Updated: 26 November 2019

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CEE 370 Environmental Engineering Principles

Lecture #30

Wastewater Treatment I:

WW characteristics, 1° & 2° treatment

Reading M&Z, Chapter 9

Reading: Davis & Cornwall, Chapt 6-1 to 6-8

Reading: Davis & Masten, Chapter 11-1 to 11-7

WW Parameters

- Conventional
  - BOD
  - TSS
  - Oil & grease
  - pH
- Nutrients
  - Nitrogen
    - Ammonia
    - Nitrate
    - TKN
  - Phosphorus
- Toxics
  - Heavy metals
    - Chromium, etc.
  - Pesticides
    - Parathion, etc
  - Industrial
    - Phenol, etc.
- PPCPs
  - Pharmaceuticals
  - Personal care products
- Others
  - TOC, etc.

Wastewater Characteristics

- Municipal/Domestic WW

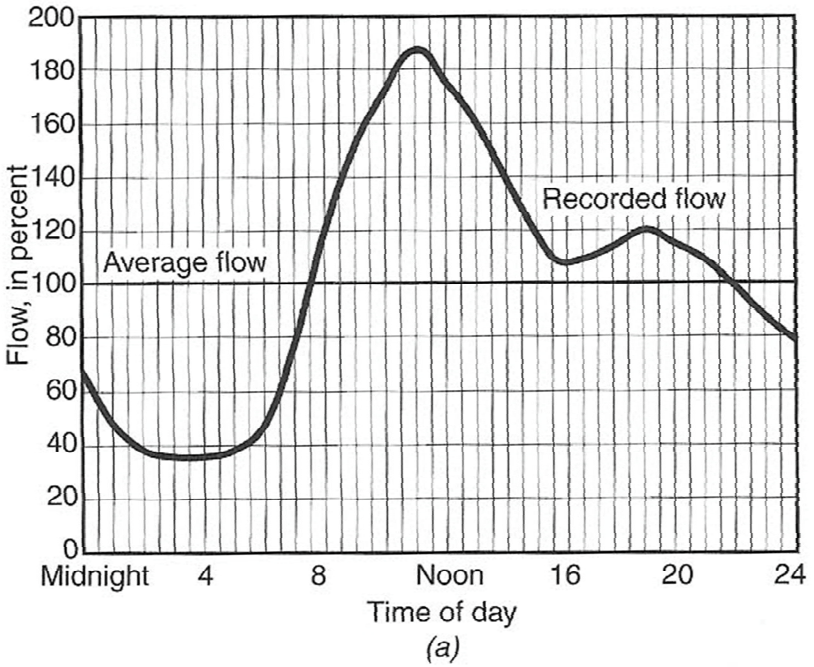
TABLE 10–1 Typical Composition of Untreated Domestic Wastewater

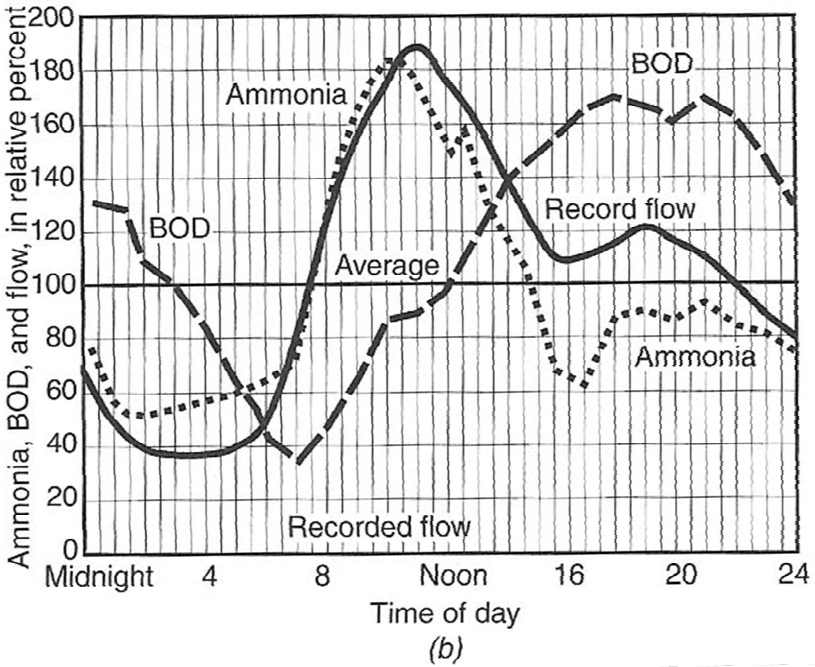
Constituent	Weak	Medium	Strong
	(all mg · L^{-1} except settleable solids)		
Alkalinity (as $CaCO_2$)[a]	50	100	200
BOD_5 (as O_2)	100	200	300
Chloride	30	50	100
COD (as O_2)	250	500	1000
Suspended solids (SS)	100	200	350
Settleable solids (in mL · L^{-1})	5	10	20
Total dissolved solids (TDS)	200	500	1000
Total Kjeldahl nitrogen (TKN) (as N)	20	40	80
Total organic carbon (TOC) (as C)	75	50	300
Total phosphorus (as P)	5	10	20

