DAILY WATER USE ESTIMATE

A. eMi^2 uses the Indian standard of 135 L/day-person for domestic use (family unit housing) with regular water supply. Use projected site population x 135 L/day to give a CONSERVATIVE ESTIMATE of proposed daily water usage while on the project trip. You may need to provide estimates for phased growth. This will help in the initial estimation of footprint areas needed for water storage facilities and the wastewater disposal area needed while the team is developing the master plan.

B. OBSERVE water use by locals. Try to estimate what the total daily use ACTUALLY is for a person living on site. This habit of using engineering judgment will pay off with a more efficient or more economical design if the conditions and practices of the client aren't average.

C. Upon return to the eMi^2 office, develop a DETAILED water use estimate. Use charts based on Indian standards (Appendix A & B) for estimating institutional water usage (schools, orphanages, dormitories, etc.). You may also complete this step while on the trip if time allows. However, it is likely that some architectural revision will occur following the trip, possibly affecting this estimate.

D. COMPARE the projected water use rates that you developed from both the empirical data you measured or estimated on site and the projections you developed from Indian standards…use your judgment and make your FINAL PROJECTIONS.

WATER SOURCES

Thoroughly consider all possible water sources regardless of your initial opinions of the feasibility of actual use. Do everything you can to identify a single sustainable, year-round water supply with enough quantity to meet the normal daily needs of the client. In many cases more than one water source will be needed.

SHALLOW WELL…Is there currently a shallow dug well on site or near the site? Is this the locally preferred water source? Investigate the construction method and make design notes. What is the expected depth? Can you take a water sample and have it analyzed? What type of water treatment methods are feasible? Will the well dry up in the dry season? Investigate the costs of construction.

DEEPER WELL…Is it feasible to have a well drilled or bored? Find a drilled well on site or very near the site and find out it's depth, capacity (liters per hour pumped), and construction method. Do everything you can to find a written well log for this well or interview the actual driller about the depth, quality, and quantity of water available.

SURFACE WATER (stream, spring, lake, etc.)…How far away is the surface water source? Can you do a water analysis? What treatment methods are feasible? Consider intake design. What is the cost of constructing the intake and treatment system?

COMMUNITY WATER SYSTEM…Is there a reliable community water distribution system nearby? What amount/pressure of water is available? How far away? Will the water need treatment to make it drinkable? Consider construction costs for tying into the system. Interview local utility manager.

RAINFALL COLLECTION… Because of the seasonal rainfall issue in India and the expense of constructing and maintaining long-term water storage facilities, it is generally expected that rainfall collection will be a supplementary solution (i.e. for watering gardens, temporary water supply during the rainy season). Find accurate regional data for precipitation in Hydrology and Water Resource Engineering (Garg) (Appendix C) or use the internet to do more detailed research. Estimate (using roof areas) how much water can be collected from the proposed roof areas during a typical day, week, and month during the monsoon season. **Note: In Tamil Nadu rainwater collection and groundwater recharge are required by law. For more information, see www.raincentre.org.**

ESTIMATING WATER STORAGE REQUIREMENTS

WATER PRESSURE: In general, Indians do not use as much water pressure as we do in the United States. Anywhere from 5 to 20 psi may be perfectly acceptable. Observe the pressure levels in the local water systems.

TYPICAL INDIAN APPROACH TO WATER STORAGE: It is typical in India to install multiple rooftop tanks, one over each bathroom or kitchen with 200 to 500 liters of storage each. This provides individuals a sense of control over the area they are using. If others run out of water, then they can conserve their own if they have their own tank. It is also common to install dead end lines.

The problem with this is that if a site is going to be developed to include multiple buildings, there is a higher maintenance burden and lack of ability to transfer water to where it is needed most.

eMi^2 APPROACH TO WATER STORAGE: Since many eMi^2 projects do involve long-term planning for multiple buildings, we recommend having dialogue with the client about accepting the idea of a battery of central water storage tanks (tough plastic tanks up to 5000 L each) coupled with a looped water distribution system (where appropriate) to allow for economical and efficient water delivery to all of the buildings.

Central water storage and a looped water distribution system are new ideas to many of our clients, so it is important to spend the needed time sharing the idea, getting feedback, and making this approach as easy to “swallow” as possible. The battery of water storage tanks may be placed on a structurally designed platform (preferred to us) or on top of the tallest building, providing that adequate water pressure can be achieved in the other buildings from that location. (FYI, most tanks are designed to fill from top and distribute from the bottom).

STORAGE TANK CAPACITY: Provide a MINIMUM of one day’s supply of water storage. Dialogue with the client to hear their views on needed water storage. They may want more storage and up to two day’s supply is actually ideal.

COMMUNITY WATER SUMP: It is common practice in India to install a community water sump at ground level which receives water from more than one source (i.e. water from the multiple wells and from the community water line). Water is then pumped from here to the elevated water storage facility. eMi^2 does recommend this option for many of our client’s sites as it provides added storage and is efficient when using more than one source.

WATER PUMPS

ELECTRICITY: Find out the typical number of hours electricity is available each day, perceived frequency of electricity interruptions (i.e. are there ever interruptions for many days and how many times a year does this happen?), whether it is single phase or three phase power, and how far away the community connection will be.

