Primary Clarifiers

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EPA Operator Webinar Series
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Clarification

OUTLINE

I. Introduction to Primary Clarifiers
II. Circular Primary Clarifiers
III. Rectangular Primary Clarifiers
IV. General Comments about Primary Clarifiers
V. Design of Primary Clarifiers
VI. Troubleshooting

Poll Question #1

What is your current knowledge of primary clarification?

a. Poor
b. Moderate
c. Good
d. Excellent

Poll Question #2

What is the design flow rate of your WWTP?

a. 0.1 to 0.99 mgd
b. 1.0 to 4.99 mgd
c. 5.0 to 15 mgd
d. > 15 mgd

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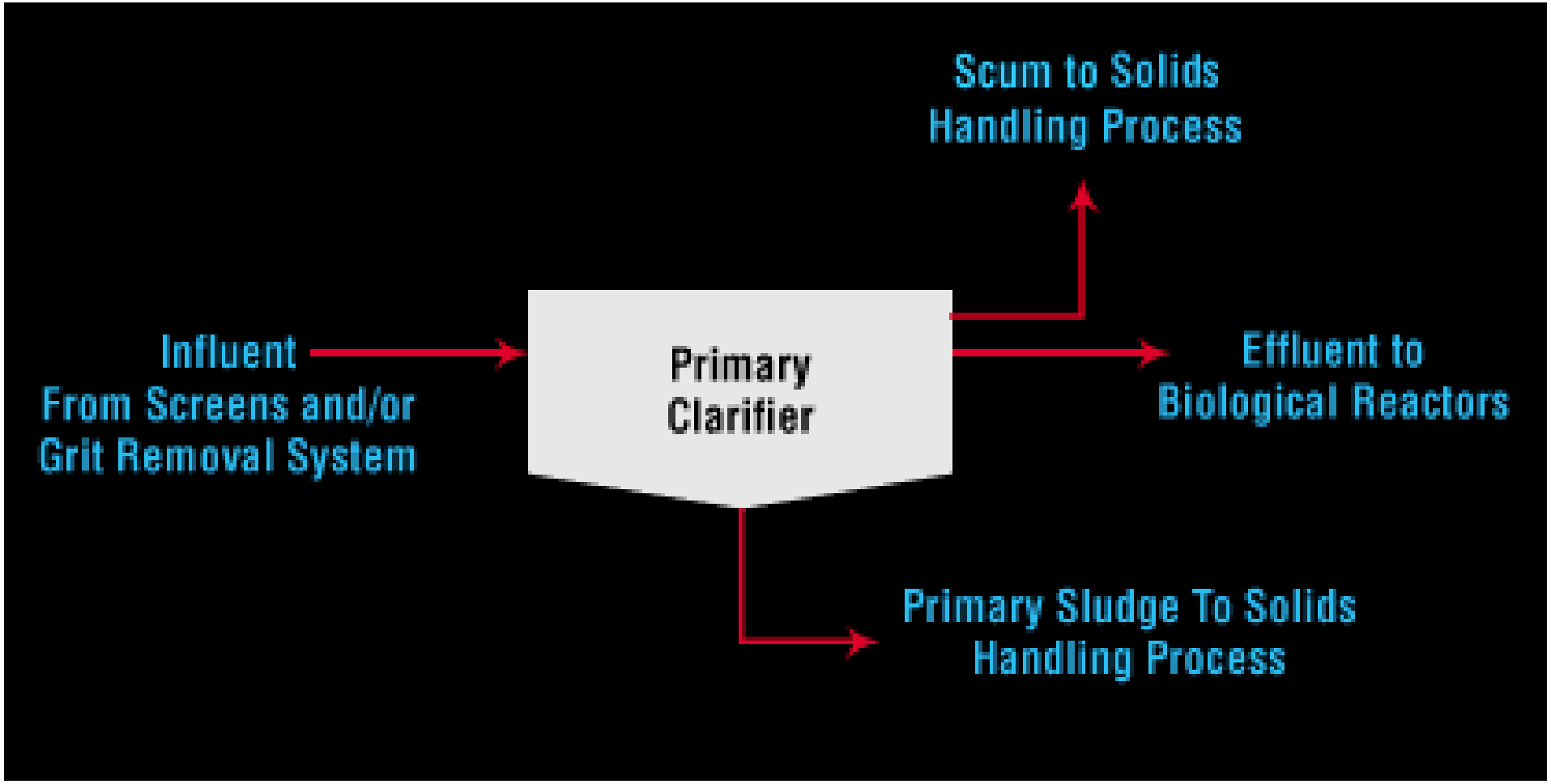
Introduction to Primary Clarifiers

***Many of the clarifier photos were provided by Water Environment Federation training materials (2002)!**

General Differences between Primary and Secondary Clarifiers

- *Primary settling* is the settling of a dilute suspension of mostly flocculent particles (raw wastewater TSS). There is no distinct interface between the settling sludge and clarified supernatant. TSS removal typically is 50% to 65%. Most TSS settle faster than activated sludge, and sludge compacts better.
- *Secondary settling* is the settling of a concentrated suspension of flocculent particles (mostly biomass). There is a distinct interface between the settling sludge and clarified supernatant. TSS removal typically is ≥ 99%. TSS settle slower than primary solids, and sludge does not compact as well.

Primary Clarification



Primary Clarification

Primary Clarifiers will remove a large portion of suspended solids and a small fraction of influent BOD_5

50 - 65% Removal of TSS
20 - 35% Removal of BOD_5

Primary Clarifiers are always located upstream of trickling filters or RBC's and are optional before the activated sludge process.

Factors Affecting TSS Removal

- Hydraulic loading on the clarifier
- Tank configuration
- Wastewater characteristics
- Particle characteristics
- Temperature
- Industrial wastewater contributions

Surface Overflow Rate (SOR)

SOR is the aerial velocity of a particle

$SOR = Q/A = ft^3/day/ft^2 = ft/day$

where:

Q is the hydraulic flow rate applied to the clarifier

A is the surface area of the settling zone

Be careful with units !!!

Weir Loading Rate (WLR)

WLR = Q/L = gpd/ft of weir

Q is the hydraulic flow rate applied to the clarifier

L is the length of weir in the clarifier

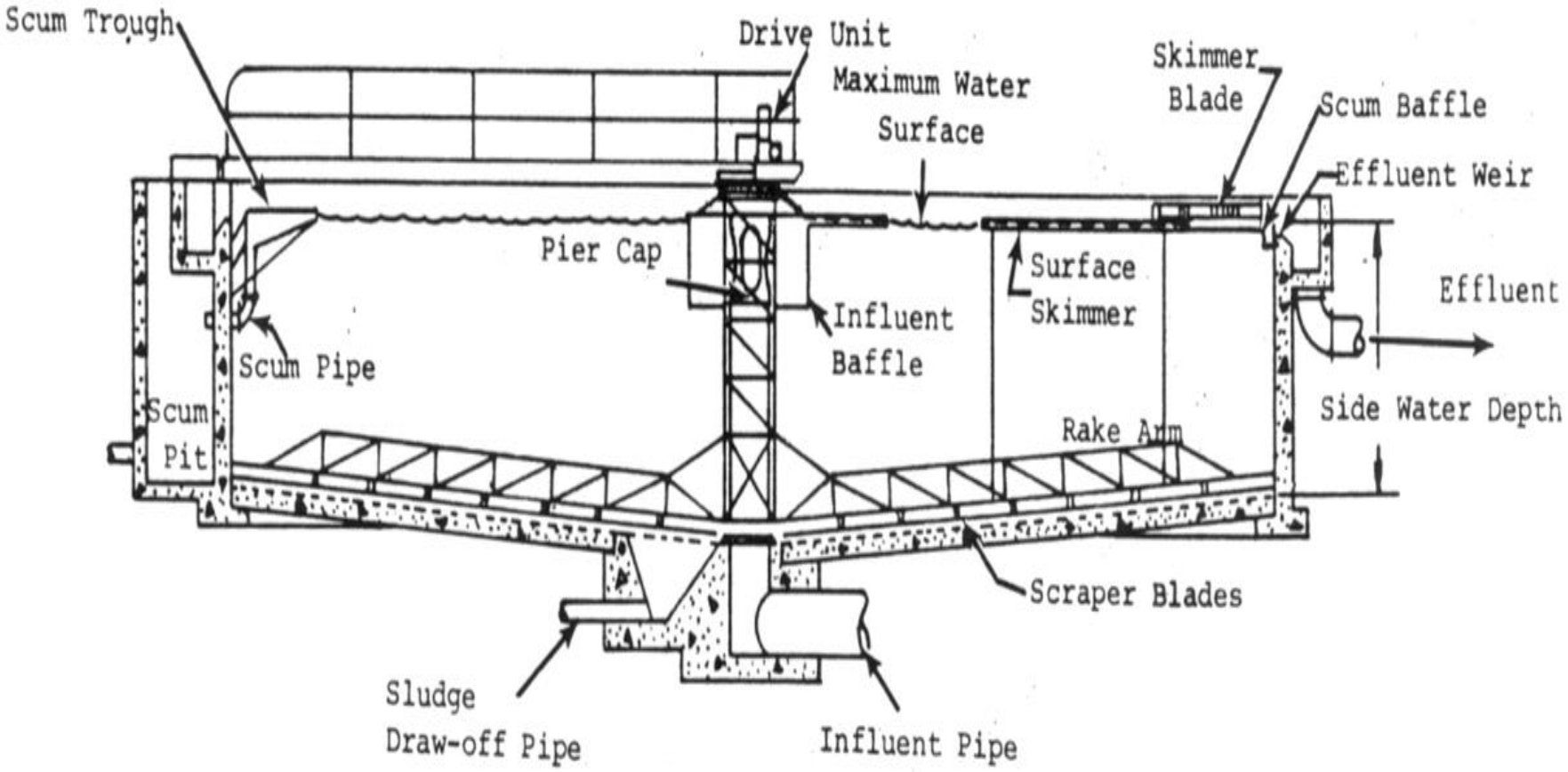
Observations about Primary Settling

- Settleability is better in fresh wastewater than in septic wastewater.
- A dense particle settles more quickly than a light one.
- An irregularly shaped particle settles slowly because of its high frictional drag.
- Particles settle better in warm water than in cold water.
- High industrial peak flows will increase surface overflow rates (SORs) and decrease detention times – thus reducing settling performance.

