RUIDP

Government of Rajasthan
Office of Project Director
Rajasthan Urban Infrastructure Development Project
AVS Building, Jawahar Circle, JLN Marg, Jaipur - 302017
Tel No.: 0141-2721966, Fax No.: 0141-2721919, email : mail@ruidp.gov.in, web site : www.ruidp.gov.in

F3 (106) (32)/RUSDIP/PMU/CMS/2007/19223 Dated:4.03.2008

Sub: Design & Construction Management System: Circular –8.
Ref: General guide lines for Drainage Sector work to be taken under RUSDIP.

The importance of adequate & efficient drainage to the structural integrity of other sector is well recognized as such it is to be planned in phased manner and with this view major short, medium & long term intervention are proposed in the fifteen towns under RUSDIP. Following are the common guidelines to be followed while developing drainage strategies for RUSDIP:-

System Design & Preparation of Master Plan

1) Any drainage plan for a RUSDIP city must begin with describing its physical & administrative dimensions, its population the ecology & its economic frame work of particular importance, a full description of the flood prone areas, including depth of floods, their frequency, and the number of hours or days the area is flooded within a particular time period, history of past floods, topographic / contour etc. The flood prone areas should be clearly marked on the city map. The availability of water supply and the means of discharging wastewater and surface drainage, the slope and contours of the land, the rainfall characteristics, and subsoil characteristics are the principal elements of consideration. In addition, environmental impact of the drainage system and the planned land development should be taken in account. A description analysis of the general topography, soils and physical features such as wooded areas, agricultural land, waterways, water bodies, flood plain areas, storage ponds, roads, political boundaries, and other existing infrastructure that may affect the general appearance and future use of drainage system, their modification with possible alternatives which will be technically, economically & environmentally viable Selection and description of final discharge / outfall point will be necessary.

2) The drainage plan of city must provide the means to accommodate future needs and likely changes in the city in next 30 years i.e. upto design year 2041 & plan for them which may not be clearly defined now. At the same time, it must be sufficiently practical to be adopted today, and must be financially feasible under present circumstances. The City's Master Development Plans must be taken into full consideration, and the report should explain how the drainage plan will accommodate the future growth of the city.

   The survey of existing drainage system with their, width, depth, length and slopes should be done and their capacity should be determined. Drainage zones to be delineated for both the existing drainage system and proposed drainage system based on the contours.

3) The drainage report should contain maps as well as a written description of the land use of the general area. The report should clearly show, by appropriate maps the assignment of land to residential, commercial, industrial, and public

lands, etc. It need not to go ıto great detail but should illustrate the designer's intentions.

4) Records of rainfall, stream flows, reservoir levels, and other pertinent data such as major reasons for the failure & deficiencies of existing storm water drains should be obtained from the relevant agency. The raw data may be included in appendices.

5) Consideration must be given to the previous studies and expert opinion regarding the economic aspects of the areas, Census data, past population data, and estimates of the probable future developments and changes in land use. The report should describe social characteristics of the area that affect the location and number of facilities used to serve the population.

6) A matter to be investigated and thoroughly studied during the concept and detailed design stages is the provision of adequate facilities for handling the storm water runoff. Topographic maps will be useful for preliminary planning, while detailed topographic survey (longitudinal surveys and cross sections), levels of the city area in a grid are an essential prerequisite for final design. Natural channels usually provide the most economic means for conveying surface drainage, but the quantity of water to be conveyed, existing features and constraints, and improvement costs are the main considerations when choosing between a closed conduit or an open channel.

7) The proper assessment & conditions of sub surface utilities, strata & water are very important for the execution of drainage system. This should be ensured before designing of the system & needs to be properly quantified. Accordingly provisions should be taken in the estimates & BOQ.

8 It is desirable to start the design considering the levels at the outfall of drainage locations of drainage system so that the level and bed slopes of the drains are fixed accordingly as per outfall to allow discharge to pass using gravity flow. While in the most cases, it would be possible to drain out the water using gravity flow, in some location pumping may be necessary and should be critically examined to avoid it with various other alternatives. Some of the important locations where special attention required are:

   a. Underpasses & Subways
   b. Rotaries
   c. Fly over & bridges
   d. Medians

9) Natural features such as rivers and streams, ridges, troughs, woodlands, water courses, ponds and lakes, wetlands, etc., should be utilized to as great a degree as possible to convey the storm water flows and/or retard the rate of runoff and minimize the design discharge. Logs of test wells and producing wells might be available with data such as strata of soils, elevation of groundwater, and location of rock. Locations of unfavorable subsurface conditions should be clearly shown. Where existing information is not available for the area, it is essential that subsurface investigations be completed before the final design. Rock at a shallow depth must be considered for the drainage plan. A water table close to the surface could be of great significance to the designer and should be mentioned if applicable.