PUMPS: Pumps typically used in India for shallow or open wells are either centrifugal pumps with suction lines or submersible pumps. Pumps for deep or bored wells are usually submersible pumps or a surface air compressor system (used on low capacity wells). Another option for a low capacity deeper well (although not commonly used) is a solar powered pump.

RECOMMEND for each scenario the acceptable pump types, pumping rate, and total dynamic head range needed for the well pump. Remember to consider the hours of electricity availability and anticipated well capacity when recommending the pumping rate for filling the water storage tanks and sump.

WATER TREATMENT SYSTEMS

In India, if bacteria is commonly present in the water source, it is not expected that all taps should yield water with drinking quality. eMi^2 usually recommends the installation of a filtration/UV disinfection unit (commonly known as Aquaguard) at key locations on the site where drinking water will be needed (i.e. kitchens). Use the Lifewater International water test kit to measure contaminants in the water sources. Contaminants such as high minerals and nitrates may indicate the need for other treatment steps. If possible, request that the client have a testing lab complete analysis of the water quality of each established water source (most helpful if done before the project team arrives). (Appendix D)

SOIL SUITABILITY FOR ON-SITE WASTEWATER DISPOSAL

EVALUATE SOIL TYPE at 1'-3' depth immediately. Use the subjective soil type flow chart. If the soil has high clay content, warn the masterplanner that ww disposal may require significant land area. Note that the soil evaluation is mainly useful for planning a leach bed or leach field wastewater disposal system. Performing the soil type test is the minimum information requirement for determining the land area needed (Appendix E).

INTERVIEW knowledgeable locals or consult a drilling log (if an on-site well has been completed already) to determine the changes in soil strata as the depth increases. Take a good digital photo of the drilling log if it is available and download the photo onto the project leader's computer project file. This information will be used to size seepage pits.

GROUNDWATER DEPTH: Important! Find out how deep the water table is during the peak of the rainy season. We want to avoid designing a system which contaminates the groundwater. Good design requires that at least 3 feet of soil thickness (not coarse sand or gravel) should separate the bottom of the seepage pit, leach bed, or leach field from the water table.

If time allows, CONDUCT PERCOLATION TEST using "Determining Soil Suitability" from the Water for the World documents (Appendix F). Saturate percolation hole prior to performing the test for 12 hours if there is any clay content. If no clay content, then proceed with test immediately. See instructions. Compare this information with the soil type results.

WASTEWATER DISPOSAL SYSTEMS

INTERVIEW locals to determine if community sewer system connection is available to the site. Most times this is not the case, but occasionally this is available.

STUDY HOW THE LOCALS DISPOSE OF WASTEWATER. Most small on-site wastewater disposal systems in the areas of India where eMi^2 has worked have consisted of a septic tank and soak pit system handling only the blackwater. Greywater is plumbed separately and allowed to runoff untreated in some way. This practice is widely accepted and used. Depending on depth to the water table, plans for site use, and the soil conditions, this type of system may or may not be recommended by eMi^2. Try to use similar technology while improving the treatment and disposal one or two steps from current practice. Where large populations are using a site, take care to deal with the greywater so that human contact is avoided (i.e. use for irrigation away from public areas or include in subsurface disposal if conditions allow).

DECIDE whether or not to split blackwater and greywater disposal. This may vary in different zones of the site if the site is larger than an acre or two. Dialogue with the client about their feelings of the importance of greywater reuse.

IF SOIL PERCS RELATIVELY WELL and groundwater is at least 5 feet deep, plan for traditional leach field, leach bed, or seepage pit (deeper groundwater for seepage pit).

ESTIMATE NEEDED LAND AREA for subsurface soil absorption using Water for the World design application rate table (Appendix G). Inform architects of needed land area.

IF SOIL DOES NOT PERC or groundwater is high…begin considering alternative treatment and disposal methods.

MINIMIZE LONG PIPELINES and AVOID PUMPS.

SYSTEM LAYOUT RULES

Remember the BASIC LAYOUT RULES and work with master planner to incorporate the water/ww systems into the master plan:

- Distance between well and septic tank….minimum of 50 feet
- Distance between well and soil absorption area…minimum of 65 feet if well is in a deeper confined aquifer, minimum of 100 feet if well is in a more shallow unconfined aquifer.
- Distance between soil absorption area and stream or embankment….50 to 100 feet or more
- Put water well on upper end of site if possible and protect from runoff drainage to the well
- Put soil absorption areas in lower parts of the site and lay out the trenches to follow the contour of the land.

DRAINING THE SITE

LOOK for signs of flooding or other drainage problems and RECORD THIS INFORMATION.

ASK several locals about drainage issues they have noticed at the site. Realize that interviews will not normally provide accurate information, but can reveal general issues.

MARK RECOMMENDED DRAINAGE ROUTES on a copy of the proposed masterplan while on site.

ASSIST IN TOPOGRAPHIC SURVEY. Make sure all topographic characteristics relevant to drainage are included in the survey.