Circular Primary Clarifiers

Round Clarifier

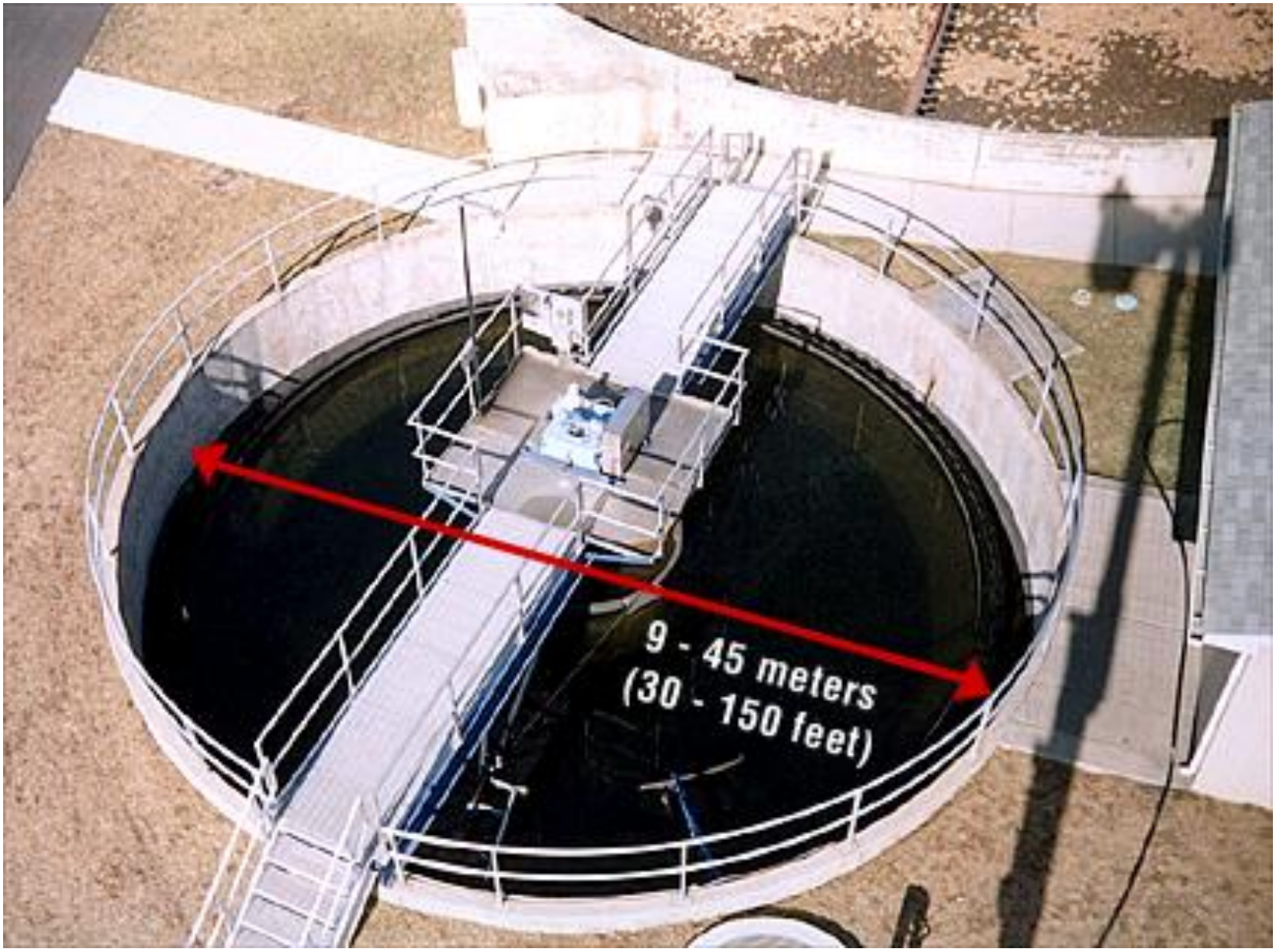
Primary Clarification



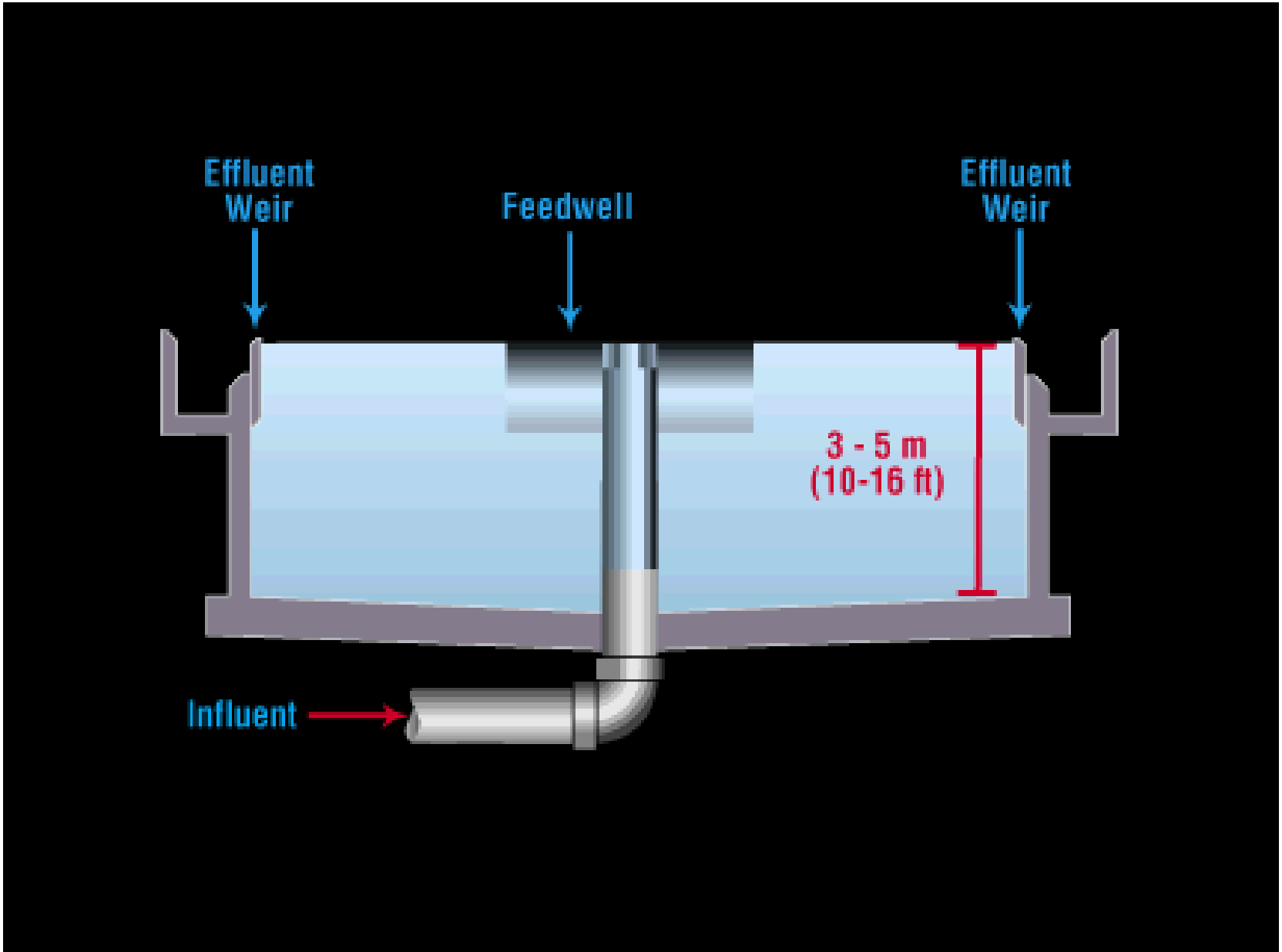
Circular Primary Clarifiers

Sludge collector tip speed	**10 to 15 ft/min**
Scum generation	**6 ft^3/mil gal (design)** **1 ft^3/mil gal (actual)**
Sludge generation	**2500 to 20,000 gal/mil gal**
Depth of feed well	**3 to 5 ft**
Maximum diameter	**200 ft**
Detention time	**1.5 to 3.0 hours**

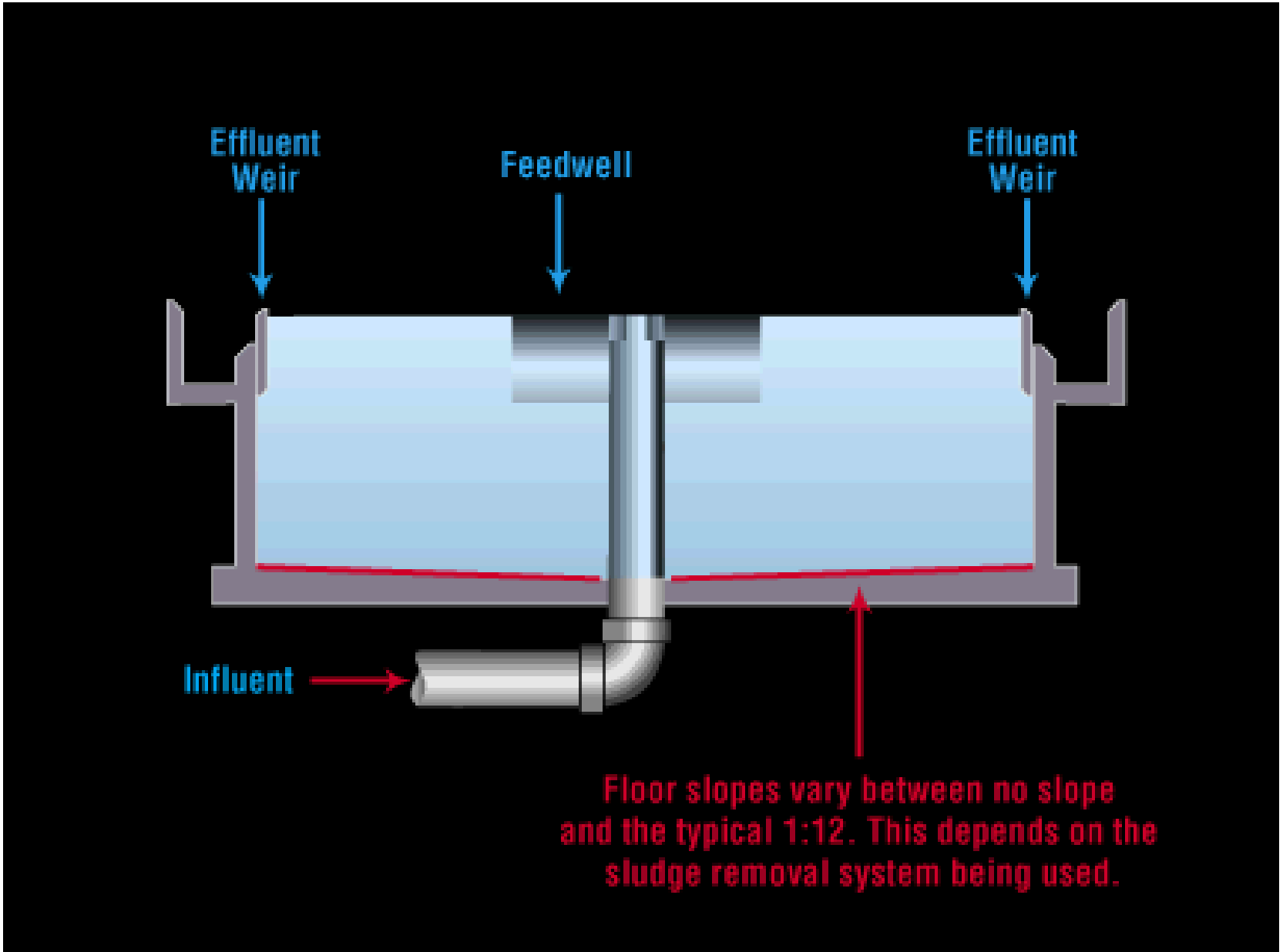
Center-Feed Peripheral Draw-off Clarifier