10) Structural interventions should be designed with simplicity and ease of maintenance topmost in mind, and complementary non-structural interventions should be recommended in the reports. Examples of these are solid waste management improvements, removing encroachments, public awareness campaigns, improved operation and maintenance procedures, introducing building controls for flood prone areas, and preservation of ponds, water bodies and wetlands.

It is generally not possible to take up work for the whole city at a time and the work may have to be prioritized. A method of prioritizing can be:

(a) Areas where lack of a drainage system is creating unhygienic living conditions or unacceptable odor levels, e.g. areas with a high population density and no drainage system.
(b) Areas where the quality of the ground water is adversely affected by permeable storm water and the ground water is a source of drinking water.
(c) City centre, commercial centre and the more densely populated areas of the town.
(d) Flood prone roads and areas.

The drainage report should delineate the various catchment areas on the contour map at an appropriate scale. The catchment area map should indicate the main features to be used for the design and should include such item as catchment area sizes, topography, channel slopes, land use and respective runoff coefficient, design rainfall frequency and intensity, design channel flows, location of major structures (existing and planned), critical elevations, flood prone areas etc.

13) General Considerations in Design of Storm Water Drain :

(a) Drain should be planned taking into consideration the ground levels, slope of the ground, valley and ridges and also the land uses planned for urban development.
(b) Drains should be planned to get good longitudinal slope, considering the nature of soil, water level. Drainage of large area can be better achieved by subdividing it into small grids to avoid a long main drain. Aim should be to get a higher velocity for the dominant flow.
(c) Efficiency in maintenance of drainage system should be an important consideration in selecting the size, (covered or open) shape and the location. The specification of the drain should also aim at preventing the possibility of ingress of other extraneous materials, debris, rubbish, vegetation etc. Where gratings are provided on drains, they should so located as to attract attention of maintenance staff, easy to approach inspect and clean it.
(d) An attempt shall be made in the design to provide higher starting and higher outfall bed levels in drains. A free outfall shall be attempted as far as possible.
(e) Design of main drain shall be so made as to allow use of normal methods for desilting operation.
(f) Inlets to the drains to be properly designed and located.
(g) It is always desirable that run off from the catchment areas outside the city boundary should be taken by suitable drain layout to bypass the township.

(h) The design flow will be the runoff from rainfall only. No other wastewater of the community will be taken into account.

Management and Maintenance of the Drainage Systems:

4) The capital cost involved in construction of drain forms a small component of the total expenditure involved in providing the infrastructure in the form of carriageway, footpath, medians, street light and other street furniture. Like any other capital asset, storm water drainage system also needs constant maintenance, if the investment is to serve the purpose it is meant for. The need for a good storm water drainage or absence of it is felt by many only during certain days of the year.

15) The drainage system is at its best when it is maintained as properly as designed. For this purpose it is necessary that drains keep their shapes and slope in designed manner during their life time. It is also necessary to ensure that the drains retain their full cross section, particularly for the monsoon. The system of maintenance can be classified into following three categories:

a) Continuous regular maintenance
b) Periodical maintenance
c) Special maintenance/ Repair for improvement

The extents of these repairs depend upon size of the drain, location of the drain, nature of habitation nearby and cross drainage structures. The difficulty in maintenances is also caused by a lesser degree of consciousness/ civic sense. Malba, garbage, solid waste and road cleanings enter the drain resulting in silting and solid crustation of extraneous material making the maintenance difficult and poor efficiency of drains. Inlet of Drains to be maintained properly for the entry of storm runoff. A broad check list is given in Appendix A-3 of IRC-SP–50 may be referred to which by no means is exhaustive.

Periodical inspection and maintenance of drains is very necessary as failure of drains may occur due to deficiency in maintenance rather than defect in design. The principal activities may be:

a) De-silting;
b) Cleaning of weeds;
c) Cleaning of obstruction, debris and blockage;
d) Repairing of lining immediately at the commencement of damage or deterioration.

Continuous action and attention to detail are important aspects pertaining to maintenance programmers. It is very essential that maintenance unit have all the drawings of existing drains showing all technical details on ground. The drain should be identified by suitable numbering with proper chainage. It should be the Endeavour to ensure that works are maintained as per details shown in inventory prepared just after completion of the drainage scheme.