GENERAL COMMENTS

Our policy is for civil engineer volunteers to have a ZERO burden when they get on the airplane to go home from India. All recommendations and observations should be collected, documented and turned over to the project leader before leaving the project site. Daily design meetings with the eMi^2 civil staff member (or eMi^2 civil intern) and the civil volunteers are HIGHLY encouraged during the project trip.

Design systems which keep maintenance to a minimum. Exception would occur when the following factors exist: (1) there is significant public health risk without more complex systems; (2) there is specific request from the client to have more environmentally friendly systems; (3) the client is capable of maintaining the system or procuring the needed help.

B.C. Punmia, Askok Jain, and Arun Jain. Environmental Engineering-I: Water Supply Engineering. New Delhi: Laxmi Publications, 1995

5.6. WATER DEMAND

An average person may consume no more than 5 to 8 litres a day in liquid and solid foods, including 3 to 6 litres in the form of water, milk and other beverages. However, the per capita consumption of water drawn from public supply is quite large. Total water requirements may be divided into the following five categories:

1. Residential or domestic use.
2. Institutional use.
3. Public or civic use.
4. Industrial use.
5. Water system losses.

1. Residential or domestic use

The residential or domestic use includes water requirements for drinking, cooking, bathing, washing of clothes, utensils and house, and flushing of water closets. Provision is sometimes made for domestic animals. IS : 1172–1957 recommends a per capita water consumption of 135 litres per day. Table 5.5 gives the break up of water requirements for domestic purposes, which forms about 50% of the total water requirements per head per day, for all the five categories mentioned above. Table 5.6 gives the water requirements for domestic animals. It should be noted that water required for lawn sprinkling and for residential gardens is over and above the values given in Table 5.5.

TABLE 5.5.
WATER REQUIREMENTS FOR DOMESTIC PURPOSES

S.No.	*Description*	*Amount of water in litres per head per day*
1	Bathing	55
2	Washing of clothes	20
3	Flushing of W.C.	30
4	Washing the house	10
5	Washing of utensils	10
6	Cooking	5
7	Drinking	5
	Total	**135 litres**

TABLE 5.6.

CONSUMPTION OF WATER FOR DOMESTIC ANIMALS AND LIVE-STOCKS

S.No.	*Animals*	*Water consumption in litres per animal per day*
1	Cow and buffalo	40 to 60
2	Horse	40 to 50
3	Dog	8 to 12
4	Sheep or goat	5 to 10

The Manual on water supply and treatment, prepared by the Ministry of Urban Development (MUD) New Delhi recommends the following rates in litres per capita per day (lcpd) for domestic and non-domestic needs (Table 5.7) :

TABLE 5.7.

WATER FOR DOMESTIC AND NON-DOMESTIC NEEDS

Description	*Amount of water (lcpd)*
1. For communities with population upto 20,000	
(*a*) Water supply through stand post	40 (min.)
(*b*) Water supply through house service connection	70 to 100
2. For communities with population 20,000 to 100,000	100 to 150
3. For communities with population above 100,000	150 to 200

2. Institutional Use

The manual on water supply and Treatment recommends the values of water requirements for *institutional needs* as given in Table 5.7.

3. Public or Civic use

Water required for public or civic uses may be for the following purposes : (*i*) Road washing, (*ii*) Sanitation, (*iii*) Public parks, and (*iv*) Fire fighting. For road washing in the municipality area, a provision of 5 litres per head per day is made. Similarly, for sanitary purposes, such as cleaning public sanitary blocks, flushing sewer systems etc., a provision of 3 to 5 litres per head per day may be made. Water required for maintaining public parks etc. may be 2 to 3 litres per square metre per day.

TABLE 5.8
WATER FOR INSTITUTIONAL NEEDS

	Institution	*Water requirement (litres per head per day)*
1.	Hospitals (including laundry)	
	(a) No. of beds exceeding 100	450 (per bed)
	(b) No. of beds not exceeding 100	340 (per bed)
2.	Hotels	180 (per bed)
3.	Hostels	135
4.	Nurse's homes and medical quarters	135
5.	boarding schools/colleges	135
6.	Restaurants	70 (per seat)
7.	Air ports and sea ports	70
8.	Junction stations and intermediate stations where mail and express stoppage (both railways and bus stations) is provided)	70
9.	Terminal stations	45
10.	Intermediate stations (excluding mail and express stops)	45 (could be reduced to 25 where bathing facilites are not provides)
11.	Day schools /colleges	45
12.	Offices	45
13.	Factories	45 (could be reduced to 30 where no bathing rooms are required to be provided)
14.	Cinema, concert halls and theatres	15

Fire demand

Water required for fire fighting is usually known as *fire demand*. It is treated as a function of population and may be computed from the following formulae :

1 ***Kuichling's formula***

$$Q = 3182\sqrt{P} \quad ...(5.17)$$

where Q = quantity of water in litres per minute
P = Population in thousands

2. ***Buston's formula***

$$Q = 5663\sqrt{P} \quad ...(5.18)$$

Appendix B: Water for the World "Village Use Only"

Water for the World: Estimating Sewage or Washwater Flows, Technical Notes No. SAN. 2.P.2; U.S. Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association

Table 1. Water from Standpipe

Country	Water Use Per Person Per Day (in Liters)*
Africa	15-35
Southeast Asia	30-70
Western Pacific	30-95
Eastern Mediterranean	40-85
Algeria-Morocco-Turkey	20-65
Latin America/Caribbean	70-190

*Averages are for areas where water is handcarried from standpipes no more than 200m distant.

