as physical treatment to make water suitable for public water supply (Badruzzaman et al, 1996). The sudden and frequent flooding as well as drying up of the river would make installation of intake works difficult and expensive.

The ground water at both bridge end site has a high iron content ranging between 2-5 mg/l. Dissolved iron is not a health hazard, but it discolors water, gives unpleasant taste and brownish color to cooked food and discolors clothes. Although a maximum iron concentration of 5 mg/l has been accepted in Bangladesh Environmental Quality Standards for drinking water in rural areas in the absence of a better alternative source, people do not use such water for all domestic purposes (DOE, 1991). So development of water supply, based on

ground water, may require installation of iron removal plant. Aeration with rapid filtration is the simplest and most efficient method to remove iron from water. Aeration causes the iron to become insoluble which can then be easily removed by filtration. Installation of deep tubewell may produce water with low iron content which will make iron removal cost effective. From bacteriological point of view and economic consideration, ground water based domestic and industrial water supply is usually a better option. The sitting of the tubewell, treatment plant and overhead water tank should be planned to meet the growing demand of the expanding township.

The estimated water demand for the future east bridge-end township is given in Table 2. Water demand for construction purposes is around 4,00,000 liters per day. River water, after plain sedimentation in a storage reservoir, may be used for construction purposes. The settlement sites near the east bridge-end may be considered as semi-rural areas. Water supply of these areas can be accomplished by community handpump tubewells. Water consumption for such rural areas may be considered to be 45 lpcd for domestic and drinking purposes. For similar situations Department of Public Health Engineering (DPHE) recommended 1 tubewell for every 75 persons. However, to remove iron content in handpump tubewell, community type iron removal plant designed by BUET, or UNICEF may be installed. From sanitary point of view, each tubewell should be installed at least 10m away from soak pit (BUET-BIDS, 1993).

Sanitation and Sullage Removal

A list of most common technologies adopted in different countries along with some governing criteria and their level of acceptance in Bangladesh has been presented in Table 3. The major considerations in the selection of an appropriate technology are technical feasibility, health benefit, cost, affordability, socio-cultural factors, and institutional framework. Considering cost, health benefit and site conditions, installation of fully on-site disposal system utilizing septic tanks or twin pit water-sealed latrines with off-set soak pits or cesspool may be recommended for bridge ends. The soak pits and cesspools should be designed to take household sullage, although sullage waste water could be disposed of by using the open channels of the surface water drainage system, but this is less sanitary.

Around 65 to 70% of the domestic water supply flows to sullage, and the septic tanks should have a retention time of at least one day (BNBC,1993). If a septic tank and soak pit is used for every 10 persons, as recommended by DPHE, the volume of sanitary sewage and sullage to be accommodated in a septic tank and soak pit is about 700 liters per day, which can be handled by the sandy soil at the JMBP site.

Table 2. Water Demand for the East Bridge-End Town (GHK/MRM, 1992).

Year	Item	Dom	Ind	Com	Misc	Sub-Total	Loss 25%	Total Demand
1	2	3	4	5	6	7	8	9
				(3+4) x 0.15	(3+4) x 0.2			
st ear	op. x 1,000	2	1					
	pcd	100	20					
	emand/day 1,000	200	20	33	44	297	99	396
nd ear	op. x 1,000	6	3					
	pcd	100	20					
	emand/day 1,000	600	60	99	132	891	297	1188
rd ear	op. x 1,000	10	5					
	pcd	100	20					
	emand/day 1,000	1000	100	165	220	48.5	495	1980
th ear	op. x 1,000	15	7.5					
	pcd	100	20					
	emand/day 1,000	1500	150	247.5	330	227.5	742.5	2970
th ear	op. x 1,000	20	10					
	pcd	100	20					
	emand/day 1,000	2000	200	330	440	2970	990	3960

Water carriage sewerage systems or small bore sewer system (SBS) should not, however, be ruled out, especially if urban densities are to be sought. The situation will be further appraised when final decisions concerning the extent of allowable urbanization at the bridge ends is made. However, the cost of construction including treatment plant and the operational constraints of a full water-borne sewerage system should be considered to arrive at a decision. Flood protection will be essential for both the facilities.

Industrial Waste

If the area is to have industries, especially fuel and auto-repair works, industrial waste could be a problem. Oil and diesel can contaminate surface and ground water, unlike human or animal waste. The self cleaning process of natural water bodies is hampered by this type of contaminants. Therefore, if large amount of industrial wastes is to be disposed of, suitable treatment and disposal methods should be adopted following the proposed Environmental Quality Standards of Bangladesh (DOE, 1991).

