

Desalination and the Environment

1.Intake Facilities

Lecture 15

Introduction

- ▶ Seawater desalination facilities require an intake system capable of providing a **reliable quantity** of clean seawater with a **minimum ecological impact**.
- ▶ Intake designs are highly site specific, possibly more than any other aspect of the desalination facility.
- ▶ The design, modeling, monitoring, and permitting activities that surround them, may represent as much as **20%** of the **capital cost** of the entire facility, and it is possible that intake-related issues may ultimately determine the feasibility and performance of the desalination plant itself.

Introduction

- ▶ The **distance of the** intake to the desalination plant site **affects plant economics**, and the available feed water **quality and quantity** will directly affect pretreatment process decisions.
- ▶ Seawater intakes can be broadly categorized as **surface intakes** where water is collected above the seabed, and **subsurface intakes** where water is collected via beach wells, or other locations beneath the seabed.
- ▶ The most appropriate location and type of the intake can only be determined after a thorough site assessment and careful environmental evaluation.

Impingement

- ▶ **Impingement** occurs when marine organisms are trapped against intake screens by the velocity and force of water flowing through them.
- ▶ The fate of impinged organisms differs between intake designs and among marine life species, age, and water conditions.
- ▶ Some hardy species may be able to survive impingement and be returned to the sea, but the **24-hour survival rate** of less robust species and/or juvenile fish may be **less than 15%**.

Entrainment

- ▶ **Entrainment** occurs when smaller organisms pass through an intake screen and into the process equipment.
- ▶ Organisms entrained into process equipment are generally considered to have a **mortality rate of 100%**.

Desalination plant intake



Factors affecting impingement and entrainment

- ▶ The number of affected organisms will, of course, vary considerably with the **volume and velocity of feed water** and the use of mitigation measures developed to minimize their impact.
- ▶ If intake velocities are sufficiently low, fish may be able swim away to avoid impingement or entrainment.
- ▶ The swimming performance for different species of fish can predict the types and ages most vulnerable, however, even large fish are frequently caught on intake screens, indicating that swimming ability is not the only factor in impingement.
- ▶ Cold temperatures or seasonal variations in age-selective migrations or growth are also factors.

1. Surface Water Intakes

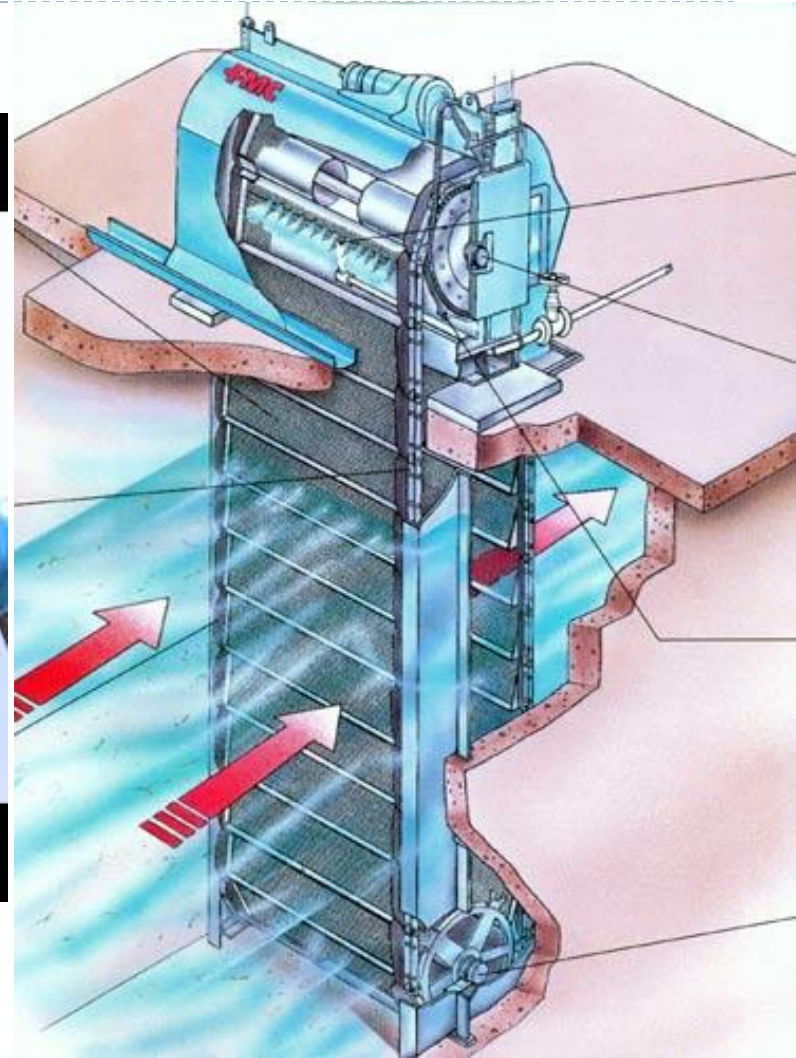
▶ There are several configurations of surface water intakes:

1. Traveling Water Screens
2. Velocity Cap
3. Passive Screens
4. Ristroph Screen

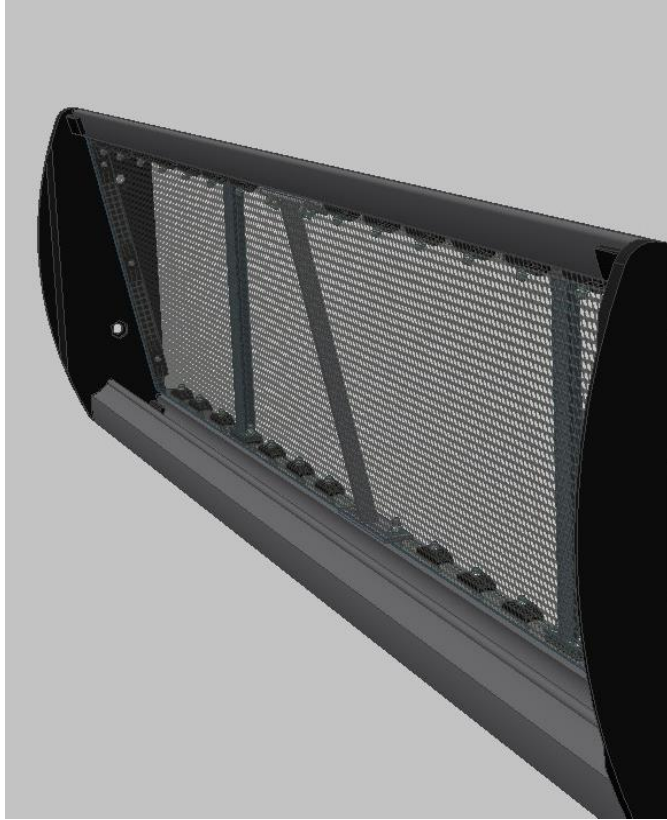
Traveling Water Screens

- ▶ Traveling Water Screens have been employed on seawater intakes since the 1890's.
- ▶ The screens are equipped with revolving wire mesh panels having 6mm to 9.5mm openings.
- ▶ As the wire mesh panels revolve out of the flow, a high-pressure water spray removes accumulated debris, washing it into a trough for further disposal.
- ▶ The screens can be located onshore, at the end of a pipe that extends out into the sea.

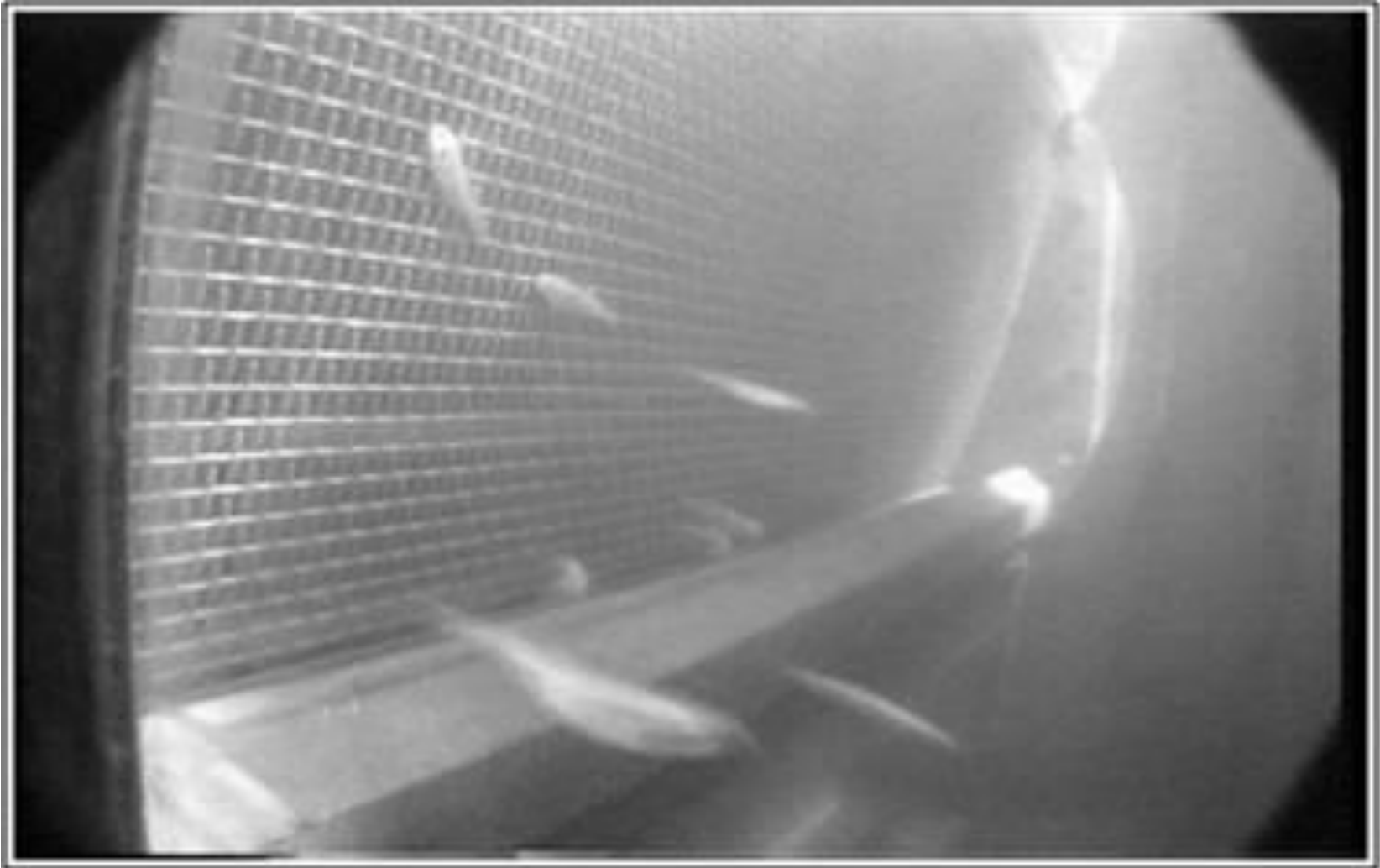
Traveling Water Screens



Traveling Water Screens



Traveling Water Screens



Fine Mesh Screens

- ▶ **Fine Mesh Screens** have successfully reduced entrainment of eggs, larvae, and juvenile fish at some intake locations where traveling water screens have been outfitted with mesh having openings ranging from **0.5 to 5 mm, reducing entrainment by up to 80%.**
- ▶ Fine mesh screens may result in operational problems due to the increased amount of debris removed along with the marine life, and in some locations, the fine mesh is only **utilized seasonally, during periods of egg and larval abundance.**

Filter Net Barriers

- ▶ **Filter Net Barriers** are a relatively new method of reducing intake impingement and entrainment.
- ▶ A full-depth, porous filter fabric with openings ranging from **0.4mm to 4mm** is placed at the entrance to an intake structure.
- ▶ The system is sized to provide enough surface area to have a through-flow **velocity low enough** to avoid impingement of marine life or debris.