18) The cleaning routine should indicate clearly the work to be done, the frequency for that work, the equipment and labour to be used and most important any safety measure and equipment required. Though, it is not practicable to assign individual frequencies for each element as a routine for each area, it should be

such to ensure that various elements are cleaned before the drain gets blocked For different localities, it may have to be based on local experience.

It is common practice that all drains are de-silted thoroughly before on set of monsoon. All kutcha side drains dressing and deepening before monsoon. It is also essential that all drains are in a state of repair and the works of re-grading, reshaping, or profile correction wherever required is completed well before the onset of monsoon.

During the rains also, a watch should be kept at the exit and entry point for water for the presence of undesirable collection of rubbish, polythene, paper bags blocking the passage of water and in everyway ensuring free unobstructed flow of rain water. During rains specially after heavy showers all cross drainage structure should be inspected to observe any blockage due to debris, log of wood and other such materials. A watch on the deficiencies in the drainage system should be kept and problem locations identified and record kept. Necessary corrective measures should be adopted immediately after rains. A watch on missing manhole covers and broken covers is also required to be kept and replacement/repairs carried out on priority to avoid accidents.

Design Criteria

The design of drainage system should generally follow the guidelines recommended in Indian Road Congress, CPHEEO manual on Sewerage and Sewage Treatment or other relevant codes with proper justification for deviation or modification if any and should involve:

- ✓ Calculating the total discharge that the system will require to drain off.
- ✓ Fixing the slope & dimensions of the drain to have adequate capacity to carry the discharge and afford proper maintenance.

The discharge is dependent upon intensity and duration of precipitation characteristic of the area and the time required for such flow to reach the drain. The storm water flow for this purpose may be determined by using the rational method, hydrograph method, rainfall run off correlation studies, digital computer models and empirical formulae. The empirical formulae that are available for estimating the storm water run off can be used only when comparable conditions to those for which the equations are derived initially can be assured of the different methods available, rational method is most commonly used and serves the purpose for design of drain satisfactorily.

The cost of any drainage structure depends on its size, which depends heavily on the return period adopted by the designer. This, in turn, depends on the level of protection that is deemed to be adequate for reducing the potential costs of flood damages and minimizing inconvenience to the public. As such, the decision on what return period to adopt for design purposes is the result of an informal cost/benefit analysis – where the potential for damages is low or costs are small a short design return period is usually considered adequate, but where the potential for damages is high or where failure would endanger expensive property, then a longer (more conservative) return period is selected.

Typical design return periods, which are recommended to be used for different types of urban areas are provided below. The drainage report should justify any amendment to these values.

Area Characteristics	Design Return Period
Low valued and residential areas	2 - 5 years
Higher valued commercial/industrial areas	5 - 10 years
Critical areas: significant potential for damage/inconvenience	10 - 25 years
Major culverts, bridges, etc. for National and State Highway	25 - 50 years
Dams, reservoirs, etc.	50 - 100 years

Most RUSDIP city areas may adopt a design return period of 1–2 yeas. CPHEEO manual is desired to be followed. Likewise, for most of the culvert and bridge return periods will be 25 and 50 years, respectively. The DSC may modify these particular design return periods if, in the DSC's best professional judgment, the local conditions justify it.

25) Based on the practice being followed in metropolitan cities in our country & cost consideration in mind, it is recommended that a return period of 1 to 2 years be adopted for estimation of runoff.

Time of Concentration: - It is the time required for the maximum run off rate to develop. It is equal to time required for a drop of water to run from the most remote point of the catchment area to the point for which the run off is being estimated. Empirical formula (IRC-SP:50) may be used to determine the time of concentration.

$$t_c = (0.87)\,\frac{(L^3)^{0.385}}{(H)}$$

Where

t_c = Time of concentration in hours

L = Distance of critical point to the drain in Km

H = fall in level from the critical point to the drain level in meters.
(for details ref: IRC: SP: -50 –1999 page 12& 13)

Rainfall Intensity: - It has been observed that shorter the duration of critical rainfall, the greater would be the expected average intensity during that period. For example, during a 30 minute rainfall, some 5 minute period, or any period less than 30 minute, will have an average rainfall intensity greater than of the whole storm. The critical duration of rainfall will be which produces maximum runoff. This duration is equal to the time of concentration, since shorter periods do not allow the whole area to contribute water, and longer duration will give smaller average rainfall intensity. The problem thus reduces to one of establishing a relationship between time of rainfall duration and probable or expected rainfall intensity. For design purpose high intensities are of importance.