Storm Water Drainage

Storm water drainage of built-up areas at the bridge ends need to be carefully designed. The quantity of storm sewage depends mostly on the rainfall intensity, the tributary area and the coefficient of runoff which represents the combined effects of ponding, percolation and evaporation. The quantity of storm sewage also depends on temperature, soil moisture, rainfall duration and time of concentration. An effective runoff coefficient for a composite drainage area can be obtained by estimating the percentages of the total area covered by roofs, pavings, lawns, etc. and multiplying each fraction by the appropriate coefficient followed by summation of the products. Since the bridge ends will be built-up areas at higher level and the topographical surfaces will be artificially created, there is an opportunity to grade the surface to predetermined levels and gradients. If surface gradients are kept around 1:1000 and the area is considered to be of compacted with sandy soil, the average runoff coefficient of 0.6 may be used in determining the storm water surface runoff following the Rational Method (Steel and McGhee, 1984). A recent study shows that the rainfall intensity at the Jamuna bridge site ranges between 50-52 mm/hr (Momtaz, 1993). In determining rainfall intensify for estimating the quantity of storm water it must be recognized that the shorter the duration, the greater will be the expected average intensity of rainfall. For design purposes one can assume a 20-minute storm of 70 mm/hr intensity for the bridge-end sites.

Storm water contains mostly inorganic impurities and is not offensive as domestic sewage, thus, may not need any treatment. Storm water drainage system may be constructed as open channels to reduce cost of construction and maintenance. After collection, storm water may be discharged into the river Jamuna or the surrounding low-lying areas without causing any damages to river water or private properties. Where appropriate, storm water details, similar to those designed for the bridge-ends by the bridge design consultants, may be implemented to ensure the completion of a coordinated and coherent drainage network. The resettlement area near east-end will have a slope toward east, away from the flood embankment, which will facilitate design of open drainage system for quick drainage of the area. Small settlement built on raised land does not require specially designed drains.

Solid Waste Management

The dwellers in an urban or sub-urban center expect regular collection of household wastes as part of a municipal service. This would also be the expectation of the dwellers of the bridge-end township. Otherwise, people of the town will dump their wastes in unplanned manner which will cause serious nuisance and hazard including odors, dust, fires, flies, rats, mosquitoes, etc.

Table 3. Alternative Sanitation Technological Options
(BUET-BIDS, 1993)

Type	Cost	Health Benefit	Water Requirement	Status in Bangladesh
Bucket	Medium	Low	None	Available, being gradually phased out
Direct Pit Latrine	Low	Low	None	Acceptable as low-cost method
Offset Pit Latrine	Moderate	None	Water near toilet	Acceptable as low-cost method
Ventilated Improved Pit (VIP) Latrine	Low	Moderate	None	Tried on experimental basis
Reed Odorless Earth Closet (ROEC)	Low	Moderate	Water near toilet	Modified version adopted in limited scale
Pour-Flash, Water Sealed Offset Pit Latrine	Low	Good	Water near toilet	Accepted in municipal sanitation program
Pour-Flash, Water Scaled Offset Pit Latrine	Medium	Very Good	Water near toilet	Accepted in municipal sanitation program
Double Vault Composting Latrines	Medium	Low / Moderate	None	Tried on experimental basis, but not accepted
Continuous Composting Latrine	Medium	Low / Moderate	None	Not available
Aqua Privy	High	Good	Water near toilet	Not available
Septic Tank and Soak Pit	High	Very good	Piped or enough water	Widely accepted in municipal sanitation
Small Bore Sewer (SBS) System	Very High	Very good	Piped water supply	Designed but not yet implemented
Conventional Sewer System	Very High	Very Good	Piped Water supply	Available in Dhaka only

Solid waste management includes storage, collection, transportation and safe disposal. From a sanitation viewpoint, it is essential to provide designated premises with appropriate arrangement for storage of refuse. The maintenance of adequate sanitary facility for temporary storage of solid wastes on the premises is considered to be the responsibility of

individual household, industries and business units. The most desirable approach in improving home-storage conditions lies in educating the general public. It is expected that the willingness of individuals to cooperate will increase when they are made aware of the hazards and nuisances associated with unsanitary practices. An average person in the Indian subcontinent generates around 400 grams of solid wastes everyday (GHK/MRM, 1992). Thus, 20,000 people in east-end site will generate about 8 tons of wastes every day. Several sweepers will be required to collect solid waste from door to door and to put wastes into hand carts for transportation either to suitably located containers/spots or to a disposal site. If the refuse is initially placed in containers or fixed spots, the wastes should be collected and transported to a final disposal site by a dump truck once a day.