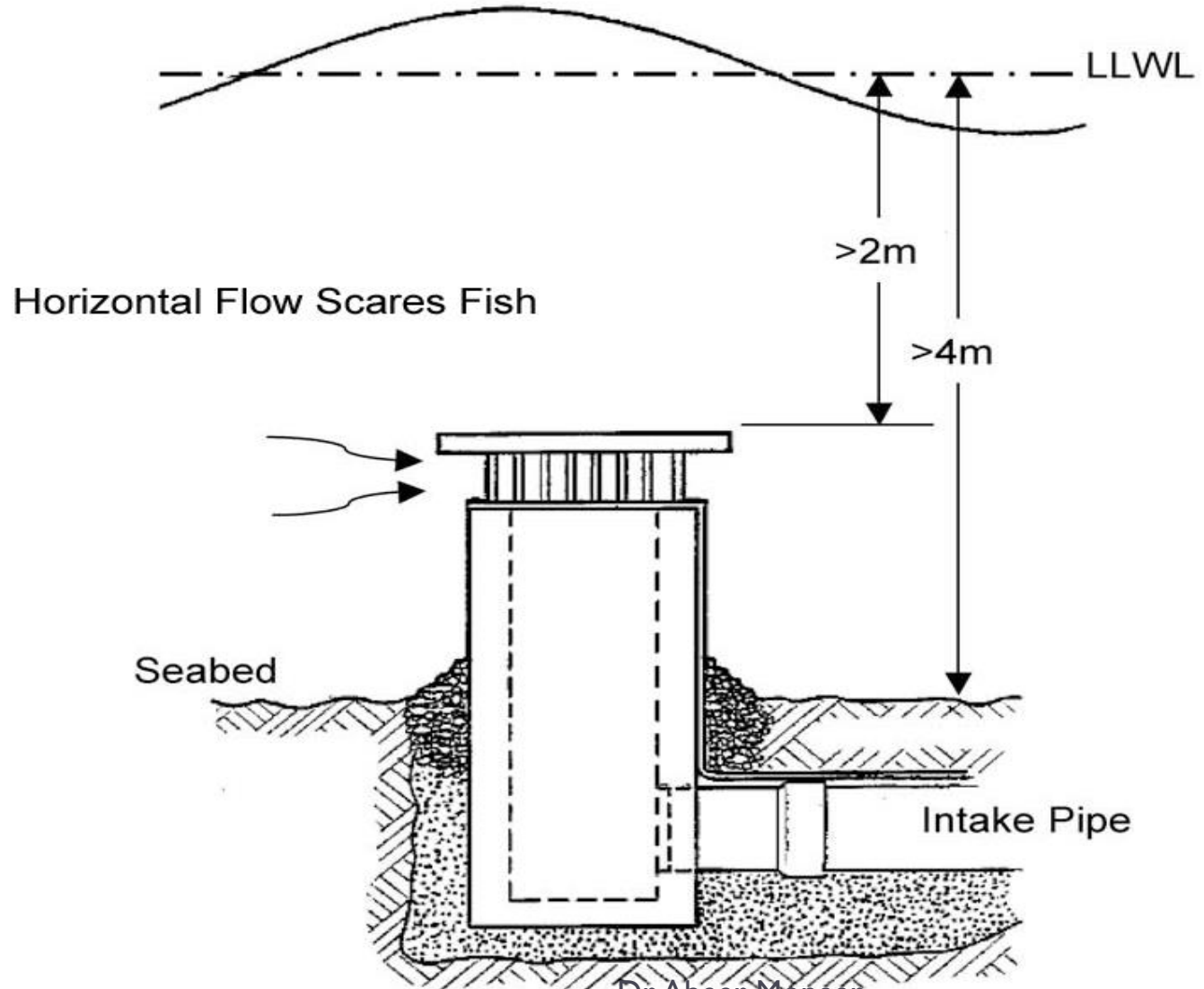
Behavioral systems

- ▶ **Behavioral systems** using lights, bubbles, or sound to enhance fish avoidance or attract them to a fish diversion system have generally been **ineffective and are used infrequently.**

Velocity Cap

- ▶ The cover placed over the vertical terminal of an offshore intake pipe is called a “velocity cap”.
- ▶ The cover **converts vertical flow into horizontal flow** at the intake entrance to **reduce fish entrainment**.
- ▶ It has been noted that fish will avoid rapid changes in horizontal flow and velocity cap intakes have been shown to provide **80-90%** reduction in fish impingement at two California power stations, and a **50-62%** impingement reduction versus a conventional intake at two New England power stations.