The rainfall intensity (I) in mm/hr will depend on design return period (storm frequency) selected by the designer, and on the time of concentration (t_c) for the storm water flow to reach the section being designed. Initial inlet times may range from 5 minutes for a steep slope on an impervious to 30 minutes for a slightly sloped city street; usually an initial inlet time of 5 to 10 minute is assumed for design purpose.

9) It is also added that as per practice being followed in most of the metropolitan cities, the calculation of runoff is being carried out using hourly rainfall intensity for a return period of one to two years. This is primarily for simplicity of

calculation. However, for a large drainage system, it is recommended that calculations be carried out on the basis of detailed analysis as the efforts may worth the savings in cost.

The designer will need to develop rainfall intensity-duration curves that are appropriate for each city, based on historical rainfall data, and use them for determining the appropriate rainfall intensity (I) for use in the critical rational formula. To do this, historical rainfall records covering several years will need to be obtained. The rainfall data may be obtained from the Meteorological Department, Government of India. For RUSDIP we suggest minimum period of 15 years, including at least one year with a major flooding event. From these records, rainfall intensities are to be computed corresponding to storms of 1,2,5,10 ,25,50 and 100 year frequencies and corresponding intensity duration curves can be developed.

Appendix 1 gives an example calculation of rainfall intensities for various durations by return period. Comparative rainfall intensity curves (intensity (I) in mm/hr v/s time of concentration in minutes) for different return periods should be developed and presented as a figure as mentioned in (30).

Rational Formula for Estimating Peak Run Off Rates

For small water sheds not exceeding 50 km^2, as in the usual case for urban drainage system, the rational method is widely used for estimating the peak run off rates. The formula is

$$Q=0.028\ PAI_c$$

Where,

Q= Design peak run off rate in cum/sec
P= Coefficient of run off for catchments characteristics
A= Area of catchments in hectares
I_c= Critical intensity of rainfall in cm per hour (corresponding to the design time of concentration (T) in hour and return period selected)

For the catchment areas exceeding 50 km^2, Bell's formula should be used for working out of the rainfall intensity and accordingly the design discharge.

The best possible estimation of peak run off rate is possible where the gauge records of rainfall are available from the automatic rain gauge recorder. An example for the same is presented in Appendix 1.

If only maximum day rainfall is collected, the intensity of rainfall in cm/hr can be calculated as follows (IRC: SP - 13 - 2004 Page 8 - 11)

$$I_c \qquad F / T\ (T + 1 / t + 1)$$

In which,
F = total precipitation
T = duration of the rainfall
I_c = is the intensity of rainfall for a duration of t (time of concentration)

The coefficient of run-off (C) is the portion of precipitation that makes its way to the drain. Its value depends on a large number of factors such as permeability of the surface, type of ground cover, shape and size of catchments area, the topography, geography, initial state of wetness and duration of storm. The value of 'C' commonly adopted for used in Rational Formula is given in Table:-

Table - Values of Co-efficient of Run-off

Sl.No	Description of surface	Coefficient of Run-off (C)
1.	Watertight pavement surface (concrete or bitumen), steep bare rock	0.90
2.	Green area (Loamy)	0.30
3.	Green area (Sandy)	0.20
4.	Unpaved area along roads	0.30
5.	Lawns and parks	0.15
6.	Flat built up area with about 60 percent area impervious	0.55
7.	Moderately steep built up area with about 70 percent area impervious	0.80

If any change is expected in the land use pattern in the contributing area during the life time of the drainage system, consideration for same should also be taken in the design. It is a common practice that the run-off coefficient for the whole area is derived after estimating or ascertaining the proportion of the various surface to the whole area. Some common figures adopted for coefficient of run-off are given in Table below. It is also to be remembered that run-off coefficient tends to become larger as rain fall continues due to filling of depressions in impervious surfaces and soaking of the upper layer of exposed soil.

