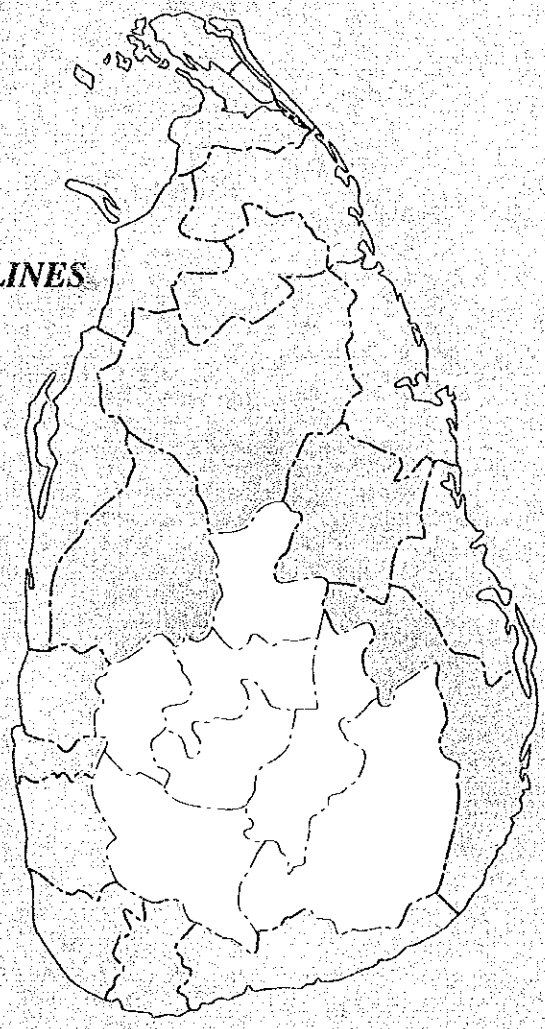
MASTER PLAN STUDY ON THE AGRICULTURAL AND RURAL DEVELOPMENT FOR UP-COUNTRY PEASANTRY REHABILITATION PROGRAMME

VOLUME IV

ANNEX 3.

PLANNING AND DESIGN GUIDELINES



AUGUST, 1994

MINISTRY OF UP-COUNTRY
PEASANTRY REHABILITATION
DEMOCRATIC SOCIALIST
REPUBLIC OF SRI LANKA

JAPAN INTERNATIONAL
COOPERATION AGENCY

MASTER PLAN STUDY ON THE AGRICULTURAL AND RURAL DEVELOPMENT FOR UP-COUNTRY PEASANTRY REHABILITATION PROGRAMME

VOLUME IV

ANNEX 3.

PLANNING AND DESIGN GUIDELINES

AUGUST, 1994

NIPPON KOEI CO., LTD.

CHUO KAIHATSU CORPORATION

ANNEX III PLANNING AND DESIGN GUIDELINES

-GENERAL-

1. Outlines

The Guidelines for planning and design involve the following fields:

A) Agricultural Supporting Services
B) Irrigation
C) Rural Road
D) Rural Water Supply
E) Farm Land Conservation

In the above fields, B) ~ E) shall be the technical planning and design, and A) shall be mainly composed the recommendation to the Government of Sri Lanka (Central Ministries and Agencies, and Local Authorities).

The objectives and contents, and users (groups) of the Guide Lines are noted follows:

2. Objective and Contents of the Guidelines

The applicable objects of the present plan, (irrigation, rural roads, rural water-supply, etc.), have all been subject to large delays because the objects are extremely small, numerous and scattered over a wide area. Feasibility studies are thus difficult.

It is hoped that the scheduled plans will reflect the needs of local inhabitants and be implemented through the necessary budgetary measures.

It is generally accepted that the projects should be implemented on the "bottom-up" basis. Accordingly, it is necessary for the "bottom" to plan and design the details of the projects. Screening of the effective projects is required from the "top".

The Government of Sri Lanka, presently strives to promote decentralization and to encourage talent in the Local Authorities. The technical level of the local authorities, however, is still far below that of the Central Ministries and Agencies. Accordingly, the Guide Lines prepared shall be most useful for the technical and administrative staff to plan and materialize the projects with sufficient quality to satisfy screening by the specialists of the central ministries and agencies.

3. Users (Groups) of the Guide Lines

The applicable projects of the present plan, as noted, are small and numerous. Delays are inevitable when projects are managed only by the administering central ministries and agencies.

In view of this, the engineering or administrative staff at the local authority (Provincial and District offices, Pradeshiya Sabha, etc.) level shall be regarded as the

primary group for using the guidelines. Further, the Guide Lines shall be prepared in a way that it is suitable for use by the representative of farmers' organizations, local communities, etc.

4. Use of Guidelines

In line with the objectives outlined above, it is necessary to work out detailed plans and engineering designs according to the Guidelines once the budgetary measures have been taken.

PLANNING AND DESIGN GUIDELINE FOR AGRICULTURAL SUPPORTING SERVICES

PLANNING AND DESIGN GUIDELINE FOR AGRICULTURAL SUPPORTING SERVICES

Table of Contents

List of Tables

List of Reference

1. Crop Recommendations for Adoption in Grama Niladari Divisions of Sri Lanka, Department of Agriculture, Peradeniya, Sri Lanka

2. Crop Recommendations Technoguide, Department of Agriculture, Sri Lanka

PLANNING AND DESIGN GUIDELINE FOR AGRICULTURAL SUPPORTING SERVICES

1. Introduction

The basbic approach to agricultural development in the Study area is essentially centered on increasing the productivity of the existing agricultural lands. It would involve the provision of necessary agricultural infrastucture as well as support services. The guidelines for improvement of related infrastucture facilities, such as irrigation and road networks, land conservation facilities, etc., are discussed elsewhere in this Report. Areas for improvement by the provision of agricultural support services, based on studies of the present conditions, are examined here. Since agricultural production in the Study area is an on-going programme and the considerations for development are based on support services, it would appear more appropriate to present a set of recommendations rather than development guidelines. Further, an assessment on agricultual and food situation in Sri Lanka and establishment of development priorities was carried out by the Ministry of Finance and Planning under the National Agriculture, Food and, Nutrition Strategy, and published in 1984. A medium-term investment and reforms that are required to accelerate the growth of the agricultural sector are being formulated by the Government through the Agricultural Growth and Restructuring Strategy (AgGro Strategy) which is under preparation.

2. Agricultural Research

The Council for Agricultural Research Policy (CARP) has used the following criteria based on capacity to contribute to the national goals and agricultural objectives in establishing its priorities for agricultural commodities:

Objective	Percetage Weighting
Income and employment generation	30
Generation of foreign currency	24
Increase in economic efficiency	18
Satisfaction of future domestic demand	18
Raising of nutrition level	10

The priority crops for commodity research established by CARP consists of 41 crops ranked into three priority groups. These are listed in Table A.1.

Commodity prioritization will impose some restrictions on the work programmes of various research organizations. For instance, DOA is presently working on over 70 crops, the majority of which are not listed in the priority list. In establishing the research priorities, it is vital that the regional importance of the crops is given due consideration. Research efforts on a priority commodity from a national

viewpoint may not justify the costs from a regional perspective. There is also the reality that the priority in terms of economic importance of commodities may change in the short term. A general guideline based on the agro-ecological zones, given in Table A.2, shows the regional relevence of crops.

Presently cultivated vegetables in the Study area are limited in range, both in relation to type and variety. Comprehensive packages of cultivation practices have been developed by DOA for the recommended crop varieties and seeds were allowed tobe importated by the private sector. The recent relaxation of conditions for the import of seeds and planting material will make available a new range of vagetables and fruit crops for local and possibly export markets. However, these crops will lack production technology support. Therefore, measures for rapid testing and demonstrating the benefits to the farmers should be undertaken by the researchers.

The development of farm level storage and post harvest technologies for agricultural produce are other areas that need urgent attention.

The adaptive research programme of DOA should be strengthened and supported to develop area specific recommendations for increasing cropping intensities and improving farming practices. Viable and sustainable production systems packages, particularly for the dry zone areas of the Study area, are an urgent need.

3. Agriculrural Extension

The complete devolution of agricultural extension to the Provincial Councils in 1989, and decentralization of administration to the Divisional Secretariats in 1992, had adverse effects on the operation of the extension system that was hitherto administered by DOA of MADR.

(1) About 2000 village level extension officers (KVSNs) of DOA were absorbed into the Ministry of Public Administration and Provincial Councils (MPA&PC) as multipurpose village level officers (GNs) for the implementation of the Janasaviya Programme. This created a vacuum at the grass root level as the time allocated to agricultural extension by the GNs became highly restricted. Recruitment of GNs outside the KVSN cardre further aggrevated the situation as they lacked even the basic training in agricultural extension.

(2) Agricultural Instructors (AIs) working at the Agrarian Services Centers (ASCs) were brought under the direct administrative control of the Divisional Secretaries who maintained a direct link with MPA&PC. This arrangement severed the line of command from the Provincial Director of Agriculture (PDA) to the AI at the Divisional Secretariats.

(3) The work of the district level administration under the government agents has been restricted to administration of activities that come under the purview of Central Government. Thus, the district level Deputy Directors of Agriculture

(DDAs), the segment level Assistant Directors of Agriculture (ADAs), and Subject Matter Officers (SMOs) who were the district based extension officers, became redundant. The arrangement also created a wide gap between the provincial set up and the divisional set up.

The following structural changes to the administration of agricultural extension are recommended to rectify the present deficiencies:

(1) Strenghtening of village level extension services by recruiting trained agricultural extension workers. In view of the changing perspective on agricultural extension which is based on the farming systems approach rather than on the rice based simple extension messages, it is recommended that the KVSN level is replaced by the AI level. The placement of proposed AIs should not be based on the number of farm families served as was done in the past, but on the productivity of the area.

(2) Reestablishment of the direct functional and administrative line of command from PDA at the provincial level to AIs at the divisional and village levels

(3) Reestablishment of the district sublevel DDAs and segment level ADAs and SMOs under PDAs.

(4) Maintenance of the uniformity of the institutional structure in the different provinces.

The Second Agricultural Extension Project (SAEP), presently being implemented by DOA under IDA funding has the following project components: (a) strengthening agricultural extension through the close integration of services, use of mass media, improved plant protection and pesticide control, provision of training. and a pilot project to promote private sector participation in extension; (b) development of a national seed policy; and (c) establishment of a project management unit. Provision has been made under this project to construct an In-Service Training Center (ISTC) in Sabaragamuwa Province and equip and upgrade ISTCs and District Agricultural Training Centers (DATCs). It is envisaged that SAEP will be implemented as planned.

4. Agricultural Credit

Although there are many institutional credit sources operating in the area, the number and amount of loans disbursed for agricultural purposes have not shown a significant improvement over the years. Many factors have contributed to the poor utilization of institutional credit by the farmers. Time consuming and often difficult procedures requiring guarantors to obtain institutional credit have discouraged the farmers from availing themselves of the service. An added factor is the hidden costs involved in repeated visits to the banks during peak production periods to obtain the loans, which are disbursed in several instalments. Default, due to crop failure, is another reason why many small farmers might lose their creditworthiness preventing

them from obtaining new loans. The rescheduling of outstanding loans, granting of loans in one payment, group loan schemes under increased supervision, etc., have been tried out from time to time by the banks with varying degrees of success.

In general, the credit schemes are drawn up at the national level for implementation at the farm level. The procedures laid down for loan administration are rigid with very little flexibility at the regional level. When the farm holdings are small and located in dry remote areas where rainfall or irrigation water is uncertain, institutional credit becomes particularly difficult to obtain. The recent decline observed in the use of agricultural inputs, particularly quality seed material and fertilizers can in part be attributed to price increases and the nonavailability of cultivation credit. The available credit schemes neither provide for the consumption requirements of the farm family during the crop growth period nor for post harvest operations, such as transportation, processing, or marketing.

Farmers' organizations that are established under the Agrarian Services Act present lawful bodies for lending transactions. They have the mandate for loan administration on behalf of the member farmers. It is recommended that a programme should be drawn up to grant agricultural loans to the farmers' organizations rather than to individual farmers. Such a programme should take into account the regional needs based on the cropping patterns, farming practices, input requirements, postharvest activities and marketing arrangements. The placement of supervisory staff to work in close coordination with the extension agents and farmers' groups would greately facilitate the credit disbursement and recovery.

Along with formal credit arrangements for agricultural activities, an important component in banking is rural savings. The promotion of the saving habit among rural people is important especially in view of the uncertainty and risk involved in agriculture.

5. Input Supply

The role of the Department of Agrarian Services in the supply of inputs, such as planting materials, fertilizers, and agrochemicals has tended to decline over the years. The trend has been in line with the current policy of the Government to promote the participation of the private sector in agribusiness. Direct and indirect subsidies given to DOA, the sole producer of seeds and planting materials, have been cut drastically inorder to create fair market conditions for private sector investments in commercial seed production. It has been observed that there is a shortage of paddy seed and low-country vegetables and grain legumes seeds. This is evident from the high usage of farmers own seeds as planting material, and could well be a contributing factor toward the levelling off of the paddy yields seen in recent years. It is, therefore, recommended that the production levels of certified seeds of the Seeds and Planting Material Division of DOA are maintained until the private sector is in a position to supply the required levels.

The relaxation of some of the import restrictions on seeds, particularly those on up-country vegetables, has resulted in a wider variety of crops being available to the growers. Vegetable seed importation and distribution is entirely handled by the private sector and no shortages were observed in the field. The use of fertilizer which dropped by 18% in 1990, following the removal of the government subsidy, picked up only marginally at an annual average of about 2%. The effect was most marked in the case of paddy. The minor food crop sector, on the contrary, showed an appreciable increase in the use of fertilizer up to 1991, but the figure declined in 1992. The reduction in the use of fertilizers with paddy could be another factor that contributed to the stagnation of paddy yields.

Although the agricultural inputs delivery system of the private sector in general appears satisfactory, there are the locations in the Study area that are not adequately served due to their remoteness and the difficulty of access. The basic functions of the extension service in the past have been confined to the dissemination of technical knowhow and establishment of a feedback mechanism on problems of adoption. No significant effort was made to ensure the availability of inputs. To adopt the technologies diffused, it is essential that the inputs delivery system functions efficiently. The scope of the field level agricultural extension agent should, therefore, include coordination on the input supplies, with relevent public and private sector organizations.

6. Agricultural Marketing

Agricultural marketing in the Study area is a complex process that has evolved through the involvement of private individuals over the years. The institutional marketing channels are restricted to the purchase of paddy, big onion, chilli, and selected pulses and operated by the Paddy Marketing Board, Cooperative Wholesale Establishment, Multi-Purpose Cooperative Societies, and Marketing Federation. Private traders, wholesalers, and commission agents operate the flows of horticultural crops and export agricultural crops while competing with the institutional sector for other crops with little Government intervention. The flows are often long with many operators involved.

Seasonal over production resulting in market gluts and low prices are particularly evident in the case of perishable commodities, such as vegetables, potato, fruits, and onions. The lack of proper storage facilities at the farm or community level has compelled the farmers to dispose of their produce immediately after harvesting. The construction of produce storage facilities in the immediate vicinity of ASCs is proposed in order to overcome the present deficiency. The facilities will be the property of the relevent ASC and will be leased to the ASC level farmers' organization for a nominal fee to be used and managed as a community storehouse. In the drier areas of the Study area where onion, chilli, and grain legumes, with relatively longer shelflives, are the predominant crops, the store house will be used for seasonal storage and the planned release of commodities to take advantage of the best price. Similarly, in the central vegetable and potato growing areas in the up-country the storehouses will

accomodate the seasonal storage of potato. In the case of vegetables, the storehouses will serve as holding places for collective transportation to the pola or collection centers under out-grower systems.

In the current market operation in the Study area, the pola plays a prominant role in the marketing flows. Its relative importance, however, varies from location to location. In general, the vegetable farmers in the up-country area operate the pola based on long standing exchange relationships with the collectors or commission agents. A relatively small proportion of the total produce reaches the pola. In other major producing areas, especially in the dry zone, the pola is the major market outlet for agricultural produce. It was observed that most of the polas in the Study area were constructed decades ago and are in a delapidated condition. The volume of commodities and population served have increased considerably over the years resulting in severe conjestion in a confined area. They often lack such basic facilities as shelter, water and electricity supply, toilets, parking areas, etc. For this reason, the establishment of new pola complexes in the mid- and low-country areas and improvements to existing polas in the up-country areas have been considered. The present pola system administration under the ownership of the Provincial Government in which operation's awarded by annual tender to private individuals appears to function satisfactorily. However, it is essential that at least 20% of the annual lease rent be reserved for maintenance of buildings and services.

Farmers are handicapped due to the non availability of market information and intelligence for production planning and possible exploitation by the traders. The choice of crops is usually based on the price structure that prevailed in the previous season and the practice often leads to over production of that commodity in the current season. Since the products are channelled to the commission agents in Colombo for sale at the terminal market through traders or transport agents the farmers are compelled to accept the stated prices. Therefore, establishment of an effective marketing information system, is strongly required in the area. The extensive use of mass media proposed under SAEP combined with the relinked line of command in the administration of agricultural extension services and ASC at the farmer level would form the elements of the market information system.

Although techniques, such as staggered planting, the use of different age classes, planned demand based production, and storage can help, to some extent. to overcome the problem of over production and the associated price reduction, such situations cannot be completely avoided. In order to protect the vegetable farmers from complete collapse under these conditions it is desirable to establish a Vegetable Production and Distribution Development Fund. The main functions of the fund would be to:

a) Coordinate production and distribution of vegetables,
b) Compensate the losses suffered by farmers due to the sharp decline in product prices,

c) Provide credit for the farmers enabling them to carry on with their farm production activities.

The small producer-large investor concept promoted by the Goverment and the incentive packages offered by the Board of Investment of Sri Lanka for nontraditional export development are expected to attract private sector investments, particularly for fruit and vegetable marketing. If the current trend in the export of horticultural crops is to continue, the present markets in the Middle East and Maldives should be expanded to more sophisticated markets in the developed countries. The practice of procuring supplies from the Colombo terminal market for export must be replaced by organized systems linking the small-scale producers with the investors. It is envisaged that cold chain facilities for cold storage and transportation will be established for horticultural crops in the Study area during the project period. These conditions would make it necessary to establish strong out-grower systems for produce supply, ideally with the direct involvement of the farmers' organizations.