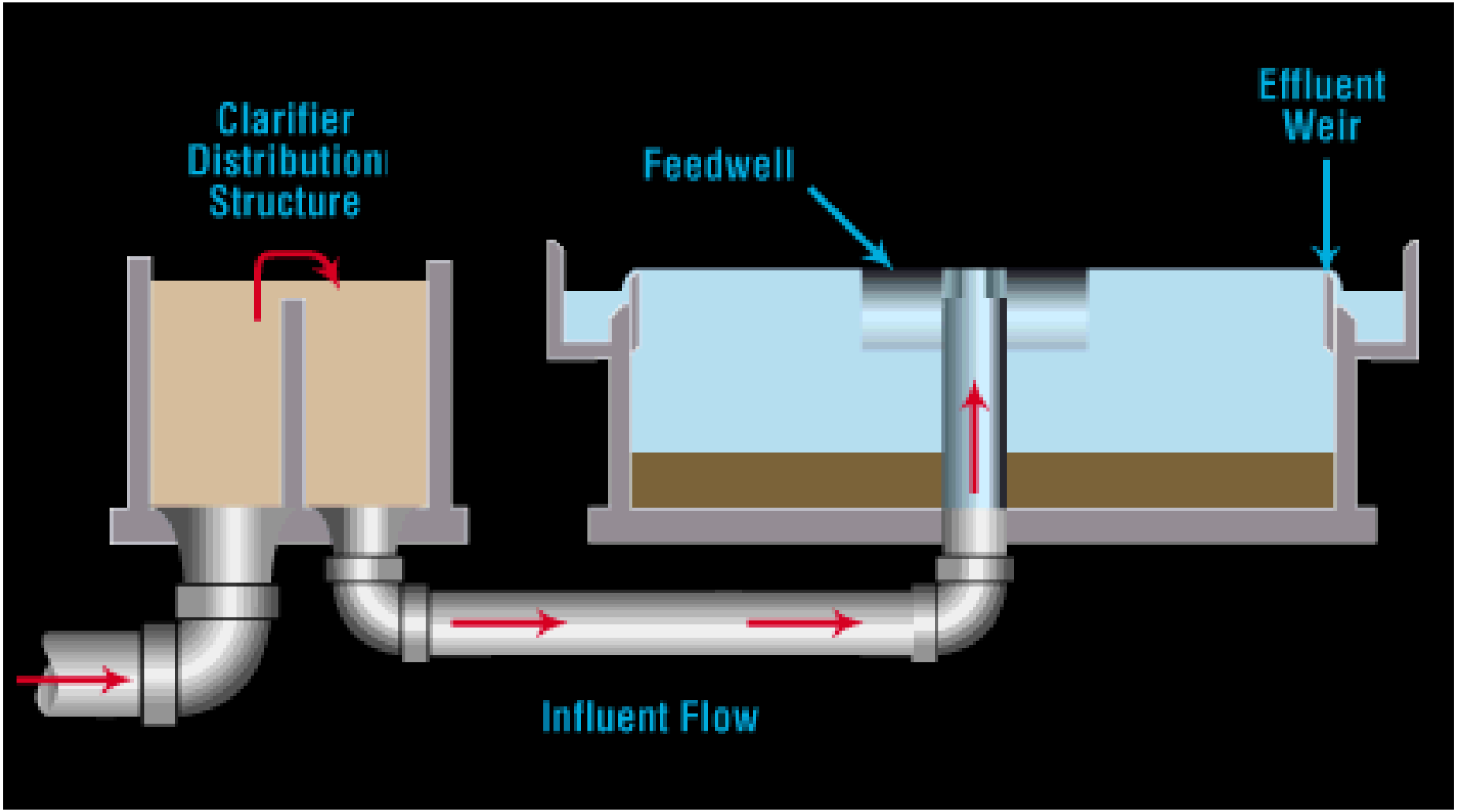
Circular Clarifier – Side Water Depth



Circular Clarifier – Floor Slope

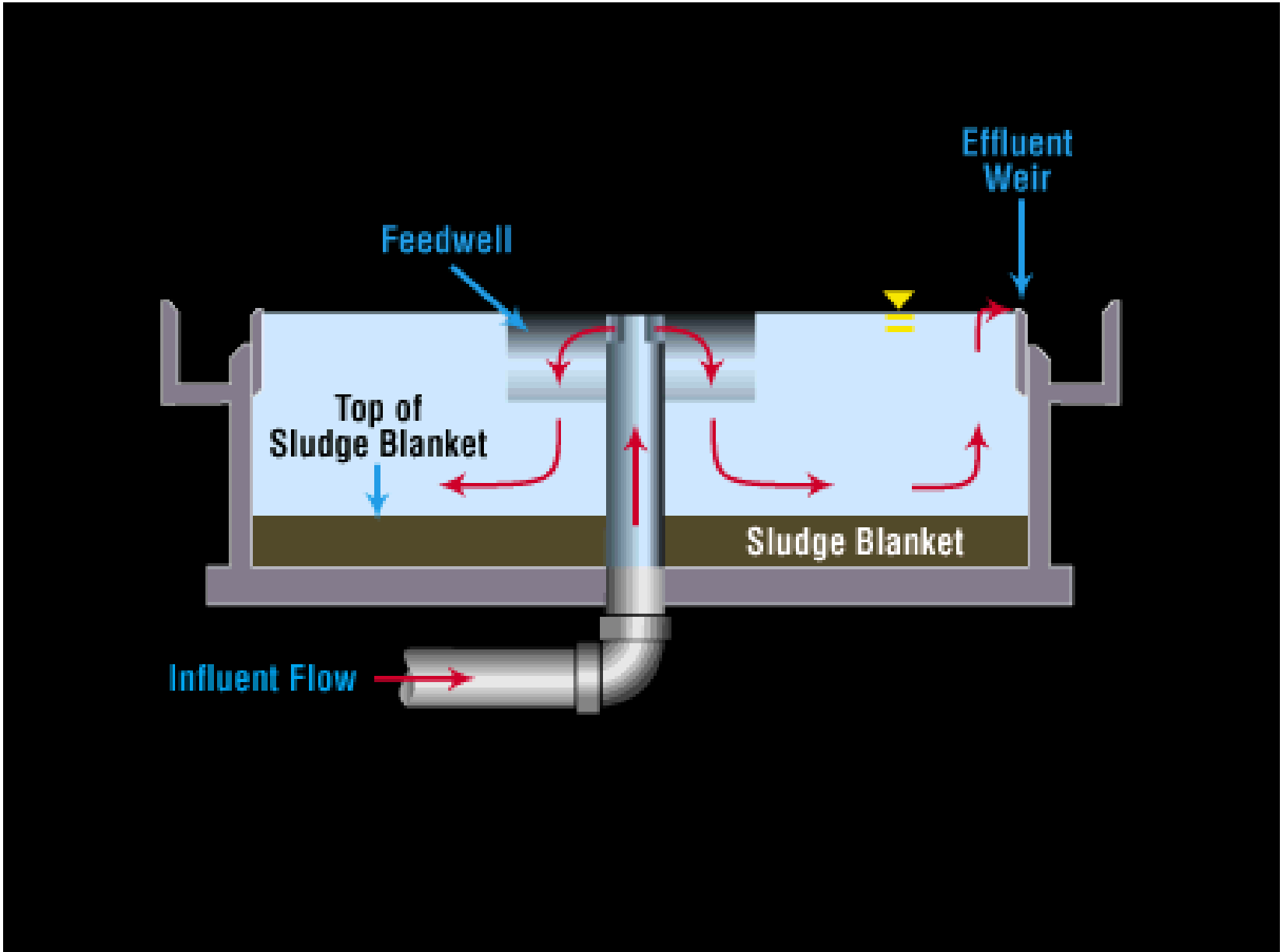


Center-Feed Circular Clarifier

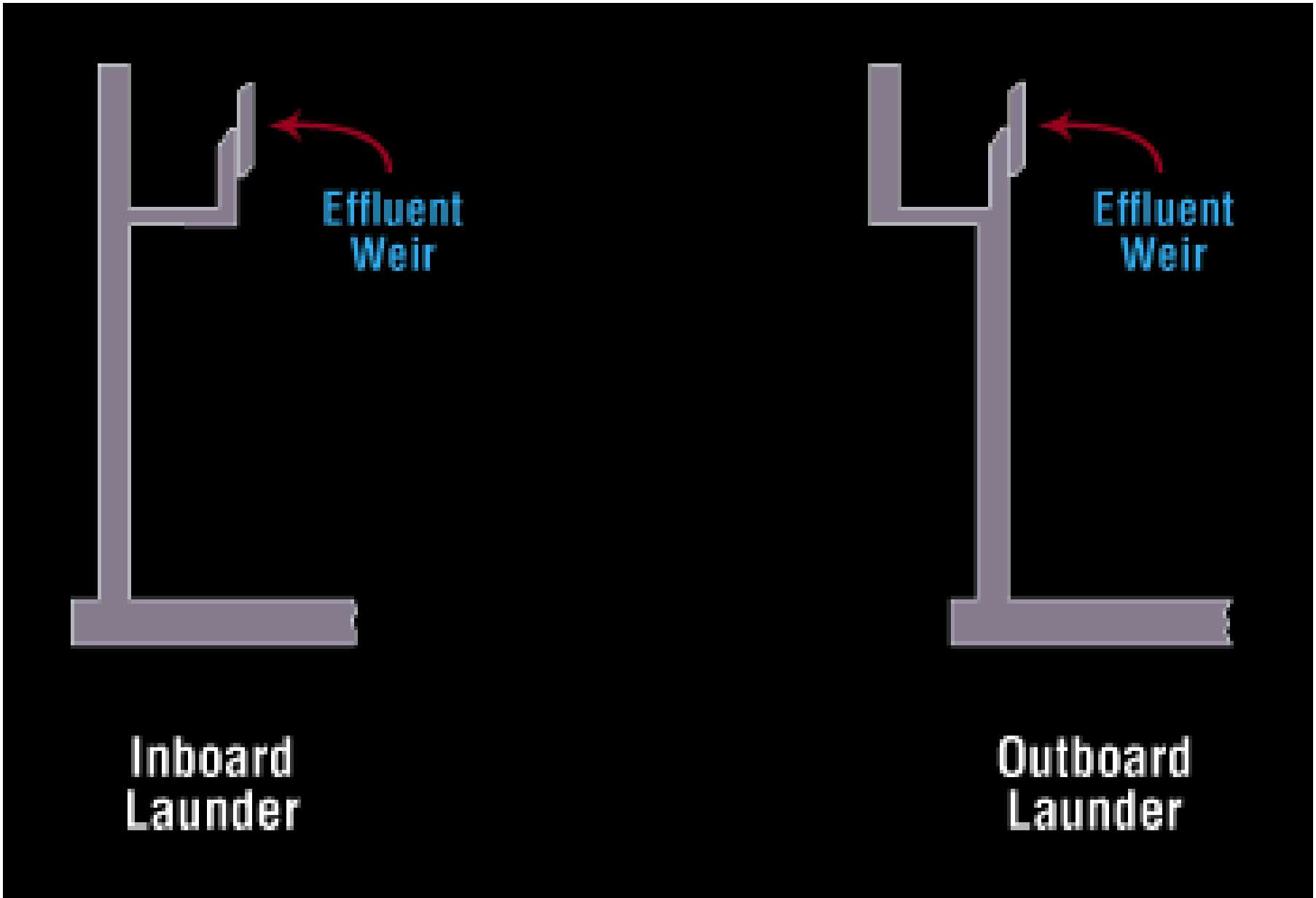


Center-Feed Clarifier Feedwell Diameter

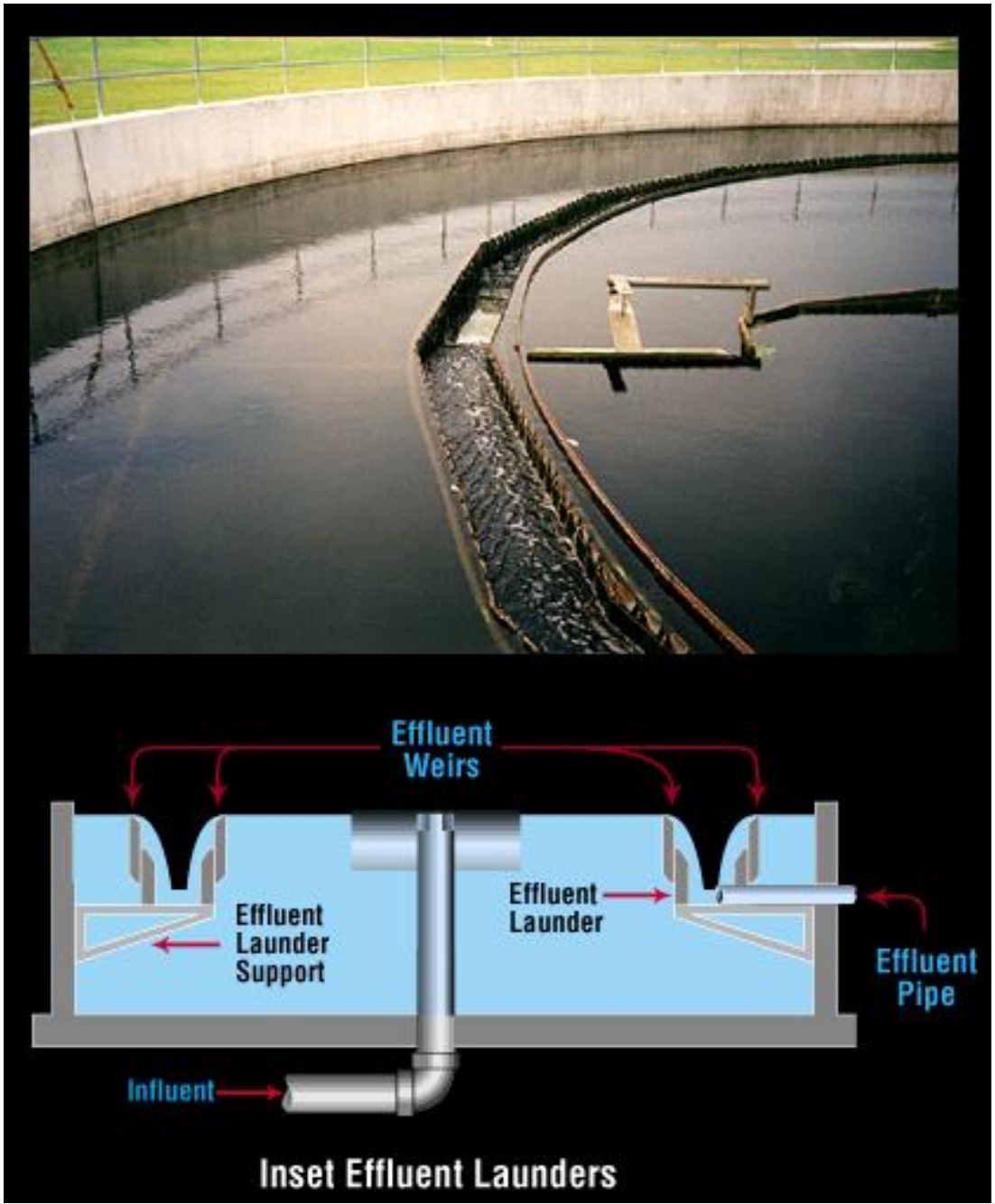
Density Currents in a Circular Clarifier



Cross-Section Thru an Inboard & Outboard Launder



Inset Effluent Launders



Clarifier Effluent Launder

Poll Question #3

Which activated sludge process typically is preceded by primary treatment?

a. Extended aeration activated sludge
b. Oxidation ditch activated sludge
c. Conventional activated sludge
d. Sequencing Batch Reactor (SBR) activated sludge

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Questions?