Usual practice for solid waste disposal in the cities/towns of Bangladesh is open dumping, which causes odors, dust, flies, rats and mosquitoes around disposal sites. Moreover, air, water and soil around the disposal sites are susceptible to pollution. To overcome these difficulties and to maintain proper sanitary condition, a sanitary landfill disposal system may be recommended. The solid waste management system, including the selection of the landfill site will be decided by JMBA- Environmental Unit when the extent of the allowable settlement is confirmed (Ahmed et al, 1995). To encourage recycling of solid waste scavenging should be controlled, but not prohibited, at the landfill site. Similarly, the dweller may be encouraged to keep rubbish and garbage separately, which will also reduce the amount of materials to be transported to the landfill site eventually reducing the cost. However, the sanitary landfill site should be carefully selected to minimize potential ground and surface water pollution.

Insect Control

Insect control, specially the control of flies and mosquitoes, is essential. To control flies and mosquitoes attention should be given to the following issues:

- the dwellers must keep house surroundings clean.
- the drains carrying sullage to septic tank should be covered.
- there should be no stagnant water in the drainage system.
- solid wastes should be collected by covered trucks.
- solid wastes should be disposed of through proper sanitary landfill method.
- Mosquito killing insecticides should be sprayed around the locality by the appropriate authority at regular interval.

Miscellaneous Hazards

Because of the construction of the bridge and the approach roads a large number of inhabitant, living in the bridge-ends and settlement

areas will be exposed to the noise created by buses, cars, trucks and construction operations. The day-night average noise levels is likely to exceed the international standard level of 50 dB(A) for outdoor sound levels in residential areas. However, the acceptable level of noise in Bangladesh is 55 dB (A) for residential areas having few commercial and industrial installations, 65 dB(A) for commercial areas (DOE, 1991).

About 1% of the total freight transported over the bridge will consist of petrol, oil, lubricants and hazardous materials. Accidents of trucks transporting hazardous materials, such as, gasoline, oil and chemical, over the bridge and across the bridge-end sites can cause severe environmental pollution. As there is lack of statistical data about accidents, in Bangladesh, it is not possible to calculate the chance of such accidents on the bridge-end sites.

Surface water along the approach roads or close to the bridge may be contaminated by polluted runoff from the road surface. The runoff of heavy metals is likely to be about 0.03 kg /km. day at both sides of the road. Vehicle exhausts usually contain high level of lead that dissipates into atmosphere and is eventually deposited on the road surface, plants, crops and the surrounding lands. Surface runoff will transport the heavy metal into the open waterway. In addition, cadmium from vehicle tires may also be deposited on the road surfaces. According to Jones *et al* (1981), the allowable cadmium concentration for crop cultivation is *3.5* mg/kg of sediment. Thus, contamination of the area around the JMBP through heavy metals is a distinct possibility.

Following the completion of the Jamuna Multipurpose Bridge settlements, both industrial and urban, near the bridge-end facilities and along the approach roads is expected. Under the existing system the industrial developments will be outside any effective regulatory control. There will also be squatter on the surplus acquired lands that have no specific use once the construction is over. It is, therefore, recommended that regulatory measures be taken to prevent uncontrolled landuse at the bridge end facilities and the lands along the approach roads.

Although during the construction phase the administrative services are being carried out by the JMBA, different alternatives of institutional arrangements may be installed for operating the bridge and bridge-end sites after the construction of the bridge. The alternatives are illustrated below:

i) JMBA may continue the administrative services, or

ii) Towns at bridge-ends or east-end township may be upgraded to municipality. The JMBA will ultimately transfer the administration of services within the bridge end settlement sites to the municipality authorities. It will work closely through a transition period with the relevant authorities to ensure that there is no significant deterioration in environmental standards at these sites,

iii) The JMBA will ultimately transfer the administration of services within the resettlement sites to the District Authorities. It will work closely through a transition period as mentioned in alternative (ii).