7. Post Harvest Technology

Thepost harvest technology of agricultural commodities is essentially linked to marketing. It involves on-farm or primary processing and off-farm or secondary processing. The main objective of applying post harvest technology is to prepare a high quality product that is acceptable to the consumer and/or industrial markets. The product quality is dependent upon the cultivar, geographical origin, maturity, processing technique, and conditions of storage, and is described based on its physical, chemical, or organoleptic properties.

Little attention has been paid to the development of this aspect of the production process either by the Goverment or the private sector. Some basic guidelines on primary processing have been developed by DOA and DEA, but are rarely adopted or have not reached the farmers for a variety of reasons. The stages of primary processing can be generalized as: gathering and bulking the harvest, drying, storage, and disposal.

In the case of horticultural produce, the post harvest handling procedure is similar in all producing areas, and is unsatisfactory for preserving the freshness of the products. The vegetables are generally packed into gunnies weighing approximately 50 kg each and carried to the roadside for motorized transportation to either collecting center or wholesale markets. In the export agricultural crop sector, the poor attention paid to the processing of cocoa, coffee, cardamom and pepper by the farmers as well as a few small scale processors has resulted in low value inferior grades of products being manufactured for the export market.

The export market for fresh and processed vegetables and fruits has expanded rapidly in the past few years. If this trend is to continue, the presently served markets of the Maldives and Middle East will have to be extended to more demanding markets in Europe, Singapore, etc. It is therefore necessary in the short medium-term, to focus

attention on educating the producers and exporters in the realities of the stringent quality standards and specifications required. Processing for the end use market, both local and foreign, with the objective of adding value to agricultural produce is an area that should be covered under post harvest technology.

The absence of an institutional facility in Sri Lanka for developing and/or introducing and testing post harvest technologies is strongly felt in view of the government initiatve to accelerate development and modernize agriculture. It is, therefore, recommended that an Institute of Post Harvest Technology (IPHT) is established by the Government to facilitate national development. The Institute should be centrally located to serve the needs in the main vegetable, fruit, and export agricultural crop production areas of Kandy, Nuwara Eliya and Badulla districts of the Study area.

TABLES

Table A.1 LIST OF PRIORITIZED COMMODITIES BY THE SRI LANKA COUNCIL FOR AGRICULTURAL RESEARCH POLICY (CARP)

Priority Group I	Priority Group II	Priority Group III
Banana	Blackgram	Bean
Coconut	Cashew	Cardamom
Dairy Cattle	Chilli	Citrus
Fish	Cinnamon	Clove
Forest Products	Cocoa	Groundnut
Pepper	Coffee	Kurakkan
Poultry	Gherkin	Onions
Rice	Gingelly	Papaw
Rubber	Grape (Table)	Pigeonpea
Sugar	Greengram	Soybean
Tea	Goat	Sweetpotato
	Maize	Tomato
	Mango	
	Manioc	
	Passionfruit	
	Pineapple	
	Potato	

Source: Sri Lanka Council for Agricultural Research Policy

Table A.2 GENERALIZED CROP RECOMMENDATIONS BASED ON AGRO-ECOLOGICAL REGIONS

District	Agro-Ecological Region	Maha				Yala				Tree Crops
		Upland		Lowland		Upland		Lowland		
		Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	
Nuwara-eliya Badulla Kandy	WU-1 WU-2 WU-3 IU-1 IU-2 IU-3	Capsicum Potato Raddish Beet Been Carrot C.Flower Leek Lettuce St.Berry Cabbage Knolkhol Turnip Braccoli Tomato Raddish	Potato Bean Carrot Raddish Potato St.Berry Beet Leek Lettuce Cabbage G.Peas	Rice Bean Cabbage Potato Beet Carrot Leek C.Flower Knolkhol Lettuce	Rice Bean Cabbage Potato Beet Carrot Leek C.Flower Knolkhol	Capsicum Bean Cabbage Raddish Braccoli Potato St.Berry Beet Carrot G.Peas Leek Lettuce Knolkhol Raddish Garlic	Carrot Potato Cabbage Beet Leek Raddish Capsicum St.Berry Bean Lettuce Knolkhol Raddish	Rice Bean Carrot Potato Beet Capsicum Cabbage Leek C.Flower Knolkhol Lettuce	Rice Tomato Been Beet Cabbage Knolkhol Raddish Leek Potato Capsicum C.Flower Lettuce	Avacado Banana Orange Clove Coffee Pepper Pear Apple Grapefruit Lime Peach Plum
Kandy Matale Ratnapura Badulla Moneragala	DL-1 IL-1 IL-2	Chilli Maize Soybean Brinjal Bean Cowpea Greengram Cucurbits Kurakkan P.Peas Tobacco Brinjal Cucurbits Mustard P.Pea	Chilli R.Onion	Greengra Cowpea Soybean Groundnut	Rice	Gingelly Greengra Groundnu P.Peas	Chilli Capsicum L.Onion R.Onion Brinjal Cucurbits Tomato	Rice Tobacco Cowpea Greegram	Rice Chilli Capsicum L.Onion R.Onion Bean Cowpea Cucurbits Greengram Soybean Tomato Soybean	Banana Lime Mango Papaya Cashew Woodapple Caster
Kandy Matale Nuwara-eliya Badulla Moneragala Ratnapura Kegalle	WM-1 WM-2 WM-3 IM-1 IM-2 IM-3	Bean Okra S.Potato Cucurbits Cassava G.Chilli Me Brinjal Cabbage Knolkhol Tobacco S.Onion Maize Cowpea Greengram	Chilli R.Onion Cowpea Soybean Tomato	Rice Cowpea Greengram Soybean	Rice	Ginger Turmeric S.Potato Kiriala Gingelly Cowpea Greengra R.Onion Bean Brinjal Cucurbits Cowpea	Chilli R .Onion B.Onion Brinjal Greengram Cucurbits S.Onion	Rice Gingelly	Rice Bean Okra Tomato Cucurbits Me Capsicum Brinjal Bushitao knolkhol Me Beet G.Chilli R.Onion B.Onion	Avacado Banana Durian Mango Mangosteen Rambutan Coffee Pepper Clove Nutmeg Sugarcane Passionfruit Papaya

Source: Crop recommendations for Grama Niladari Divisions (Condensed)

PLANNING AND DESIGN GUIDELINE FOR IRRIGATION

PLANNING AND DESIGN GUIDELINE FOR IRRIGATION

Contents

List of Tables

List of Figures

List of Reference

1. Design Guide Lines for Small Catchment Irrigation Scheme, Ponraja, Irrigation Department, Sri Lanka

2. Design Guide Lines for Irrigation Scheme, Ponraja, Irrigation Department, Sri Lanka

3. FAO Irrigation Paper No. 24, Crop Water Requirement, FAO

PLANNING AND DESIGN GUIDELINE FOR IRRIGATION

This guideline shows the planning and design of the rehabilitation of minor irrigation schemes by anicut in the up-country area, the since majority of the schemes that require rehabilitation are anicut schemes.

1. Planning Guideline for Rehabilitation

Rehabilitation planning shall make maximum use of the existing facilities considering the technical causes of under-performance and/or other constraints. Determination of the exiting facilities usage shall be carried out based on the present condition of the facilities and present requirements of the facilities. Procedures for the planning are: (1) data collection and field reconnaissance, (2) field survey, and (3) basic planning. As for hydrological analysis, it is recommended to refer to the "Design of Irrigation Headworks for Small Catchments" and "Technical Guidelines for Irrigation Works" published by the Irrigation Department.

1.1 Data Collection and Field Reconnaissance

1.1.1 Data Collection

For the planning of the rehabilitation, the following data will be required:

- rainfall and other meteorological data,
- hydrological data of the river,
- topographic map of the catchment,
- irrigation and drainage network data,
- irrigation and drainage flow diagram,
- longitudinal and cross sectional drawing of the river,
- design floodwater level and discharge of the intake facilities,
- design intake discharge (duty) and water level, and
- as-built drawing of the scheme.

1.1.2 Field Reconnaissance

Field reconnaissance on the river and facilities will be carried out based on the above basic data. The field reconnaissance items are as follows:

- catchment area conditions:
  vegetation, geology, slope failure, environment, etc.
- flow conditions:
  river channel, riverbed material, flood marks, sediment, etc.
- infrastructure conditions:
  confirmation of the location, structuring, function, quality, deterioration, etc.

1.2 Field Survey

After field reconnaissance, field survey on the: (1) performance of the facilities, (2) quality of the structure, (3) river discharge, (4) environment, (5) topography, (6) socio-economy, and (7) agriculture, shall be carried out.

(1) Facility performance

The hydraulic and structure performance of the facility shall be examined by comparing the present and designed performance as the well as technical causes of under-performance and/or other constraints.

(2) Quality of the structure

The quality of the structure including the cracks, foundation condition, leakage, damage, etc. shall be examined. Based on this examination, the possibility of reuse of the structures will be determined.

(3) River discharge

The hydrological analysis will determine the minimum Yala season flow and maximum flood runoff during the Maha season. If the discharge data are not available to determine these parameters, the monthly yield shall be determined by referring to the "Design of Irrigation Headworks for Small Catchments" and "Technical Guidelines for Irrigation Works" published by the Irrigation Department.

(4) Environment

The following environmental survey as a result of the rehabilitation works shall be carried out:

- catchment degradation (deforestation and cultivation),
- waterlogging in the irrigable area due to poor drainage conditions (flood backwater, silting, man-made obstructions along natural drains, and borrow pits),
- agro-chemical and industrial pollution and effects on domestic water supplies,
- health hazards due to polluted water and insects,
- silting of tanks, and
- seepage at tank bunds and waterlogging downstream of tank bunds.

(5) Topographic survey

The topography of the river basin, reservoir and its surrounding area, proposed tank/anicut site, and proposed and/or existing canal route shall be clarified through data collection and topographic surveys. The Irrigation Department set up the

specifications for surveys as the following schedules to be adopted for the survey investigations required for the works:

SS1 Specifications for survey of the Village Tank Bunds.
SS2 Specifications for survey of the Village Tank Bed.
SS3 Specifications for survey of the Major and Medium Reservoir Dam Axis.
SS4 Specifications for surveys of the Dam Site, and Sites of Closures/Breaches and Structures.
SS5 Specifications for close contour survey required for blocking out plans and the Major/Medium reservoir beds.
SS6 Specifications for strip survey of main and branch canals.
SS7 Specifications for strip survey of distributary and sub-distributary canals.
SS8 Specifications for strip survey of field and sub-field canals.
SS9 Specifications for surveys of the exiting canals and drainage for Rehabilitation/Modernization.

for the Anicut system

Survey specifications SS4 for headworks, SS5 for downstream development, the requirements in SS7 or SS8 for the supply canals branching off from the anicut, if the same area is required, and SS9 in the case of rehabilitation shall be adopted.

for the Tank system

Survey specifications SS1, SS2, and SS4 for breaches and spills, SS5 for downstream developments, and SS9 in the case of rehabilitation shall be adopted.

(6) Socioeconomy

The following items on socio-economy shall be investigated in beneficial area:

- Number of farmers:
  the number of farmers in the area shall be checked,
- Farm holding size:
  farm holding size by family shall be examined,
- Farmers' economy:
  the present farmers' economy shall be investigated. Revenue (farm income, off-farm income, and non-farm income) and expenses (living expenses by category, such as food, education, farming, etc.) shall be described,
- Water right:
  the existence of water right in the proposed river shall be confirmed if, any.

(7) Agriculture

The following agricultural aspects shall be examined in the Study area:

- cultivated crops by cropping season,
- cropping pattern including the cropping calendar,
- cultivation area by cropping season and crop,
- yield and production by crop and cropping season,
- agricultural supporting services including cooperatives, agricultural extension, agricultural credit, etc, and
- considering the above conditions, the constraints encountered shall be described. Water shortage, lack of available labor, insufficient input, lack of developed land, poor living standards, of farmers', etc. may be identified as constraints.

1.3 Basic Planning

The basic planning for the rehabilitation works comprises: (1) runoff analysis, (2) flood analysis, (3) determination of anicut size, (4) determination of tank storage capacity, (5) determination of water requirement, and (6) irrigation planning.

1.3.1 Run-off Analysis

The runoff analysis shall be conducted according to the following procedures:

- Selection of methods for the runoff analysis
- Analysis and verification of the results

(1) Selection of methods for the runoff analysis

Proper methods shall be selected based on the availability of data. The following methods are recommended:

a) Regression analysis
b) Drainage area proportion
c) Thomas and Fiering model
d) Tank model
e) Runoff coefficient

(2) Analysis and verification of the results

a) Computation

The inflow to the proposed tank or anicut site as the results of the analysis shall be computed for at least 10 years on a monthly or 10-day basis.

b) Checking of the results

The results of the analysis shall be verified at least on the annual runoff depth/coefficients which should be effected by the characteristics of the meteorological, hydrological, and watershed conditions of the Project.

1.3.2 Flood Analysis

The flood analysis for the inflow design flood for design of the spillway shall be conducted according to the following procedures:

- Computation of the inflow design flood
- Magnitude criteria of the flood and checking of the results

(1) Computation of the inflow design flood

a) Design storm

The incremental rainfall derived from the depth/intensity duration curve is rearranged to attain the most critical rainfall pattern or distribution. The initial and continuing losses are subtracted from the derivation of the design storm.

b) Unit hydrograph

A synthetic unit hydrograph shall be adopted. The Modified Snyder's method shall be adopted for the log time.

(2) Magnitude criteria of the flood and checking of the results

a) Magnitude criteria

The magnitude of the inflow design flood shall be at least 25 years flood.

b) Checking of the results

The results of the analysis should be checked and compared to the existing data of the inflow design floods of other projects.

1.3.3 Determination of the Water Requirement

In order to ensure the irrigation benefit of the tank or anicut construction, water balance study, and facility design of irrigation canals, the irrigation water requirement shall be estimated. The irrigation water requirement shall be estimated on a monthly basis. The standard calculation procedure of the irrigation water requirement for paddy, which is one of the main crops in the Study area, and standard value are explained as follows:

(1) Calculation formula:

$$IWR = (LP + ETp \times C + P - ER)/IE$$

Where

IWR	:	irrigation water requirement (mm).
LP	:	land preparation requirement including nursery water requirement (mm),
ETp	:	potential evapotranspiration (mm),
C	:	crop coefficient,
P	:	percolation (mm),
ER	:	effective rainfall (mm).
IE	:	irrigation efficiency (mm).

(2) Calculation basis:

- monthly basis or 10 day basis

(3) Land preparation requirement:

- RBE soils	400 mm
- LHG soils	200 mm

(4) Potential evapotranspiration:

- refer to attached Table B.2.

(5) Crop coefficient:

- initial stage	1.00
- development stage	1.15
- mid stage	1.20
- late stage	0.90

(6) Percolation:

- 40 % of the crop water requirement or 4 mm/day for RBE soils and 2 mm/day for LHG soils

(7) Effective rainfall:

- on a monthly basis mm/month	(rainfall - 25) x 0.67
- on a daily basis	Re= (daily rainfall - 5 mm) Re max. is 25 mm/day

(8) Irrigation efficiency:

Conveyance Efficiency (Ec)	
- earth canals:	0.80
- concrete lined canals:	0.95
Field Efficiency (Ea):	0.60
Overall Efficiency (Ec x Ea)	
- earth canals:	0.48
- concrete lined canals:	0.57

(9) Diversion Water Requirement

From the above (1) to (8) and cropping pattern, the diversion water requirement can be computed. Table B.3 shows the sample calculation results of the diversion water requirement by earth canal for the respective agro-ecological regions by applying the recommended cropping pattern for paddy. In the case of concrete lined canals, the diversion water requirement will decrease.

1.3.4 Irrigation Planning

Through the field reconaissance and field survey, it some differencies will be found in the runoff ratio, irrigation water requirement, water distribution, etc. from the original design due to the changing of the river conditions, irrigation command area, cropping paterns etc. A new irrigation diagram shall be completed which reviews the changed conditions.

1.3.5 Water Balance Study of the Anicut Scheme

In order to check the water availability in the command area, a water balance study based on the irrigation diagram shall be carried out.

The diversion capacity of an anicut and the extent of land that could be irrigated under the anicut scheme depend upon the available base flow of the stream across which the anicut is to be constructed and the elevation of the land that could be commanded downstream of the anicut with the minimum submergence of upstream developed agricultural land or flooding of upstream developments.

The operation study shall be carried out at monthly or 10-day intervals to confirm that the adoption of a diversion scheme is sufficient.

1.3.6 Determination of the Tank Storage Capacity

In order to determine the storage capacity of the reservoir, a monthly water balance study interval shall be conducted.

(1) Water balance equation

The water balance study can be completed by using the following water balance equation:

$$I - O = S_{t+1} - S_t$$

$$S_{min} \leqq S_{t+1}, S_t \leqq S_{max}$$

where

I : total inflow to the reservoir during a specific time period (MCM),

O : total outflow from the reservoir during the same specific time period (MCM), consisting of water release for all purposes, such as irrigation, existing water right, if any, river maintenance flow, and evaporation losses and surplus flow from of the reservoir,

St+1, St : storage at times (t+1) and (t) (MCM),

Smin : dead storage capacity (MCM),

Smmax : maximum storage capacity subject to the topographic, geological, and socio-economi conditions of the reservoir site (MCM).

(2) Input data

a) Reservoir inflow

This consists of the estimated runoff at the proposed tank site. The direct precipitation into the reservoir is considered to be a part of the inflow.

b) Evaporation loss

The evaporation from the reservoir surface can be assumed to be 60 % of the pan evaporation or calculated evaporation.

c) Reservoir demand

This consists of irrigation, water supply, and power demand, if any.

d) Existing water right and river maintenance

The existing water right, if any, and river maintenance flow should be counted in the water balance calculation with the first priority being the water demands.

e) Storage-elevation-area relationship

A storage-elevation-capacity curve should be prepared.

f) Dead storage capacity

The dead storage capacity shall be determined in consideration of the sediment volume and inland fishery planning, if any.