For example, suppose water for a six-person dwelling in Southeast Asia is hand-carried from a standpipe 30m distant. Using Table 1 the daily flow = 70 liters x 6 = 420 liters per day.

Table 2. Sewage or Washwater Per Fixture

Fixture	Amount Per Use (in Liters)
Pour-flush Latrine	1-3
Tank-type Flush Toilet	13-23
Wash Basin	5
Shower	95-120
Kitchen Sink	15-18
Laundry Sink (wash/rinse)	150-190

If there is doubt as to which number to use in Table 2, use the higher number. When using Table 2, first determine the number of times each fixture is used per day. For example, suppose the pour-flush latrine is used 18 times, the wash basin six, the kitchen sink three, and the laundry sink once. Then the daily flow is:

Pour-flush latrine = 3 liters x 18 = 54 liters, plus:

Wash basin = 5 liters x 6 = 30 liters, plus:

Kitchen sink = 18 liters x 3 = 54 liters, plus:

Laundry sink = 190 liters x 1 = 190 liters, equals:

The daily flow = 328 liters per day.

Table 3. Sewage Flow by Building Type

Building Type	Amount Per Person Per day (in Liters)
Private Home (full plumbing)	150-300
Public Buildings (toilets/sinks)	11-38
Communal Latrines	40

If there is doubt as to which number to use in Table 3, use the higher number. When using Table 3, first determine the type of building and the number of persons living in or using the building. For example, suppose a school has 40 pupils and three teachers for a total of 43 persons.

Then the daily flow = 43 x 38 liters = 1634 liters per day.

