# CHAPTER 4
# BASIC DESIGN CONSIDERATIONS

## 4-1. General.

The required treatment is determined by the influent characteristics, the effluent requirements, and the treatment processes that produce an acceptable effluent. Influent characteristics are determined by laboratory testing of samples from the waste stream or from a similar waste stream, or are predicted on the basis of standard waste streams. Effluent quality requirements are set by Federal, interstate, State, and local regulatory agencies. Treatment processes are selected according to influent-effluent constraints and technical and economic considerations.

## 4-2. Design population.

Treatment capacity is based on the design population, which is the projected population obtained by analysis. The design population is determined by adding the total resident and 1/3 the non-resident populations and multiplying by the appropriate capacity factor (para 4-6) taken from table 4-1 which allows for variations in the using population. The resident population is determined by adding the following:

*Table 4–1. Capacity factors.*

| Effective Population | Capacity Factor |
|---|---|
| under 5,000 | 1.50 |
| 5,000 | 1.50 |
| 10,000 | 1.25 |
| 20,000 | 1.15 |
| 30,000 | 1.10 |
| 40,000 | 1.05 |
| 50,000 | 1.00 |

**a. Military personnel.** The sum of existing and proposed (programmed) family housing units; permanent, temporary and proposed BOQ and BEQ spaces.

**b. Dependents and others**. The sum of units times 1.6 dependents; the number of National Guard, ROTC and Reserve personnel peak populations normally expected (not in the field); population of any boarding schools; anticipated overnight visitors such as TDY personnel; guesthouse spaces; any satellite functions such as service to a local community or other Federal bodies; and others not shown above. The non-resident population is found by summarizing the following:

— Off-post military. This is the difference between the resident military as indicated in 4-2a above and the strength shown in the Army Stationing and Installation Plan (ASIP).

— Civilian personnel under Civil Service.

— NAF personnel.

— Contractor personnel.

— Daytime schools.

— Daytime transients.

The effects of birth rates, death rates, and immigration are not applicable to military installations. The assigned military population both present and foreseeable, is obtained from the ASIP.

## 4-3. Estimating future service demand.

**a. Nature of activities.** The nature of the activities of the personnel at a military installation are a very important factor in determining per capita waste loads because different activities have different water uses. Table 4-2 illustrates this fact in terms of gallons per capita per day (gpcd); table 4-3 shows how waste loadings vary between resident and non-resident personnel. The values shown in table 4-3, for that portion of the contributing population served by garbage grinders, will be increased by 30 percent for biochemical oxygen demand values, 100 percent for suspended solids, and 40 percent for oil and grease. Contributing compatible industrial or commercial flows must be evaluated for waste loading on a case-by-case basis.

*Table 4–2. Per capita sewage flows.*

| | For Resident Personnel (gpcd) | |
|---|---|---|
| Type of Unit | Permanent | Field Training |
| Hospital units | 300–600 | 100 |
| All other units | 100 | 35 |

*NOTE:* Add 30 gallons per 8–hour shift per capita for non–resident and civilian personnel.

*Table 4–3. Sewage characteristics.*

| Item | Resident Personnel lb/capita for 24 hrs | Non–resident Personnel lb/capita for 8–hr shift |
|---|---|---|
| Suspended Solids | 0.20 | 0.10 |
| Biochemical Oxygen Demand | 0.20 | 0.10 |
| Oil & Grease | 0.09 | 0.05 |

## 4-4. Volume of wastewater.

**a. Variations in wastewater flow.** The rates of sewage flow at military installations vary widely throughout the day. The design of process elements in a sewage treatment plant is based on the average daily flow. Transmission elements, such as conduits, siphons and distributor mechanisms, will be designed on the basis of an expected peak flow rate of three times the average rate. Clarifiers will be designed for a peak hourly flow rate (i.e., 1.75 times the average daily rate). Consideration of the minimum rate of flow is necessary in the design of certain elements, such as grit chambers, measuring devices and dosing equipment; for this purpose, 40 percent of the average flow rate will be used.

**b. Average daily wastewater flow.** The average daily wastewater flow to be used in the design of new treatment plants will be computed by multiplying the design population by the per capita rates of flow determined from table 4-2, and then adjusting for such factors as industrial wastewater flow, stormwater inflow and infiltration. Where shift personnel are engaged, the flow will be computed for the shift when most of the people are working. A useful check on sewage volumes would be to compare water consumption to the sewage estimate (neglecting inflltration, which will be considered subsequently). About 60 to 80 percent of the consumed water will reappear as sewage, the other 20-40 percent being lost to irrigation, fire-fighting, washdown, and points of use not connected to the sewer.