ENVIRONMENTAL PLANNING OF RESETTLEMENT SITE

A resettlement site, about 3 km north of the east bridge-end, has been completed to accommodate 20% of the 2,166 households displaced from their homestead. The resettlement site has a provision for expansion depending on the demand of PAPs for such accommodation. The plan shows that the resettlement site will be developed in urban density in a rural setting. In the absence of adequate environmental consideration, it will turn into an urban slum having an environmental quality inferior to that they enjoyed in their previous homestead. Water supply, sanitation and drainage in resettlement site need special consideration.

Considering the social setting, affordability, technical feasibility and health benefit, the on-site sanitation system is an acceptable option for such a settlement. Water sealed direct pit or water sealed twin pit latrines for each household may be recommended. These systems have been found acceptable in the rural and semi-urban areas in Bangladesh. The households preferring to settle elsewhere in clusters should also be brought under proper water supply and sanitation.

ENVIRONMENTAL HEALTH EDUCATION

Provisions for water supply and environmental sanitation facilities do not ensure better environment and health benefits. Knowledge, attitude and practice play most important roles in maintaining a high level of environmental quality. Hygiene education campaign is needed to communicate appropriate environmental health information to all concerned. The health education campaign include:

- Common water borne, water related and vector borne diseases.
- Modes of communication of diseases.
- Effective intervention of communicable diseases.
- Health benefits related to safe water supply and sanitation.
- Promotion of use of safe water for all purposes.
- Hygienic use and maintenance of latrines.
- Community participation in maintenance of water supply system.
- Promotion of personal hygienic practices.
- Motivation of women in food and family hygienic practices.
- Food sanitation practices.
- Industrial hygienic education.
- Environmental sanitation and aesthetics.

The target groups for environmental health education campaign are as follows:

- PAPs to be accommodated at resettlement site
- PAPs to be settled at cluster homesteads
- Food item vendors at bridge-ends
- Commercial and industrial workers at bridge-ends
- Construction workers

The health information packages have been designed for each target groups with some modifications and are being delivered in the most effective method. The total cost of environmental health education campaign has been estimated to be US $ 35,000. The first phase of six month long health education campaign has been completed in 1995. The second phase of the campaign is nine months long and is being conducted since the mid- 1996.

DISCUSSIONS

The Jamuna Multipurpose Bridge Project with a total estimated cost of US $ 900 million is the largest development project in the history of Bangladesh. a number of people have already been affected by the acquisition of land on both sides of the proposed bridge. These Project Affected Persons have been rehabilitated in an orderly and planned manner. This process not only requires tedious management practices it also requires an environmentally sound approach. The bridge ends will be used to house peoples required for operation and maintenance of the bridge. In addition, the bridge ends will also have facilities for passenger aid, bus terminals, rail station, etc. Thus, development of the bridge ends is essential along with the development of the resettlement sites. Salient features in the development of these sites have been addressed in this paper. Since, it is expected that a small to moderate size township will develop on each bridge ends and the resettlement site a health education campaign has been conducted to educate people on issues related to healthy and sanitary living habits.

REFERENCES

Ahmed, M.F., Badruzzaman, A.B.M., Hussain, M.Z., Rahman, M.H., and Hossain, M.D. (1995), Environmental Management Action Plan, ISBN 984-30-0151-6.

Badruzzaman, A.B.M., Jalil, M.A., and Ali, M.A. (1996) , 1st Annual Report on Water Quality Monitoring of the JMBP, Environmental Engineering Division, Dept. of Civil Engg., BUET, Dhaka, Bangladesh.

BUET and BIDS (1993), Development of New Design of Cyclone Shelters and Killas, Multipurpose Cyclone Shelter Program..

DOE, Envirionmental Quality Standards (1991), GOB.

GHK/MRM International Ltd. (1992), Land Use Master Plan.

JMBA - RU (1993), Revised Resettlement Action Plan.

Jones, A.K., Johnson, M.S. and Bell, R.M. (1981), The Movement of Metals in Reclaimed Metal Contaminated Land, International Conference Heavy Metals in the Environment, Amsterdam.

Momtaz, R. (1993), Development of Short Duration Rainfall Equation for Design of Urban Drainage System in Bangladesh, M. Sc. Thesis, Dept. of Civil Engg., BUET, Dhaka, Bangladesh.

RPT-NEDECO-BCL (1989), Feasibility Report of the JMBP, Phase-II Study, Vol. - VIII, Annex-M: Environmental Impact Assessment.

Steel E.W. and McGhee, T.J. (1984), Water Supply and Sewerage, McGraw-Hill International Book Company.