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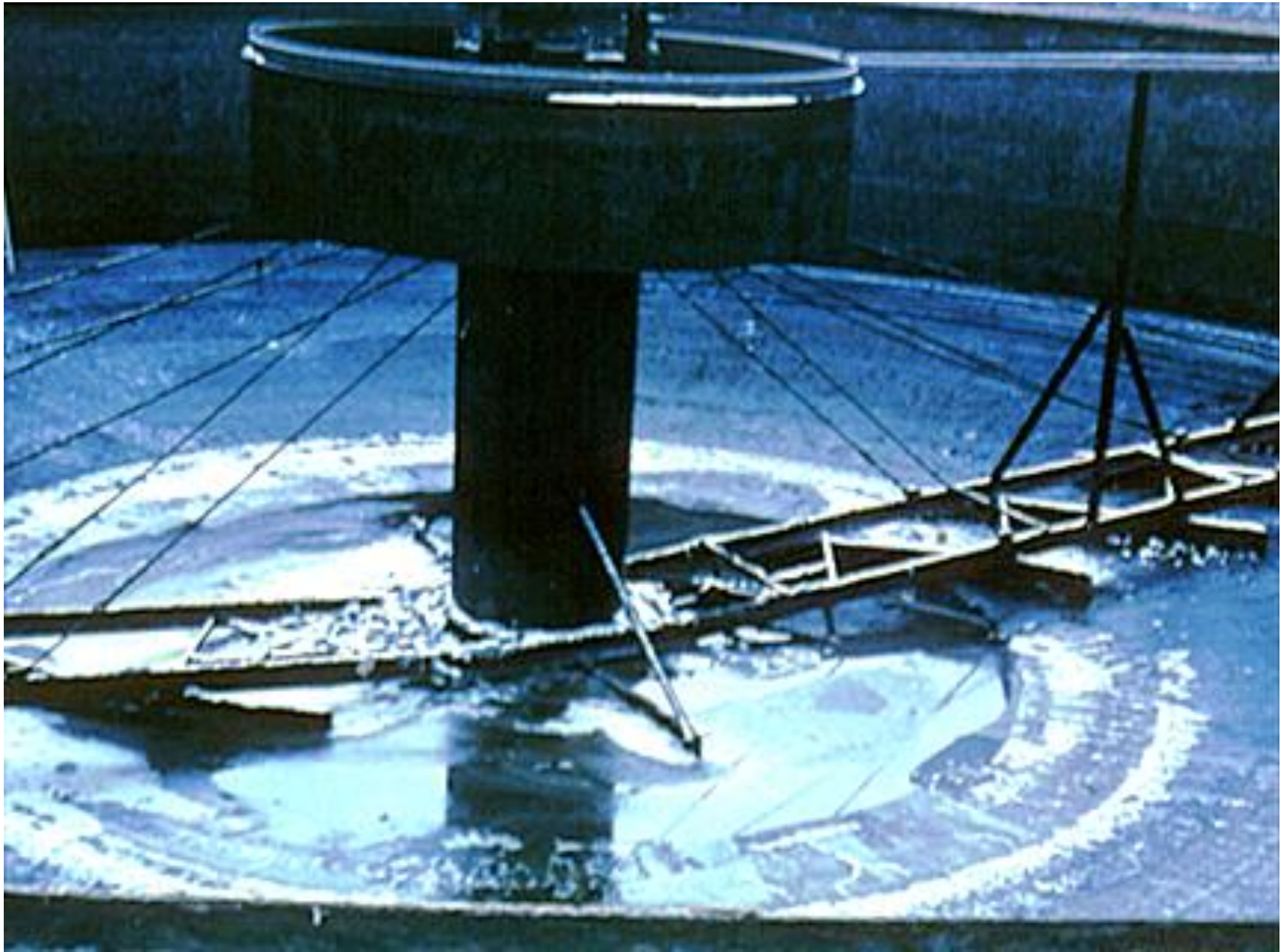
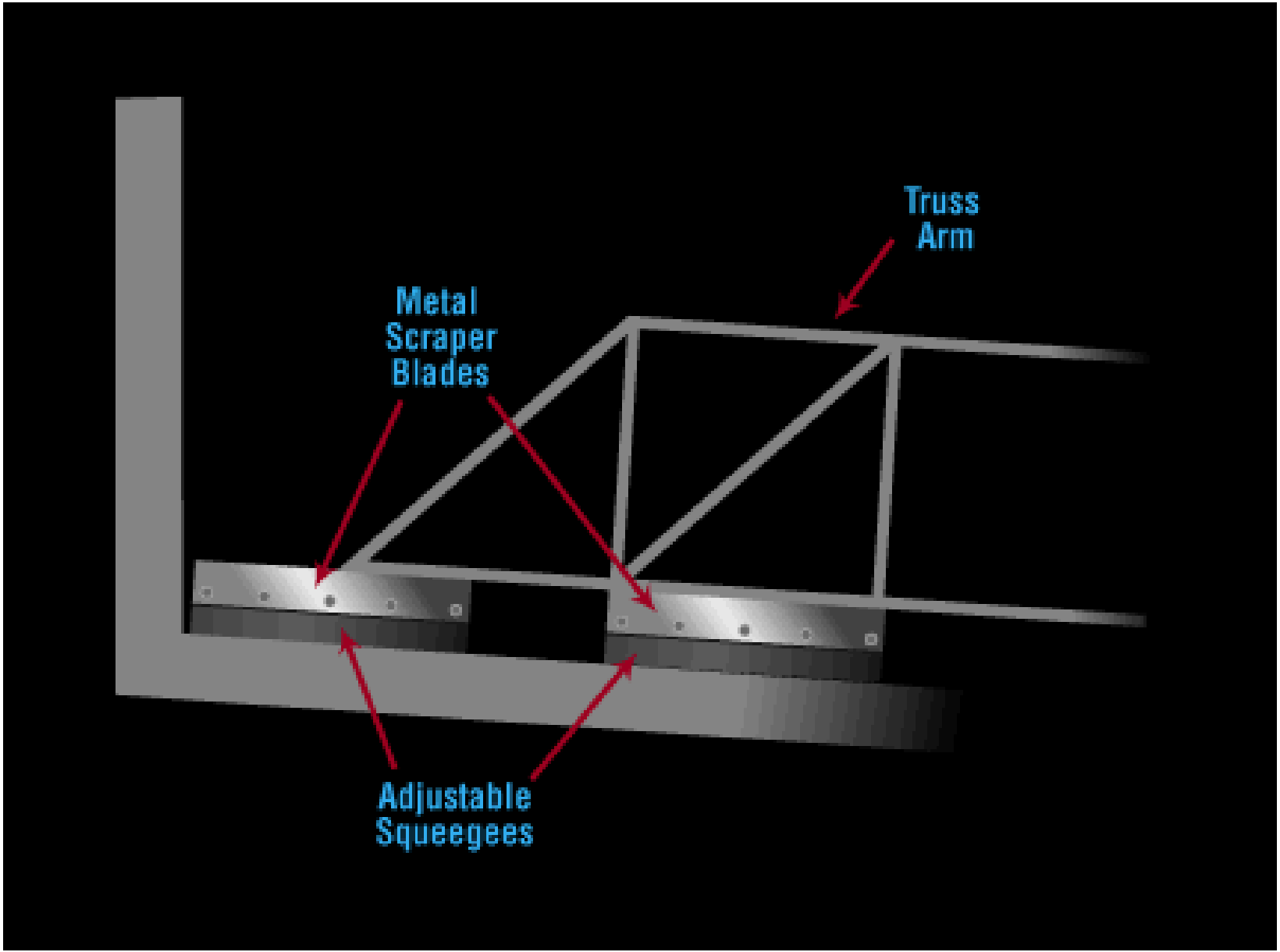
Types of Sludge Collection Equipment for Circular Clarifiers

- Rotating scrapers
- Spiral arm sludge removal
- Pumped sludge removal

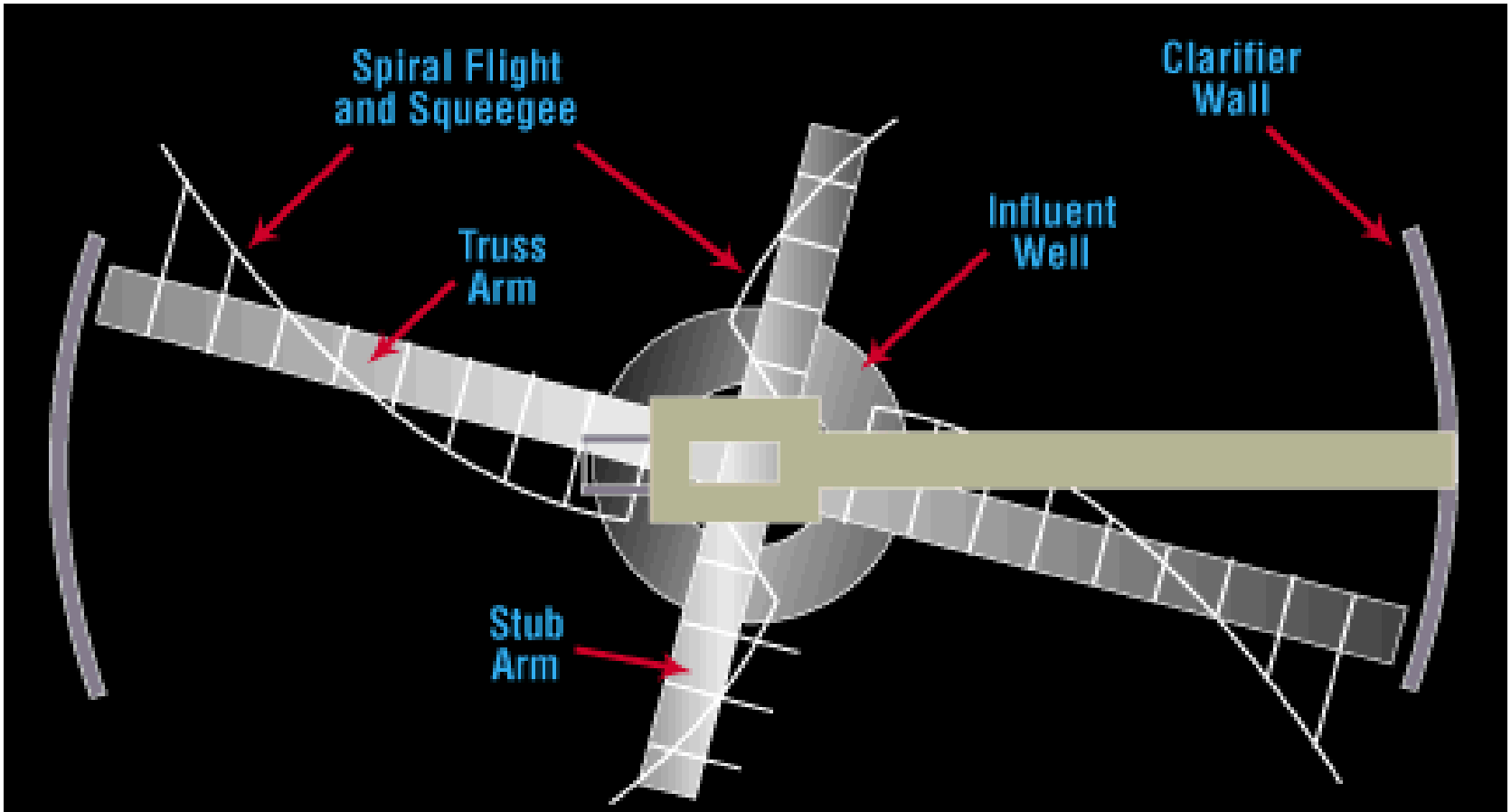
Scraper Arm for Mechanical Solids Removal