[a]This amount of alkalinity is the contribution from the waste. It is to be added to the naturally occuring alkalinity in the water supply. Chloride is exclusive of contribution from water-softener backwash.

Municipal WW

- Temporal Patterns in flow and quality
  - Seasonal
  - Weekly
  - Daily





On-site disposal

- Septic Systems
  - Requires minor levels of maintenance

FIGURE 10–1

Schematic of a conventional septic system. (*Source:* R. Crites and G. Tchobanoglous, *Small Decentralized Wastewater Management Systems*, WCB/McGraw-Hill, Boston, MA, 1998. Reprinted by permission.)

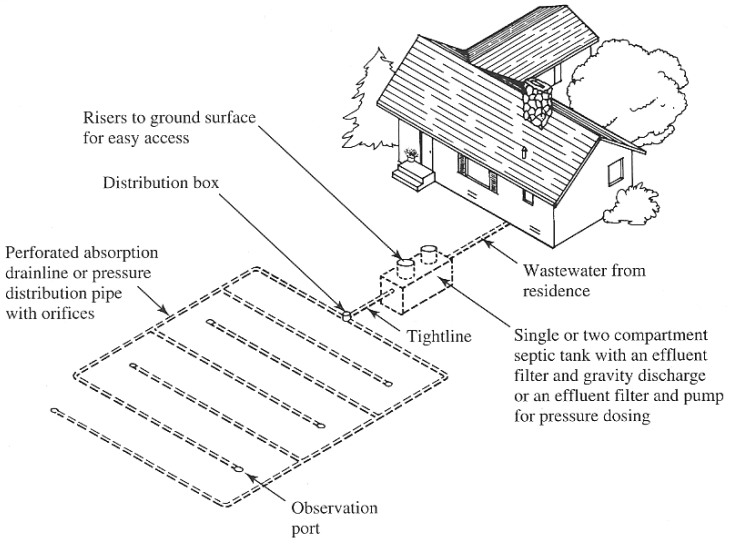


FIGURE 10–2

Definition sketch for the sludge, clear water, and scum zones that form in a septic tank. (*Source:* R. Crites and G. Tchobanoglous, *Small Decentralized Wastewater Management Systems*, WCB/McGraw-Hill, Boston, MA, 1998. Reprinted by permission.)