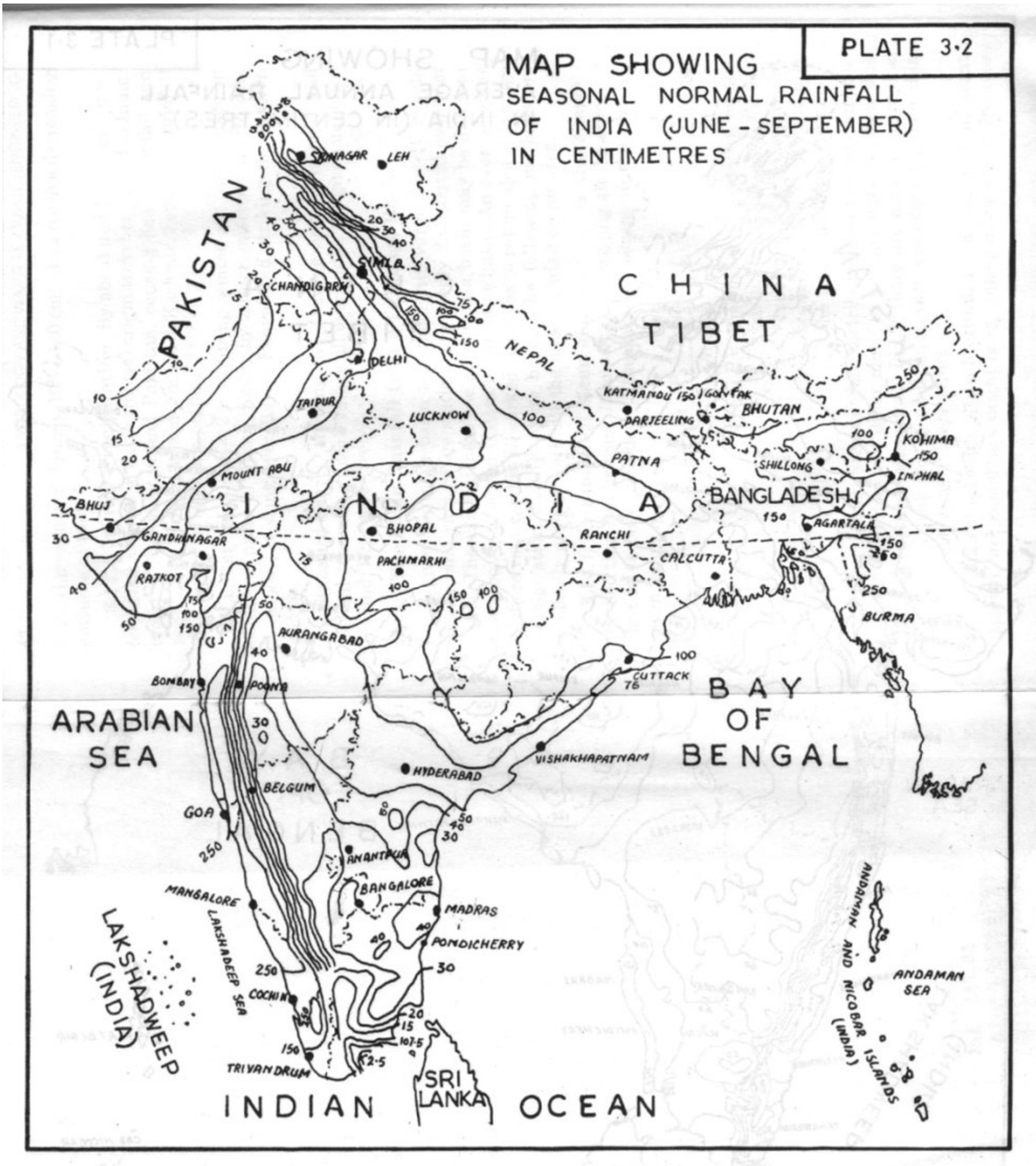
Water Meter Estimates

If water is piped to a building equipped with a water meter, take two meter readings one week apart, subtract the first reading from the second, and divide by seven to estimate the daily flow. The meter readings should be made on days of typical usage, not holidays or other times of slack use.

$$\frac{\text{second reading} - \text{first reading}}{7} = \text{daily flow}$$

3

Appendix C:
Santosh Kumar Garg. Hydrology and Water Resources Engineering. Delhi: Khanna Publishers, 2000