Velocity Cap

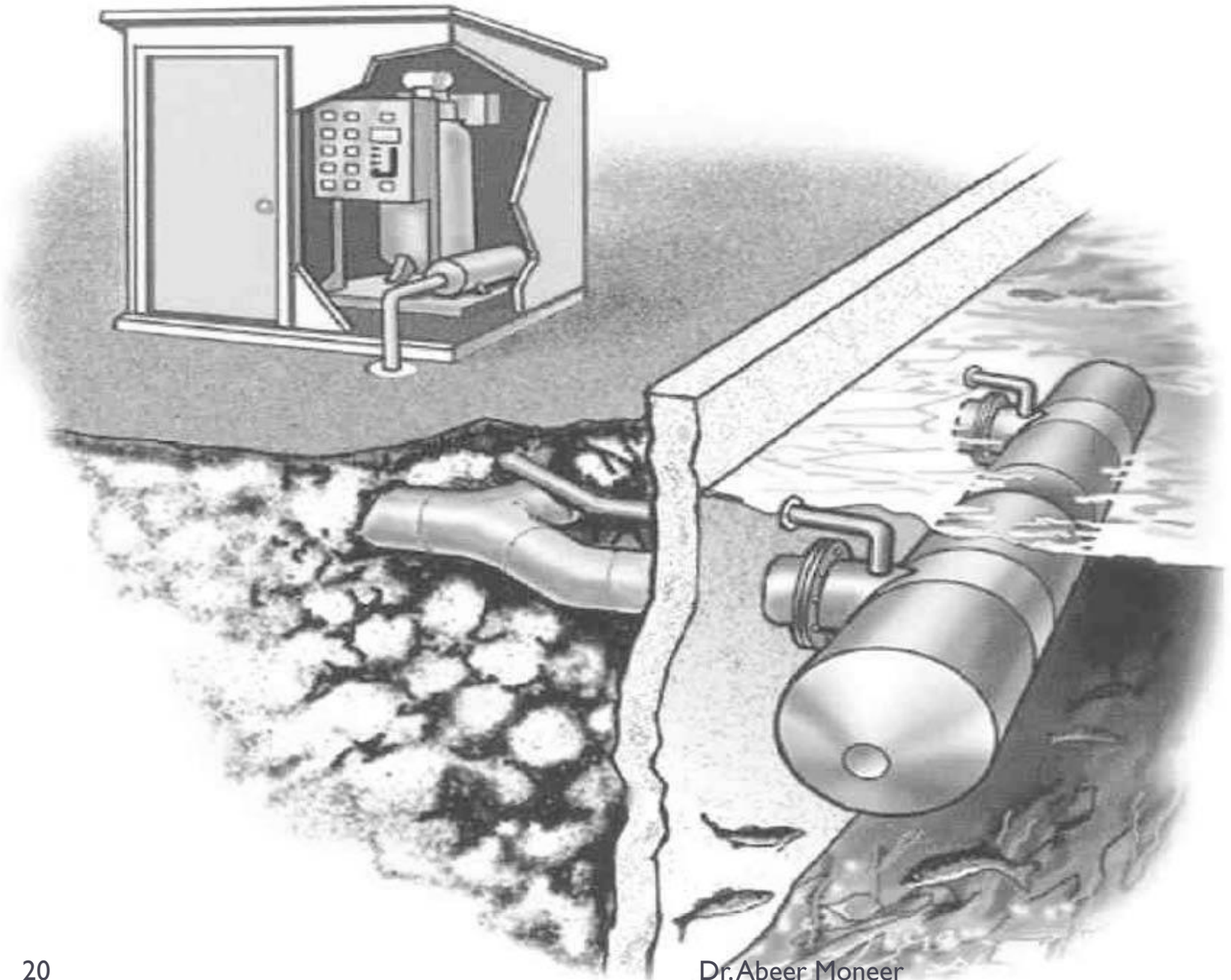


Passive Screens

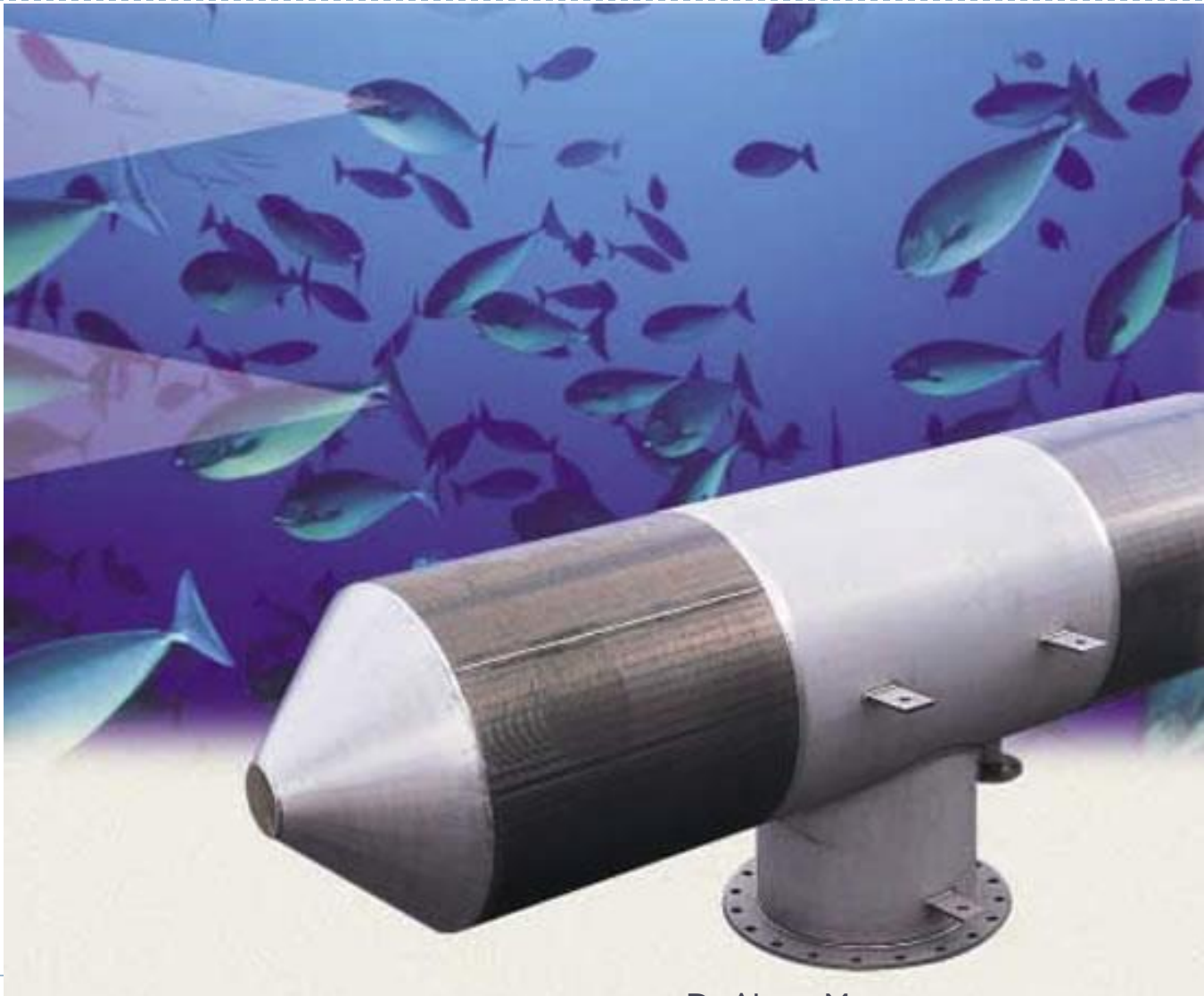
- ▶ A cylindrical screens have openings ranging from 0.5-10 mm are usually oriented on a horizontal axis with screens sized to maintain a **velocity of less than 15 cm/s** to minimize debris and marine life impingement.
- ▶ Passive screens are **best-suited for areas where an ambient cross-flow current is present**, and air backwash system is usually recommended to clear screens if debris accumulations do occur.
- ▶ As with all submerged equipment, material selections should reflect the corrosion and biofouling potential of seawater.