Table -Co-efficient of Run-off for Various Surfaces

Sl. No.	Description of surface	Coefficient of Run off
1.	Most densely built up areas	0.7 to 0.9
2.	For adjoining area to built up areas	0.5 to 0.7
3.	Residential areas	0.25 to 0.5
4.	Sub-urban areas with few building	0.10 to 0.25

36) **Hydraulic Design**

Design of Drain Section:
Capacity of the drain is normally designed using Manning's formula

$$Q = (l/n)\, A\, R^{2/3}\, S^{1/2}$$

And

$$V = l/n\, R^{2/3}\, S^{1/2}$$

Where
Q = discharge in cum/sec
V = Mean velocity in m/sec
n = Manning's rugosity coefficient
R = Hydraulic mean radius which is area of flow cross section divided by wetted perimeter.
S = Gradient of drain bed
A = Area of flow cross section in m^2

The coefficient of rugosity for various surfaces given in IRC:SP:42 may be referred. Some average values are however indicated in table for general guidance:

S.no	Type of Surface	Value of n
1	Brick pitched drain	0.017
2	Plastered brick masonry surface	0.015
3	Plastered brick masonry surface with neat cement finish	0.013
4	Concrete pipes* Upto 600 mm dia Above 600 mm dia	 0.013** 0.015**
5	Dry rubble masonry	0.033
6	Dressed ashlar surface	0.015
7	Dry stone pitching	0.020
8	Katcha drain	0.025

*- However it is desirable that in drains S&S joint concrete pipes should be used for which value of n should be considered as 0.011.

38) **a) Velocities**

S.no.	Type of drain	Minimum m/sec	Maximum m/sec
1	Internal drain (brick pitched or plastered)	0.45	1.5
2	Intercepting and main drain (brick pitched or plastered).	0.75	1.5
3	Pipe drain (running full)	0.75	1.8

Suitable judgment has to be made to use maximum velocities to ensure a section of drain which will pass through a narrow road width.

The designer may select any internationally accepted design standard for open channel flow as well as for retention basins, flow control structures, culverts, drops, manholes, and other hydraulic structures, but must clearly state what these are and justify them. We recommend that the Manning's Formula be used for calculating the velocity of flow (and discharge) in open channels; [See Section (36)]

To ensure self cleaning of the drain, a minimum velocity of 1.5 m per second may be desirable, which may require installation of concrete drains or paved drains. In urban drainage maximum velocity should be tried to be achieved to have minimum cross section of the drain keeping in mind the limited availability of space on the road sides and should be paved to consider the same. The max velocity may be considered to the extent of allowable velocity to prevent erosion as detailed in IRC-SP-42 table 6 which mentions up to 6m/sec in cases of rock surfaces and paved drains.

b) **Free Board:** Generally adopted free board is as follows:

S. No	Drain size	Free board
1	300mm bed width	10cm
2	300mm & upto 900 mm bed width	15cm
3	900mm & upto 1500 mm bed width	30cm

In RUSDIP, in the design free board should be avoided.

c) **Minimum section of drain:** It should be possible to clean the drain periodically using a spade. Accordingly, it is recommended that minimum width of a drain should not be less than 250 mm. In case of pipe the minimum diameter should not be less than 450 mm.

d) The effective section of the drain carrying design discharge should be considered below the bell mouth pipe so that there is no back flow of water on to the road.

39) **Channel Shapes**: The usual channel shapes are:
- i) Parabolic
- ii) Trapezoidal
- iii) Rectangular
- iv) Triangular or V shaped

The parabolic profile is considered to be best for hydraulic flow but its actual construction and maintenance is difficult. The V shaped drain is not very popular in urban areas as its de-silting is difficult. The trapezoidal and rectangular sections are easy to construct and are considered most suitable. In urban areas all drains passing through built up area and near to bus stand, crossing etc should preferably be covered so that the drains are not used as dust - bins. Even if drains cannot be covered in the initial stage due to economy reasons provision should be available for covering it at a later stage. However, it should be kept in mind that pipe drains are difficult to de-silt and maintain.

Economical sections (for lined drains)

As far as possible, for obtaining economical sections the relation between bed width and depth shall be as follows:

i)	Rectangular drain	b=2d
ii)	Trapezoidal	b= 0.82 d (1:1 side slope)
		b= 1.24 d (1/2: 1 side slope)

For main or trunk drains the side slopes should be 1:1 or ½: 1 depending upon nature of soil and availability of land.

41 **Silt Pit:** A silt pit shall be constructed at all the inlet points of every covered drain and also provided with vertical grating in order to avert entry of floating material into the drain.

Drainage over surface: All surface water is initially drained over the surface before it is collected in the drainage system. The drains are located along road side and the water is let into the drain through gulleys, bell mouths or other such water entrances. Minor roads in residential areas are narrow and it may be difficult to provide separate space for drains. In such cases the water can be allowed to flow in kerb channel which can be led into the main drainage system where the minor street meets the main road. Beside saving in the cost of drain the water is kept at higher level which may help either in reducing the depth of drain at downstream or provide a better gradient and reduce silting and other maintenance problems. Another advantage is that the water takes longer to enter the drain and reduce the peak flow.