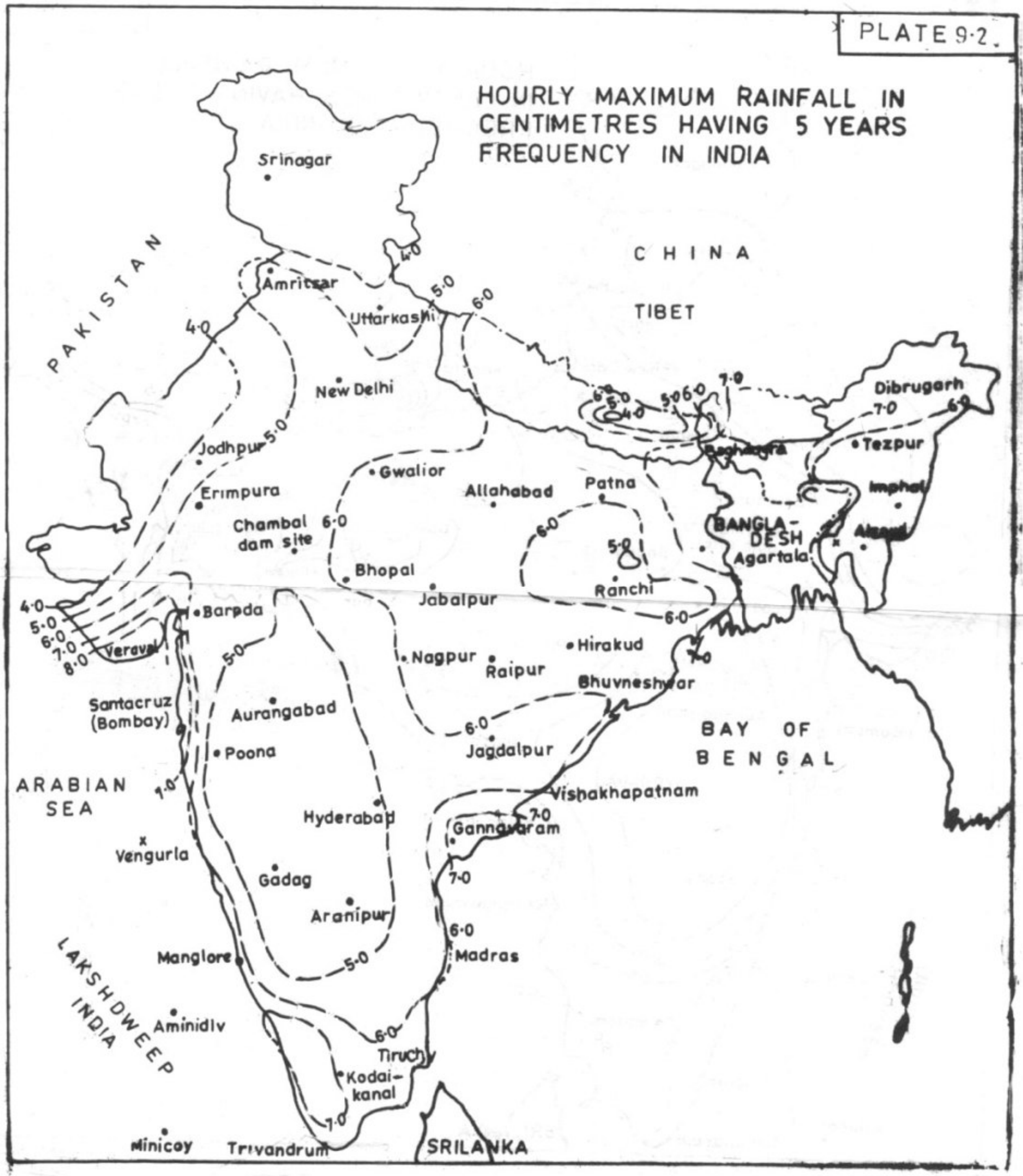


PLATE 9·2.
HOURLY MAXIMUM RAINFALL IN CENTIMETRES HAVING 5 YEARS FREQUENCY IN INDIA
CHINA
TIBET
PAKISTAN
Srinagar
Amritsar
Uttarkashi
New Delhi
Jodhpur
Erimpura
Chambal dam site
Gwalior
Allahabad
Patna
Bhopal
Jabalpur
Ranchi
Dibrugarh
Tezpur
Imphal
BANGLA-DESH
Agartala
Baroda
Veraval
Nagpur
Raipur
Hirakud
Bhuvneshwar
Santacruz (Bombay)
Aurangabad
Poona
Jagdalpur
BAY OF BENGAL
ARABIAN SEA
Vishakhapatnam
Hyderabad
Gannavaram
Vengurla
Gadag
Aranipur
Madras
Manglore
LAKSHDWEEP INDIA
Aminidlv
Tiruch
Kodai-kanal
Minicoy
Trivandrum
SRILANKA

C.S. Ramasesha. "Ground Water Quality and its Effects on Human Health." Special Lecture DST Sponsored Second SERC School on "Mathematical Modelling on Atmospheric Pollution"

INDIAN DRINKING WATER STANDARDS

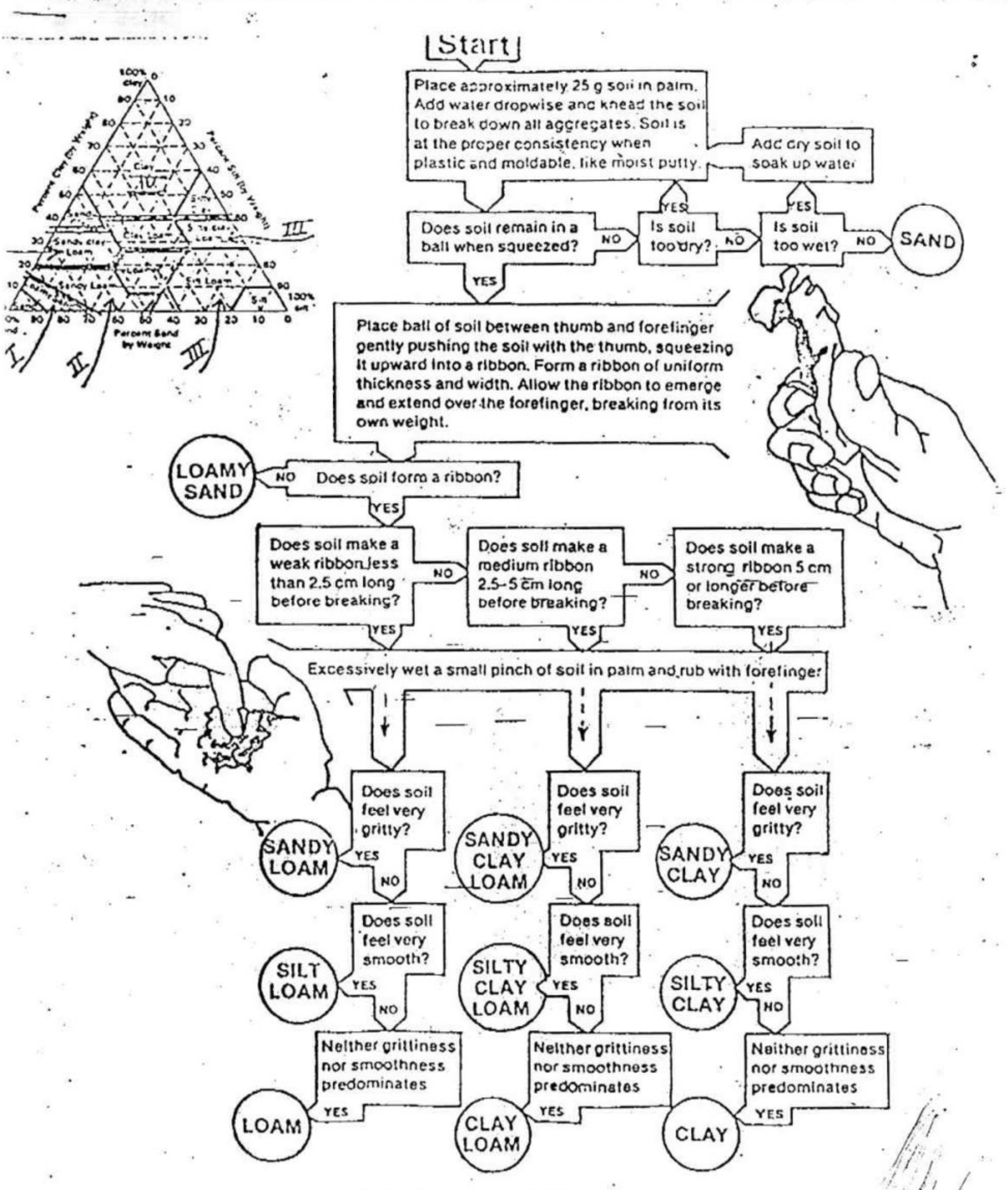
Property / Constituent	Desirable limit	Permissible limit	Undesirable effect outside the desirable limit
Physio-chemical Characteristics			
Thrbidity JTU Scale	2.5	10	Aesthetically undesirable
Colour (Platinum - Cobalt Scale)	5.0	25	Aesthetically undesirable
Taste and Odour	unobject-ionable	unobject-ionable	Aesthetically undesirable
Major - Chemical Constituents			
pH	6.5-8.5	6.5-9.2	Affects taste
Total dissolve solids, mg/l	500	1500	Causes gastrointestinal irrita tion
Total Hardness, as $CaCO_3$ mg/l	300	600	May cause urinary concretion, disease of kidney, bladder and stomach disorder
Calcium, mg/l	75	200	Essential for nervous and mus cular system, cardiac function and coagulation of blood. De ficiency causes rickets. Excess concentration causes kidney or bladder stone and irritation in urinary passage
Magnesium, mg/l	<30 if SO_4 is 250 mg/l	100	Essential as an activator for many enzyme system. Defi ciency results in structural and functional changes. Excess concentration may have laxa tive effects. Magnesium salts are cathartic and diuretic.
Chloride, mg/l	250	1000	Affects taste and palatability, Causes indigestion may be in-jurious to people suffering from heart and kidney diseases.
Sulphate, mg/l	200	400	Causes laxative effects in pres ence of Magnesium
Nitrate, mg/l	45	100	Causes infantMethemoglobin emia (Blue babies). May cause gastric cancer and affects cen tral nervous system and Cardio-vascular system
Fluoride, mg/l	1.0	1.5	Essential for teeth and bones, reduces dental caries in con centration range of 0.8 - 1.0 mg/l and at high level teeth mottling, skeletal and crip pling fluorosis.
Iron, mg/l	0.3	1.0	Gives bitter sweet astringent taste
Manganese, mg/l	0.05	0.5	Unpleasant taste