Passive Screens

- ▶ Passive screens have a proven ability to reduce impingement and entrainment.
- ▶ Their effectiveness is related to their slot width, and low through-flow velocity.
- ▶ It has been demonstrated that 1 mm openings are highly effective for larval exclusion and reduce entrainment by 80% or more.



Passive Screens



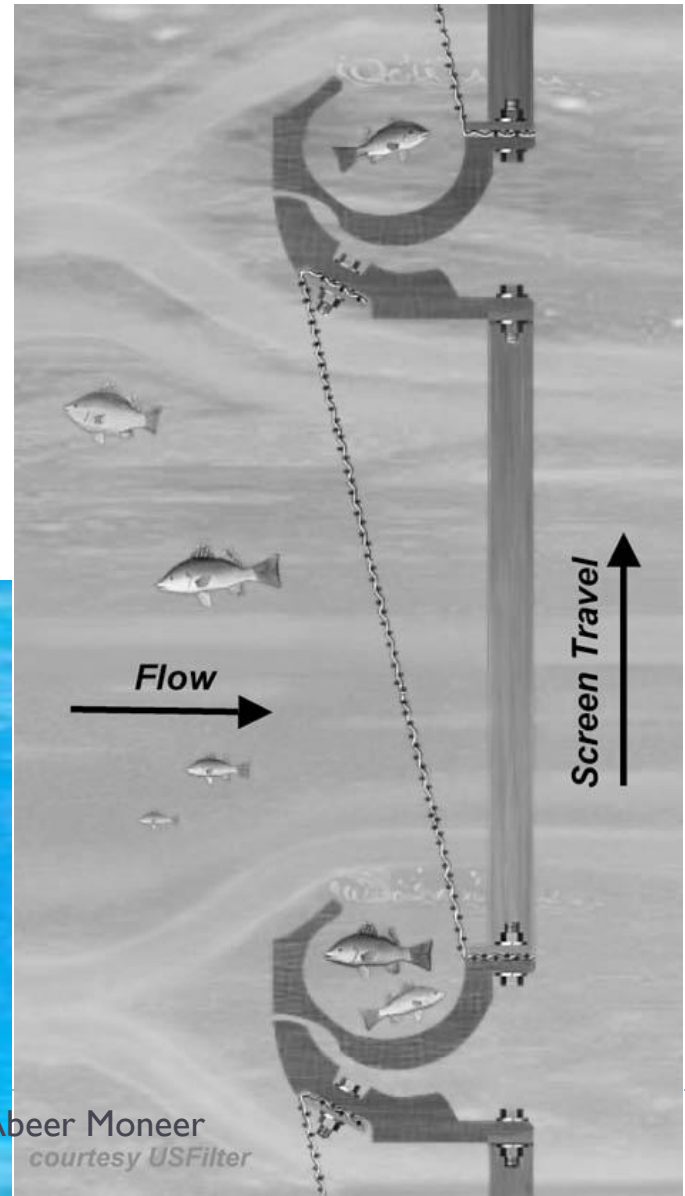
Passive Screens



Ristroph Screen

- ▶ A *Ristroph Screen* is a modification of a conventional traveling water screen in which screen panels are fitted with **fish buckets** that collect fish and **lift them out** of the water where they are gently **sluiced away** prior to debris removal with a high pressure spray.
- ▶ At one New York seawater intake, the 24-hour survival of conventional screens averaged 15% compared with 79-92% survival rates for Ristroph Screens.
- ▶ A review of 10 similar sites reported that Ristroph modifications improved impingement survival 70-80% among various species.

Ristroph Screen



2. Subsurface intakes

- ▶ Subsurface intakes may consist of **horizontal or vertical** beach **wells**, **infiltration galleries**, or seabed filtration systems. In each of these designs, the open seawater is separated from the point of intake by a geologic unit.
- ▶ A subsurface intake can be used where **geologic conditions** beneath a surface water are relatively **impermeable** or of **sufficient thickness** and depth to support water extraction.
- ▶ In addition to providing some **natural filtration**, this arrangement has the advantage of **separating** most of the marine organisms from the water intake.

2. Subsurface intake

- ▶ The use of subsurface intakes offers a distinct environmental advantage because the ecological impact associated with impingement and entrainment of marine life is virtually eliminated.
- ▶ However, subsurface designs should consider their potential negative impact on nearby fresh groundwater aquifers.