Clarifier Sludge Scraper Arm

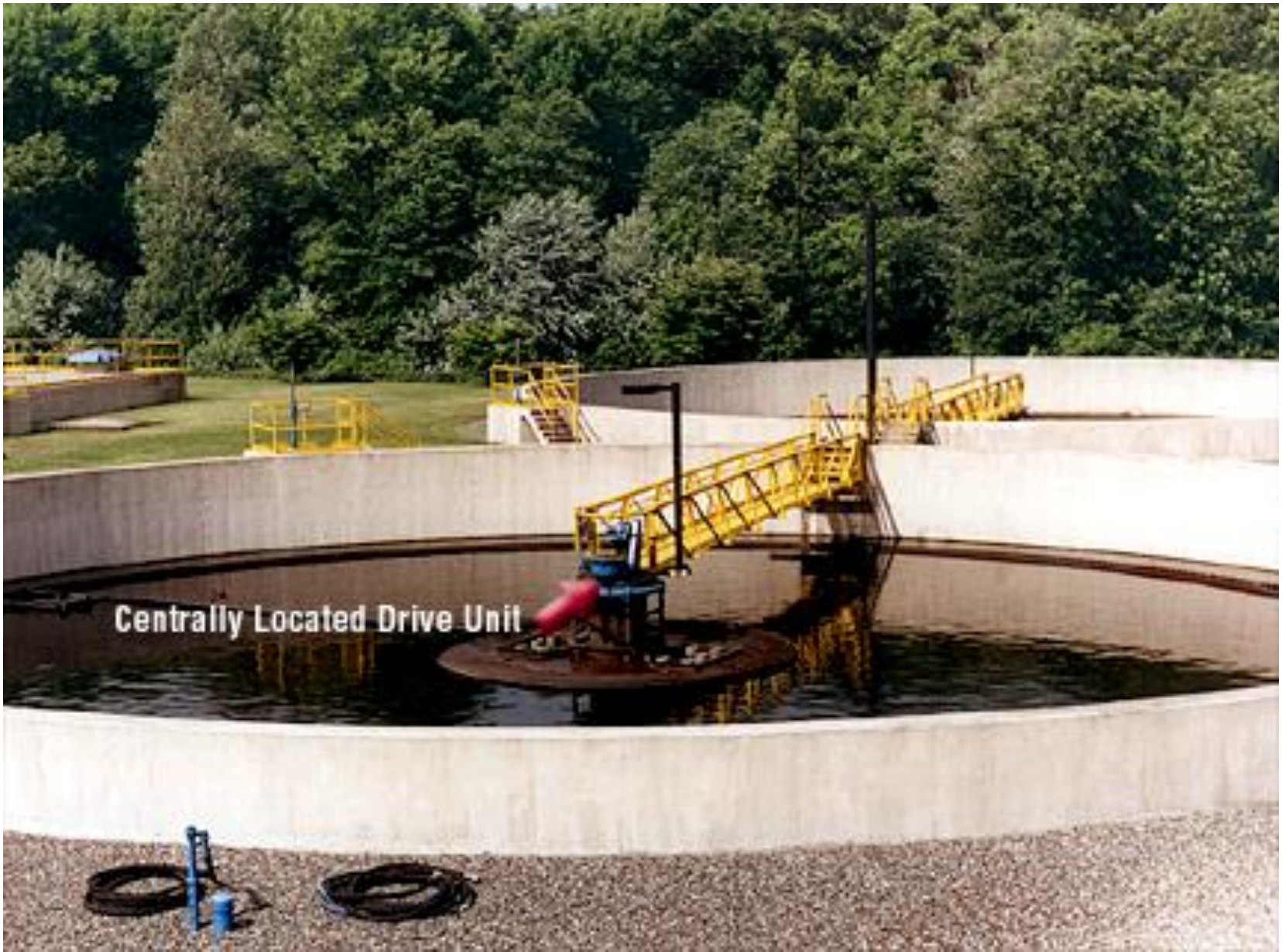


Spiral Arm Solids Removal System



1. One spiral flight per arm, typical of mechanisms less than 30.5 m (100 ft) in diameter.
2. Two spiral flights per arm, typical of mechanisms more than 30.5 m (100 ft) in diameter.
3. Stub arms are optional.

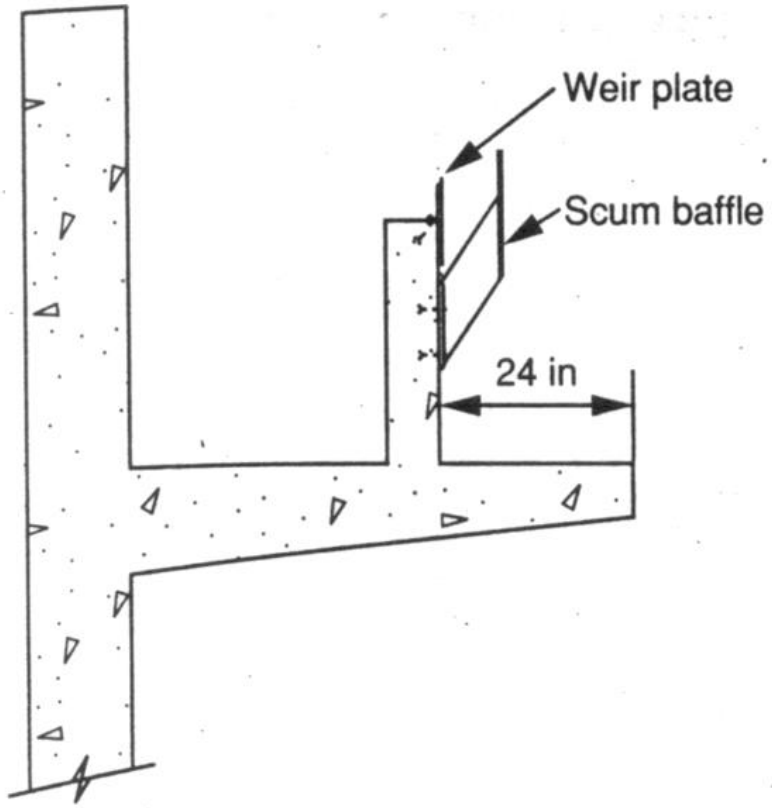
Centrally Located Drive Unit



Overview of Clarifiers Showing Bridges

Clarifier Showing Scum Baffle

Horizontal Baffles for Wastewater Weirs



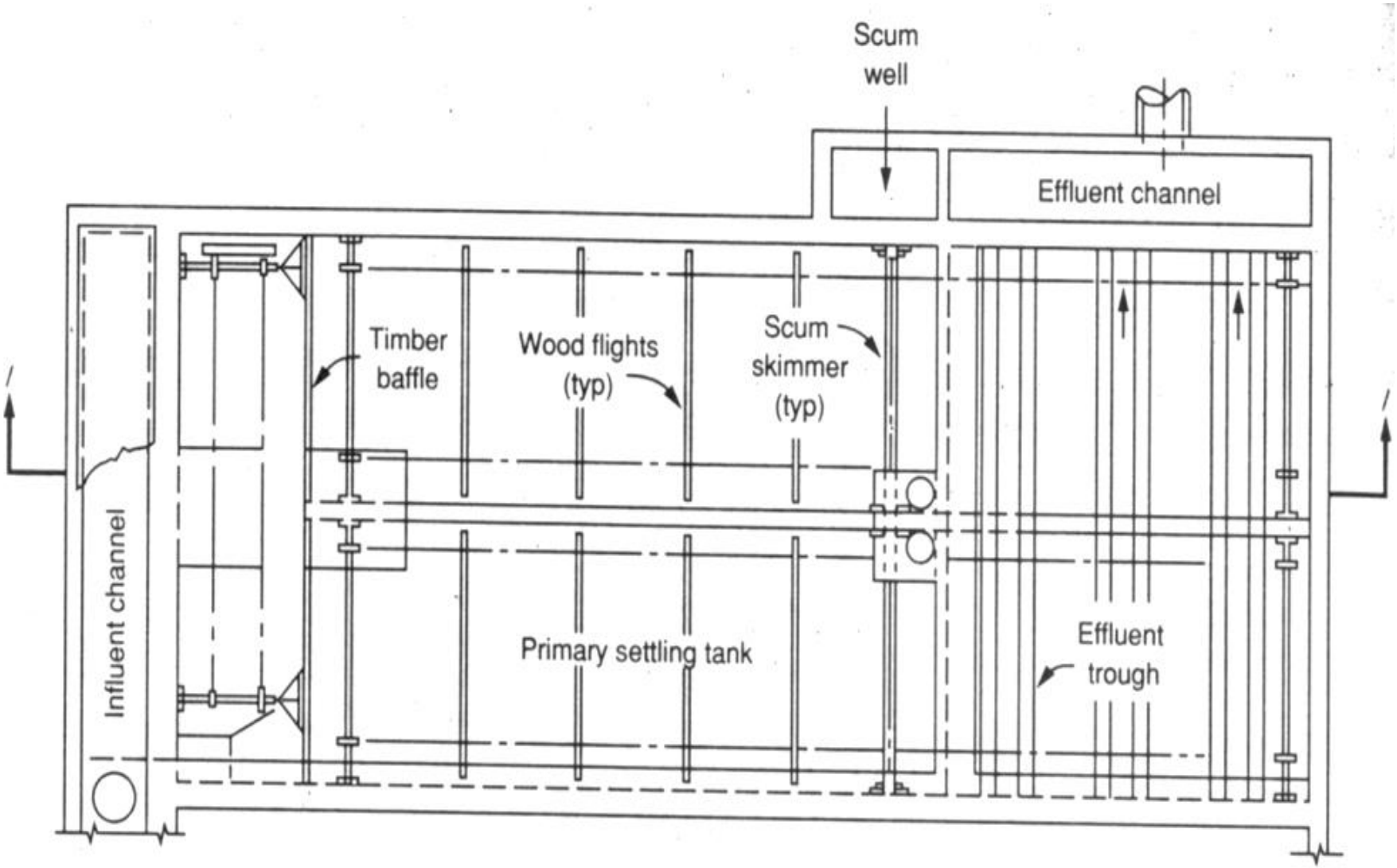
Scum baffle prevents floatable solids and scum/foam from going over the weir and into downstream processes or in the final effluent.