Special Lecture DST Sponsored Second SERC School on "Mathematical Modelling on Atmospheric Pollution"

Copper mg/l	0.05	1.5	Astringent taste, deficiency results in nutritional anaemia in infants, high concentration may damage lever and cause central nervous system irritation and depression.
Zinc, mg/l	5.0	15	very small amount beneficial. Imparts astringent taste at higher concentration
Toxic Constitutents			
Arsenic, mg/l	0.05	0.05	Skin diseases, circulatory system problem, risk of cancer.
Cadmium, mg/l	0.01	0.01	Kidney damage
Chromium, $^{+6}$ mg/l	0.05	0.10	Lung tumor, Allergic detmatitis.
Cyanide, mg/l	0.05	0.05	Causes nerve damages and thyroid problem.
Lead, mg/l	0.05	0.05	Serious Cumulative body poison.
Selenium, mg/l	0.01	0.10	Small amount beneficial, large amount toxic.
Mercury, mg/l	0.001	0.001	Large amount causes brain and kidneydamage.
Polynuclear Aromatic hydrocarbon, microgram/l	0.20	0.20	Toxic

Appendix E: Soil Test

R-29-02 MON 08:48 AM IHS SUPPLY LAME DEER FAX:14064774426 PAGE 2



Instructional diagram for determining soil texture by feel.

Water for the World: Determining Soil Suitability, Technical Notes No. SAN. 2.P.3; U.S. Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association

Materials Needed

Shovel
Watch or other timepiece
Measuring tape or ruler
Lath, slat, or straight stick about 1m long
Board or piece of lumber about 0.6m long
Pencil
Auger with extension handles (optional; although not essential, this is an extremely useful tool for digging test holes)

Determining Soil Permeability

Soil permeability refers to the rate at which liquid percolates into the soil. Percolation of water into soil can be measured by digging a hole, pouring in water, and timing the rate at which the water drains out of the hole. This is called a percolation test. The test is fairly simple to conduct, but it must be done carefully in order to yield accurate results.

Conducting a Percolation Test.

1. Two percolation tests must be conducted at the proposed site. If the system is an absorption field or soakage trench, the tests should be conducted about one-third of the distance in from each end of the system, as shown in Figure 1. The test holes for a field or trench are dug to the depth of the system. For example, if the proposed trench is 1m deep, the test hole should also be 1m deep. If the proposed system is a cesspool or soakage pit, the tests are conducted in the center of the system at the proposed site of the cesspool or the soakage pit. The first test should be carried out at half the depth of the cesspool or pit, and the second test at the full depth. For example, if the proposed pit is 2.4m deep, the first percolation test is conducted at a depth of 1.2m, and the second at 2.4m. Generally, the results of the two tests will be about the same. If they differ, use the slower of the two percolation rates to design the system.

2. Dig or bore a hole about 300mm in diameter, or 300mm square, to the proper depth. Do not use the same hole used for locating groundwater and bedrock. That hole is too deep and, if filled in to the proper depth, will yield inaccurate test results. Make the walls of the hole vertical. Scrape the walls to remove any patches of compacted soil. Place about 50mm of clean gravel in the bottom of the hole.

3. Fill the hole with water and let it soak overnight. This will allow ample time for soil swelling and saturation, and provide more accurate test results.

