in holding basins can also be loosely categorized as pretreatment processes.

B. PRIMARY TREATMENT

Primary treatment is a mechanical (settling) process used to remove most of the settleable solids. A 25 to 35% reduction in BOD is also achieved, but BOD reduction is not the goal of primary treatment.

Plain Sedimentation: Plain sedimentation basins are described in chapter 7. Design characteristics for wastewater treatment are:

• BOD reduction	20% to 40%
• total suspended solids reduction	35% to 65%
• bacteria reduction	50% to 60%
• organic content of settled solids	50% to 75%
• specific gravity of settled solids	1.2 or less
• typical settling velocity	above 4 feet/hr
• plan shape	rectangular or circular
• basin depth	6 to 15 feet (12 typical)
• basin width	10 to 50 feet
• minimum freeboard	18 inches
• minimum hopper wall angle	60°
• aspect ratio (rectangular)	3:1 to 5:1
• detention time	1.5 to 2.5 hours
• circular diameter	30 to 150 feet (100 common)
• flow-through velocity	0.005 ft/sec
• flow-through time	at least 30% of detention time
• overflow rate	400 to 2000 gpd/ft^2 (800 to 1200 typical)
• bottom	slight slope (8%) towards hopper
• inlet	baffled for uniform velocity
• scum removal	mechanical or manual
• weir loading	10,000 to 20,000 gpd/ft

Chemical Sedimentation: Chemical flocculation (*clarification* or *coagulation*) is similar to that described in chapter 7 except that the coagulant doses are greater. Typically, the most economical coagulant used is ferric chloride. Lime and sulfuric acid may be used to adjust the pH for proper coagulation. Chemical precipitation is used when the stream into which the outfall discharges is running low, when there is a large increase in sewage flow, and generally when plain sedimentation is insufficient.

C. SECONDARY TREATMENT

Secondary treatment is a biological treatment. It became mandatory for all publicly owned water treatment plants as of July 1977 under the Federal Water Pollution Control Act ammendments of 1972.

Trickling Filters: Trickling filters (also known as *biological beds*) consist of beds of 2″ to 5″ rocks up to 9 feet thick (6 feet typical) over which influent is sprayed. The biological and microbial slime growth attached to the rocks purify the wastewater as it trickles through the rocks. The water is introduced into the filter by rotating arms which move by virtue of the spray reaction. The clarified water is collected by an underdrain system. Some water may be returned to the filter for a longer contact time.

On the average, one acre of standard filter area is needed for each 20,000 people served. Trickling filters can remove 70% to 90% of the suspended solids, 65% to 85% of the BOD, and 70% to 95% of the bacteria. Most of the reduction occurs in the first few feet of bed, and organisms in the lower part of the bed may be in a near-starvation condition. The bed will periodically slough off (unload) parts of its slime coating, and sedimentation after filtering is necessary.

Since there are limits to the heights of trickling filters, longer contact times can be achieved by returning some of the collected filter water to the filter. This is known as *recirculation*. Recirculation is also used to keep the filter medium from drying out and to smooth out fluctuations in the hydraulic loading.

High rate filters are now in use by most modern facilities. The higher hydraulic loading flushes the rockpile and inhibits excess biological growth. High rate filters may be only 3 to 4 feet deep. The high rate is possible because much of the filter discharge is recirculated.

The *hydraulic loading* of a trickling filter is the water flow divided by the plan area. Typical values of hydraulic loading are 25 to 100 gpd/ft^2 for standard filters, and up to 1000 gpd/ft^2 for high-rate filters.

$$L_H = \frac{Q_w + Q_R}{A_{\text{filter}}} = \frac{Q_w + R_R Q_w}{A_{\text{filter}}} = \frac{Q_w(1+R_R)}{A_{\text{filter}}} \quad (Q \text{ in gpd}) \qquad 8.27$$

The *recirculation ratio* is given by equation 8.28. It can be as high as 3 for high rate filters, although it is zero for standard low-rate filters.

$$R_R = Q_R/Q_w = \frac{L_H A_{\text{filter}}}{Q_w} - 1 \qquad 8.28$$

The *BOD loading* (same as *organic loading*) is calculated without considering any recirculated flow. BOD