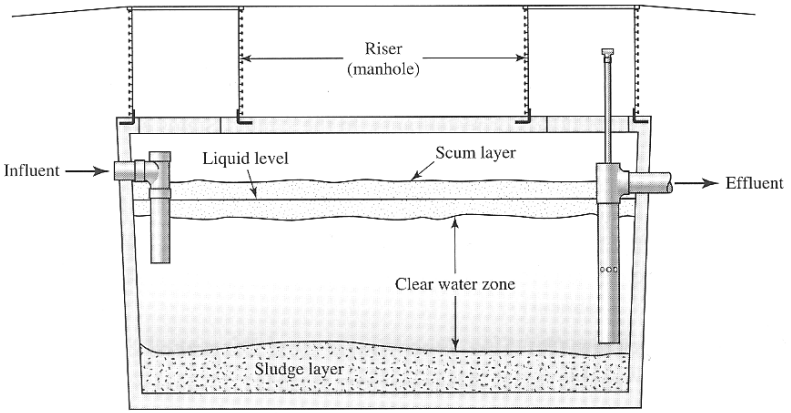
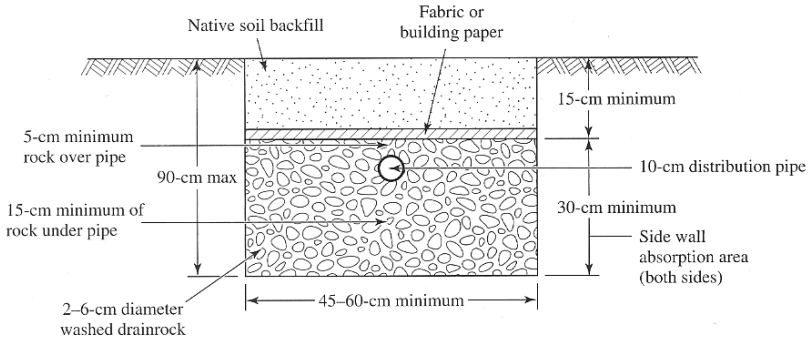


FIGURE 10–3

Typical cross section through conventional absorption trench. (*Source:* R. Crites and G. Tchobanoglous, *Small Decentralized Wastewater Management Systems*, WCB/McGraw-Hill, Boston, MA, 1998. Reprinted by permission.)