(3) Criteria to be used in the reservoir operation

In order to select the optimum reservoir capacity, criteria have been established, which are based on experience and norms set forth for the effective utilization of the reservoir storage. In this Project, the following criteria shall be used:

a) The maximum shortage per year should be less than 50 % of the average annual irrigation demand. If irrigation demand is computed on a 10-day basis, the allowable consecutive periods of less than 50 % shortage shall be two decades for paddy and none for highland crops.
b) The maximum cumulative shortage for any successive 10 years should be less than the average annual irrigation demand.
c) No shortage of domestic water supply demand.
d) The carryover period should be less than 12 months.
e) The reliability of the reservoir should be over 75 % to 80 % for irrigation.

1.3.7 Justification of the Water Balance

If water defisit would be found trough the water balance checking, the following countermeasure could be considered;

(1) upgrading or improvement of the anicut or tank capacity,
(2) improvement of canal material from earth to concrete lining to decrease conveyance loss, and
(3) revision of the cropping pattern or cultivation crops.

2. Design Guideline

2.1 Anicut

2.1.1 Sluice Size and Sill Level

The sluice is designed as a submerged orifice for delivering the full discharge of the following formula:

$$Q = C_d \times A \times (2 \times g \times h)^{0.5}$$

where

Q : canal capacity,
C_d : coefficient of discharge,
A : area of sluiceopening ,
g : gravity acceleration, and
h : head loss across the sluice.

In a section of a suitable size for the sluice, the height of the opening should be not more than **d**, where **d** is the design full supply depth of the diversion canal. This is to ensure the submerged orifice flow assumed in the above equation. The width of the sluice under the full open condition will not exceed twice the velocity of flow in the diversion channel. The sluice will then require only nominal structural provision for energy dissipation.

2.1.2 Crest Elevation

In order to determine the crest elevation of the anicut, **d** and **h** are required. As seen in the above section, **h** could be given a constant value of 0.15 m. Hence, the minimum anicut crest elevation will be (d + 0.15) meters above the sill of the sluice. As the anicut crest should be as low as possible for optimum economy, no extra head is needed over this value. If any debris or other matter partially block the sluice, the canal flow will be reduced and spilling over the crest may commence or increase. On observing the reduced flow in the canal, the sluice should be inspected and obstructions cleared.

2.1.3 Width or Length

The width of the anicut is determined in relation to the cross section of the stream at the selected location for the anicut. If the banks are well defined, at approximately the same elevation, and not too for apart (such as in steep terrain) then the width of the anicut may be the distance between the banks.

The typical cross section of a stream in flat terrain consists of a well defined waterway which has a capacity of carrying floods for a low return period. When higher floods are experienced in the catchment, the banks overflow and the extent of land submerged by such overflow is normally designated as the flood plain. The floodplain in some cases can be quite wide. Also the crest level of the anicut as determined in subsection 2.1.2 may be above the defined banks. In such cases the anicut, if it abuts the high ground on either bank, will be very long and uneconomic. The economic and practical solution would be to restrict the anicut width and construct earthen flank bunds between the anicut and the high ground on either side. The design of flank bunds is described in subsection 2.1.6.

2.1.4 Flood Gates

Hitherto the practice has been to provide planked openings in the anicut to be manually removed on the occasion of a flood. In some cases screw operated gates have been used. For the sizes of the catchments considered, the time of concentration T_c, within which the critical flood peak occurs is found to be less than 5 hours for steep terrain. Further, the storm is found to continue even after the peak discharge has occurred. Under these circumstances, it is presumptous to assume that during a storm the person responsible for re-planking or operation of the gates could carry out the tasks before the flood reaches the peak.

An opening adjustment to the abutment and close to the sluice should be incorporated in the anicut for release of water downstream for any specified purpose, including manual desilting. The width of such opening may be up to 1.50 meter and the height may be up to the full height of the anicut.

2.1.5 Scour Gates

In many anicuts, scour gates have been provided to flush out the silt that would be deposited upstream of the anicut so that the entrance to the sluice will be clear of silt. This arrangement is rarely, if ever, found to be effective for the purpose intended. The area of influence of the scour gate is very small and the silt is removed only from the close vicinity of the gates. Scour gates may be necessary in anicuts constructed across the rivers or very large streams.

2.1.6 Flank Bunds

The anicut usually functions as a clear overfall spill and the critical afflux **H** is computed from the relationship:

$$Q = C \times L \times H^{1.5}$$

where

Q : the computed flood peak discharge,
C : the coefficient,
L : the width of the anicut.

The top level of the abutment and flank bunds is fixed at the high flood level, which is the anicut crest level plus the critical afflux. Freeboard is not considered necessary.

Overtopping of flank bunds of less than 1.5 meters (5 feet) in height due to flooding in excess of that of the design return period is permissible provided the downstream slopes are well turfed. The duration of the critical flood is short and hence only minimal damage will be caused to the flank bund by such overtopping and repairs can be economically and rapidly effected.

Flank bunds of up to 1.5 meters (5 feet) in height designed for overtopping as described above may be considered along with the anicut for determination of the maximum flood afflux. It is desirable to keep the design afflux over the bund at a low value, such as 0.3 meters (1 foot).

The overtopping area of the flonk bund may be considered as a broad-crested weir and the discharge over the flank bund is given as follows:

$$Q_b = C \times L_b \times H_b^{1.5}$$

where

Q_b : the ischarge over the flank bunds,
C_b : cthe oefficient,
L_b : the flank bund length,
H_b : the afflux.

It will be noted that the discharge from the critical storm will be made up of the sum of the discharges over the bund and the anicut.

2.1.7 Structural Design

The pressure exerted by the tailwater on the downstream side of the anicut enhances the stability of the anicut. In order to determine the downstream head to when critical outflow occurs it would be necessary to prepare a tail-water rating curve.

For the stability considerations of anicuts, it is safe to assume the downstream tailwater depth to be the same as the critical afflux H. This assumption is conservative because even when the tailwater width is more than that of the anicut, the variation of the tailwater depth from the afflux will be negligible. This will be so the tailwater velocity is much less than the velocity of discharge over the anicut. Thus, for the stability considerations, the downstream tailwater depth is assumed to be zero when the upstream water surface is at the crest level of the anicut, and the downstream depth is assumed to increase according to the afflux over the anicut with the depth being equal to the afflux.

Based on the above assumptions, stable sections of the anicut founded on completed rock foundation in the riverbed have been determined for different heights of the anicut. These sections can be obtained by using Figure B.1 for the top width of 0.3 meters (1 foot) and Figure B.2 for the top width of 0.6 meters (2 feet). The most economic section is when the upstream face is vertical. However, an upstream batter may be provided without seriously affecting the economy of the section. Such a batter reduces the chances of obstruction by floating logs, etc. The upstream edge may be rounded for improved hydraulic performance of the anicut as well as to assist floating logs in rolling over. When the height of the anicut above the foundation and design afflux are known, either of the above Figures B.1 or B.2 could be used to determine the downstream slope. The parameters may be used for quick selection of stable economic sections.

2.1.8 Flank Bund Sections

The cross sections given below may be used for the flank bunds using selected fill material. The downstream slopes should be well turfed and the bund top graveled or turfed. The top width of the bunds should be between 1.2 meters (4 feet) and 1.8 meters (6 feet).

Max Height of Bund	Designed for Overtopping up to 0.3 meters	Side Slopes	
		U/Stream	D/Stream
1.50 meters	No.	1 on 1.5	1 on 2.0
1.50 meters	Yes	1 on 2.0	1 on 2.5
2.10 meters	No.	1 on 1.8	1 on 2.0
3.00 meters	No.	1 on 2.0	1 on 2.5

2.1.9 Abutments

Where the anicut crest abuts the well defined stream banks and no flank bunds are necessary the abutments can be of a basic construction consisting of rubble pitching matched to the profile of the bank and cut to a stable slope, where necessary. If the stability of such an abutment length is in doubt, a box return type of abutment could be adopted, with a sufficient length of return wall for the protection of the bank slope.

Where it is necessary for a flank bund to extend from the anicut, generally a splayed type abutment with the top of the splayed wingwalls matched to the bund slope is found to be suitable economically, hydraulically, and aesthetically. However, depending upon the site conditions and topography, variation of the above generalization may be necessary.

Stability analysis is not considered necessary for the abutment sections and the adoption of a base width of about 0.4 times the height of the abutment or wingwalls would result in safe and economic design. The earth side of the abutment or wall can be of stepped construction or sloped construction.

2.1.10 Location, Type, and Operation of the Sluice

The sluice is normally located in the flank bund. It may also be located in the high ground with or without an inlet channel. The actual location depends on the site topography and other factors and the decision should be tempered with sound judgment and experience. The convenience of operation of the gates, especially for easy closure during floods, also contributes to the decision making.

The head of water at the sluice is generally small so that screw operated wooden sluice gates are normally sufficient. Steel lining is to be provided at least for the downstream faces of the concrete grooves. The use of steel or cast iron gates should be decided on using discretion and taking cost into account.

The sluice should be preferably operated at or near maximum opening. Partially open conditions may produce high velocities just downstream of the sluice which should be avoided as only nominal energy dissipation features are provided for the outlet from the sluice.

2.1.11 Automatic Collapsible Gates

In order to economize in the construction of anicut and to ensure minimum disturbance of the historic flood elevations at site of construction of anicut, it is desirable that maximum waterway with the sill near the bed level be provided during floods. This condition can be closely achieved by incorporating automatic collapsible gates in the structure so that when the spilling reaches pre-determined levels the gates can open (fall downwards by gravity) progressively one by one to obtain the required opening. Operators are not required so that the short flood warning is immaterial. After the flood is over the gate are re-set manually.

2.2 Tank

2.2.1 Determination of the Full Supply Level

From the parameters detailed in subsection 1.3.6, an Operation Study is carried out to determine the optimum capacity of the reservoir and irrigable area under the reservoir.

From detailid site and other investigations, if variations from the above optimum values are necessary, the final design capacity and design irrigable area are modified as required.

2.2.2 Design Flood of Reservoirs

For the design of reservoirs, the following return periods are recommended:

- For bunds of height up to 30 feet (9.0 m)	50 years
- For bunds of height above 30 feet (9.0m)	100 years

2.2.3 Limit on the Duration of Spilling

To allow for the possibility of another storm occurring before the spilling is over, the spill size is selected to keep the duration of spilling to less than 3 days (72 hours), this being a reasonable period before another storm of a similar magnitude might occur. When the detention volume is high the critical outflow is low and the duration of the critical storm becomes long. Consequently, the duration of spilling becomes much longer. If the duration of spilling exceeds 3 days, the detention volume is reduced in order to limit the duration of spilling to about 3 days (note : the design afflux will also be reduced). Thereafter, the corresponding critical storm and duration are determined. From these values the critical outflow is calculated and a suitable spill

size computed. The spill size so computed is the smallest permissible when the limit on the duration of spilling governs.

Under the conditions described above, the design afflux may become so low that the spillway width will be excessively high. In such an event, it is recommended to assume that another flood of the same intensity will occur simultaneously by considering twice the value of X in the formula $I=XD^{-Y}$, and limiting the duration of spilling to about 5 days (120 hours). If this gives a smaller acceptable spill, then this value may be adopted. For the safety check against the overtopping (ie. HFL=BTL) condition, the same criteria as for the design detailed above are imposed on the duration of spilling.

2.2.4 Determination of Spill Type

The spill type to be adopted is determined mostly from the prevailing conditions at the site with respect to topography, geology, etc. The spills within the scope of this guideline are generally ungated spills of the following types:

a) Natural spill,
b) Clear overfall spill, and
c) Morning glory spill.

Due to the very short time of concentration of small catchments, there is hardly any flood warning period for the timely operation of gates and hence the use of gated spillways is not recommended for works within the scope of this booklet. However, where upstream submergence of developed lands cannot be avoided without the provision of gates, it is recommended that automatically operating gates be used. The design details of such gates for local fabrication are in hand and until a prototype is tried out and proven to be effective and reliable, it is recommended that the designs be restricted to ungated spillways.

2.2.5 Determination of Spill Size

(1) Natural Spill.

The width of the natural spill is determined from the formula for broad-crested weirs :

$$Q = 2.8 \times L \times H^{1.5}$$

where
Q : the oritical outflow,
L : length of spill,
H : design afflux.

Theoretically a coefficient of 3.09 can be used. However, experimental results on broad-crested weirs show the coefficient to be closer to 2.8. The tailchannel is

designed for a depth of flow of two-thirds of the design afflux and generally the bedwidth is the same as the width of the spill. The Manning's equation is used to design the tailchannel. The equation is:

$$Q = \{ A \times 1.49 \times R^{0.667} \times S^{0.5} \}/n$$

where

Q : critical outflow,
A : water flow area,
R : hydraulic mean depth,
S : gradient of the channel, and
n : Manning's rugosity coefficient.

It is recommended that a value of 0.04 be used for 'n' to allow for average maintenence conditions. The only unknown in the equation is 'S' which can be calculated. This determines the minimum gradient of the spilltail channel. If a flatter gradient is adopted, the afflux will increase. The velocity of flow should be determined by: V= Q/A and confirmed below 10 feet /sec.

If the velocity exceeds 10 feet /sec., the spill may be redesigned maintaining the same afflux. The width may be increased and the gradient flattened to obtain a depth of flow in the channel between 2/3 and the full afflux. Under these circumstances, submerged conditions will prevail and the above equation will no longer be applicable.

The formula to be used to determine the spill width for submerged conditions is:

$$Q = 2.8 \times L \times (H + D/2) \times (H - D)0.5$$

where

Q : critical outflow,
L : length of the spill,
D : depth of the tail channel measured above the crest of the spill,
H : afflux.

(2) Clear Overfall Spill

This spill is designed using the formula:

$$Q = 3.3 \times L \times H^{1.5}$$

where

Q : critical outflow,
L : length of the clear overfoll spill,
H : design afflux.

The tailchannel is designed using Manning's equation and the conditions checked for submerged flow and excessive velocities.

(3) Morning Glory Spillway

This is designed for full flow conditions for the scope of this guideline. The formula to be used is:

$$H=(v^2 / 2g)x\ (fL / D + K)$$

where

H : head in feet between HFL and the tailwater level,
v : velocity to be calculated,
L : total length of the conduit,
D : diameter of the conduit,
f : friction coefficient = 0.14 for concrete conduits,
K : constant for loss at bends, transitions, inlets, etc. = 0.5,
g : acceleration due to gravity =9.8 m/sec^2 or 32.2 ft/sec^2

From the velocity and diameter of the conduit the discharge is calculated. The discharge should be equal to the critical outflow. The afflux should be at least 1.2 times the diameter of the conduit full when flow conditions prevail.

2.2.6 Determination of Freeboard

Freeboard is the vertical distance between the top of the bund and the reservoir water surface. More specifically the term "Normal Freeboard" is defined as the difference in elevation between the top of the embankment and the Full Supply Level (FSL). "Minimum Freeboard" is the difference in elevation between the top of the embankment and the designed High Flood Level (HFL). For the scope of this booklet "Freeboard" refers to minimum freeboard.

Minimum freeboard is provided to prevent overtopping of the embankment by wave action which may coincide with the occurence of the inflow design flood. Minimum freeboard also provides a safety factor against other contingencies. Elaborate calculations to determine the freeboard based on wave action etc. are not necessary for the sizes of reservoirs within the scope of this guideline. Hence the values given below are recommended:

Fetch* (miles)	Normal Freeboard (feet)	Minimum Freeboard (feet)
0 to < 0.5	3	2
0.5 to < 1	4	3
1 to < 2.5	5	4
2.5 to < 5	6	5

* Fetch is the distance over which the wind can act on a body of water. This can be taken as the longest dimension of the water spread of the reservoir.

2.2.7 Hydraulic Design of the Sluice

The sluice is designed as an orifice where the design discharge (daily peak water requirement expressed in Cusecs) takes place with the gate fully open and the reservoir at the minimum operating level. The minimum operating level for the scope of this booklet is taken as 1 foot above the top of the opening of the sluice. The formula governing the size of the opening is:

$$Q = 0.6 \times A \times (2gh)^{0.5}$$

where

Q : daily peak water requirement in Cusecs,
A : maximum area of opening of the sluice,
h : head of water above the center of the sluice when the water level is at minimum operating level,
g : acceleration due to gravity =9.8 m/sec^2 or 32.2 ft/sec^2.

A gradient is generally not required for the barrels of sluices designed for the scope of this booklet. The barrels may also be redesigned with a gradient to satisfy other hydraulic and structural requirements provided the introduction of the gradient does not result in a loss of command area.

2.3 Canal and Related Structures

2.3.1 Canal Conveyance

The canal is designed to convey the "daily peak water requirement" for the growing of crops. The daily peak water requirement is determined according to the land classification of the soils and the selected cropping pattern.

2.3.2 Canal Duties

The irrigation requirement (duty) is the amount of water to be delivered from the intake to the farm for land preparation and crop water requirement. The irrigation water requirement can be computed using the formula in subsection 1.3.3.

2.3.3 Canal Design

(1) Velocity

Canal velocity is determined according to Manning's formula as follows:

$$V = 1/n \times R^{2/3} \times I^{1/2}$$

where
- V : velocity,
- R : hydraulic radius,
- I : hydraulic gradient,
- n : oughness coefficient.