(1) Good practice requires exclusion of stormwater from the sanitary sewer system to the maximum practical extent. Infiltration must also be kept to a minimum. Both must be carefully analyzed and the most realistic practical quantity that can be used in design must be assigned to these flows, Leakage of stormwater into sewer lines often occurs through manhole covers or collars, but this usually is no more than 20 to 70 gallons per minute if manholes have been constructed and maintained properly. However; leakage into the sewer mains

and laterals through pipe joints and older brick manholes with increase in groundwater levels can result in large infiltration. The amount of water that actually percolates into the groundwater table may be negligible if an area is occupied by properly guttered buildings and paved areas, or if the subsoil is rich in impervious clay. In other sandy areas, up to 30 percent of rainfall may quickly percolate and then lift groundwater levels. Infiltration rates have been measured in submerged sewer pipe. Relatively new pipe with tight joints still displayed infiltrations at around 1,000 gallons per day per mile, while older pipes leaked to over 40,000 gallons per day per mile. Sewers built first usually followed the contour of water courses and are often submerged while more recent sewers are not only tighter, but are usually built at higher elevations as the system has been expanded. In designing new treatment facilities, allow for infiltration as given in TM 5-814-1/AFM 88-11, volume 1, except as modified by this design manual. Utilize existing flow records, sewer flow surveys, and examine the correlation between recorded flows and rainfall data to improve the infiltration estimate. The economic feasibility of improving the collection system to reduce the rate of infiltration should be considered.

(2) Another method for calculating the infiltration component of total flow is to multiply the miles of a given pipe size and condition by the diameter in inches and to sum the inch-miles. The sums of inch-miles of pipe estimated according to conditions are then multiplied by factors between 250 and 500 to obtain gallon/day. If infiltration is known to be negligible at manholes, then an infiltration allowance may be calculated based upon area served and figure 4-1. Curve A should be used for worst conditions when pipes are old and joints are composed of jute or cement. Curve B applies to old pipes with hot or cold asphaltic joints or for new pipes known to have poor joints. Curve C is used for new sewers where groundwater does not cover inverts and when joints and manholes are modern and quite tight. Of course, field tests may be conducted to more closely estimate infiltration.

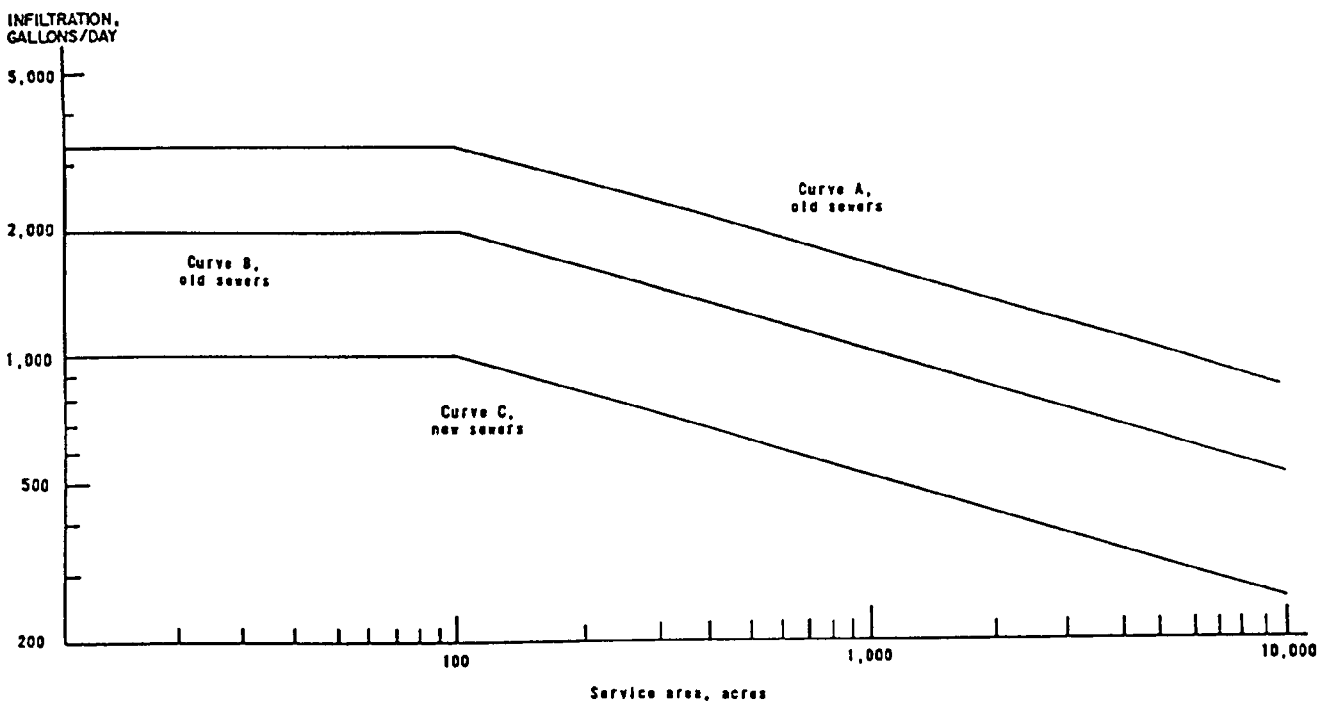


*Figure 4-1. Infiltration allowances.*

(3) Average wastewater flow is usually expressed in million gallons per day, but will be calculated in the appropriate units for design of the unit process under consideration.