Clarifier Skimmer & Trough System

Ducking Scum Removal System

Rectangular Primary Clarifiers

Plan View of Rectangular Primary Clarifier



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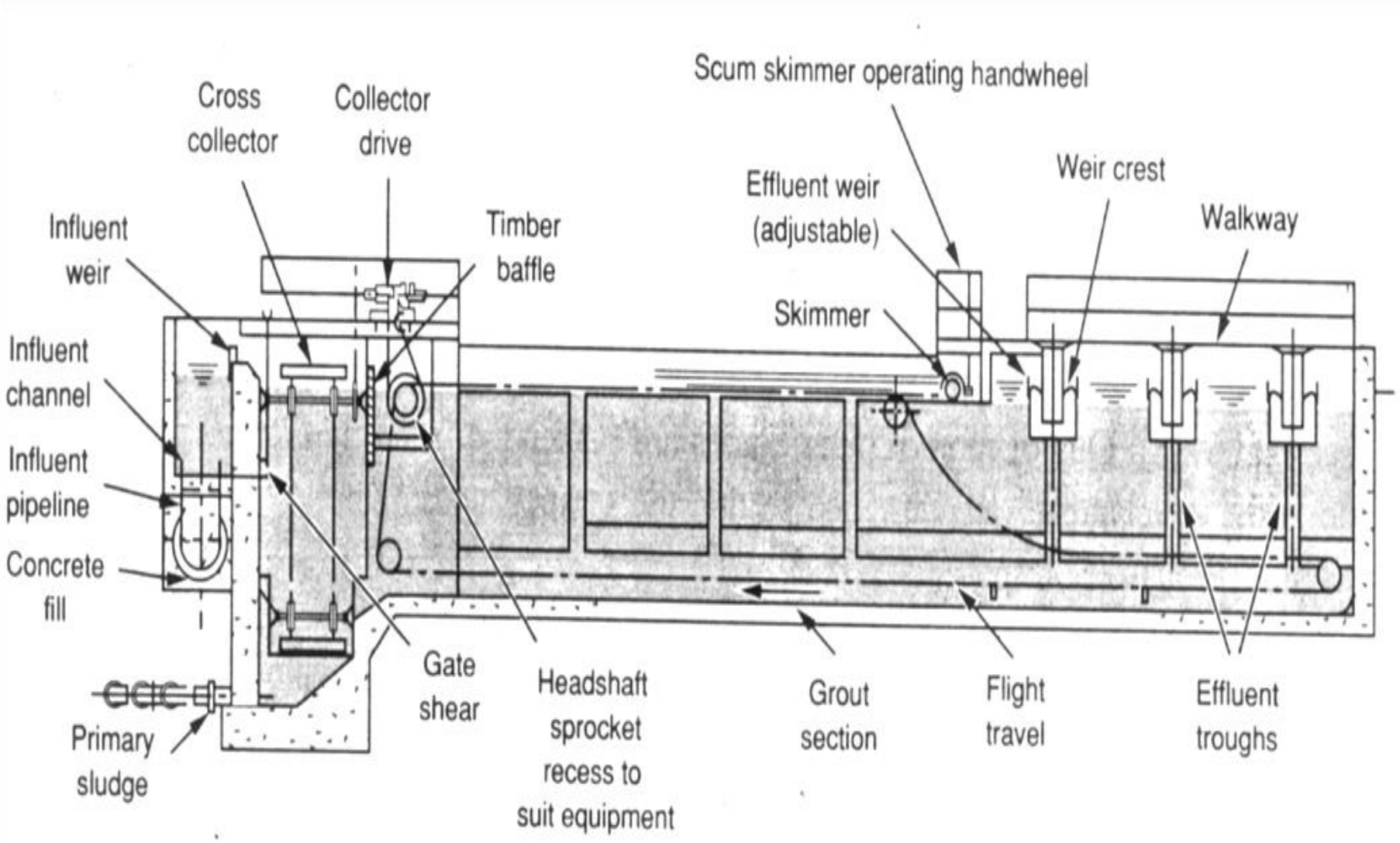
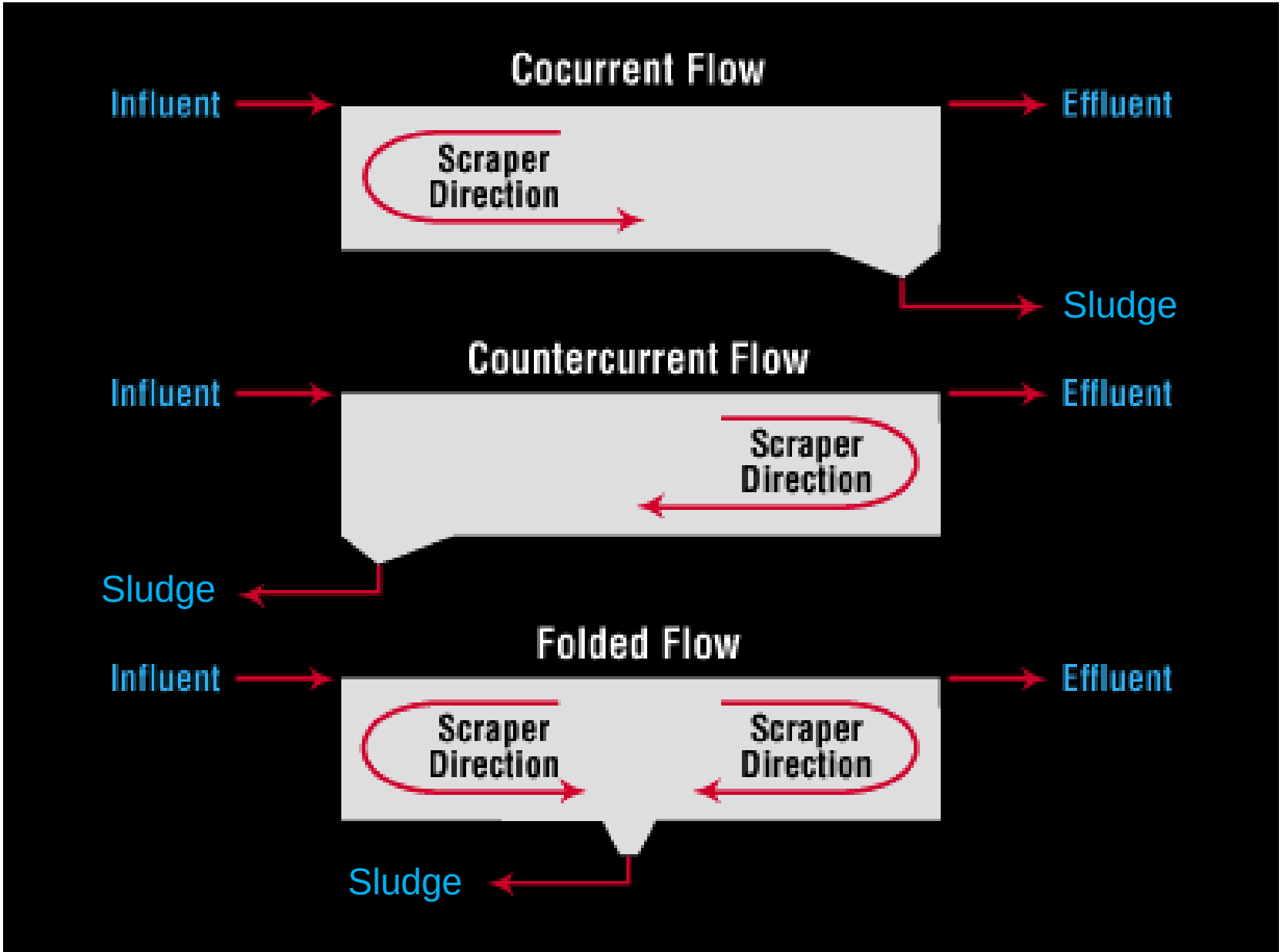
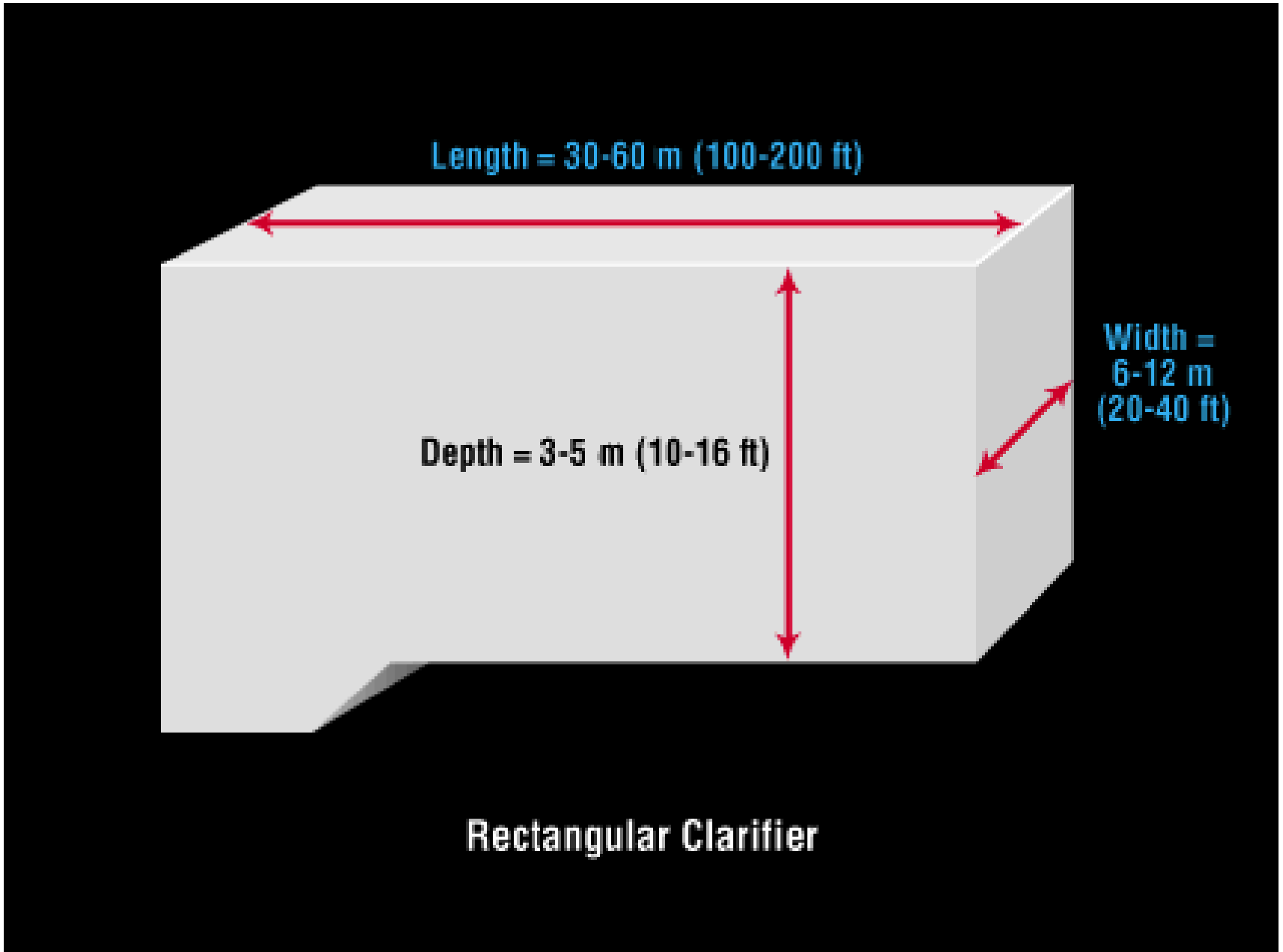
Section View of Rectangular Primary Clarifier