The determined velocity should be between the limiting velocities for silting and scouring. This is ensured by the following relationship:

- Critical Velocity Ratio= $V/V_c = 0.90$ to 1.25
- where critical velocity $V_c = 0.84 \times d^{0.64}$ and d= full supply depth

The maximum permissible velocities in earth canals are as follows:

- Earth canals capacity upto 0.7 m^3/sec	0.45 m/sec
- Earth canals capacity 0.7 to 8.5 m^3/sec	0.75 m/sec

(2) Roughness Coefficient

The following roughness coefficients "n" are adopted in the Manning's formula for canal design for the different types of materials:

- Earth	0.025
- Rock	0.035
- Concrete	0.015
- Cement Mortar	0.018

(3) Side Slopes

Side slopes for excavated canals are provided as follows to approximate to observed regimen slopes:

- Canal capacity less than 1.0 m^3/sec	1 on 1.0
- Canal capacity 1.0 to 2.8 m^3/sec	1 on 1.5
- Drainage canal	2 on 1.0

(4) Gradient

The following factors are considered in selecting a suitable gradient for a canal:

a) limitation of maximum permissible velocity I= 0.00030 to 0.00040
b) relative a loss in command area
c) increase in seepage loss I= 0.00035

(5) Curve Radius at Bends in Canals

At bends in canals, the stream flow tends to increase in velocity on the for side and decrease invelocity on the near side to the center of the curve to maintain laminar flow. The minimum radius for various ranges of bed width is as follows:

Bed width	Min. Radius
0.6 to 1.5 meters	25 to 36 meters
1.8 to 3.0 meters	40 to 54 meters

2.3.4 Road Crossings

Road crossings consist of pipe or box culverts and bridges. These structures are required to convey the canal water under the roads or railroads. The width of the carriageway to be adopted or bridges and culverts is as follows:

Classification	Width of plat form	Width of road way	Width of bridge	Width of culvert 0.3 m dia.	Width of culvert over 0.3 m dia.
O&M road	4.8 m	3.6 m	4.8 m	5.4 m	6.0 m
Internal roads	6.6 m	5.4 m	5.4 m	7.2 m	7.2 m
External roads	7.2 m	5.4 m	7.2 m	9.0 m	9.6 m

2.3.5 Culverts

Pipe culverts are relatively economic and easy to construct compared with box culverts and bridges. The hydraulic design consists of selecting a pipe diameter or box size that will result in either:

a) a maximum velocity of 1.05 m/sec with earth transitions, or
b) a maximum velocity of 1.50 m/sec with concrete transitions or other concrete inlet and outlet structures.

Pipe culverts should have a minimum earth cover of 0.60 m. The road may be ramped at the culvert using a 10 % grade to provide the minimum earth cover. Alternately, the culvert invert may be depressed below the canal invert to obtain the minimum cover, such depression not exceeding 1/2D. Depressing the culvert invert should be avoided if it may result in the introduction of silt, etc. into the culvert.

2.3.6 Bridges

The maximum permissible velocity under the bridge is 1.05 m/sec. With this permissible velocity bridge spans are proportioned to limit the spans as far as possible to the base width of the canal. To minimize head loss, concrete transitions are provided at the inlet and outlet for the bridge.

The hydraulic design details the following losses:

- Entrance Loss = 0.4 x velocity head at the entrance
- Exit loss = 0.7 x velocity head at the exit
- Friction loss = Negligible.

2.3.7 Flumes and Syphons

The discharge capacity of a flume or syphon in a canal should be more than the normal capacity of the canal as determined according to the requirement. This is necessary as the canal may not always be at the design grade due to poor maintenance and also to provide flexibility for the operation discharge of the canal under contingency conditions.

As far as possible, the inlet and outlet transitions of flumes and syphons are to be located away from the edges of the banks of the stream. Thus, the limiting positions for the end supports of the flumes will be the edges of the banks of the streams. It is not economical or advisable to reduce the regimen width of a stream or restrict the water-way when constructing a flume.

3. Cost Estimate

The base cost of the Engineer's estimate is obtained by applying unit rates in the data for costing to the quantities of the items of work to be done, including any lump sum provisions for items of work. The unit rates provide for the overheads of the construction agency for supervision, camps, stores, etc. These unit rates shall refer to the base cost tariff issued by the Irrigation Department for the respective regions.

Physical contingency as well as price contingency shall be considered for the works. These rates for the works are as follows:

- Physical Contingency 10.0 % of base cost
- Price Contingency 12.4 % of base cost

4. Economic Evaluation

After the technical feasibility has been established, the project has to be analyzed to determine whether investment in such a project would bring in commensurate returns.

Most of the minor schemes have been justified on the basis of a predetermined, prorata cost. This method consists of only the capital cost of the Project and does not take into account the cultivation costs, O&M costs, and benefits accruing from the Project. Further, this method does not indicate the benefits of the Project to the national economy. Hence the economic feasibility of the projects has to be based on social and national economic profitability. Thus, it becomes necessary to have a benefit-cost analysis to determine the economic feasibility of a project.

TABLES

Table B.1 MONTHLY 75% PROBABILITY RAINFALL

in mm

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum in Maha	Sum in Yala
WU1	64.0	51.0	127.0	229.0	318.0	533.0	432.0	381.0	330.0	406.0	279.0	127.0	1,054.0	2,223.0
WU2	89.0	51.0	89.0	165.0	140.0	279.0	229.0	203.0	178.0	279.0	203.0	127.0	838.0	1,194.0
WU3	89.0	51.0	76.0	140.0	102.0	127.0	127.0	102.0	102.0	203.0	152.0	114.0	685.0	700.0
WM1	76.0	64.0	152.0	279.0	381.0	432.0	305.0	292.0	305.0	432.0	254.0	127.0	1,105.0	1,994.0
WM2	25.0	13.0	76.0	152.0	102.0	152.0	102.0	89.0	114.0	267.0	178.0	102.0	661.0	711.0
WM3	89.0	38.0	51.0	127.0	76.0	127.0	102.0	76.0	102.0	229.0	203.0	152.0	762.0	610.0
WL1	76.0	64.0	152.0	254.0	330.0	254.0	152.0	127.0	178.0	381.0	267.0	127.0	1,067.0	1,295.0
WL2	38.0	51.0	102.0	178.0	152.0	178.0	102.0	89.0	102.0	292.0	203.0	76.0	762.0	801.0
WL3	51.0	38.0	64.0	152.0	203.0	152.0	76.0	64.0	76.0	241.0	165.0	64.0	623.0	723.0
WL4	51.0	38.0	64.0	152.0	203.0	152.0	76.0	64.0	76.0	241.0	165.0	64.0	623.0	723.0
IU1	356.0	140.0	102.0	191.0	102.0	127.0	102.0	89.0	102.0	305.0	356.0	432.0	1,691.0	713.0
IU2	279.0	102.0	102.0	152.0	64.0	38.0	38.0	51.0	64.0	178.0	229.0	305.0	1,195.0	407.0
IU3	102.0	51.0	76.0	152.0	76.0	38.0	38.0	51.0	76.0	178.0	203.0	152.0	762.0	431.0
IM1	305.0	114.0	89.0	114.0	38.0	13.0	13.0	13.0	51.0	152.0	229.0	330.0	1,219.0	242.0
IM2	51.0	25.0	127.0	178.0	76.0	25.0	13.0	13.0	25.0	152.0	254.0	127.0	736.0	330.0
IM3	127.0	38.0	51.0	102.0	51.0	51.0	38.0	25.0	38.0	152.0	178.0	165.0	711.0	305.0
IL1	38.0	25.0	76.0	127.0	102.0	89.0	51.0	25.0	51.0	114.0	152.0	76.0	481.0	445.0
IL2	254.0	89.0	64.0	89.0	25.0	0.0	13.0	13.0	51.0	127.0	203.0	279.0	1,016.0	191.0
IL3	51.0	38.0	51.0	102.0	51.0	38.0	25.0	13.0	38.0	191.0	165.0	89.0	585.0	267.0
DL1	76.0	25.0	51.0	127.0	51.0	13.0	0.0	13.0	25.0	127.0	152.0	127.0	558.0	229.0
DL2	178.0	64.0	38.0	64.0	13.0	0.0	0.0	13.0	13.0	127.0	191.0	216.0	814.0	103.0
DL3	38.0	25.0	25.0	51.0	25.0	0.0	0.0	0.0	25.0	127.0	178.0	114.0	507.0	101.0
DL4	38.0	25.0	25.0	51.0	25.0	0.0	0.0	0.0	25.0	127.0	178.0	114.0	507.0	101.0
DL5	51.0	13.0	25.0	76.0	51.0	25.0	13.0	13.0	25.0	51.0	127.0	102.0	369.0	203.0

Table B.2 REFERENCE CROP EVAPOTRANSPIRATION

mm/month

Region	Soil Type	Station	Method	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 Dry Zone Low Country	RBE	Anuradahpura	P	120.0	140.0	186.0	180.0	186.0	195.0	201.5	201.5	195.0	155.0	120.0	124.0
2 Dry Zone Low Country	RYL	Kankasanturai	P	165.0	168.0	201.5	210.0	217.0	210.0	201.5	201.5	195.0	155.0	135.0	139.5
3 Dry Zone Low Country	NCB	Batticaloa	P	135.0	154.0	186.0	180.0	201.5	195.0	201.5	201.5	195.0	170.5	135.0	124.0
4a Wet Zone Low Country	RYP	Colombo	P	150.0	154.0	186.0	165.0	139.5	135.0	139.5	155.0	135.0	139.5	120.0	139.5
4b Wet Zone Mid Country	RYP	Peradeniya	B	150.0	154.0	170.5	150.0	170.5	120.0	139.5	155.0	135.0	155.0	120.0	124.0
4c Wet Zone Up Country	RYP	Nuwara Eliya	P	90.0	112.0	124.0	105.0	93.0	90.0	77.5	93.0	90.0	93.0	90.0	93.0
5a Intermidiate Zone Low Country	RBE	Batalagoda	P	135.0	140.0	170.5	165.0	170.5	150.0	155.0	170.5	150.0	139.5	120.0	124.0
5b Intermidiate Zone Mid Country	RBE	Badulla	B	105.0	98.0	108.5	135.0	139.5	165.0	170.5	170.5	105.0	93.0	90.0	93.0
5c Intermidiate Zone Up Country	RYP	Diyatalawa	P	105.0	112.0	139.5	105.0	139.5	150.0	170.5	170.5	150.0	124.0	90.0	93.0

Note

Soil Type

- RBE Reddish Brown Earth
- RYL Red Yellow Latosol
- NCB Non Calic Brown
- RYP Red Yellow Podzolic

Method

- P Modified Penman Method
- B Blaney Criddle Method

Source of Data : Some Aspects of Water Resources of Sri Lanka

Table B.3 DIVERSION WATER REQUIREMENT (1/5)

Agro-Ecological Region WU2 District: Nuwara Eliya

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	134.8	169.6	0.0	10.6	67.3	0.0	0.0	7.1	0.0	0.0	25.0	98.1

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	127.9	210.9	194.5	87.8	67.3	0.0	0.0	7.1	0.0	0.0	73.8	78.5

Agro-Ecological Region WM1 District: Nuwara Eliya

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	270.9	230.5	21.5	0.0	47.3	0.0	0.0	0.0	0.0	0.0	8.5	159.1

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	272.6	233.3	21.5	0.0	47.3	0.0	0.0	0.0	0.0	0.0	34.3	166.5

Agro-Ecological Region WM1 District: Ratnapura, Kegalle

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	209.1	0.0	21.5	0.0	47.3	0.0	0.0	0.0	0.0	0.0	42.6	172.9

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	272.6	233.3	21.5	0.0	47.3	0.0	0.0	0.0	0.0	0.0	34.3	166.5

Agro-Ecological Region WM2 District: Nuwara Eliya, Kandy

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	313.3	262.9	0.0	116.5	250.1	139.4	193.5	57.0	0.0	0.0	72.3	180.1

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	315.0	265.6	0.0	116.5	250.1	139.4	193.5	57.0	53.3	23.9	98.0	187.5

Table B.3 DIVERSION WATER REQUIREMENT (2/5)

Agro-Ecological Region WM3 District: Kandy, Matale, Moneragala

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	231.3	102.3	106.0	123.6	290.6	164.8	169.9	0.0	0.0	52.0	71.8	147.4

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	261.8	255.1	106.0	123.6	290.6	164.8	169.9	0.0	63.4	55.8	77.0	145.6

Agro-Ecological Region WL1 District: Kegalle, Ratnapura

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	242.1	80.4	21.5	28.6	17.4	89.8	128.0	0.0	0.0	0.0	18.1	200.0

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	272.6	233.3	21.5	28.6	17.4	89.8	128.0	0.0	0.0	0.0	23.4	198.0

Agro-Ecological Region WL2 District: Kegalle, Ratnapura

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	241.0	0.0	158.4	175.5	179.1	129.9	35.1	0.0	63.4	0.0	85.4	247.8

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	304.5	244.1	158.4	175.5	179.1	129.9	35.1	0.0	63.4	0.0	77.0	240.8

Agro-Ecological Region IU2 District: Nuwara Eliya, Badulla

Case 1	Maha: 105 Days Paddy				Yala :							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	6.9	127.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0

Case 2	Maha: 135 Days Paddy				Yala :							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	5.5	160.6	42.3	0.0	0.0	0.0	0.0	0.0	0.0	94.8	0.0	0.0

Table B.3 DIVERSION WATER REQUIREMENT (3/5)

Agro-Ecological Region IU3 District: Badulla

Maha: 135 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	133.8	205.3	250.6	77.8	0.0	265.1	337.9	301.9	60.0	0.0	0.0	67.8

Agro-Ecological Region IM1 District: Kandy

Maha: 105 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	0.0	0.0	146.8	201.8	261.3	112.8	0.0	0.0	106.0	57.3	5.3	0.0

Agro-Ecological Region IM1 District: Nuwara Eliya

Case 1 Maha: 105 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	0.0	93.0	0.0	53.3	186.9	322.0	354.8	286.0	0.0	21.5	3.2	0.0

Case 2 Maha: 135 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	0.0	94.8	0.0	53.3	186.9	322.0	354.8	286.0	106.0	67.8	0.0	0.0

Agro-Ecological Region IM1 District: Badulla, Ratnapura

Case 1 Maha: 105 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	0.0	113.1	29.5	53.3	186.9	322.0	354.8	286.0	0.0	0.0	52.0	0.0

Case 2 Maha: 135 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	0.0	113.1	29.5	53.3	186.9	322.0	354.8	286.0	0.0	0.0	52.0	0.0

Agro-Ecological Region IM2 District: Badulla, Ratnapura

Case 1 Maha: 105 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	197.8	167.3	0.0	0.0	155.0	322.0	354.8	286.0	0.0	21.5	0.0	98.1

Case 2 Maha: 135 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	199.0	169.0	0.0	0.0	155.0	322.0	354.8	286.0	127.5	67.8	0.0	103.8

Table B.3 DIVERSION WATER REQUIREMENT (4/5)

Agro-Ecological Region IM3 District: Kandy, Matale, Nuwara Eliya

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	134.1	156.8	106.0	133.3	251.0	322.3	275.5	0.0	0.0	21.5	46.0	66.4

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	132.8	186.3	188.8	133.3	251.0	322.3	275.5	0.0	0.0	116.5	29.8	70.4

Agro-Ecological Region IL1 District: Moneragal, Ratnapura

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	245.5	102.4	85.1	135.0	268.9	259.1	238.4	0.0	0.0	148.3	114.5	211.0

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	269.5	280.9	215.1	135.0	268.9	259.1	238.4	0.0	0.0	148.3	104.0	207.1

Agro-Ecological Region IL2 District: Kandy, Matale, Badulla, Meneragala

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	64.5	49.1	95.1	166.9	333.0	312.4	259.9	0.0	0.0	137.4	71.8	41.0

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	88.5	227.6	225.1	166.9	333.0	312.4	259.9	0.0	0.0	137.4	61.3	37.1

Agro-Ecological Region DL1 District: Matale

Case 1	Maha: 105 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	203.1	267.8	247.8	146.4	341.8	406.1	337.9	0.0	0.0	0.0	116.5	143.4

Case 2	Maha: 135 Days Paddy				Yala : 105 Days Paddy							Unit : mm
Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	209.6	241.5	106.0	146.4	341.8	406.1	337.9	0.0	127.5	141.1	119.8	166.5

Table B.3 DIVERSION WATER REQUIREMENT (5/5)

Agro-Ecological Region DL1 District: Ratnapura, Moneragala, Badylla

Case 1 Maha: 105 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	203.1	267.8	247.8	146.4	341.8	406.1	337.9	0.0	0.0	0.0	116.5	143.4

Case 2 Maha: 135 Days Paddy Yala : 105 Days Paddy Unit : mm

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Diversion Water Requirement	206.6	280.9	247.8	146.4	341.8	406.1	337.9	0.0	0.0	137.4	104.0	164.4

FIGURES

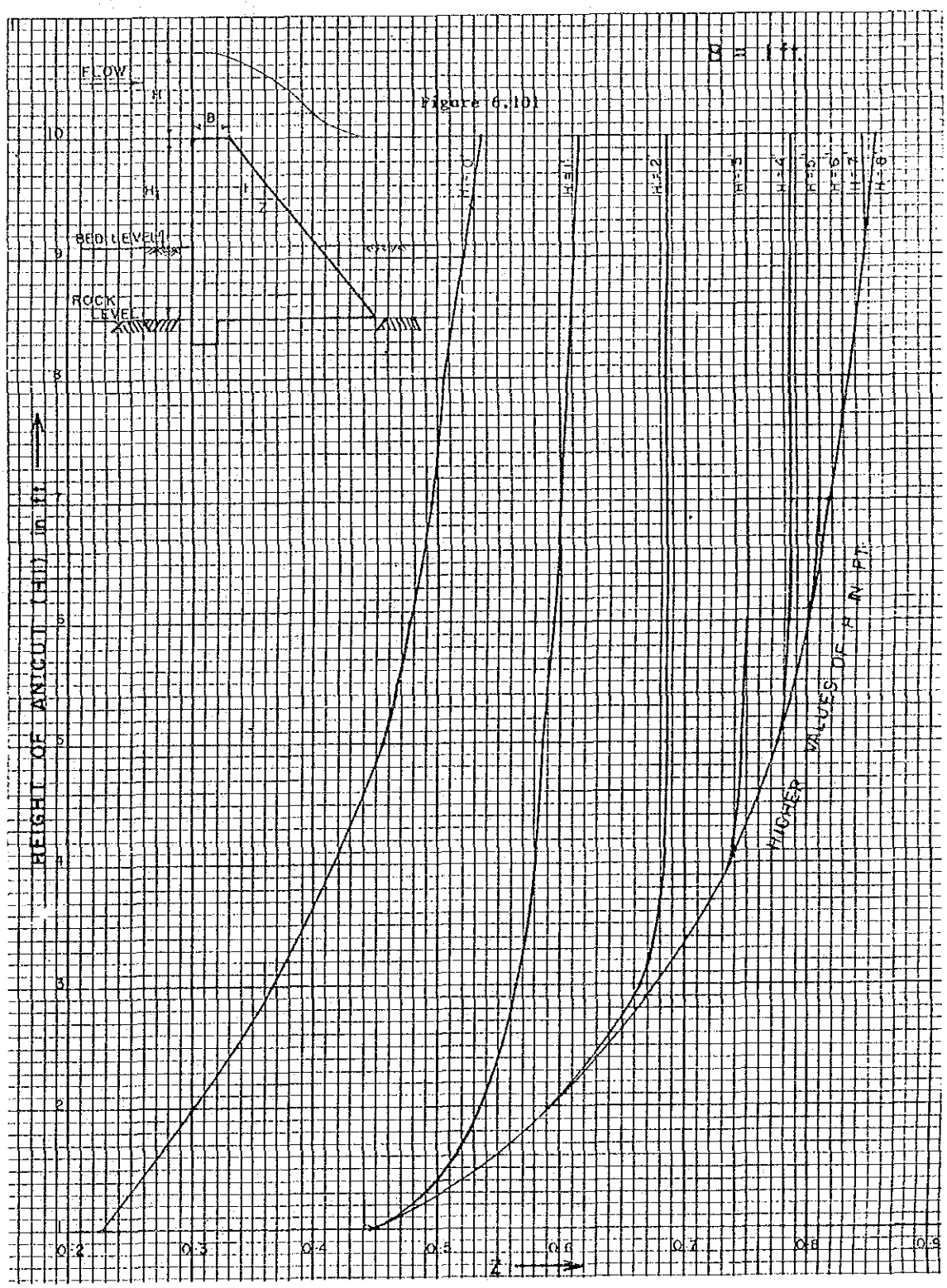


Figure B.1 ANICUT HEIGHT - DOWNSTREAM SLOPE (B=1ft)