Drainage through open channel: The open drains along the road side definitely have to be away from the shoulders or the berm and require additional space. They are easier to maintain and allow removal of silt and other solids easily. Also, for a given cross section open drain can carry much larger discharge particularly in flood conditions when the drain is surcharged.

However, open drains have their inherent disadvantage of being used as a dust-bin. Due to this reason their hydraulic capacity for most part of the year remains poor.

44) **Covered drains or pipe:** Covered drain i.e. rectangular drain with cover slabs are free from garbage dumping problems. Also, they can be located below the footpath or in extreme cases below the carriageway where space is restricted. The closed system, in many cases, is demanded by residents of the adjoining area. Pipe drains also have the above advantage but they should be used for small lengths as cleaning of such drains is not possible by ordinary method and they need special equipment. Also due to minimum size requirement and cushion requirement, such drains tend to become deep and increase the depth of drain at the downstream end. Pipe lines should be preferred in cases of steep slopes up to 900 mm dia to 1200 mm.

45) **Manholes Ordinary manholes & Spacing:** A manhole is an opening constructed on the alignment of a covered or pipe drain for facilitating a person access to it for the purpose of inspection, testing, cleaning and removal of obstructions from the drain. The spacing of manhole depends upon the nature of drain and the cleaning devise likely to be used. Generally manhole in straight reaches is at a spacing of 50 to 100 m or so.

Maintenance of the Drainage system:

Adequate arrangements should be considered for maintaining the drainage system for proper flow condition.

General :

- ✓ The surface drains should not be connected to the sewer systems as they also carry rain water, solid wastes and silt which tend to choke the sewers.
- ✓ During construction full care needs to be taken for diverting traffic and for fencing and safety of the excavation sites. The excavated materials may have to be transported to other suitable sites (to maintain flow of traffic) and transported back for refilling of trenches. The provisions for properly supporting the trenches should be taken.
- ✓ The issues related to safety, excavation in different strata, underground water conditions, shifting of under ground utilities, on site testing, backfilling of trenches, road restoration should be properly attended in the technical specifications, estimates and BOQ.
- ✓ The standard bidding document should be understood very clearly and should ensure required details (i.e. special conditions of the Contract, Technical specifications, drawings and BOQ items including preamble to BOQ etc.) for a particular sub-project and there should be harmony in the documents prepared by the DSC/IPIU /IPMC/ in-charge packages in PMU.
- ✓ The estimates should be reflective of the present market prices and should be based on the current SOR to be issued by RUSDIP and the market prices for items not included there.
- ✓ Safety aspects needs to be attended in the design of the system and included in Bid Documents properly - Excavation in deep trenches, barricading, crossing with water supply lines, execution in narrow streets

Design Report Format:

- ✓ The report should consist two parts:
  - **(a) City status report**
  - **(b) Sub-project specific report**
- ✓ The **city status report** should contain at least the following chapters:
  - (a) Index
  - (b) Salient Features of the town – Topography, Hydrology, Geology, and Ground Strata Existing drainage, Rainfall history, flood prone areas with respect to the designed depths etc.
  - (c) Introduction – History of drainage schemes with up to date details, ongoing & future plans and their status;
  - (d) Analysis of deficiency in the town with present requirements and future requirements of Year 2021, 2031 and 2041, measures to mitigate the deficiencies with improvement in the existing system and
  - (e) Executive summary for suggestive measures to mitigate deficiencies / long term solutions and list of proposed works in totality.
  - (f) Phasing of the proposed works in line with allocations under RUSDIP for fulfilling its goal matrix and indicators. Identification of works to be taken up by the concerned line agency. Define role of RUSDIP/ULB/ others to meet out the deficiencies.

- ✓ The **sub-project specific report** should contain at least the following chapters:
  - (a) Index
  - (b) Introduction - Analysis of Priority for RUSDIP
  - (c) Detail analysis of the sub-project specific requirement and justification.
  - (d) Sub-project specific present level of indicators and indicators after execution of the project covering:

General:

- ✓ Increase in coverage of drainage system and its maintenance
- ✓ Reduction in pollution and use of effluent
- ✓ Improvement in sanitation facility
- ✓ Corresponding health benefits

Technical Report will contain - narrative of the various design aspect, parameters, alternatives and conclusions – highlighting special features; Work Program; Operation and Maintenance; Benefits expected from the investment.