Rectangular Clarifier Flow Schemes



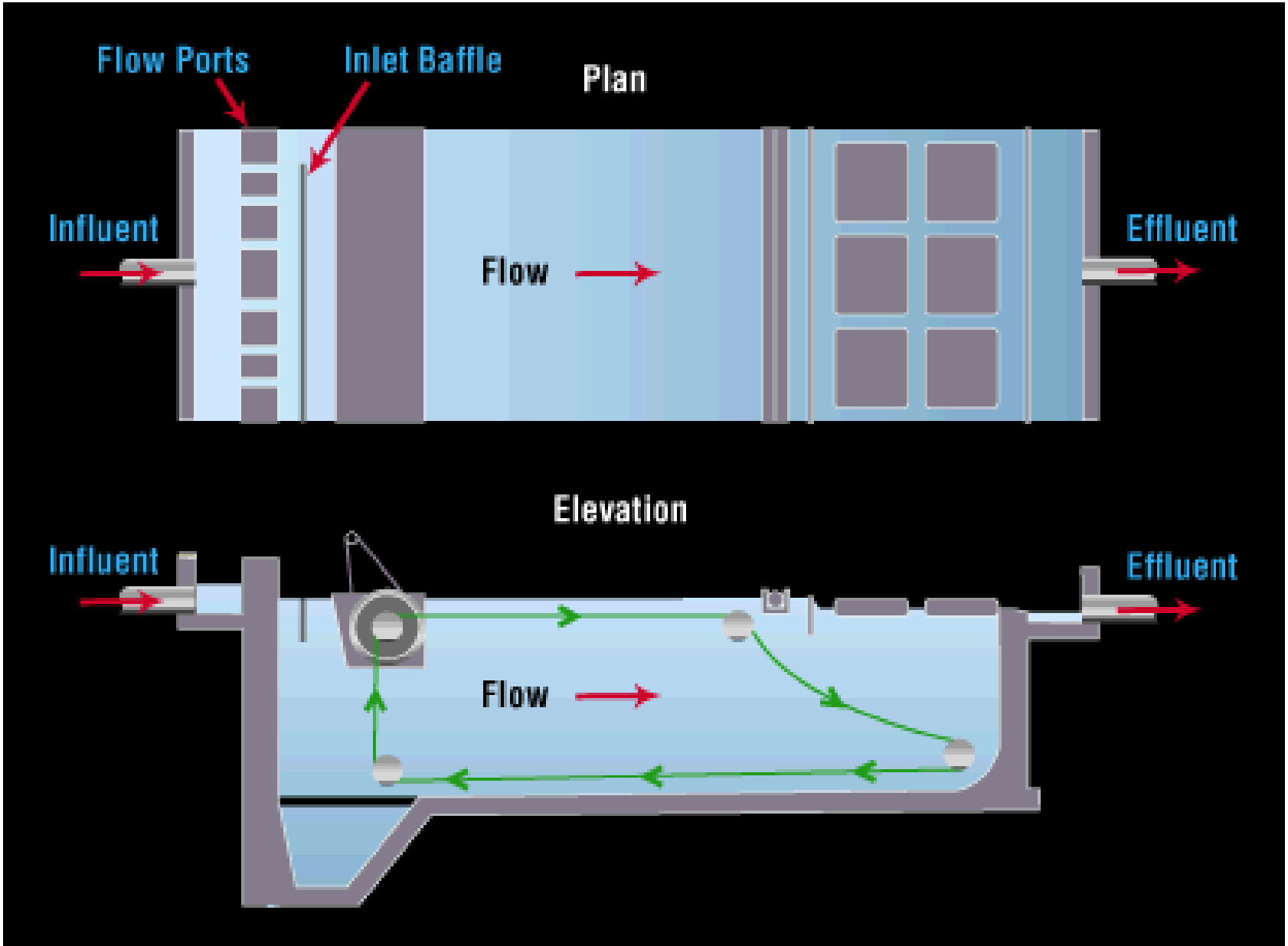
Rectangular Clarifier



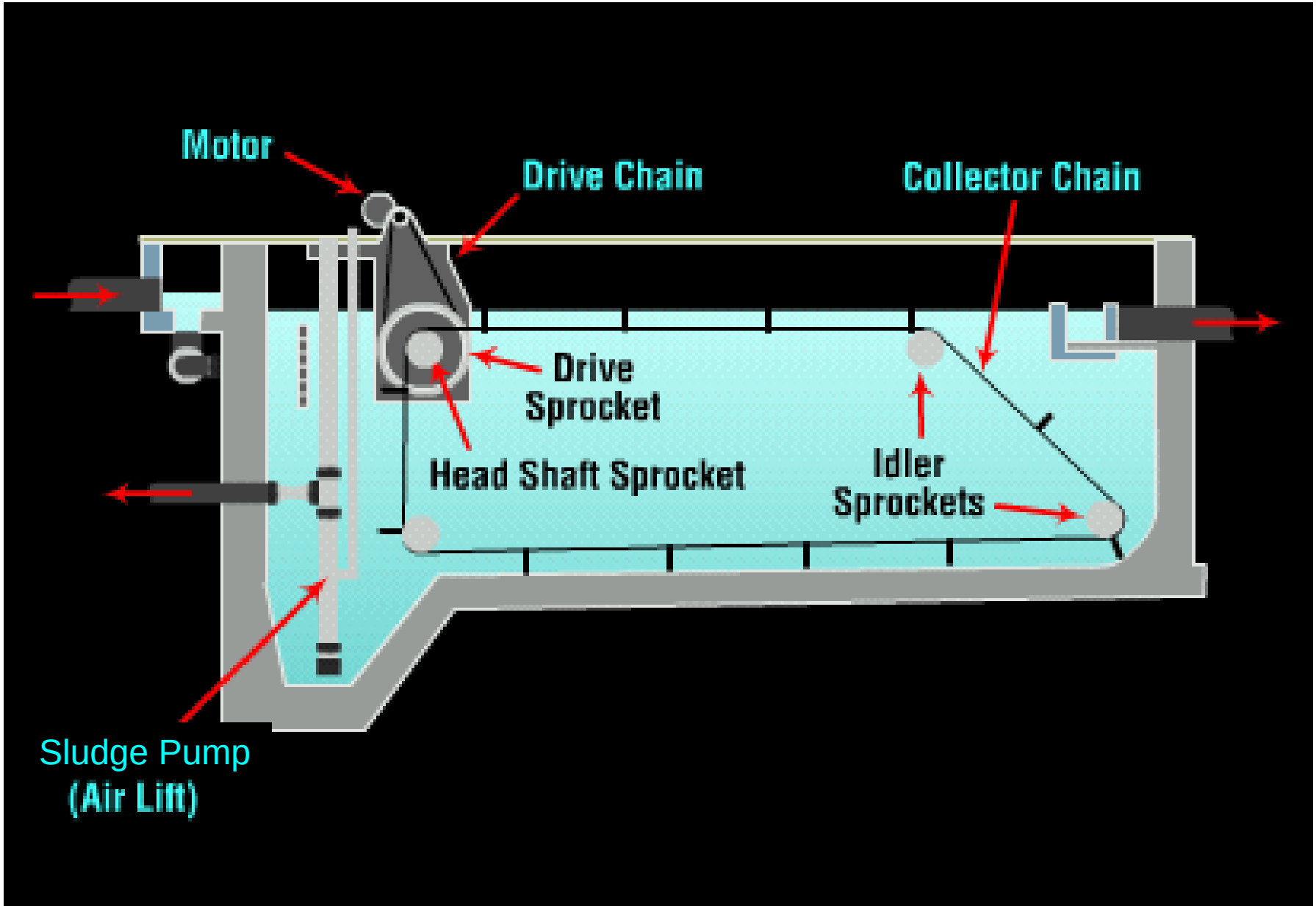
Types of Sludge Collection Equipment

- Flight and chain
- Traveling bridge
- Traveling bridge with pumped sludge removal

Rectangular Clarifier Views



Chain & Flight Sludge Removal System



Internal Wooden Baffles in Rect. Clarifier

Advantages of Non-metallic Chain, Flights, and Sprockets

- They are lighter.
- They are easier to maintain.
- They require less horsepower to operate.
- They are less susceptible to corrosion.

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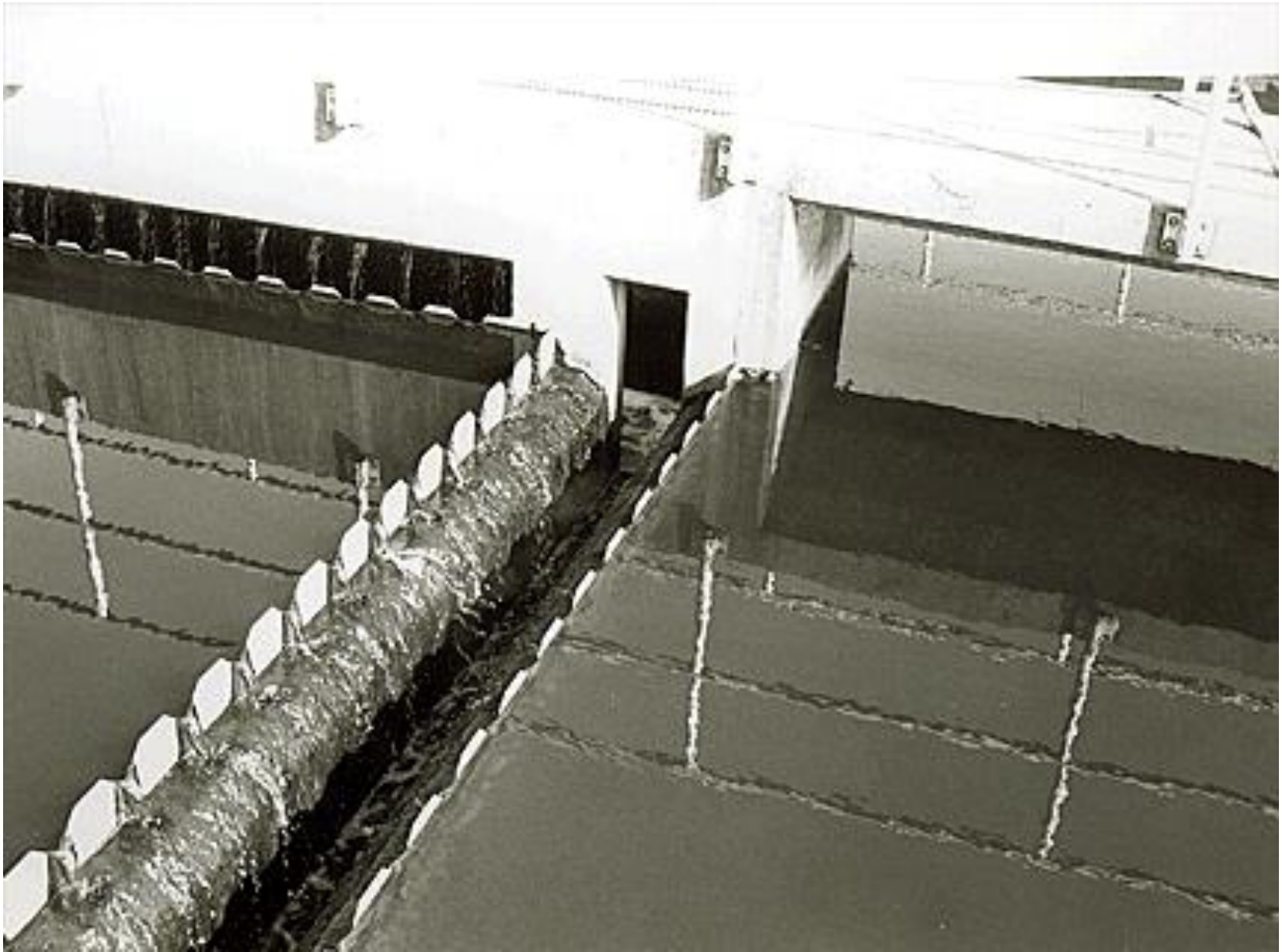
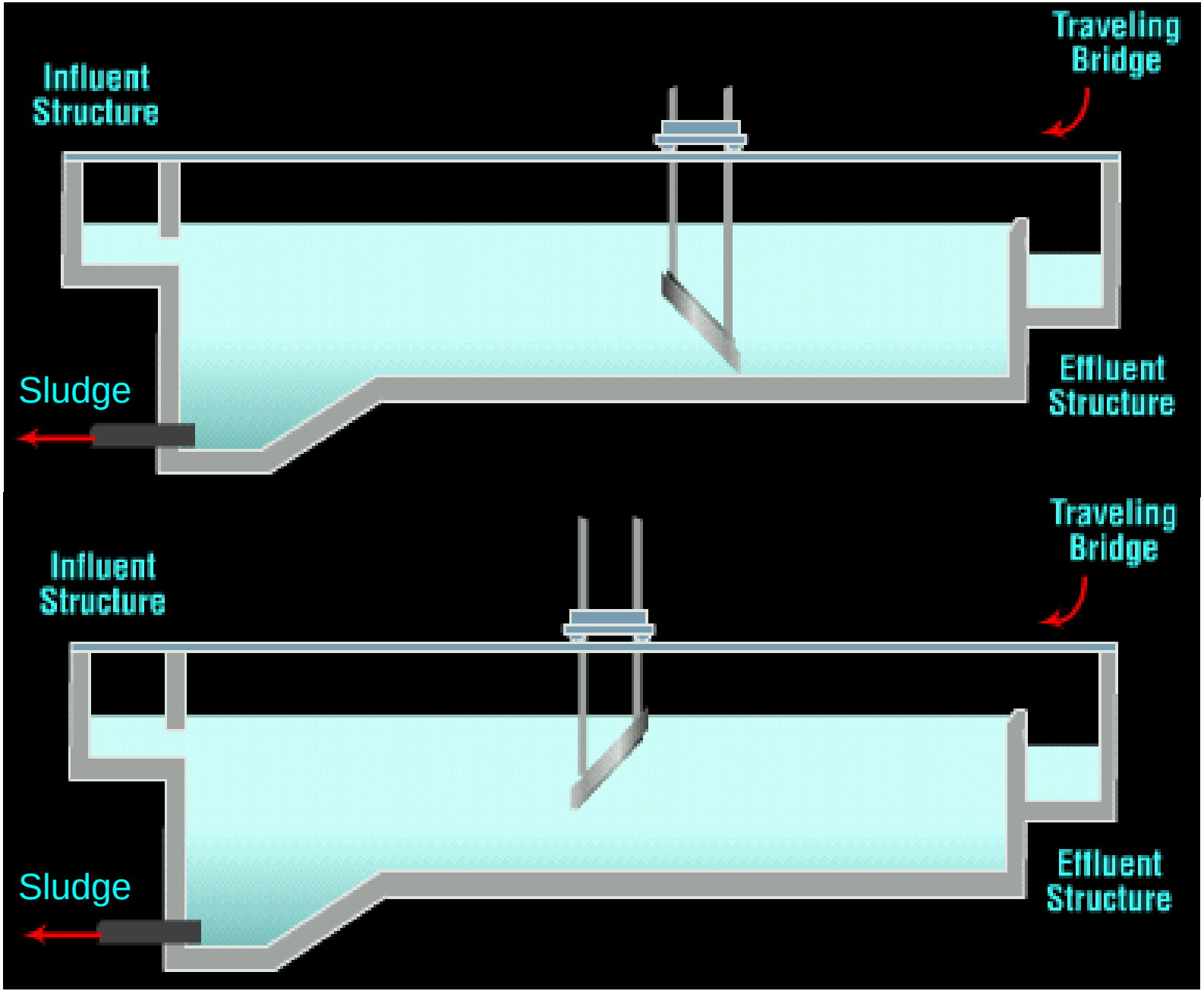
Effluent Weirs & Launder in Rect. Clarifier