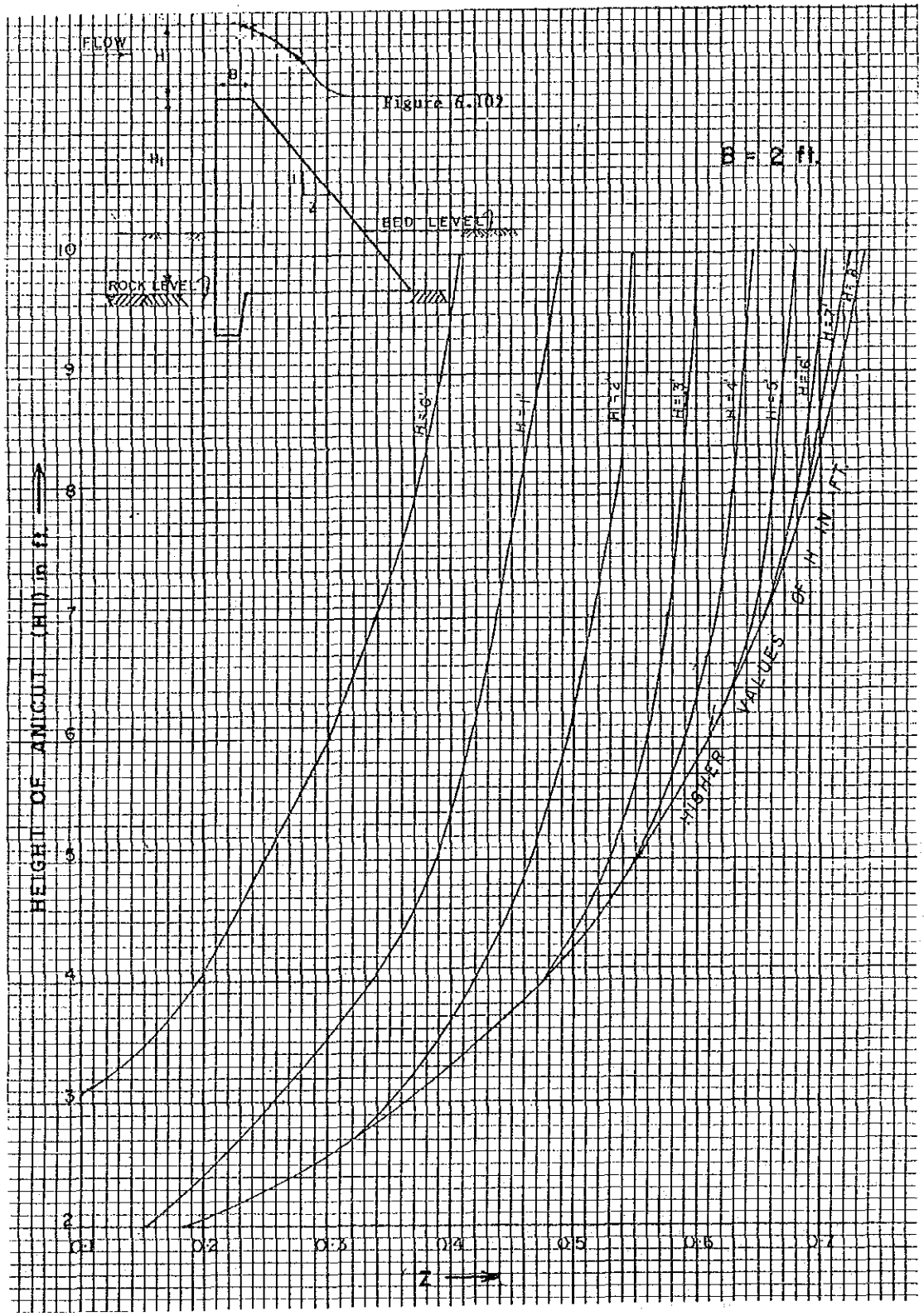


Figure B.2 ANICUT HEIGHT - DOWNSTREAM SLOPE (B=2 ft)

PLANNING AND DESIGN GUIDELINE FOR RURAL ROAD

PLANNING AND DESIGN GUIDELINE FOR RURAL ROADS

Contents

List of Tables

List of Figure

List of Reference

1. Standard Specifications for Construction and Maintenance of Road and Bridges, Road Development Authority, Sri Lanka

2. Road Structure Ordinance, Japan

PLANNING AND DESIGN GUIDELINE FOR RURAL ROADS

1. Object

This guideline is set up for the application manual of rural roads of Class C, D, and E in the Study area, for the purpose of mainly agricultural transport in mountainous areas.

2. Definition of the Basic Condition

2.1 Location of the Scheme

The location of the rural roads shall be described as follows, including a location map:

a) Name of the roads
b) District
c) Division
d) Grama Niladari
e) Villages
f) Location maps

2.2 Study of the Present Situation

The following items should be defined for the planning and design of the Rural Roads Rehabilitation Scheme:

a) Road length
b) Classification of roads (class C, D, E)
c) Present road condition:
   - width
   - road surface
   - base course
   - traffic flow volume
d) Drawings of the longitudinal section (refer to Table C.1), cross section, and plan
e) Inspection list for the structure (refer to Table C.2)
f) Agricultural beneficiaries, benefited area, and name of village (refer to Table C.3)

3. Basic Planning

The basic planning is set up for general rural roads of class C, D, and E. The particular cases, however, will be given in the planning considering that the Study area is mostly in a mountainous area.

3.1 Cross sections of the Road Width

3.1.1 Composition of the Cross section

In principle, single traffic lane operation is adequate with 3.5 meters of carriageway and 1.2 meters of shoulder on each side. A single drain shall be built on the mountain-side and 3.0 to 5.0 meter high retaining walls provided at the valley side on steep slops of over 60 percent, as standard.

The recommended typical cross section is given in Figure C.1.

3.1.2 Cross Slope

The normal cross slope should be 2.0 percent on tarred pavement and 4.0 to 6.0 percent on gravel pavement.

3.1.3 Passing Places

In the design of the cross section, no passing will be considered. Instead, passing places must be provided. The width at the passing places should be 3.0 meters at least and the length should be 10 ~ 20 meters with pavement.

Passing places should be constructed every 300 meters depending mainly on the ground condition.

3.2 Design Speed

The design speed, which is selected in accordance with the type and function of roads, is the basis for planning of the alignment. The design speed should not exceed 40 km/hour as their is only 3.5 meters of carriageway width.

3.3 Plan of the Alignment

The alignment of roads consists of a series of horizontal and vertical curvatures. In the plan of the horizontal alignment, the curve radius, curve length, and superelevation shall be designed, so that traffic flows smoothly and safely. The vertical alignment is planned to considering the driving speed and hill climbing ability of vehicles.

The following values of each item are used depending on the design speeds.

3.3.1 Horizontal Alignment

The minimum values of the curve radius and curve length depending on the design speeds are given below:

(1) Curve Radius

Design Speed (km/hr)	Horizontal Minimum Curvature Values (m)
40	60
30	30
20	15
driving slowly (particular case)	no value

For the particular case of driving slowly at sharp bends, the minimum curvature value is not given. Instead, the bends shall be widened 3.0 meters at least to prevent the need for sharp turning.

(2) Curve Length

The minimum curve length of each intersection angle and design are shown bellow:

Design Speed (km/hr)	Curve Length (m)
40	70
30	50
20	40
driving slowly (special case)	no value

(3) Superelevation

For a small radius curve and higher speeds, the removal of adverse cross slope alone will be insufficient to reduce frictional needs to an acceptable level, and cross slope should be increased by the application of superelevation.

The superelevation values, shown below, depend on the design speeds and curve radii:

Curve Radius (m)			
Superelevation	Design speed (km/hour)		
(%)	40	30	20
6	130~160	60~80	30~40
5	160~210	80~110	40~50
4	210~280	110~150	50~70
3	280~400	150~220	70~100
2	400~800	220~500	100~200

3.3.2 Vertical Alignment

(1) Vertical Gradient and Limited Tangent Length

The maximum gradients are recommended as follows:

Design Speed (km/hr)	Vertical Gradient (%)	Limited Tangent Length (m)
40	8	400
	9	300
	10	200
30	9	300
	10	200
	11	100
20	10	200
	11	100
	12	100

In a particular case, the vertical gradient at 20 km/hour design speed will be up to 15 percent in consideration of the steep topography. In addition, the gradients are kept within 20 percent, and distance of sections with gradients between 15 and 20 percent the shall be kept within 100 meters, to be connected with sections of over 30 meters with gradients below 2.5 percent.

(2) Vertical Curves

At sections of the crest and sag curve, the minimum curve radius and the minimum length of the vertical curves at each design speed are given as follows:

Design speed (km/hour)	Curve type	Curve radius (m)	Vertical curve length (m)
40	crest sag	450 450	35
30	crest sag	250 250	25
20	crest sag	100 100	20

3.4 Subgrade and Features of the Cross Section

3.4.1 Subgrade

Physical and mechanical soil tests for subgrade soil are required in the initial stage of the study. It is recommended suitable stabilization in be provided case the subgrade has insufficient bearing capacity.

3.4.2 Features of the Cross Section

The pavement consists of a basecourse subbasecourse, and surface course. The thickness and materials should be determined based on the work types of the pavement.

In this guideline, the following types of pavement are recommended:

Road Class	Type of Pavement	Thickness (mm)
C	Tarred	300
D	Gravel (partly tarred)	100 ~ 300
E	Gravel	100 ~ 300

In consideration of steep mountainous areas, the pavement shall be tarred to prevent the road surface from washing away during heavy rain.

The following features of are recommended for the pavement:

Sub basecourse		Basecourse		Surface course
Thickness	Aggregate	Thickness	Aggregate	Tarring
200 mm (100mm x 2 layers)	ϕ 50 mm	100 mm	ϕ 50 mm ϕ 18 mm	3 l/m^2 (2 coats)

3.5 Road Structures

3.5.1 Rational Formula

A rational formula has been recommended for calculation of the design discharge as follows:

$$Q = 1/3.6 \times f \times r \times A$$

Where
- Q : design discharge (m^3),
- f : coefficient of runoff,
- r : intensity of rainfall (mm/hour),
- A : catchment area (km^2).

3.5.2 River / Stream Crossing Structures

The following structures shall be provided depending upon the design discharge calculated by the rational formula and topography, and also cosidering the traffic flow volume.

Crossing	Specification	Crossing Length	For
1) Bridge	5 m x 2 ~ 3 spans	10 ~ 15 m	Small river
2) Causeway			
box type	3 m x 10 ~ 15 spans	15 ~ 50 m	Medium river
pipe type	ø600 mm x 4 lanes	5 ~ 10 m	Small stream
pipe type	ø600 mm x 2 lanes	3 ~ 5 m	Small stream
3) Culvert			
box culvert	3 m x 1 span	2 ~ 3 m	Small stream
box culvert	3 m x 1 span	1 ~ 2 m	Small stream
pipe culvert	ø600 mm x 1 lane	0.5 ~ 1 m	Road surface drains

4. Documents and Drawings

4.1 Design Calculation Documents

In preparing the design calculation documents, the basis of the design, such as the design criteria used, design speed, and other factors considered should be described. Calculations should be complemented, if needed, with sketches of the design details to be included in the design calculation documents.

4.2 Drawings

In general, a layout of the following salient components of the proposed scheme should be shown in the drawings using an appropriate scale.

a) Boundaries of districts divisions, and Grama Niladaris,
b) Curve radius, curve length, and superelevation,
c) Vertical gradient, vertical curve radius, and vertical curve length,
d) Names of bridges and other road structures.

4.3 Road Register

The oad register should include the following inspection list:

a) Name of the road
b) Classification of the road
c) Beginning and ending point of the route
d) Main passage point on the route
e) Length of the route and its items
f) Area of the road site and its items
g) Minimum carriageway, radius of curve, and maximum vertical gradient
h) Number of intersections
i) Plans of the route

TABLES

Table C.1 **DRAWING FOR LONGITUDINAL SECTION (SAMPLE)**

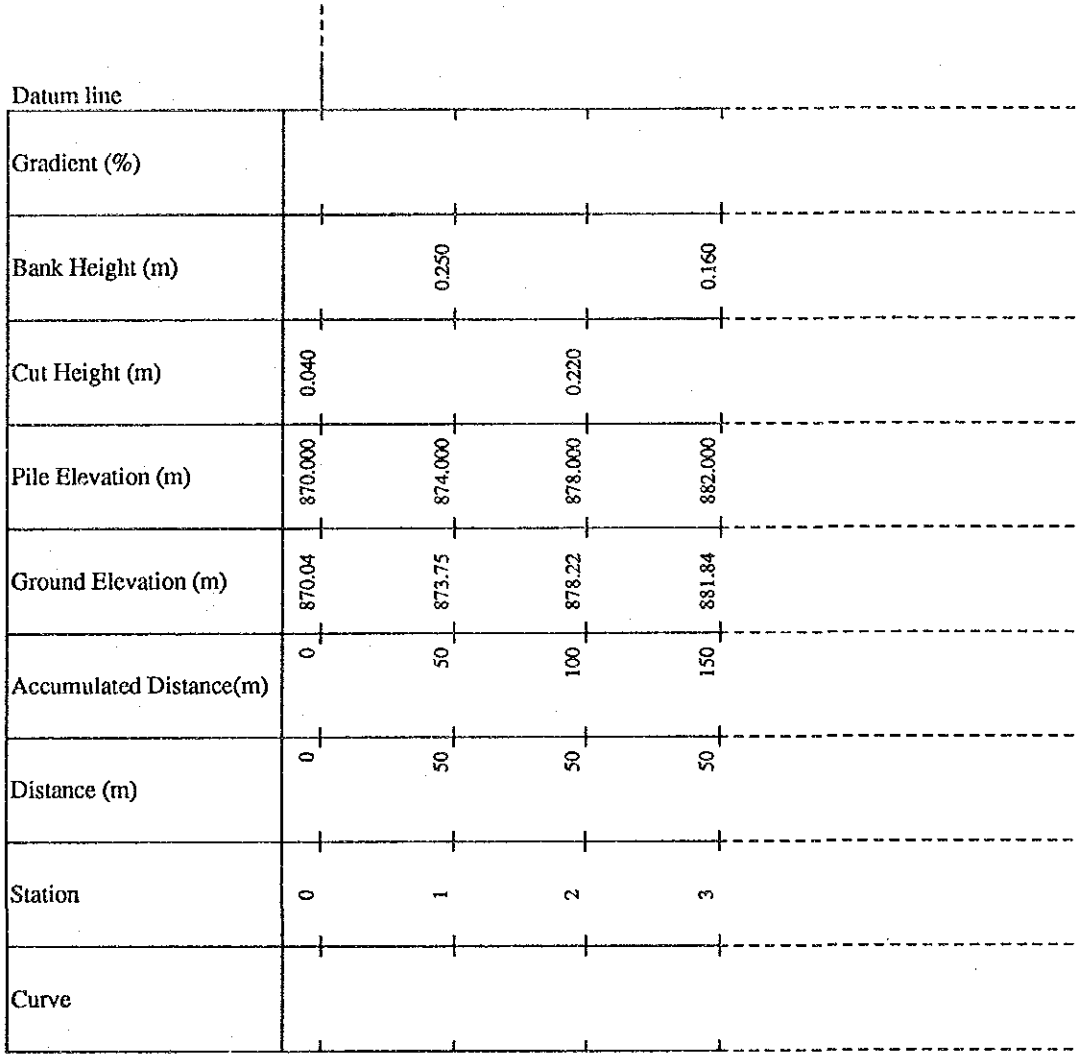


Table C.2 **ROAD STRUCTURE INSPECTION LIST (SAMPLE)**

Structure No.	Station No.	Structure Type	Size (m)	Main Elevation (m)	Materials	Completed Year	Stream Name	Present Condition

Table C.3 **SUMMARY OF BENEFITED AREA (SAMPLE)**

District	Division	Grama Niladari	Village	Road Class	Road Length (m)	Benefited Agricultural Area		Beneficiaries (families)
						Agricultural Crops	Area (ha)	