2. Subsurface intake

▶ There are several types of subsurface intake:

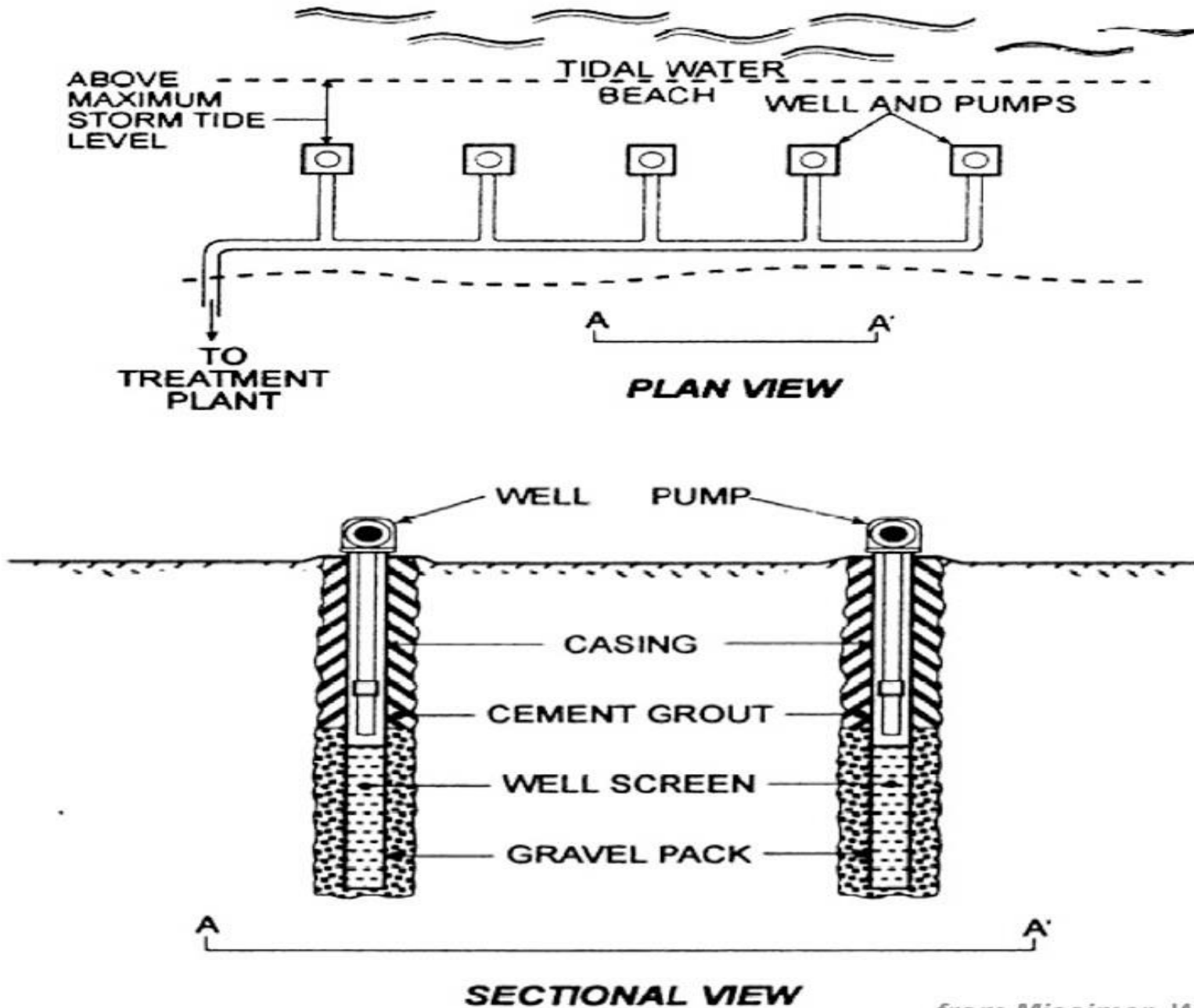
1. Vertical Beach Wells
2. Radial Well
3. Infiltration Galleries

Vertical Beach Wells

- ▶ Vertical beach wells are shallow intake wells that make use of beach sand or other geologic structure as a filter medium.
- ▶ Beach wells can be an economical alternative to open sea intakes for desalination plants with capacities less than 20,000 cubic meters per day (m^3/d).
- ▶ They have the advantage of delivering “pre-filtered” water that may greatly reduce additional pretreatment requirements.

Vertical Beach Wells

- ▶ A vertical beach well consists of a non-metallic casing, well screen, and vertical turbine pump.
- ▶ Site suitability is determined by drilling test wells and conducting a detailed hydrogeologic investigation to determine the transmissivity and substrate characteristics.
- ▶ It is preferred to locate beach wells as close to the coastline as possible, and the maximum yield from individual wells range up to 4000 m³/d.