4. Place a board or piece of lumber across the center of the hole and anchor it firmly in place, perhaps by placing a rock on each end. The board must not be moved until the test is complete. Mark a point near the center of the board to be used as a guide for the remainder of the test.

5. Most or all of the water poured in the day before will have drained away. Pour in enough water so that the depth is 200mm.

6. Place a pointed slat or similar measuring stick next to the reference mark on the board and slide it down until it just touches the water surface. Ripples on the water can be observed when the slat touches. Note the exact time and draw a horizontal

line on the slat, using the edge of the board for a guide, as shown in Figure 2.

7. Repeat step 6 at 10-minute intervals. If the water level drops rapidly, repeat at one-minute intervals. Do not allow the water to drop lower than 100mm. If it does, pour in more water to the 200mm depth and continue the test.

8. Note the spacing between the pencil marks on the slat. When at least three spaces become approximately equal, as shown in Figure 3, the test is completed. This may take as little as one-half hour or as long as several hours.

9. Using the measuring tape or ruler, measure the space between the equal pencil markings and compute how long it took the water level to drop 25mm. This step is necessary because percolation rates are described in terms of "minutes per 25mm." This can be approximated closely with the ruler and a series of equally spaced markings on the slat, as shown in Figure 3, or it can be calculated. Worksheet A shows how to tabulate information and calculate soil suitability.

To find how long it takes for the water level to drop 25mm, divide 25mm by the distance between two equal markings and multiply by the time interval for those two markings.

For example, suppose the markings are made at 10-minute intervals and the distance between the equal markings is 9mm. Then:

$$\frac{25mm}{9mm} \times 10 \text{ minutes} = \text{about } 27 \text{ minutes}$$

The percolation rate is 27 minutes per 25mm.

If the percolation rate for 25mm is between 10 and 60 minutes, the soil is acceptable. The percolation rate can be used to determine the size of the system as described in the next section. If the percolation rate is less than 10 minutes or more than 60 the proposed system cannot be constructed as designed. There remain two choices: select another site for testing; or select and design an alternate system that can be used at this site.

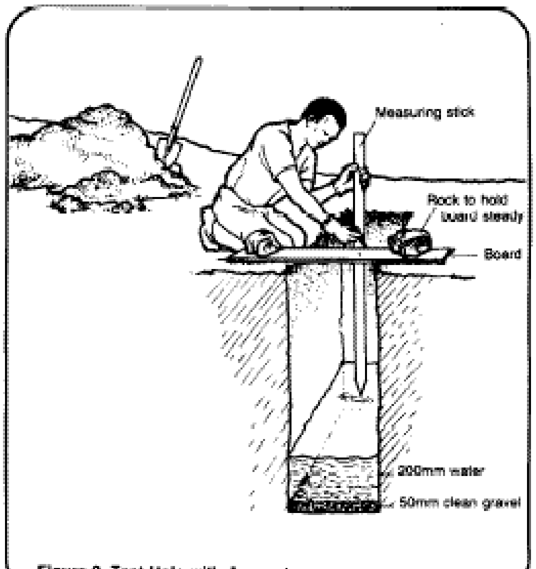


Figure 2. Test Hole with Apparatus

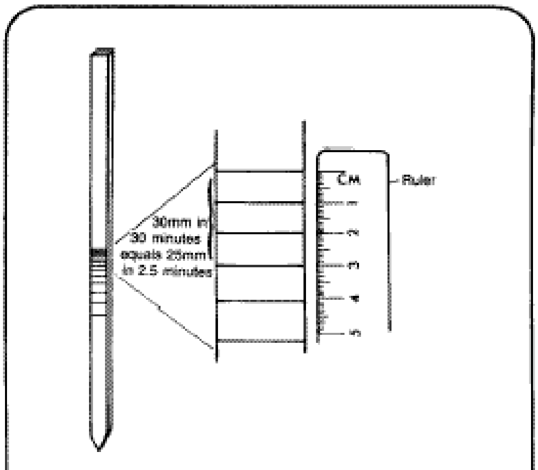


Figure 3. Typical Markings on Measuring Stick at Ten-Minute Intervals

Appendix G: Wastewater Application Rates

eMi^2 Recommended Rates of Wastewater Applications for Trench and Bed Bottom Area[a]:

Soil Texture	Percolation Rate Min/in	Application Rate[b] Lpd/ft^2
Gravel, coarse sand	<1	Not Suitable[c]
Coarse to medium sand	1-5	8.2
Fine sand, loamy sand	6-15	5.4
Sandy loam, loam	16-30	4.1
Loam, porous silt loam	31-60	2.9
Silty clay loam, clay loam[d]	61-120	1.3

To determine the allowable rate of application, use the results from the percolation test and the table above. This information will be used to determine the size of the soakage pit or trench, cesspool, or absorption field.

a. May be suitable estimates for sidewall infiltration rates
b. Rates based on septic tank effluent from a domestic waste source. A factor of safety may be desirable for waste of significantly different character
c. Soils with percolation rates <1 min/in can be used if the soil is replaced with a suitably thick (>2ft) layer of loamy sand or sand
d. Soils without expandable clays