FIGURES

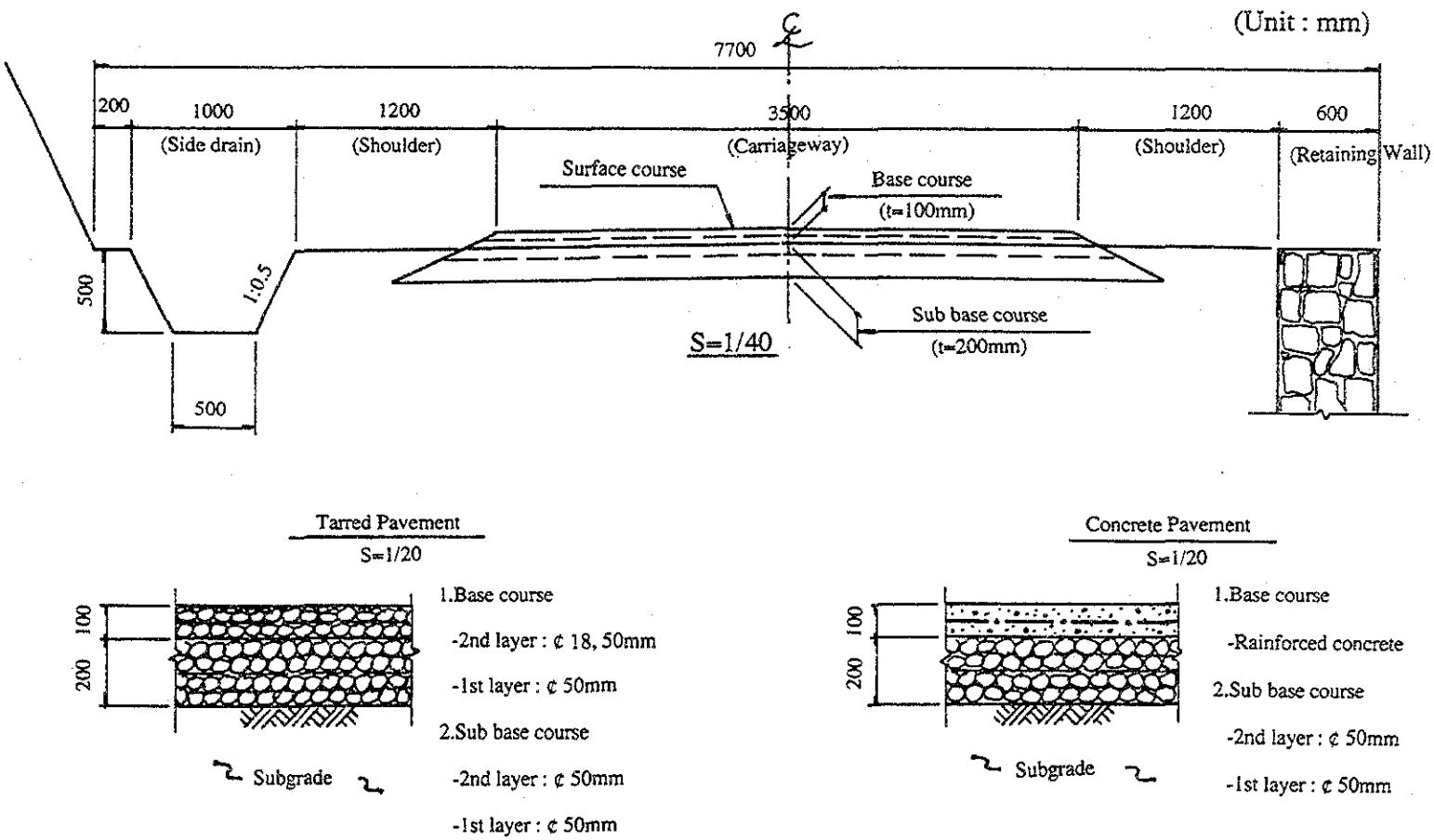


Figure C.1 **Typical Cross Section of Agricultural Feeder Road**

PLANNING AND DESIGN GUIDELINE FOR RURAL WATER SUPPLY

PLANNING AND DESIGN GUIDELINE FOR RURAL WATER SUPPLY

Table of Contents

List of Tables

List of Figures

List of Reference

1. Design Manual on Small Community Water Supplies, National Water Supply & Drainage Board, Sri Lanka

PLANNING AND DESIGN GUIDELINE FOR RURAL WATER SUPPLY

1. Application of the Criteria

This guideline for the rural water supply was prepared, mostly for the piped water supply system in the rural up-country area, by referring to the "Design Manual on Small Water Supplies" published by NWS & DB. This guideline, therefore, does not cover the details of tubewells and dug wells, and instruction may be needed from respactive organizations.

This guideline is composed to follow Figure D.1, Design Flow Chart for Water Supply Schemes, which also should be followed when schemes are planned.

2. Definition of Basic the Condition

2.1 Location of the Scheme

The location of the water supply scheme shall be described as follows, including a location map:

a) District
b) Division
c) Grama Niladari
d) Villages
e) Concerned local authority

2.2 Study of the Present Water Supply Situation

2.2.1 Water Supply Facilities

The following items shall be investigated to understand the water supply facilities of the planning area:

(1) Water Source

All possible water sources in the vicinity and their yields and quality of water shall be investigated. A physical inventory and survey of all the existing water supply systems and facilities, including handpumps and dug wells, shall be taken.

(2) Water Supply Volume

Investigation and estimation on the present water supply volume of each water source shall be carried out. An interview survey shall also be carried out to determine if beneficiaries receive enough water for their domestic use.

(3) Beneficiaries (service area)

The number of beneficiaries of each water source and the distance from the water source to the beneficiaries shall be determined/investigated.

(4) For Augmentation Schemes

The original designs and plans of the existing schemes should be collected and information on the present condition, capacity (average and minimum), water quality, and minimum yield of the sources should be compared to that of the originally designed schemes.

2.2.2 Health and Social Aspects

a) Describe any available health information on the incidence of waterborne diseases in the area.
b) Describe the existing sanitary conditions of the community regarding water supply and waste disposal (i.e. excreta disposal).
c) Assess the social and economic status of the community in terms of their willingness and ability to participate in implementing and operating the Project.

2.2.3 Water Quality Standard

The following guidelines on raw water quality are recommended:

Items	Unit	Acceptable	Cause for Refection
- Turbidity	(JTU Units)	2.5	15
- Colour (Platinum scale)	mg/l	5.0	50.0
- Taste and odour	-	Not objectionable	Objectionable
- pH	-	7.0 to 8.5	6.5 to 9.0
- Total dissolved solids	mg/l	500	1500
- Total hardness (Ca Co_3)	mg/l	200	600
- Sodium (as Na)	mg/l	120	400
- Calcium (as Ca)	mg/l	75	200
- Magnesium (as Mg)	mg/l	30	150
- Chlorides (as Cl)	mg/l	200	1000
- Sulphates (as SO_4)	mg/l	200	400
- Fluorides (as F)	mg/l	1.0	2.0
- Nitrates (as No^3)	mg/l	50	100
- Iron (as Fe)	mg/l	0.3	1.0

Items	Unit	Acceptable	Cause for Refection
- Manganese (as Mn)	mg/l	0.05	0.5
- Copper (as Cu)	mg/l	0.05	1.5
- Zinc (as Zn)	mg/l	5.0	15.0
- Arsenic	mg/l	0.05	0.1
- Chromium (hexavalent)	mg/l	0.05	0.1
- Lead	mg/l	0.05	0.1
- Mercury	mg/l	0.001	0.005
- Cadmium	mg/l	0.005	0.01
- Phenolic compounds (as phenols)	mg/l	0.005	0.002
- Anionic detergents (as MBAS)	mg/l	0.2	1.0

Bacteriological Standard

The coliform count in any sample of treated water should be zero.

When coliform organisms are found, repeated sampling should be done.

Detection of coliforms in a repeated sample is a cause for investigation and removal of the source of pollution.

In rural untreated supplies, coliform levels of not more than 10 per 100 ml may be considered acceptable.

2.3 Target Beneficiaries (Service Area)

Based on the study of the present water supply situation, the target beneficiaries (service area) should be determined excluding beneficiaries from the existing facilities. In the case of planning for the piped water supply system, however, the present beneficiaries should be carefully for considered inclusion in the target beneficiaries in terms of the following aspects ;

a) A safe water supply
b) A be reliable, sufficient water volume
c) Efficient construction and maintenance of facilities

3. Basic Planning

3.1 Target Year (Design Period)

Water supply schemes are normally designed to meet the requirements over a 20 year period. However, some units, such as dams, intakes, and transmission main, which cannot be easily increased in capacity, are often designed for longer periods. The components are normally designed to meet the requirements of the following periods:

Components	Design period (years)
a) Dam for reservoirs	50
b) Intake	20 ~ 30
c) Pumpset	10
d) Treatment units	10 ~ 15
e) Transmission main	20 ~ 30
f) Storage tank	15
g) Distribution System	20 ~ 30

3.2 Population Projection

Estimating the future population is carried out by the geometric progression method, using the following formula :

$$Pn = P(1+r)^n$$

Where

Pn : population at the "n" th year,
P : initial population,
r : rate of population increase,
n : number of years.

On average, the rate of increase from 1980 to 2000 may be assumed as 1.5 % in rural areas and 2.5 ~ 3.0 % in urban areas.

3.3 Future Water Demand

The water demand, recognized as the average daily water demand, for domestic needs is related to the percentage of the population served by house connections or stand posts. The standard percentage and unit water demand of house connections and stand posts are as follows;

Population of the Community	House connection		Stand post	
	Population (%)	Unit demand (liter / day)	Population (%)	Unit demand (liter / day)
lessthan 1500	-	-	100	45
1500 ~ 5000	10	145	90	45
over 5000	20	185	80	45

As far as possible, the percentage of the population should be decided after careful study in consultation with local authorities and with regard to the income levels.

The following institutional / commercial needs should be provided in addition to the domestic demands:

Institutional / Commercial establishments	Unit	Unit demand (liter / day)
a) Hospitals	bed	220 ~ 300
b) Boarding schools	resident	80 ~ 120
c) Day schools	pupil	15 ~ 30
d) Restaurants	seat	60 ~ 90
e) Bus / Railway stations	user	15 ~ 20
f) Factories	person	20 ~ 30
g) Cinemas	seat	10 ~ 15

3.4 Proposed Maximum Daily Water Supply Volume

The roposed maximum daily water supply volume is normally tdesigned o add 25 % to the required average daily water demand.

3.5 Selection of a Water Source

3.5.1 Essential Aspects

For site selection of the source, the following aspects should be essentially considered:

a) A careful sanitary survey should be carried out and siting should be as far as possible or upstream from the pollution sources.
b) The location should be at as high an elevation as possible to prevent flooding and for easy drainage.
c) The source yield should be assessed during the driest period of the year to examine the seasonal variation.
d) Consideration should be given to possible conflicts, which may arise after developing the source, such as objections from downstream users.

3.5.2 Selection of Water Supply Facilities

The following facilities are considered:

a) Pipe borne water supply system
b) Tube well with handpump
c) Dug well

a) is the most reliable facility in terms of supplying safe water. In rural sparsely populated areas, however, the economic condition and efficiency should be examined for the target beneficiaries.

Where the population density is more than 2,000 / km^2 in the service area, the pipe borne water supply system shall be adopted as standard. To include institutional and commercial needs, however, it is desirable that less densely populated areas be included in the same system as far as possible. The balance areas where excluded from the system are provided with water by b) or c) in the following manner as standard:

a) Tube well with handpump : 20 households per facility
b) Dug well : 15 households per facility
c) Absence of the above facilities within a distance of 200 m.

3.5.3 Water Source Volume

(1) Surface Source

The available of water volume must be more than the proposed maximum daily water supply volume, so that the following data can be observed and collected at the intake point for one year at least:

a) Minimum discharge in the stream/river during the year
b) Minimum depth in the reservoir/tank at intake point during the year
c) Existing downstream users

(2) Groundwater

The construction of wells depends on the size and depth of the well, characteristics of the material to be excavated, and quantity of water to be obtained. The siting of production wells involves exploration by geophysical and hydrogeological studies and in the case of deep wells, test drilling is also necessary for obtaining the aquifer characteristics, which enable assessment of probable yields from production wells.

The available water volume should be determined to ascertain the permissive, sustained yield by the pumping test (aquifer test), which is carried out by the authorized agency.

4. Design of the Respective Facilities

4.1 Intake Facilities

4.1.1 Intakes for Surface Sources

With respect to the locating of intakes for surface sources, such as rivers, streams and tanks, attention should be given to the following:

a) Intakes should be sited on the outside bend of a river where the sediment concentration is usually less.
b) Intake openings should face downstream or parallel to the stream flow in order to minimize the inflow of floating debris during flood periods.
c) Intake depth should be sufficient so that bottom deposits are not stirred up by wave action.
d) Multiple intake points should be included to provide flexible intake operations if the river level varies seasonally.
e) Iintakes in reservoirs should be located away from the shore, where debris does not accumulate.
f) The outlet pipe or pump suction should be located in a quiescent area to minimize air entrainment.

Where the watercourse changes during the year, a low diversion weir could be constructed to lead the water into the intake structure.

Raw water intake, where the source is of low turbidity, requires only a bar rack with 50 ~ 70 mm openings.

4.1.2 Pumping Plants

(1) Selection of the pump

Factors to be considered in the selection of pumps are the capacity, depth of the well and pumping level, inside diameter of the well, abrasive properties, total head, type of power available, and cost. In selecting a pump, the operating service characteristics should be compared to the manufacturer's performance characteristics of the selected pump for maximum efficiency and satisfactory operation.

The following pumps are adopted in terms of water sources in general:

Water sources	Pumps
River/reservoir/dug well	Centrifugal pump
Deep tube well	Deep-well turbine pump

When pumping requirements vary, it is common to install one or more pumps in parallel rather than to use a single large one. As the demand drops, one or more pumps may be shut-down, allowing the others to operate at maximum efficiency. Moreover, this arrangement allows easy maintenance of each pump in turn.

(2) Design aspects

The pumping capacity should be based on the maximum water supply volume. The recommended maximum pumping period may be 20 hours per day, as pumps need a rest period.

4.1.3 Tube Wells with Handpumps

Up to now, various kinds of handpump wells have been constructed by donor agencies, such as DANIDA, FINNIDA, and others. This guideline refers to DANIDA handpumps, whose detailed designs are shown in DANIDA Reports.

(1) Well types

The Handpump wells are divided into shallow wells and deep wells.

The shallow wells have an average depth of 15 m, with the cylinder approximately 1m above the bottom of the well. The overview drawing is shown in Figure D.3.

The deep tube wells have an average depth of 48m, and a cylinder setting of 23m. The overview drawing is shown in Figure D.2.

Both well types are provided with Modified MK II pumps. All spares, however, are interchangeable between the two well types, and all conform to the Sri Lankan Standard for reciprocating deep tube wells.

(2) Design criteria

On average, each well serves 20 families of around 5 persons each, and the design criteria are:

a) Average consumption: 30 l / capita / day, corresponding to a minimum hourly yield of 0.3 m^3.
b) Maximum distance from the well to the furthermost household: 200 m.

4.2 Transmission Supply Facilities

4.2.1 Hydraulic Design

The hydraulic design of conveyance pipeline may be based on the Hazen-Williams formula for large diameter pipelines more than 75 mm, and the scobey formula for small ones less than 75 mm. Respective formulas are showing as follows :

(1) Hazen-Williams formula

$$V = 0.35464 \cdot C \cdot D^{0.63} \cdot I^{0.54}$$

$$Q = 0.27853 \cdot C \cdot D^{2.63} \cdot I^{0.54}$$

$$D = 1.6258 \cdot C^{-0.38} \cdot D^{0.38} \cdot I^{-0.205}$$

$$I = Hf/L = 10.666 \cdot C \cdot D^{-1.85} \cdot I^{-4.87}$$

Where

C : coefficient values,
D : diameter (m),
I : slope,
Q : discharge (m^3/s),
Hf : friction head loss (m),
L : length of the pipeline (m),
V : velocity (m/s).

Six types of pipe with their C coefficient values are given below:

Type of Pipe	C (Hazen-Willians)	Ks (Scobey)
a) Cast - iron, uncoated	100	0.45
b) Cast - iron, coaltar or cement lined	130	0.36
c) Galvanized steel	100	0.45
d) Asbestos cement	130	0.36
e) Polyvinyl Chloride (PVC)	140	0.32
f) Concrete	120	0.40

Figure D.4 shows the graphical hydraulic discharge characteristics based on the H-W formula with the coefficient C as 100, 120, 130, and 140.

(2) Scobey formula

$$Hf = 2.59 \cdot Ks \cdot L \cdot V^{1.9} / 1000 \cdot D^{1.1}$$

Where

Hf : friction head loss (m),
Ks : Coeficient (avove tabel)
L : length of the pipeline (m),
V : velocity (m/s),
D : diameter (m).

The minimum velocity in the pipeline should not be less than 0.6 m/sec to prevent the deposition of silt. The maximum velocity should be limited to 1.8 ~ 3.0 m/sec to protect the water hammer.

4.2.2 Structural Designs

When preparing the structural designs the following aspects should be carefully considered:

a) The minimum earth cover of pipes should be 0.8 m except in roads where the cover should be increased to 1.0 m at least.
b) The gravity mains should be designed with the hydraulic gradient above the ground surface in order to prevent negative pressures and with air and scour values at high and low points.
c) Where the available head is too large, a break pressure tank(s) should be located at an appropriate place(s).

4.3 Treatment System

4.3.1 General

The object of water treatment is to obtain water of on approved quality, as shown in 2.2.3. The methods of treatment consist of the following standard procedures.

a) Plain sedimentation — slow sand filtration — specific treatment
b) Flocculant sedimentation — rapid sand filtration — specific treatment

Treatment, however, must be both economical and reliable and requiries capital investment and operation and maintenance. In the case of rural areas, it is assumed that a) is recommendable in terms of economic factors and easy operation and maintenance with only chlorination for specific treatment. The water sources containing levels of Fe, Mn, and others above the listed limits should be avoided for the rural water supply.

The following table shows the standard minimum treatment requirements for various sources:

Source of Supply	Recommended Treatment
1. Groundwater without iron	Chlorination only
2. Groundwater containing iron	
a) Iron removal without pH adjustment	Aeration followed by plain sedimentation, with or without filtration and chlorination
b) Iron removal with pH adjustment by chemical addition	Full treatment and chlorination
3. Irrigation tanks and canals	Slow or rapid sand filtration and chlorination

Source of Supply	Recommended Treatment
4. Small hill streams where turbidity is within the limits and the source is in a protected watershed	Chlorination only
5. Small streams where turbidity occasionally rises above 10 JTU's	In streams: roughing filter or slow sand filter and chlorination
6. Streams where turbidity is above the limit throughout the year	Infiltration system or full treatment and chlorination
7. Streams where turbidity and color are above the limit	Full treatment and chlorination

4.3.2 Chlorination

The capacity of the chlorinator will vary with the chlorine dosage needed for disinfection and the amount of residual to be maintained in the distribution system. The dosage will vary with the chemical and physical characteristics of the water. It also varies with the nature and concentration of pathogens in the water and the length of contact time. For design purposes, a chlorine dosage of 2 mg/l may be used for clear water. A minimum contact time of 20 minutes should be provided.