Effluent Launder in Rectangular Clarifier

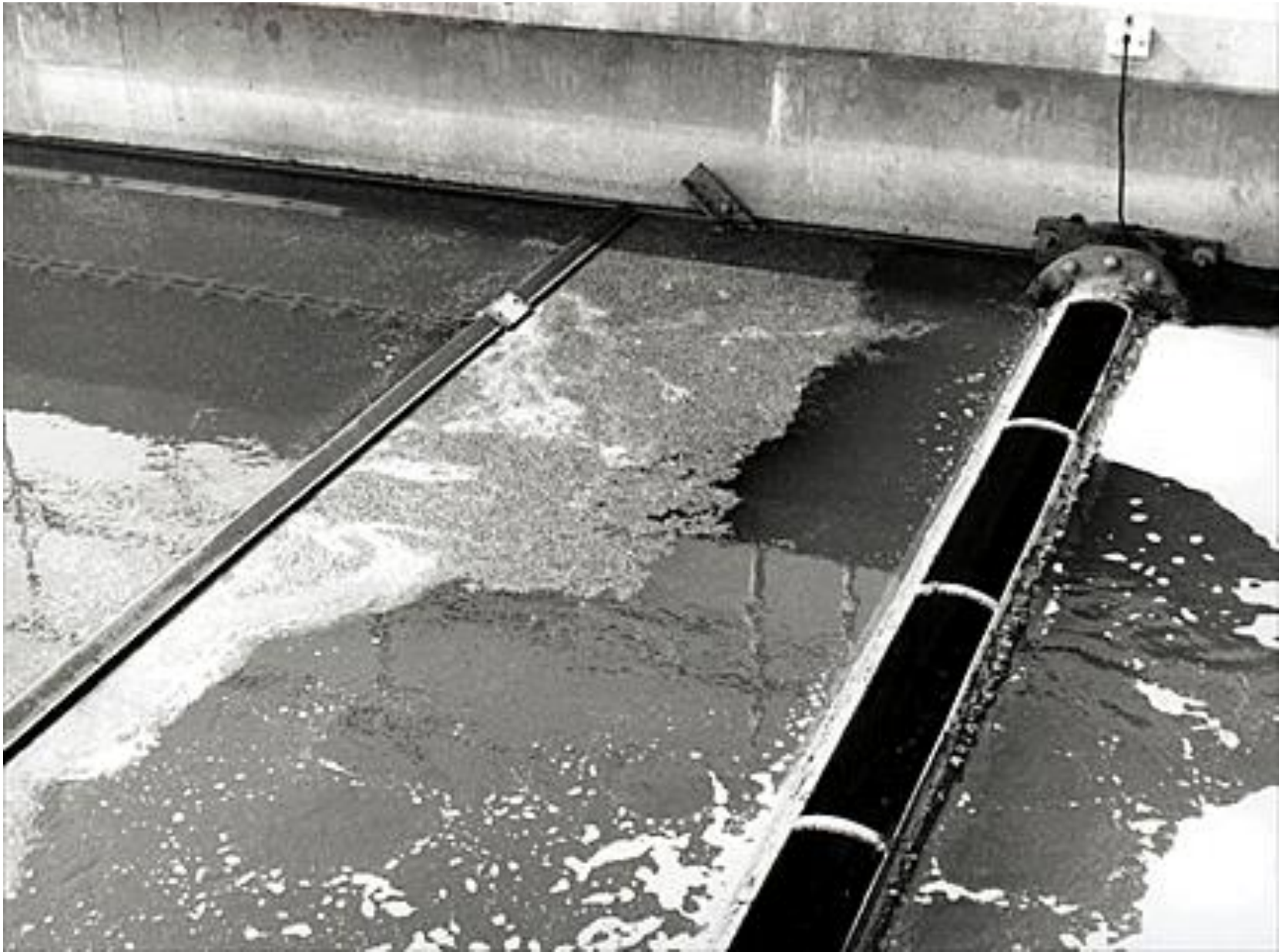


Traveling Bridge Sludge Removal System

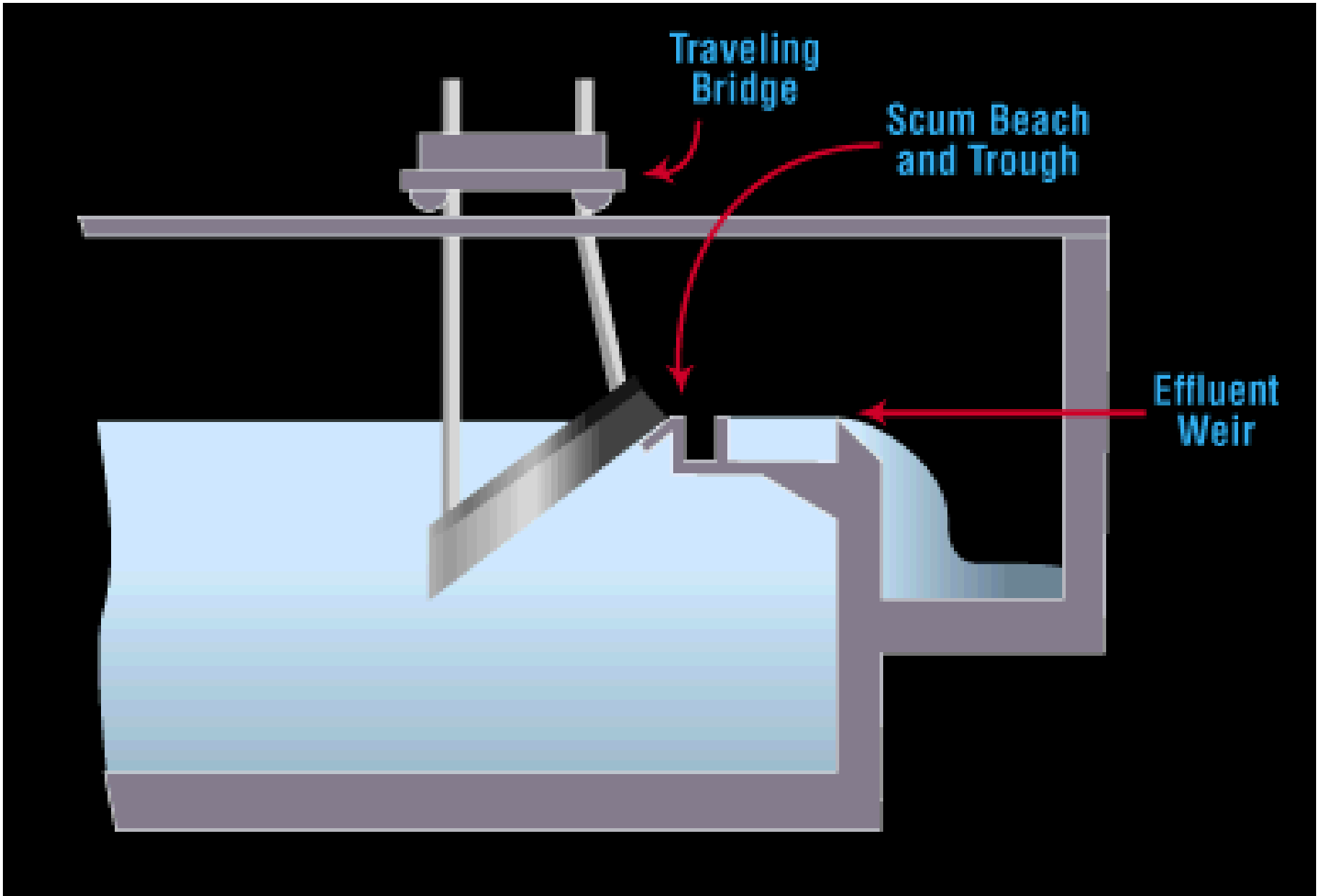


Scum Removal for a Rectangular Clarifier

Scum Removal for Chain & Flight System



Scum Removal for a Traveling Bridge



Poll Question #4

What pollutants is a primary clarifier designed to remove?

a. Dissolved solids
b. Colloidal Solids
c. Suspended Solids
d. Dissolved, colloidal, and suspended solids

Questions?

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General Comments about Primary Clarifiers

Problems of Grit in Primary Tanks

- Grit causes excessive wear of collector mechanisms.
- Grit causes excessive wear of pump impellers.
- Grit causes excessive wear of sludge lines.
- Buildup of grit will reduce the tank's effective volume and reduce detention time.

Types of Sludge Pumps

- **Positive displacement pumps:**
  - **piston pumps**
  - **progressive cavity pumps**
  - **diaphragm pumps**

- **Torque-flow centrifugal-type pumps**

Which Settling Tank is Less Prone to Short Circuiting?

- Rectangular tank
- Center-feed circular tank
- Peripheral-feed circular tank

Why Sludge Collectors Should Run Continuously

- To avoid overloading the mechanism with accumulated solids
- To allow easy operation of an automatic sludge withdrawal system
- To reduce the time needed to move the sludge to the sludge hoppers

Which is Better for Pumping Sludge?

- **Pumping for short durations at frequent intervals**
- **Pumping for long periods at infrequent intervals**

Factors Affecting Frequency of Sludge Line Cleaning

- Velocities in the pipe
- Grease content of the sludge
- Grit in the pipe
- Chemical constituents in the line
- Temperature

Ways to Overcome Short Detention Times

- Use all available primary settling tanks
- Reduce downtime by a comprehensive maintenance program
- Minimize impact of recycle flows by altering their timing, redirecting them to another portion of the plant, and eliminating nonessential flows
- Modify influent flow by adjusting pumping stations and reducing I/I
- Add chemicals to increase TSS removal efficiency while one tank is out of service

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Conditions that Cause Poor Flow Distribution to Primary Tanks

- Poorly designed flow distribution structures
- Weirs that are not level
- Sections of weirs are missing
- Influent gates that are improperly adjusted

Typical Tests for Evaluating Primary Tanks

- Suspended and settleable solids
- Total and volatile solids in wastewater
- Total and volatile solids in sludge
- BOD_5
- pH
- Fats, oils, and grease

Design of Primary Clarifiers

Primary Clarification

Typical design information for rectangular and circular sedimentation tanks used for primary treatment of wastewater

Item	Value	
	Range	Typical
Rectangular		
Depth, ft	10–15	12
Length, ft	50–300	80–130
Width, ft[a]	10–80	16–32
Flight speed, ft/min	2–4	3
Circular		
Depth, ft	10–15	12
Diameter, ft	10–200	40–150
Bottom slope, in/ft	$\frac{3}{4}$–2	1
Flight travel speed, r/min	0.02–0.05	0.03

Design Criteria for Primary Clarifiers

TABLE 9.7 *Overflow Rates and Depths for Primary Clarifiers*

TYPE OF TREATMENT	OVERFLOW RATE gal/day-ft^2 (m^3/d-m^2)		DEPTH ft (m)
	Average	Peak	
Primary Settling Followed by Secondary Treatment	800–1200 (32.6–48.9)	2000–3000 (81.5–122)	10–12 (3.0–3.7)
Primary Settling with Waste Activated Sludge	600–800 (24.5–32.6)	1200–1500 (48.9–61.1)	12–15 (3.7–4.6)

From EPA, *Suspended Solids Removal*, EPA Process Design Manual, January 1975.

TROUBLESHOOTING

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Solving Floating Sludge Problem

- Remove sludge more frequently or at a higher rate
- Repair or replace worn or damaged scrapers
- Vary age of returned activated sludge or move point of waste sludge recycle
- Flush or clean plugged sludge withdrawal line
- Repair or replace damaged inlet baffles

Solving Septicity Problem

- Remove sludge more frequently or at a higher rate
- Repair or replace worn or damaged sludge collectors
- Require pretreatment of strong industrial wastes

Solving Septicity Problem (cont.)

- Flush or clean plugged sludge withdrawal line
- Add chemicals or aerate septic influent
- Improve quality of sludge digester supernatant
- Regulate or curtail dumping by septage haulers

Sludge is Hard to Remove from Hopper

- **Improve operation of grit removal system**
- **Increase velocity in sludge withdrawal lines & check pump capacity**
- **Backflush clogged pipe lines and pump sludge more frequently**

Poor TSS Removal in Primary Tanks

- **Use available tankage or chemical addition to solve hydraulic overloading**
- **Pretreat with oxidizing agent to resolve septic influent**
- **Change weir settings or repair baffles to resolve short circuiting problem**

Poor TSS Removal in Primary Tanks (cont.)

- Frequently and consistently pump sludge
- Eliminate industrial wastes that hinder settling
- Eliminate storm flows from sewer system to prevent hydraulic overloading

Erratic Operation of Sludge Collector

- Repair or replace damaged collector parts
- Remove debris from sludge collector
- Increase frequency of pumping sludge from tank
- Annually drain and inspect the tank

Noisy Chain Drive

- Tighten and align casing and chain; remove dirt or other interfering matter
- If chain does not fit sprockets, replace with correct parts
- If chain is loose, adjust chain to manufacturer’s recommended tension

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Noisy Chain Drive (cont.)

- Lubricate the chain properly
- If there is misalignment, correct alignment and assembly of drive
- Replace worn chain or bearings

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Broken Chain or Sprockets

- Avoid shock and overload or isolate through couplings
- If chain does not fit sprockets, replace chain; reverse or replace sprockets
- If chain is rusty or corroded, replace chain and correct corrosive conditions

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Broken Chain or Sprockets (cont.)

- If there is misalignment, correct alignment
- Make sure no solids interfere between chain and sprocket teeth; loosen chain if necessary for proper clearance over sprocket teeth

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Questions?

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