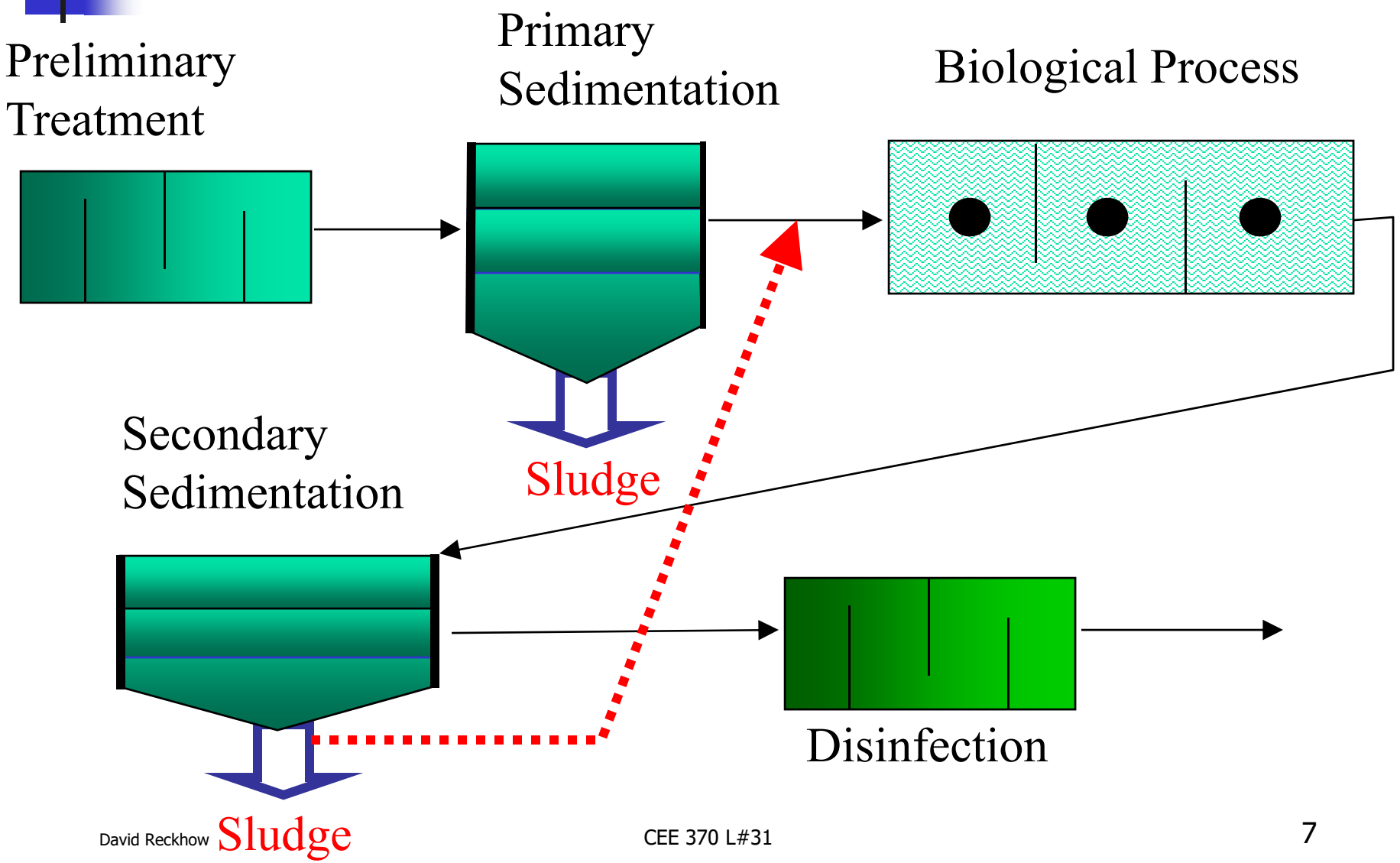
Municipal WW Treatment

- Primary
  - Solids removal
- Secondary
  - Biological treatment
  - BOD control
- Tertiary or Advanced
  - Biological or chemical
  - Nutrient control, etc

Conventional

Also must treat residuals (e.g., sludge)