a) **Bidding document -** Incorporation of Scope of work, special conditions of contract, Technical specifications, Tender & Detailed Construction Drawings, Estimate & Bill of quantities and preamble to BOQ etc. in Standard Bidding document.

b) **Operation and maintenance -** Expectations from the line agency (personal requirement / cost requirement), Expectations from the contracting firm.

c) **Execution Methodology -** Sequence of execution, Tentative work plan, interface with other works, Quality Assurance and Quality Control, Safety aspect during execution.

d) **Time line for completion of sub-project.**

e) **Likely Impact after the completion of sub-project under RUSDIP** – Improvement in sanitation facility, reduction in pollution, no. of beneficiaries/ colonies covered/ houses & %of total city area,

f) Linkage of existing and proposed work on base maps prepared by RUSDIP (Availability of plans/ details of existing system)

g) **Sub - project Issues**

   i. Status of land availability / Land acquisition for structures
   ii. Inter departmental issues with Forest, Railways for crossings of Railway lines and works through railway land, National Highways for road cutting / crossings and Bridges, Power availability from VVNL,
   iii. BSNL, Pollution Control Board, License from explosive department, Removal of encroachment and their resettlement.
   iv. Time line for clearance from concerned department
   v. Shifting of under ground utilities (sub-project wise) - Details of concerned department, Mode of shifting, Clearance from line agency, Likely impact of shifting
   vi. Deposit works to be executed by other departments for execution of the sub-project.

This circular should be abided by all members of PMU, IPIU, IPMC & DSC.

(Karni Singh Rathore)
Project Director

F3 (106) (32)/RUSDIP/PMU/CMS/2007/19223-70 Dated: 21-03.2008

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6. Dy. Team Leader, RUSDIP, DSC-I, Alwar/ Dholpur/ Karauli/ Sawai Madhopur, RUSDIP.
7. Dy. Team Leader, RUSDIP, DSC-II, Churu/ Jaisalmer/ Barmer/ Sikar
8. Dy. Team Leader, RUSDIP, DSC-III, Chittorgarh/ / Rajsamand/ Bundi/ Baran, RUSDIP.
9. ACP, PMU, RUIDP, Jaipur to send by e-mail and put up the Guidelines on the website.

Dy. Project Director (T)

INTENSITY OF PRECIPITATION

The intensity of rainfall decreases with duration. Analysis of the observed data on intensity duration of rainfall of past records over a period of years in the area is necessary to arrive at a fair estimate of intensity-duration for given frequencies. The longer the record available, the more dependable is the forecast. In Indian conditions, intensity of rainfall adopted in design is usually in the range of 12mm/hr to 20mm/hr.

Table 1.1 gives the analysis of the frequency of storms of stated intensities and durations during 26 years for which rainfall data were available for a given town.

TABLE 1.1

Duration in Minutes	Intensity mm/hr: 30	35	40	45	50	60	75	100	125
	No.of Storms of intensity or more for a period of 26 years								
5					100	40	18	10	2
10			90	72	41	25	10	5	1
15		82	75	45	20	12	5	1	
20	83	62	51	31	10	9	4	2	
30	73	40	22	10	8	4	2		
40	34	16	8	4	2	1			
50	14	8	4	3	1				
60	8	4	2	1					
90	4	2							

1 ANALYSIS OF FREQUENCY OF STORMS

The stepped line indicates the location of the storm occurring once in 2 years, i.e. 13 times in 26 years. The time-intensity values for this frequency are obtained by interpolation and given in Table 1.2

Table 1.2
TIME INTENSITY VALUES OF STORMS

I (mm/hr)	t (min)
30	51.67
35	43.75
40	36.48
45	28.57
50	18.50
60	14.62
75	8.12

The relationship may be expressed by a suitable mathematical formula, several forms of which are available. The following two equations are commonly used:

(i) $i = a / (t^n)$

(ii) $I = a / (t + b)$

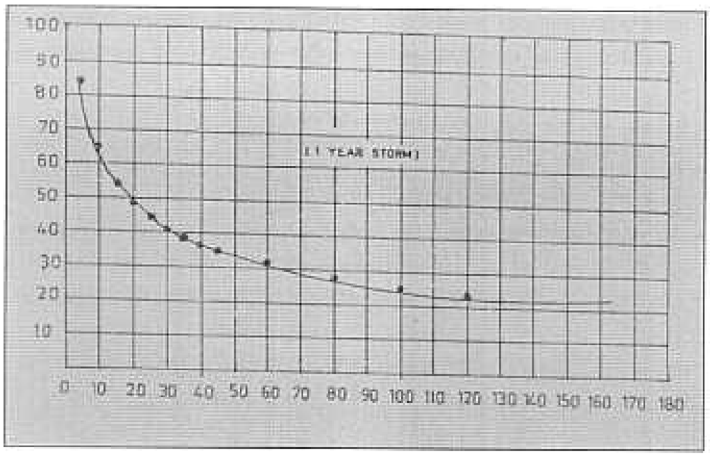
Where,
i = intensity of rainfall (mm/hr)
t = duration of storm (minute) and