**c. Contributing populations**. In calculating contributing populations, use 3.6 persons per family residen-tial unit. In hospitals, count the number of beds, plus the number of hospital staff eating three meals at the hospital, plus the number of shift employees having one meal there. This total is the number of resident personnel to be used in the design calculations. Individuals will be counted only once, either at home or at work. The capacity factor still applies in calculating design populations.

**d. Industrial flow.** Industrial wastewater flows will be minimal at most military installations. When industrial flows are present, however, actual measurement is the best way to ascertain flow rates. Modes of occurrence (continuous or intermittent) and period of discharge must also be known.

Typical industrial discharges include wastewaters from the following:

— wastewater treatment plant itself;
— maintenance facilities;
— vehicle wash areas;
— weapons cleaning buildings;
— boiler blowdowns;
— swimming pool backwash water;
— water treatment plant backwash;
— cooling tower blowdown;
— fire fighting facility;
— photographic laboratory;
— medical or dental laboratories.

**e. Stormwater flow.** Including stormwater flows is important in treatment plant design either when combined sewer systems are served or when significant inflow enters the sewer system. Combined sewer systems will not be permitted in new military installations. Separate sewers are required and only sanitary flows are to be routed through treatment plants. For existing plants that are served by combined sewer systems, capacities will be determined by peak wet-weather flow determined from plant flow records. In the absence of adequate records, hydraulic capacities of four times the dry-weather flow will be used in the design. (Reference to existing systems is applicable to Army facilities only.)

## 4-5. Population equivalents.

Suspended solids and organic loading can be interpreted as population equivalents when population data constitute the main basis of design. Typical population equivalents applicable to military facilities were given in table 4-3. These equivalent values can also be used to convert non-domestic waste loads into population design values. The effects of garbage grinding will be incorporated into population-equivalent values when applicable. The waste stream to be treated at existing military installations should, when feasible, be characterized; this actual data should be used in the design.

## 4-6. Capacity factor.

A capacity factor (CF) taken from table 4-1 is used to make allowances for population variation, changes in sewage characteristics, and unusual peak flows. The design population is derived by multiplying the actual authorized military and civilian personnel population (called the effective population) by the appropriate capacity factor. Where additions are proposed, the adequacy of each element of the plant will be checked without applying the capacity factor. When treatment units are determined to be deficient, then capacity factors should be used to calculate the plant capacity required after expansion. However, the use of an unnecessarily high CF may so dilute waste as to adversely effect some biological processes. If the area served by a plant will not, according to the best current information, be expanded in the future, the capacity factor will not be used in designing treatment components in facilities serving that area. The following equation (eq 4-1) may be used to estimate total flow to the sewage plant where domestic, industrial and stormwater flows are anticipated.

$$x = a + b \quad \text{(eq 4-1)}$$

Where

x = Total flow to sewage plant

a = Flow from population (effective population × 100 gpcd × capacity factor

b = Infiltration + industrial wastewater + stormwater (4 × dry-weather flow)

## 4-7. Wastewater characteristics.

**a. Normal sewage**. The wastewater at existing facilities will be analyzed to determine the characteristics and constituents as required in paragraph 4-5. Analytical methods will be as given in the current edition of American Public Health Association (APHA) publication, **Standard Methods for the Examination of Water and Wastewater** and as approved by the Environmental Protection Agency (EPA). For treatment facilities at new installations which will not generate any unusual waste, the treatment will be for normal domestic waste with the following analysis:

| | |
|---|---|
| pH | 7.0 std units |
| Total solids | 720 mg/L |
| Total volatile solids | 420 mg/L |
| Suspended solids | 200 mg/L |
| Settleable solids | 4 ml/L |
| BOD | 200 mg/L |
| Total nitrogen | 30 mg/L |
| Ammonia nitrogen | 15 mg/L |
| Oils and grease | 100 mg/L |
| Phosphorus | 10 mg/L |
| Chloride | 50 mg/L |

Concentrations are presented above in milligrams per liter; which is equivalent to parts per million (ppm). These values represent an average waste and therefore should be used only where detailed analysis is not available. When the water supply analysis for the installation is known, the above analysis will be modified to reflect the normal changes to constituents in water as it arrives at the wastewater treatment plant. Changes will be as follows:

P in water supply + 12 mg/L = P in plant influent;
Cl in water supply + 8 mg/L = Cl in plant influent;
Total nitrogen in water supply + 12 mg/L = Total nitrogen in plant influent.

**b. Nondomestic loading.** Nondomestic wastes are stormwater; infiltration, and industrial contributions to sewage flow. Stormwater and infiltration waste loadings can be determined by analyses for the constituents of normal sewage, as presented in the previous section. For these types of flows, the major loading factors are suspended solids, biochemical oxygen demand, and coliform bacteria.

**c. Industrial loading.** Industrial waste loadings can also be characterized to a large extent by normal sewage parameters. However; industrial waste contains contaminants not generally found in domestic sewage and is more more variable than domestic sewage. This is evident in terms of pH, biochemical oxygen demand, chemical oxygen demand, oil and grease, and suspended solids; other analyses (e.g., heavy metals, thermal loading, and dissolved chemicals) may also be necessary to characterize an industrial waste fully. Each industrial wastewater must be characterized individually to determine any and all effects of treatment processes.