Conventional WW Treatment

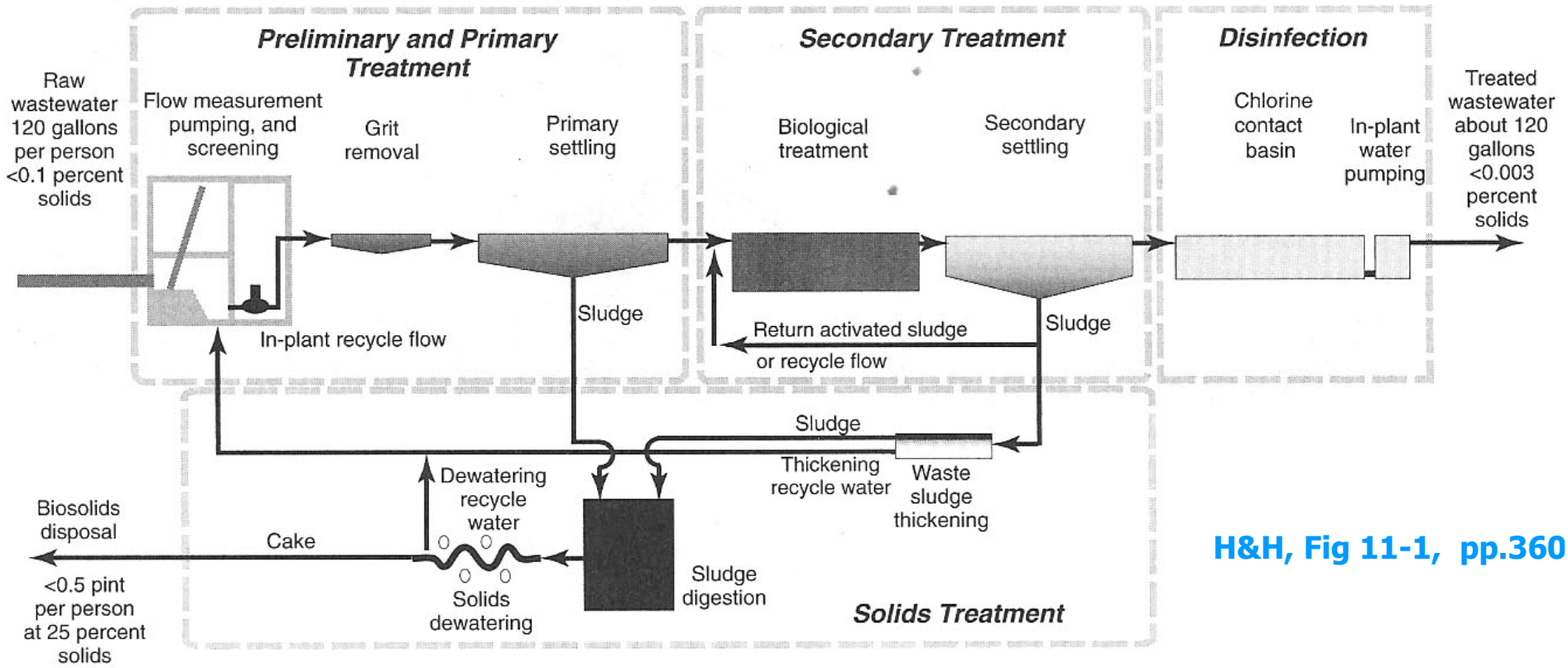


Saskatoon WWTP

- Activated Sludge

Intro to WWT

- Incorporating 1° and 2° treatment
  - May also need 3° treatment



H&H, Fig 11-1, pp.360

Small WWT Systems

- From a few hundred people to several thousand

H&H, Fig 11-2, pp.361

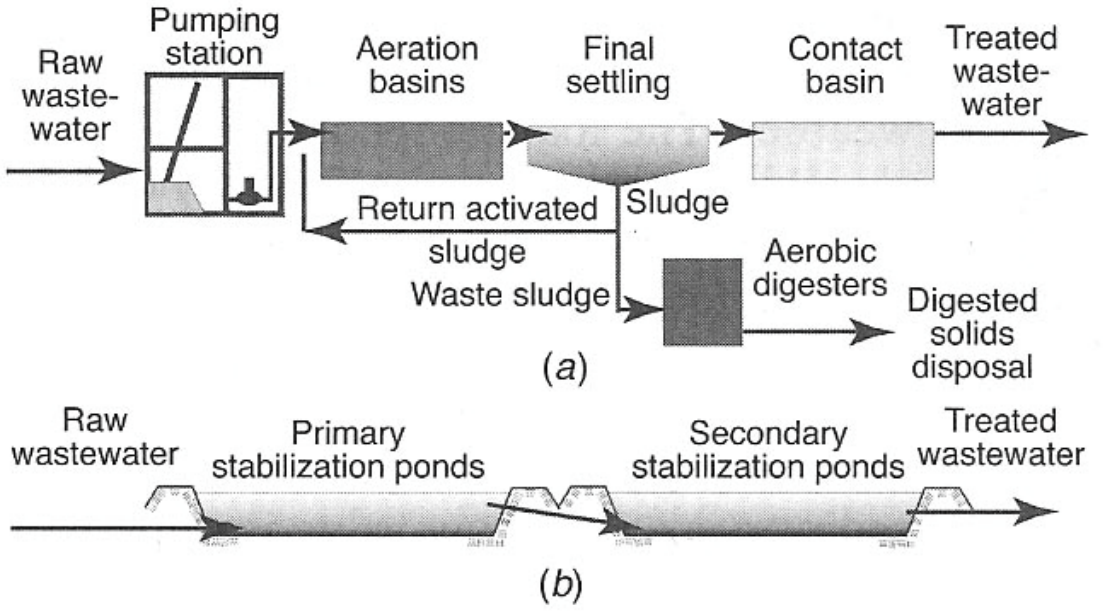


Figure 11–2
Processing diagrams of systems for treatment of small wastewater flows. (*a*) Biological processing without primary sedimentation. (*b*) Natural facultative stabilization ponds.

Design Loading & Parameters

- Peak hourly – often occurs during storm event

H&H, Table 1-1, pp.363

TABLE 11–1

Typical Design Criteria for the Treatment Processes Shown in Figure 11–1

PROCESS	LOADING
Flow measurement	Peak hourly flow
Bar screen	Peak hourly flow
Pumps	Peak hourly flow
	Min. hourly flow
Grit chamber	Max. monthly flow
	Peak hourly flow
Primary settling	Max. monthly flow
Biological treatment	Max. monthly BOD loading
	Check peak hourly BOD loading
Final settling	Max. monthly flow
Disinfection	Peak hourly flow
Thickening	Max. daily sludge flow
	Check max. solids loading
Digestion	Max. monthly volatile solids load
	Check max. monthly sludge flow
Dewatering	Max. sludge flow
	Check max. solids loading
Land application	Max. nutrient loading (sludge)
	Max. hydraulic loading (water)