4.3.3 Plain Sedimentation

The purpose of sedimentation is to remove suspended impurities by gravity. The detention period in the sedimentation tank without subsequent filtration may be one to several days. The design criteria and tank dimensions of plain sedimentation under the filtrate system are as follows:

(1) Design criteria

a) Detention period : 8 hours
b) Average velocity of flow : 0.3 m/min

(2) Tank dimensions

a) Length to with ration : 2 to 4
b) Effective depth : 2.5 ~ 4.0 m
c) Sludge storage depth : 0.3 m

4.3.4 Slow Sand Filtration

The purpose of filtration is to separate suspended and colloidal impurities from water by passage through a porous bed, usually made of gravel and sand or other granular material. The types of slow sand filtration commonly used are described below:

a)	Influent Trubidity	:	less than 50 JTU (greater than 50 but less than 100 JTU for a few weeks)
b)	Filtration rate	:	100 ~ 150 l/hour/m^2
c)	Filter media	:	sand: 75 - 90 cm thick E.S.: 0.3 - 0.5 mm U.C.: 2.5m gravel: 20 ~ 30 cm thick in about 4 layers.
d)	Depth of water over sand	:	1.0 ~ 1.5 m.

4.3.5 Remarks

In this subsection (4.3 Treatment System), minimum, explanation was carried out for rural water supply use. Other methods up of grading, such, as flocculant sedimentation, rapid sand filtration, etc. should be instructed by the respective organizations when occasionally necessary.

4.4 Distribution System

4.4.1 General Factors

The water supply scheme should be designed for 24 hours continuous supply. Intermittent supply is neither desirable from a public health point of view nor economic. However, it may become necessary to provide intermittent service when the available supply is inadequate to meet the demand.

4.4.2 Storage

(1) Volume of Storage

In order to economize on the capacity of distribution storage, only equalizing storage should be provided initially, to meet the difference in supply and demand.

The amount of equalizing storage depends on the rate of inflow and consumptive pattern throughout the day. The local pattern of water use will produce hourly variations in the pattern of drawoff.

The period of supply of inflow should be carefully considered to minimize storage. It should be set up to preferable coincide with the drawoff period especially during high consumption hours. As a general guide and pending field data the following table may be used in estimating the storage requirements in rural communities for different periods of supply:

Daily supply period (hours)	Storage as of maximum daily demand
18 ~ 24	50
12 ~ 18	13
9 ~ 12	25

(2) Other remarks

Where intermittent pumping to slow sand filters results in intermittent filter operation which may be detrimental to the operation of the filter, sufficient storage should be provided ahead of the filters to assure continuous filter operation.

Distribution storage should be located as close as possible to the area of maximum consumption to minimize the cost of the distribution main.

Where possible, elevated storage tanks should be avoided to reduce costs and ground reservoirs installed. The reservoir side wall(s) should be designed as a partition wall(s) when expansion of the reservoir capacity is anticipated.

4.4.3 Distribution Network

(1) Pipe network

In general, a gridiron or loop distribution system should be provided in dense business and residential areas and dead-end supply in sparsely built-up areas, mostly adjacent to main roads.

The following criteria should be acceptable for design of the pipeline:

a) The minimum distribution pipe diameter is 50 mm when only stand posts are provided. If house connections are provided the minimum pipe size is 100 mm. When sizing distribution lines, the possibility of future extensions should be considered.
b) The service connections to stand posts and houses should not be less than 12 mm.
c) Water mains should be laid at least 3 m horizontally (edge to edge) from any sewer. Where this is not possible the bottom of the water main should be at least 0.5 m above the top of the sewer.

(2) Pressure requirements

Water distribution should have adequate pressure throughout the system. The mains are designed for supplying the ultimate demand at 6.0 m of minimum residual pressure:

- Rural supplies : 6 m
- Urban supplies : 9 ~ 12 m

The maximum static pressure in the distribution system should be not exceed 50 m normally.

4.4.4 Stand post Consideration

The locations of standposts should be selected in consultation with the local authority. In order to derive revenues to operate the water system, stand post supply should be limited to low-income users who cannot afford house connections.

The design criteria of the stand posts are as follows:

a) Single tap stand post
   - Number of users : about 100 persons/tap
   - Limit of distance : 200 m
b) Cistern stand post
   - Number of users : 700 ~ 800 persons/tap
   - Limit of distance : 500 m
c) Discharge at a tap : 0.2 ~ 0.3 l/sec

5. Cost Estimation

5.1 Construction Cost Estimation

5.1.1 General aspects

The construction cost should be estimated according to the following items:

a) An itemized list for each component
b) Materials and labor listed separately
c) The type of materials used and the size, quantity, and unit rates in the cost schedules
d) Permanent road reinstatement and disaffection bleaching powder required as separate items for pipeline estimates
e) Where electric power supply is required, the cost of substations and/or transmission lines should be obtained from CEB

5.1.2 Specific aspects

(1) Preliminaries

Between 0.5 and 1.0 % of the construction cost is set aside for the includes temporary office, scores, and transport of materials.

(2) Land acquisition

The land cost at the district level should be included if the land is acquired for the scheme.

(3) Maintenance of the scheme for 6 months upon completion

This cost is needed to start up and operate the scheme prior to handing over to the local authority.

(4) Board's overhead charges

Fifteen percent of the construction cost,is set aside for the investigation design, construction and administrative overhead costs.

6. Plans and Documents

6.1 Design Calculations

In preparing the engineering calculations files, the basis of the design, such as the design criteria used, size, capacity, and other factors considered should be described. Calculations should be complemented, if needed, with diagrams and sketches of the design details to be included in the construction drawings.

6.2 Preparation of the Engineering Drawings

6.2.1 Key Plan

In general, a layout of all the salient components of the proposed scheme should be shown in the key plan using an appropriate scale. A location map should be included as an inset in the key plan using a scale of 1 inch to 1 mile or 1:5000. Where there already is an existing scheme, it should be clearly distinguished from the proposed scheme by using a different notation.

The key plan should show the following general data:

a) Location of values, stand posts, diameter and length of each pipe, etc. as a description with legend.
b) Direction of north.
c) Title box with the drawing title, number, and signatures of the responsible offices.
d) Designed salient features, such as the supply volume, storage volume, pipe length of the respective diameters, etc.
e) Index of all drawings.

6.2.2 Flow Diagram

A flow diagram showing the schematic layout plan and profile of the salient tfeatures of the scheme from source to distributuion should be shown in the key plan or elsewhere. The schematic layout plan should include the hydraulic profile of the project elements showing the critical water surface elements with respect to ground levels.

6.2.3 Site Plan

Detailed site plans are prepared for the headworks, treatment works, reservoirs, and other structures of a scheme. The site plan includes the following information as needed:

a)	Levels	:	Benchmarks, ground, maximum flood level,
b)	Physical features	:	Access roads, power lines, buldings, etc.
c)	Boundary	:	rivate, public, extent of acquistion, etc.

6.2.4 Pipeline Layout and Longitudinal Sections

(1) Longitudinal sections

a) The vertical to horizontal scale is 1 to 5.
b) The pipeline trace is shown with distances and elevation of the ground and pipe size, length, slope, and materials.
c) The location and dimensions of all values and crossing of existing structures are shown in the longitudinal sections.

(2) Pipeline layout

a) The layout of the pipeline shows the type and size of the pipes as well as details relating to other elements of the scheme, such as the intake, reservoir, pump station, and distribution system.
b) The pipeline trace shows the permanent benchmarks.

6.2.5 Structural Layout Plans

The structural layout plans of the intake, storage tank, and treatment plant should be described in the following manner:

a) A scale of 1:20 to 1:50 is used for the drawings
b) Plans are prepared based on the contour survey plan
c) Details of the piping arrangements are shown in the plan
d) Sectional drawings show all the installation details, dimensions, pipe invert levels, ground elevations, and operating water levels.

6.3 Preperation on Summary Report

The main objectives of the Summary Report, shown in Table D.1, are to present the technical and financial details of the proposed scheme in order to define the scope of the engineering and funding commitments.

TABLES

TABLE D.1 FORMAT OF SUMMARY REPORT

Local Authority :	Repared by :	Date :
District :	Investigation File No.	
Electorate :	Design Caluculation File No.	

1. New / Augementation Scheme :	2. Pumping / Gravity Scheme :
3. Area of supply (part or whole of L.A.) :	
4. Design Year :	Design Period :
5. Design Population :	Present Population 19
6. House Connections allowed :	population Number:
7. Stand Posts allowed :	population Number:
8. Per Capita Allowance :	
a. House Connections: Averageay	_____ l/capita/d
b. Stand Posts Supply : Average	_____ l/capita/d
9. Institutional daily demand :	_____ lm^3/day (Number of connections .....)
10. Commercial and Industrial daily demand :	_____ m^3/day
11. Total Design capacity (Avg. day demand)	_____ m^3/day
12. Source of Supply (Assessed yield and quality of raw water)	
13. Major Elements of the Scheme (brief details)	
a. Intake:	
b. Low Right or Lift Pumping Sets (Raw water pumping):	
c. Treatment Plant:	

e. High Right or Life Pumping Sets (Treated water pumping):

Raw water:

Treated water:

f. Service Storage (Ground level / elevated):

i) Basis

Design hours of distribution:

Peak Flow Factor:

Min. Residual Pressure:

ii) Network (size and length)

14. Estimated Costs:

a. Construction Costs :

Headworks (up to and including the service storage) _____ Rs.

Distribution System) _____ Rs.

Total _____ Rs.

Funding Sources

Govt. Constibution: _____ Rs.

Local Contribution: _____ Rs.

Foreign Components : _____ Rs.

Unit Cost

Cost/capita : _____ Rs.

Cost /m^3: _____ Rs.

b. Estimated Annual Expenditures

i) Repayment on capital cost

ii) Operation & Maintenance costs

Personnel : _____ Rs.

Energy /fuel : _____ Rs.

Repairs / replacements : _____ Rs.

Chemicals : _____ Rs.

Miscellaneous : _____ Rs.

Sub-total O & M _____ Rs.

Total Estimated Annual Expenditure _____ Rs.

iii) Unit Cost of Annual Expenditures

Cost/capita : _____ Rs.

Cost /m^3: _____ Rs.

15. Estimated Revenues Based on Water Rates :

a. Fixed Annual Charge Rs...../month/premise and/or assessment on property: _____ Rs.

b. Private Connections

i) Domestic Consumption

Metered Supply:	@ Rs... / 5000 l	_____	Rs.
Unmetered Supply:	@ Rs... / month / premise	_____	Rs.

ii) Commercial / Industrial Consumption

Metered Supply:	@ Rs... / 5000 l	_____	Rs.
Unmetered Supply:	@ Rs... / month / premise	_____	Rs.

iii) Public Institutions:

Metered Supply:	@ Rs... / 5000 l	_____	Rs.
Unmetered Supply:	@ Rs... / month / premise	_____	Rs.
	Total Revenue	_____	Rs.