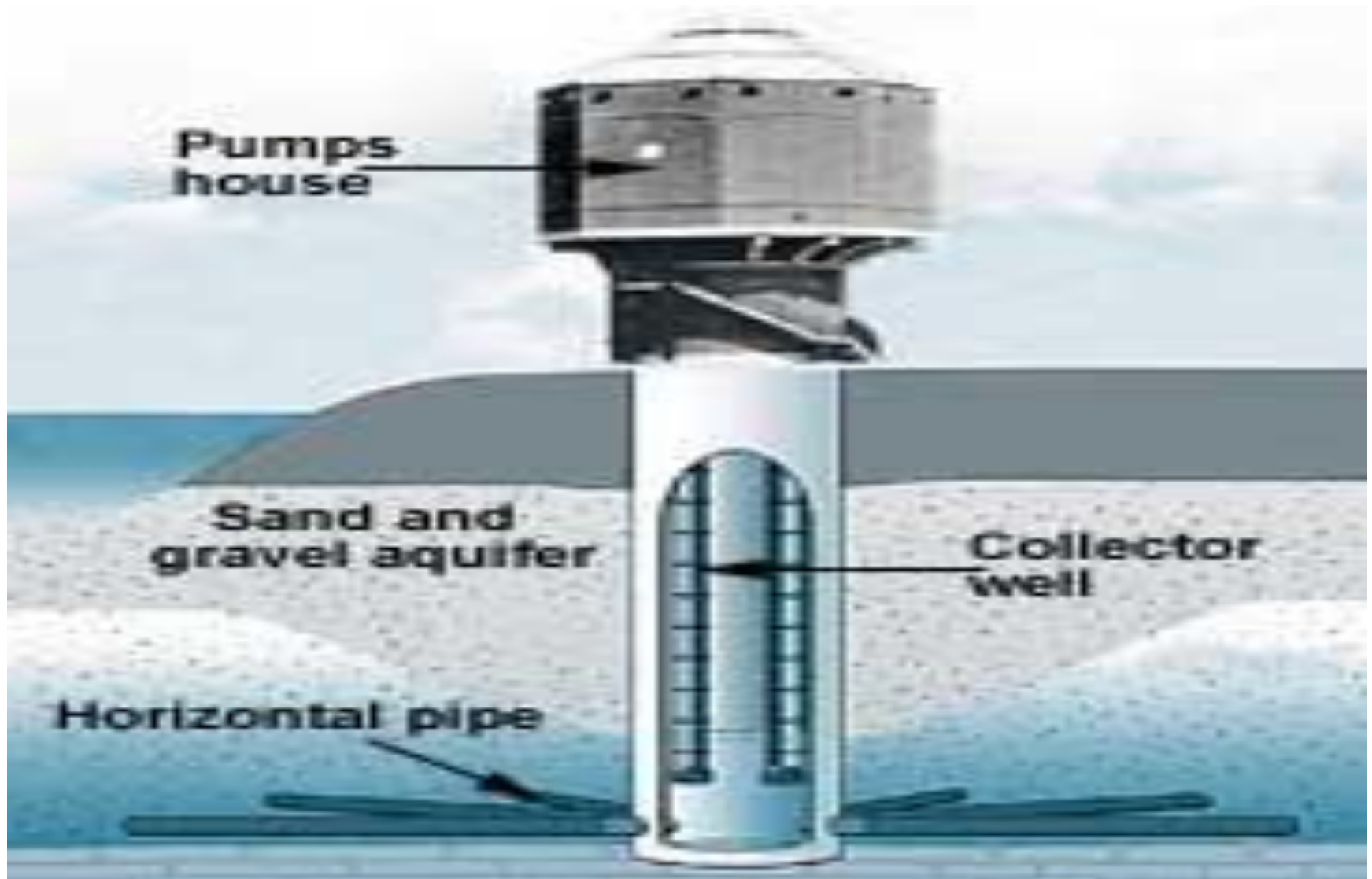


from Missimer, Wright 1997

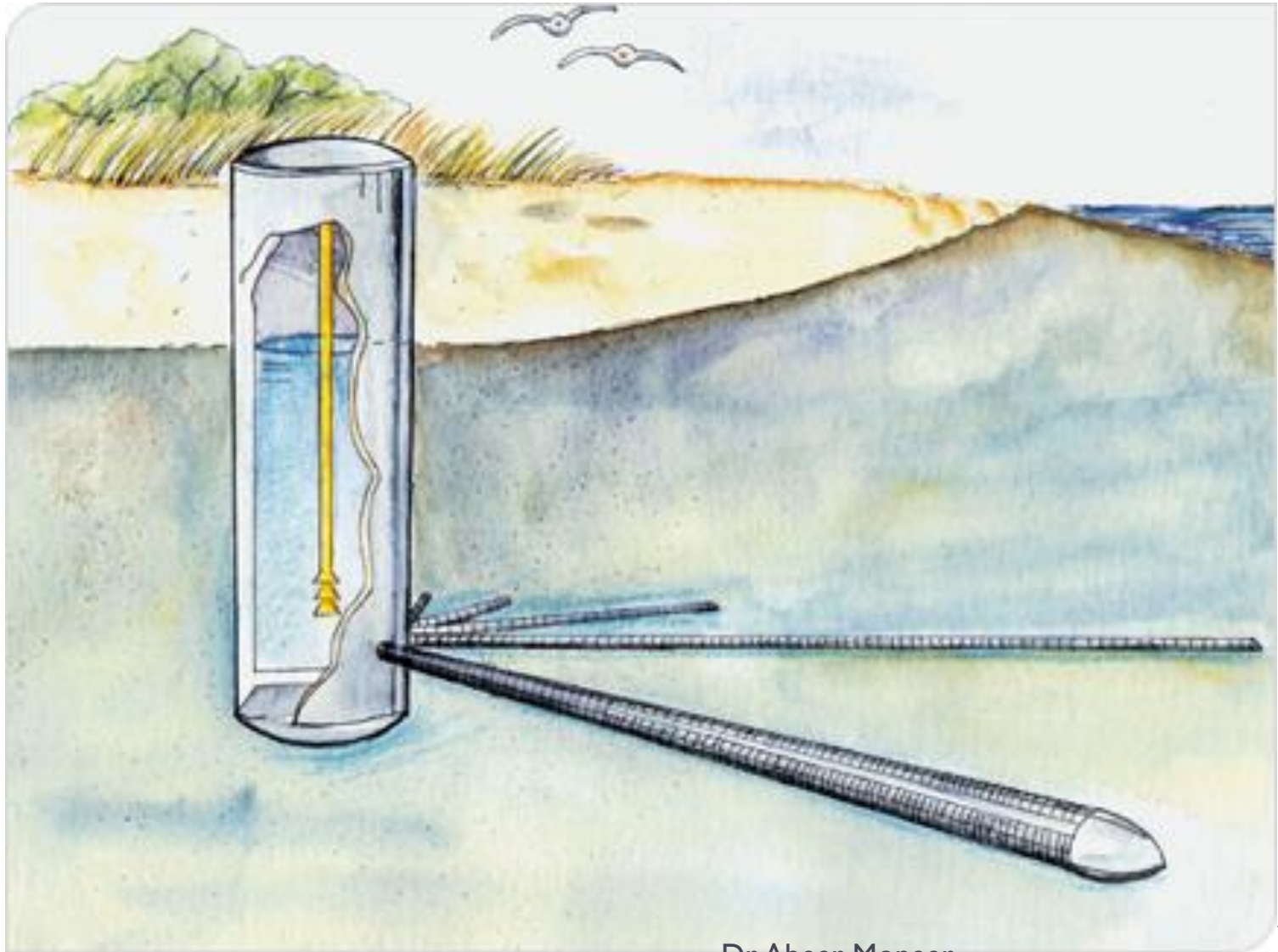
Radial Well

- ▶ Radial collector wells are a variation of the beach well where **multiple horizontal collector wells** are connected to a central caisson which acts as a pumping station from which water is pumped to the desalination plant.
- ▶ The use of multiple horizontal wells means that the production of each radial well can be **significantly greater than a single vertical well.**
- ▶ Caissons may be 2.75-6 m in diameter and 9-45 m deep, and radial arms are usually 200-300 mm in diameter.

Radial Well



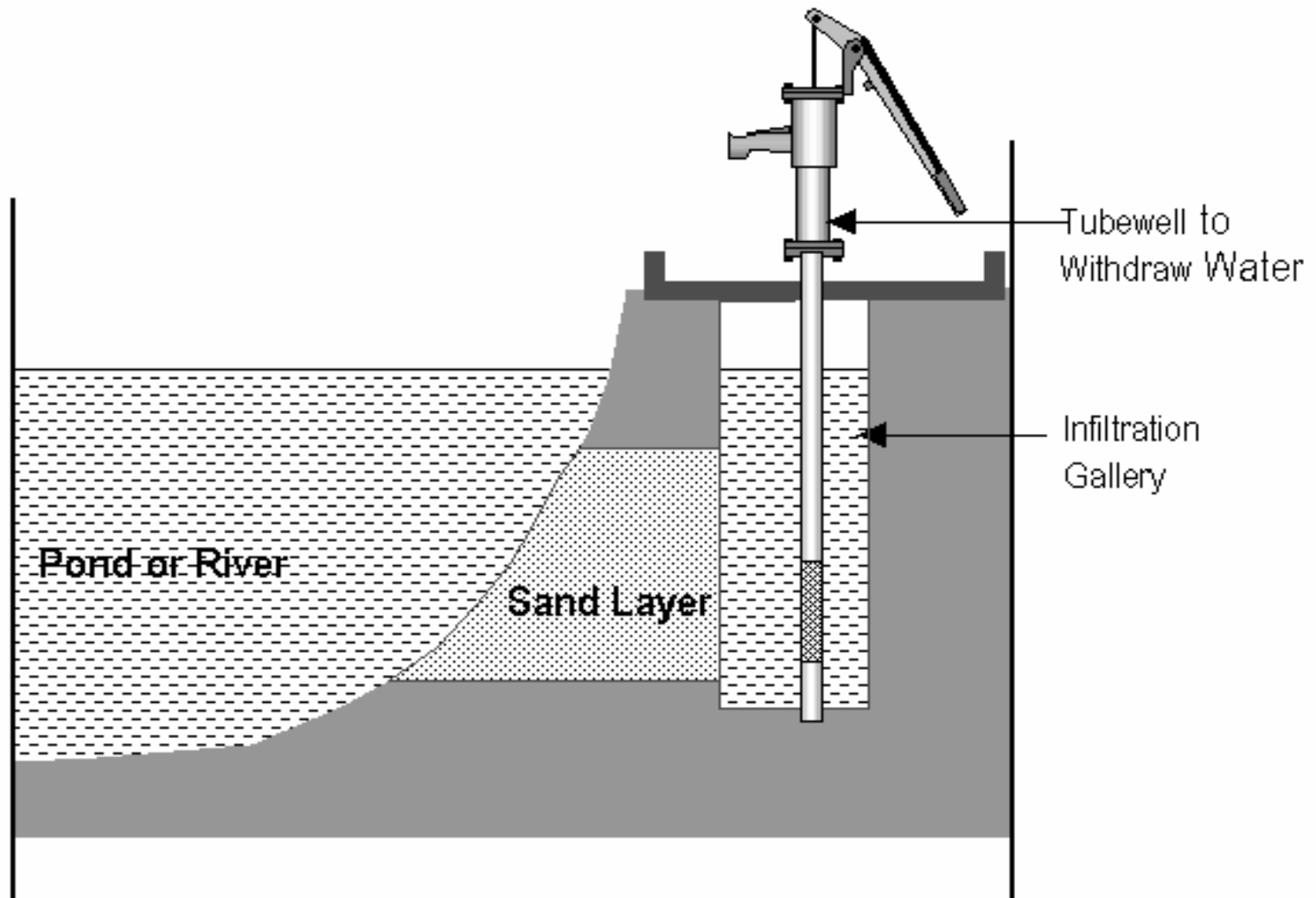
Radial Well



Infiltration Galleries

- ▶ ***Infiltration Galleries*** – An infiltration gallery intake is a variation of the radial collector well arrangement and is used where geologic conditions are relatively impermeable or of insufficient thickness and depth to support groundwater extraction.
- ▶ In these locations, it is necessary to install the radial arms and screens in trench that is then backfilled with a gravel pack and/or selected filter materials after the screens are installed.

Infiltration Galleries



Question

- ▶ Answer with Yes or No and correct the false ones:
 1. The design, modeling, monitoring, and permitting activities that surround intake facilities, may represent as much as 40% of the capital cost of the entire desalination plant.
 2. Some hardy species may be able to survive impingement and be returned to the sea, but the 24-hour survival rate of less robust species and/or juvenile fish may be less than 35%.
 3. The velocity cap converts horizontal flow into vertical flow at the intake entrance to reduce fish entrainment.

Questions

- ▶ Draw schematic diagrams for the following intake facilities:
- ▶ Velocity cap
- ▶ Passive screen
- ▶ Travelling screen
- ▶ Vertical Beach Wells
- ▶ Radial Well