10 States Standards; 2004 Edition

Preliminary Treatment

- Chemical addition
  - Not common
- Flow measurement
  - Parshall flumes are most common
- Screening
- Pumping
- Grit Removal

H&H, Fig 11-4, pp.364

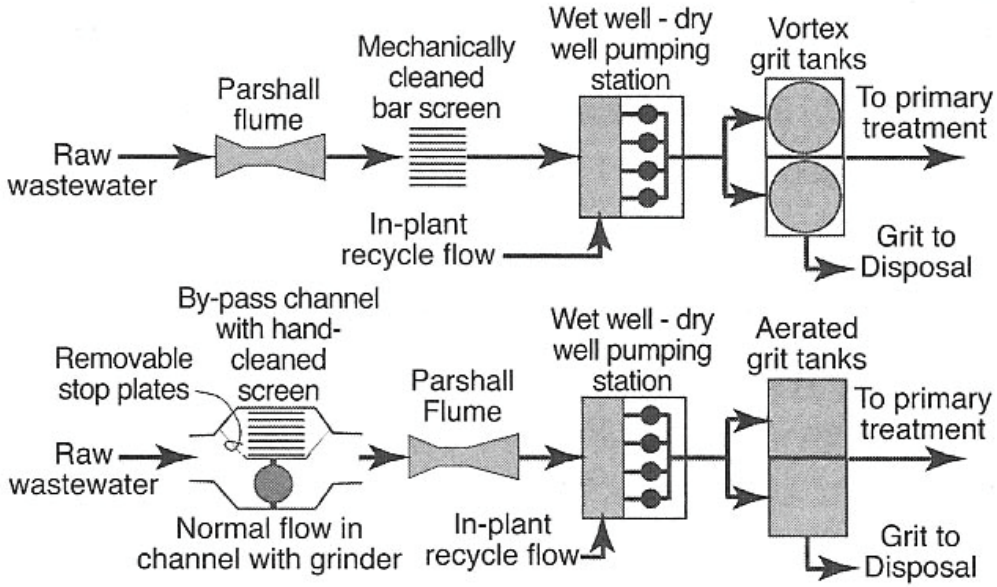


Figure 11–4
Typical arrangements of preliminary treatment units in municipal wastewater processing: flow measurement, screening, sewage pumping, and grit removal. The lower sequence is common for smaller plants.

Screens

- Bar Screens
  - openings from 0.5-2.25 in
  - Cleaned by mechanical travelling rake
- Fabric Screens
  - Finer (0.125-0.25 in), more common in Europe