a, b and n are constants,

The available data on I and t are plotted and the values of the intensity (i) can then be determined for any given time of concentration, (t_c) (Fig. 1.1)

Figure 1.1

Intensity
mm/hr



DURATION (mins.)

1.2 Time of Concentration

It is the time required for the rain water to flow over the ground surface from the extreme point of the drainage basin and reach the point under consideration. Time of concentration (t_c) is equal to inlet time (t_1) plus the time of flow in the drain (t_2). The inlet time is dependent on the distance of the farthest point in the drainage basis to the inlet point, the shape, characteristics and topography of the basin and may generally very from 5 to 30 minutes. In highly developed sections, the inlet time may be as low as 3 minutes. The time of flow is determined by the length of the drain and the velocity of flow in the drain. It is to be computed for each length of drain to be designed.

1.3 COEFFICIENT OF RUNOFF

The portion of rainfall which finds its way to the drain, is dependent on the imperviousness and the shape of tributary area apart from the duration of storm.

a) Imperviousness

The percent imperviousness of the drainage area can be obtained from the records of a particular district. In the absence of such data, the following may serve as a guide:

Type of area | Percentage of Imperviousness

Commercial and Industrial area	70 to 90

Residential Areas:

i)	High density	60 to 75
ii)	Low density	35 to 60

Parks and undeveloped areas	10 to 20

The weighted average imperviousness of drainage basin for the flow concentrating at a point may be estimated as

$= A_1 C_1 + A_2 C_2 \ldots\ldots / A_1 + A_2 +$

A_1, A_2	=	drainage area tributary to the section under consideration
C_1, C_2	=	imperviousness of the respective areas and
C	=	weighted average imperviousness of the total drainage basin

b) **Tributary Area**
For each length of storm sewer, the drainage area should be indicated clearly on the map and measured. The boundaries of each tributary are dependent on topography, land use, nature of development and shape of the drainage basins. The incremental area may be indicated separately on the compilation sheet and the total area computed.

c) **Duration of Storm**
Continuously long light rain saturates the soil and produces high coefficient than that due to heavy but intermittent rain in the same area because of the lesser saturation in the latter case. Runoff from an area is significantly influenced by the saturation of the surface nearest the point of concentration, rather than the flow from the distant area. The runoff coefficient of a larger area has to be adjusted by dividing the area into zones of concentration and by suitably decreasing the coefficient with the distance of the zones.

d) **Computation of Runoff Coefficient**
The weighted average runoff coefficients for rectangular areas of length four times the width as well as for sector shaped areas with varying percentages of impervious surface for different times of concentration are given in Table 1.3. Although these are applicable to particular shapes of areas, they also apply in a general way to the areas which are usually encountered in practice. Errors due to difference in shape of drainage are within the limits of accuracy of the rational method and of the assumptions on which it is based.

TABLE 1.3

Duration, t, minutes	10	20	30	45	60	75	90	100	120	135	150	180
1) Sector concentrating in stated time												
(a) Impervious	.525	.588	.642	.700	.740	.771	.795	.813	.828	.840	.850	.865
(b) 60% Impervious	.365	.427	.477	.531	.569	.598	.622	.641	.656	.670	.682	.701
(c) 40% Impervious	.285	.346	.395	.446	.482	.512	.535	.554	.571	.585	.597	.618
(d) Pervious	.125	.185	.230	.277	.312	.330	.362	.382	.399	.414	.429	.454
2) Rectangle (length = 4 x width) concentrating in stated time												
(a) Impervious	.550	.648	.711	.768	.808	.837	.856	.869	.879	.887	.892	.903
(b) 50% Impervious	.350	.442	.449	.551	.590	.618	.639	.657	.671	.683	.694	.713
(c) 30% Impervious	.269	.360	.414	.464	.502	.530	.552	.572	.588	.601	.614	.638
(d) Pervious	.149	.236	.287	.334	.371	.398	.422	.445	.463	.479	.495	.522