FIGURES

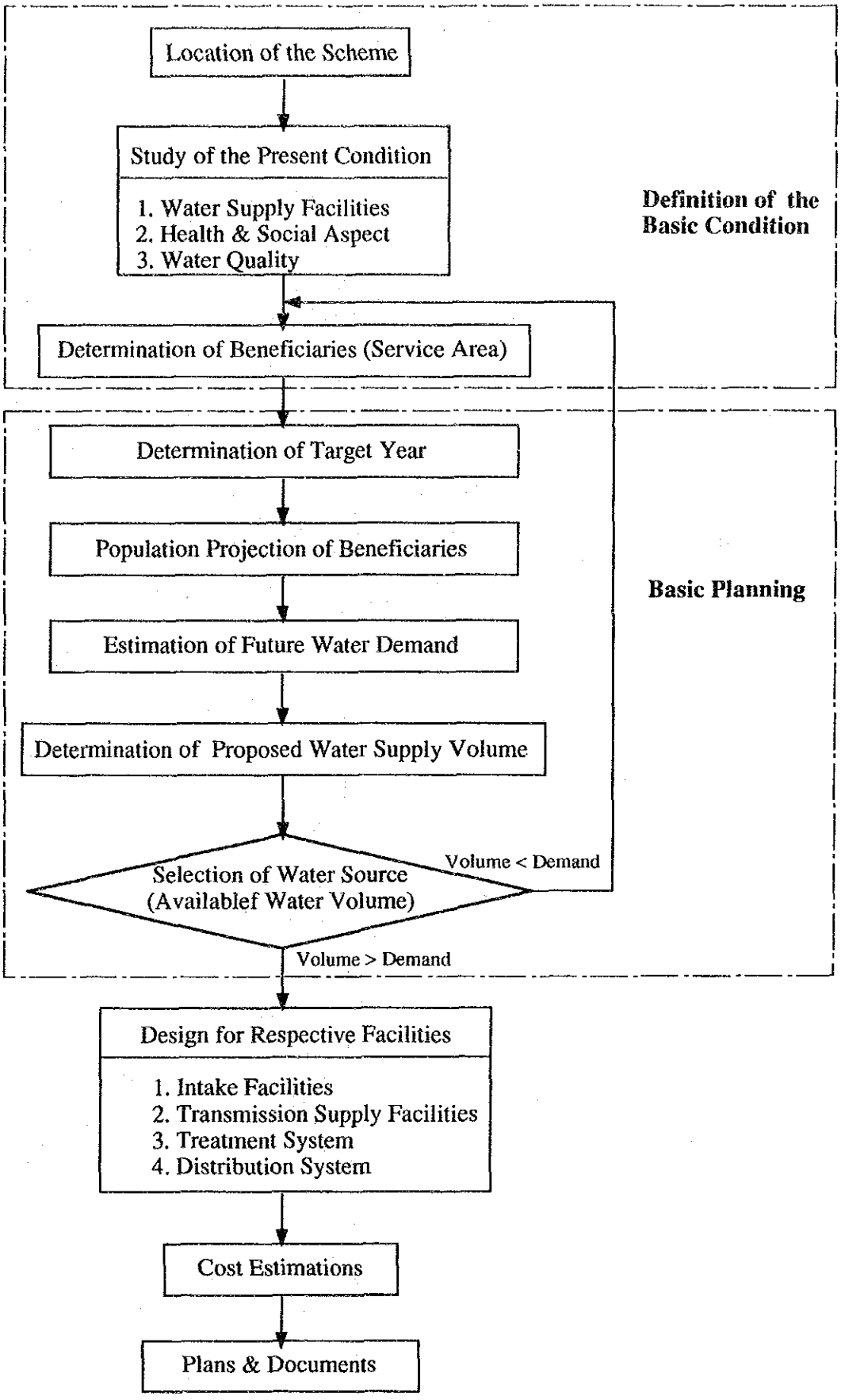


Figure D.1 **DESIGN FLOW CHART FOR WATER SUPPLY SCHEME**

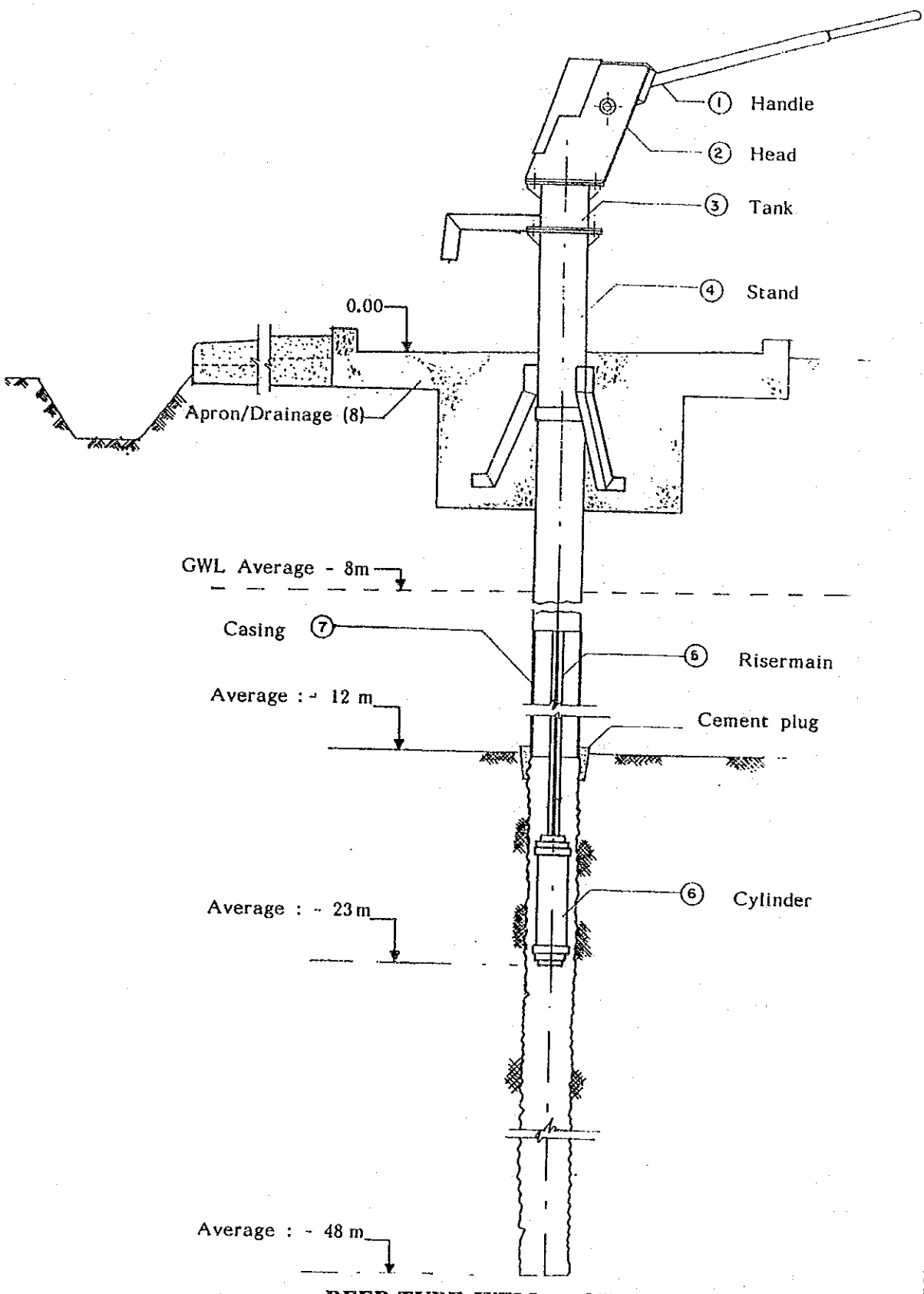
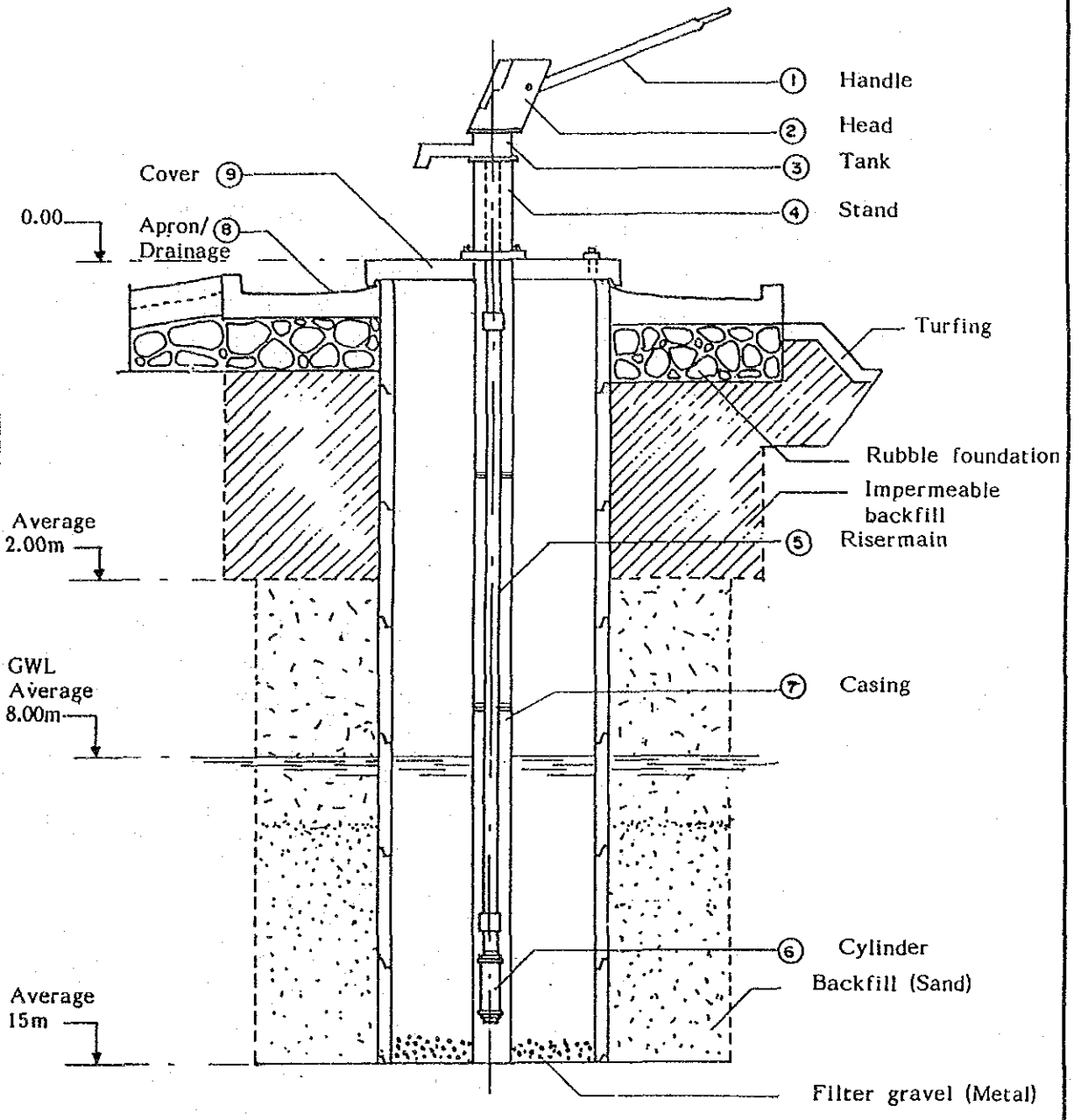


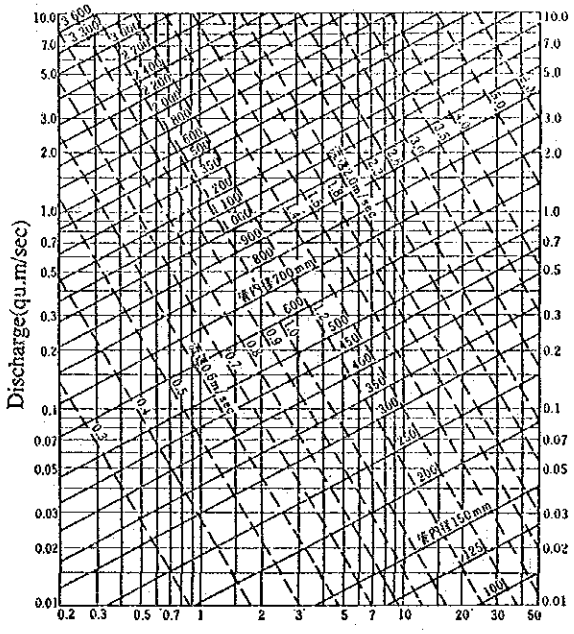
Figure D.2 **DEEP TUBE WELL - OVER VIEW -**



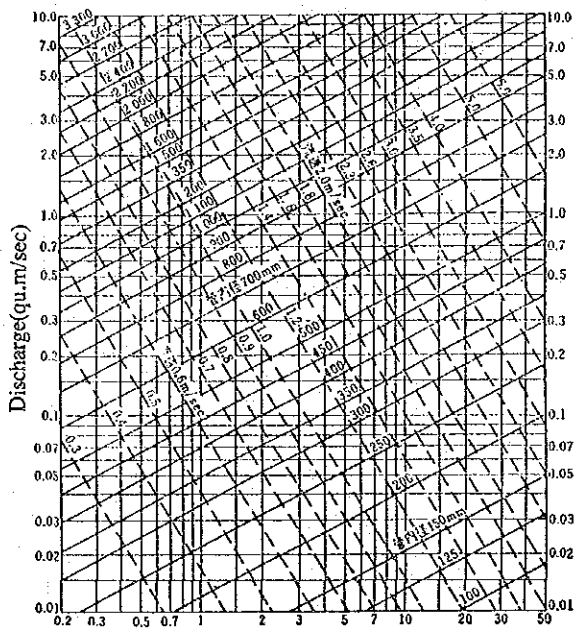
Note : The following parts are identical to the same parts in the Deep Well, Annex A :

- 3 Tank Assembly
- 5 Risermain Assembly
- 6 Cylinder

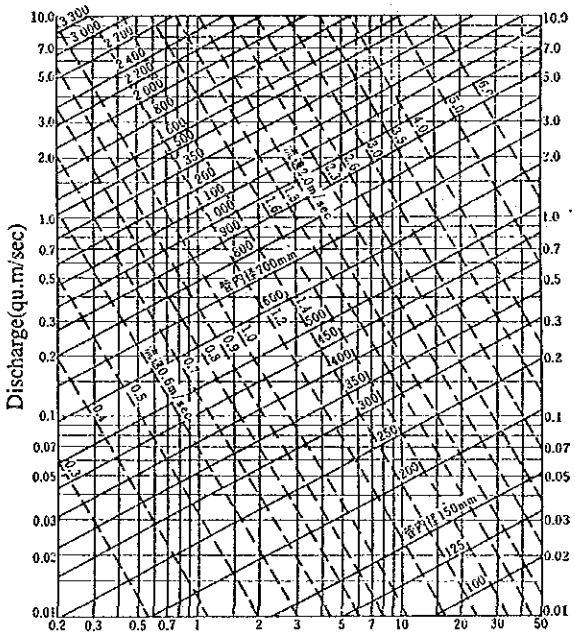
Figure D.3 **SHALLOW TUBE WELL - OVER VIEW -**



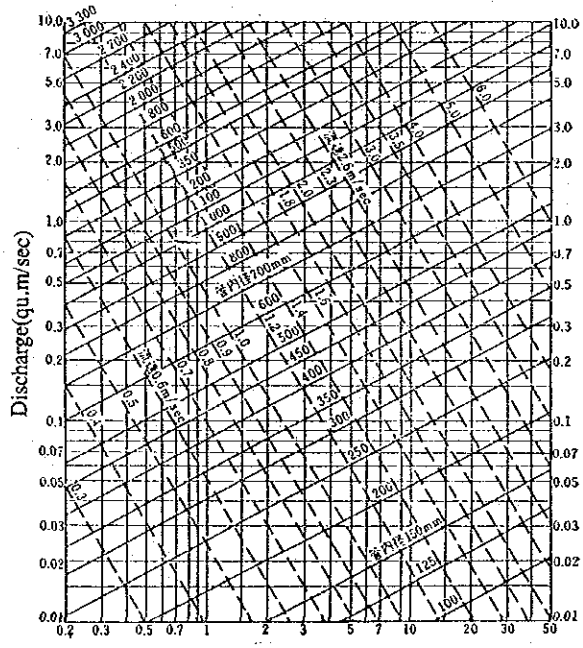
(C = 1 0 0)



(C = 1 2 0)



(C = 1 3 0)



(C = 1 4 0)

Figure D.4
GRAPHICAL HYDRAULIC DISCHARGE OF HAZEN-WILLIAMS

PLANNING AND DESIGN GUIDELINE FOR FARMLAND CONSERVATION

PLANNING AND DESIGN GUIDELINE FOR FARMLAND CONSERVATION

Table of Contents

List of Appendix

List of Tables

List of Figures

List of Reference

1. Watershed Management Field Manual, FAO
2. Soil Conservation for Small Farmers in the Humid Tropics, FAO
3. Soil and Water Conservation in Semi-arid Areas, FAO
4. Planning and Design Standard for Land Improvement Project, Japan
5. Handbook of Land Improvement Projects Planning, Japan

PLANNING AND DESIGN GUIDELINE FOR FARMLAND CONSERVATION

1. General

1.1 Objectives

This guideline is prepared as a tool for the planning of farmland conservation in the up-country area in line with the Up-Country Agriculture Development and Rehabilitation Project. The target areas of this guideline are the intensively and sparsely used agricultural lands except for the plantation estates in the up-country area, and the major users are the regional officers of the district and/or divisional levels who are in charge of farmland conservation.

The farmland conservation plan attempts to prevent and minimize the adverse effects of soil erosion by water by providing solutions and practices related to conservation and protection. The main objectives of the plan are to prevent farmland degradation and achieve sustainable conditions for agricultural development in the up-country area.

The scope of farmland conservation is very wide and encompasses much more than mere physical works for erosion control. It comprises a comprehensive approach to soil, water, and farm management, in which all physical soil conservation practices contribute only partly towards the overall targets of improving and maintaining soil fertility and soil-water-vegetation relationships, and through these the attainment of sustained high crop yields. Thus, farmland conservation is an important tool for achieving improvements and is of direct benefit to the farming population by dealing with soil erosion in the target area.

1.2 Types of Soil Erosion

In the up-country area, the following major types of erosion can be found. Since any combination of these four types of erosion could occur in the area, it is very important to identify the major causes which bring about damage in the actual project area.

a) Surface or sheet erosion, including rill and inter-rill erosion caused by raindrop impact and surface runoff,
b) Gully erosion, including continuous and noncontinuous gullies formed by surface runoff over exposed soil,
c) Channel erosion, mainly caused by the velocity of runoff water in the waterways, and
d) Mass soil movement, including landslides, mud flows, and debris avalanches.

1.3 Constraints of Planning

(1) Human behavior

The human element is probably the most serious limiting factor in carrying out improvements on farmlands. Pressure on the land by a rapidly increasing rural population has been the cause of most of man's destructive activities. The need to produce more and the constantly decreasing cultivated area per household have caused the conversion of marginal areas into cultivated fields. The result is accelerated erosion on steep hillsides, which should not have been cultivated at all.

(2) Fragmentation

Hereditary laws and the fragmentation of lands may sometimes prevent any physical work for the conservation of small and scattered plots of individual farmers and whole communities. Soil conservation practices have to be applied irrespective of the irregular boundaries of the small plots. On sloping uplands, often intersected by uncultivable plots and changing slopes, individual plots are scattered over large areas and have a wide variation of use suitability. Since the land consolidation under such conditions is difficult, an agreement among farmers to conduct soil conservation without regard to the boundaries of individual owners is the minimum requirement, though it is only a temporary solution. The selection of soil conservation measures depends to a large degree on the land consolidation, cooperation between farmers and other aspects which may be different in each locality. It is important to investigate and fully comprehend these prerequisites to prevent a patchwork approach which would lead to certain failure.

2. Investigations for Planning and Design

2.1 Preparation of Topographic Maps

(1) Topographic maps of in and around the project area should be prepared with an appropriate scale for planning and design.

(2) Topographic maps should be used for calculation of the catchment area, estimation of the runoff volume and erosion load, and layout of conservation facilities.

(3) In principle, the following scale should be used for preparation of necessary maps:

- Topographic map	:	1/2,500 - 1/5,000 scale (5 m contour lines at least)
- Drainage system map	:	1/2,500 - 1/5,000 scale
- Soil map	:	1/2,500 - 1/5,000 scale
- Land use map	:	1/2,500 - 1/5,000 scale

- Erosion damage map : 1/2,500 - 1/5,000 scale
- Others, such as longitudinals and cross sections of the main and secondary drains.

2.2 Field Survey of Topography, Geology, and Soil Conditions

(1) Additional and supplemental survey should be conducted to obtain basic data related to topography, geology, and soil conditions in and around the project area.

(2) Soil erosion in the project area depends on the site-specific conditions of topography, geology, and soil. Thus, the gradient of farmlands, slope of terracing lands, and site-specific characteristics of topography, geology, and soil should be clarified on the maps.

(3) The gradient of farmlands should be classified into 4 groups: < 8° (<15%), 8-15° (15-25%), 15-30° (25-60%), and > 30° (>60%).

2.3 Investigation of the Land Use Pattern

(1) The existing land use pattern in and around the project area should be investigated carefully, because it could be the essential factor for the planning of the drainage system.

(2) Land use maps which categorize paddy, upland, grassland, forestland, and barren land, should be prepared by field investigation.

(3) In the upland cultivation area, the type of crops, coverage by crops, and direction of ridges during the rainy season should be checked in the field investigation.

2.4 Collection of Meteorological Data

(1) Meteorological survey, including specific items, such as daily maximum rainfall, hourly maximum rainfall, maximum duration of rainfall, and probability of occurrence of them, should be conducted in and around the project area.

(2) The records of meteorological data in the last 10 years (30 years for specific items) should be collected from the adjacent gauging stations.

(3) The items of meteorological data to be collected are: the mean temperature (monthly and annual), mean rainfall (monthly and annual), and number of rainy days (monthly and annual).

2.5 Drainage and Water Use Network Survey

(1) Since the improvement of the drainage system is to be one of the important components of the farmland conservation project, a detailed survey related to the

existing drainage and water use system should be conducted in and around the project area.

(2) Rivers and channels which will receive the runoff water from the project area, are to be investigated carefully, especially in terms of the cross section, high water level, flood discharge, management of rivers and facilities, and existing flood control plan.

(3) The drainage network, discharge from the upper reaches, runoff water to the lower reach, and conditions of soil erosion should be investigated based on the existing data, inquiry survey of the local people, and field survey.

(4) Information related to location, scale, capacity, and maintenance of drainage facilities, such as channels, canals, and gates should be collected and plotted on a drainage network map.

(5) The location, structure, and capacity of irrigation facilities in the downstream area which receive runoff water from the project area should be carefully examined through the existing documents and field investigation.

(6) Based on the collected data and information, a current drainage and water use network map should be prepared for in and around the project area.

2.6 Road Conditions

(1) Road conditions, such as the layout, width, structure, and surface erosion should be investigated in and around the project area.

(2) As for the roads that ara heavily eroded, more detailed information, such as gradient, condition of the road surface and drains, degree of erosion, and impact on farmland conservation should be obtained at the same time.

2.7 Investigation of Farmland Conservation Facilities

(1) Information on existing and planned farmland conservation facilities, such as sabo works and river training and slope conservation works in and around the project area should be collected, and their locations are to be plotted on a map.

(2) The data to be collected on the facilities are: the year of construction, organization of maintenance, construction method, scale, structure, capacity, and effect.

(3) Information related to the agronomic measures for farmland conservation should be collected in the project area.

2.8 Agronomic Conditions

(1) The cropping pattern and land ownership in the project area should be investigated for consideration of the appropriate agronomic practices which contribute to soil erosion control.

(2) The items to be surveyed are: major agronomic types, number of households, cropping area, income, number of livestock, agricultural machinery, cropping pattern and period, agricultural methods, and agronomic measures for prevention of soil erosion.

2.9 Damage by Soil Erosion

(1) A combination of four types of erosion, namely surface and sheet erosion, gully erosion, channel erosion, and mass soil movement, can occur in the project area. Thus, it is very important to identify major causes which bring about serious damage.

(2) An erosion and sedimentation survey should be conducted to delineate project areas requiring immediate conservation measures. Survey areas being deemed critical due to severe soil erosion should be subjected to a detailed investigation for preparation of a farmland conservation plan.

(3) Qualitative and quantitative analysis of damage caused by flood and soil erosion including costs for reconstruction and rehabilitation should be conducted in and around the project area.

(4) The magnitude and seriousness of damage should be evaluated for selection of the priority areas.

(5) It is important to prepare a data base for the farmland conservation plan in the project area. The items to be observed are as follows:

a) Inventory and characterization of critical areas of soil erosion,
b) Survey data of gullies, creeks and waterways, and sources of sediment materials,
c) Location of actual sites where erosion control structures are to be installed,
d) Survey of available local technology and materials for erosion control, and
e) Local institutions actively involved in farmland conservation.

2.10 Consideration of Farmland Conservation Measures

(1) By considering all the survey results mentioned above, cause-effect relationships and proper mitigation measures should be considered for farmland conservation.

(2) Then, priority areas and project components should be identified for formulation of a farmland conservation plan.