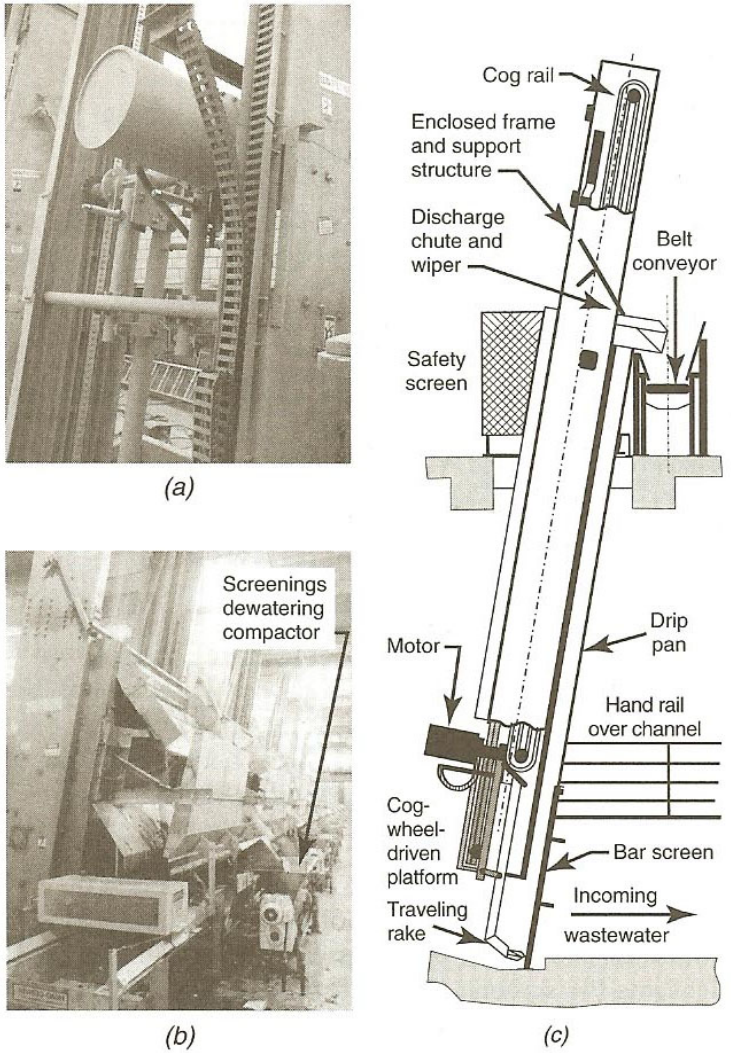
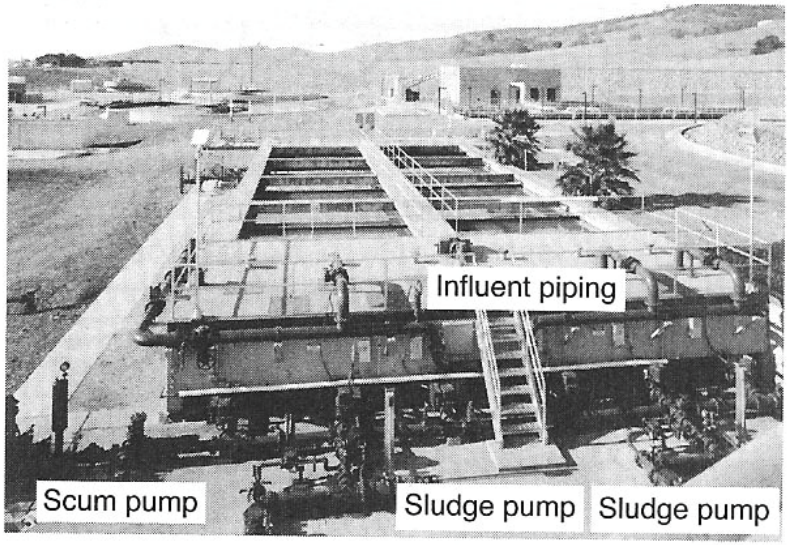


Figure 11–5
Climber-style mechanically cleaned bar screen. *(a)* Photo of drive at the top of the bar screen showing motor and cog wheels on the fixed plate between side rails. *(b)* Photo from behind the unit where screenings travel on a belt conveyor prior to compression dewatering and final disposal in a landfill. *(c)* Drawing of the bar screen. Screen openings are $\frac{3}{4}$ in. No moving parts are submerged in wastewater. The bottom portion of the bar screen is shown in Figure 11–11*b*.

H&H, Fig 11-5, pp.365

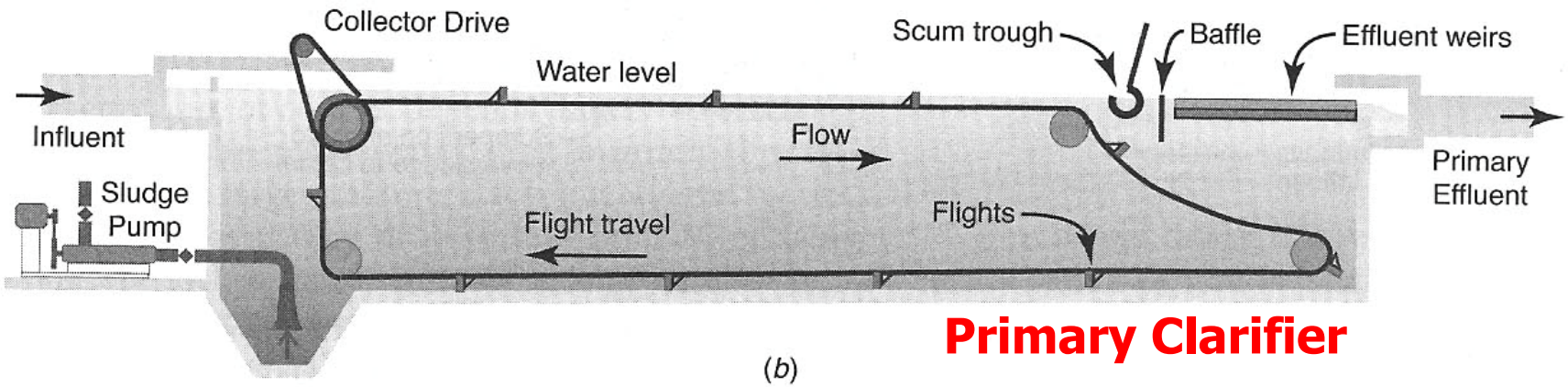
1° Settling

- Rectangular or circular tanks
  - Similar to drinking water treatment
  - Flow enters behind an inlet baffle
  - Baffles placed in front of effluent weirs prevent loss of floating materials
    - Removed by a mechanical skimmer (dual purpose)



(a)

H&H, Fig 11-9, pp.368



(b)

Primary Clarifier

Biological Processes

- Secondary Treatment
  - Activated Sludge
    - Many variations
  - Ponds & lagoons
    - Many types

  Suspended growth

  - Trickling Filters
  - Rotating Biological Contactors

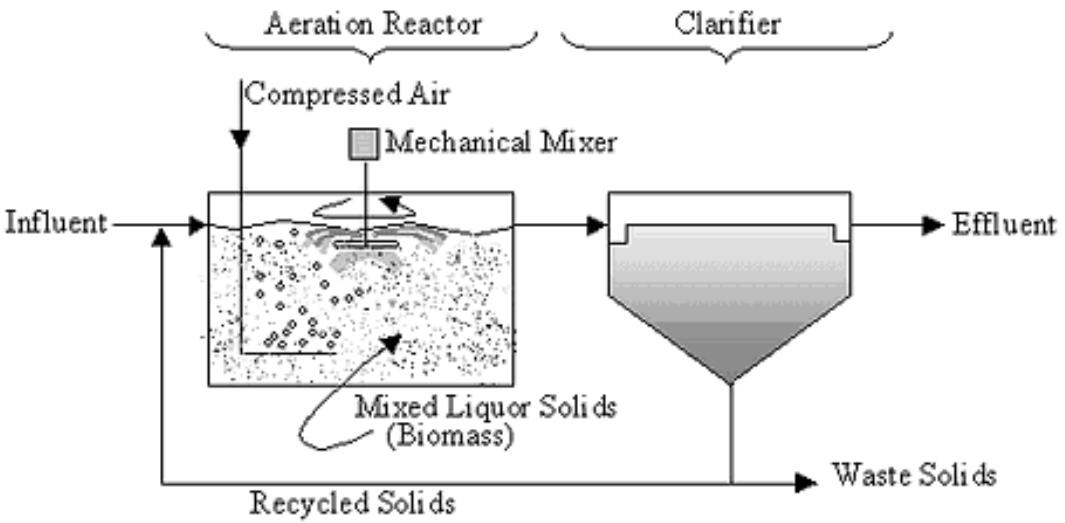
  Attached Growth
- Sludge
  - Aerobic digestion
  - Anaerobic digestion

Microorganisms & treatment

- Stabilization of organic matter
  - Mostly oxidation to CO_2 in aerobic processes
  - Mostly to CH_4 & CO_2 in anaerobic processes
- Formation of cellular biomass
  - Requires management of population
  - Disposal of excess (biological sludge)
- May require intensive addition of electron acceptor
  - O_2 added in some aerobic processes

Activated Sludge

- Two components
  - Aeration basin
  - Clarifier & return sludge



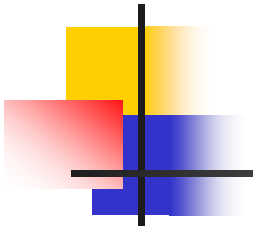
From University of Birmingham

Activated Sludge

- Mixed liquor
- Return Activated sludge

Aeration!

1. Surface aerators
2. Bubble diffusers



- To next lecture