Wastewater Treatment Technologies For Water Reuse In Saudi Arabia

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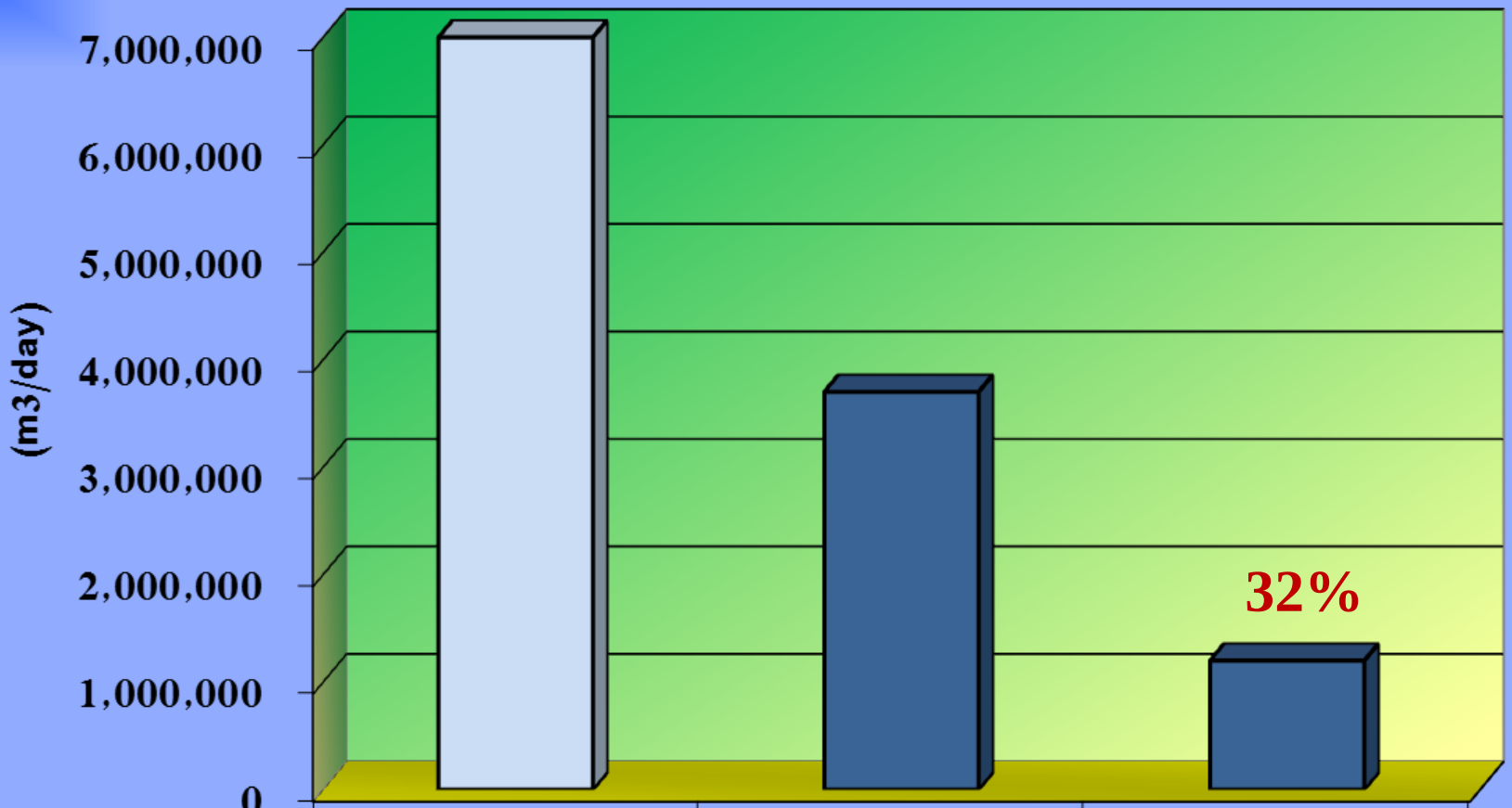
  - **Quantity**
  - **Types of Uses**
  - **Treatment Plants**
- ✓ **Evaluation of Oxidation Ditch Plants in SA**
  - **Performance**
  - **Cost Effectiveness**

Quantity of Reused Water In Saudi Arabia

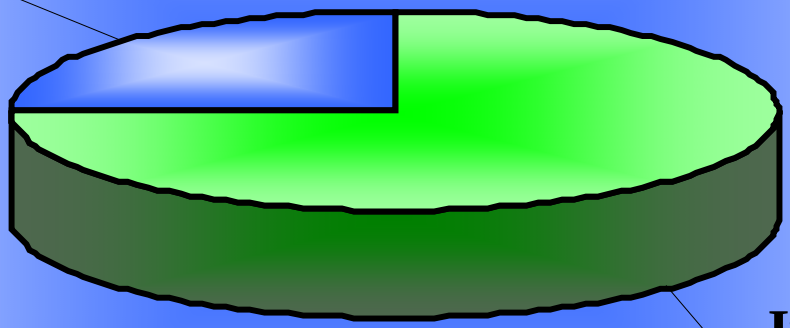


	Potable Water	Treated WW	Reused
Quantity	7,000,000	3,700,000	1,200,000

Uses of Reclaimed Water in SA

- Industrial (cooling, processing, ...)
- Stream Flow Augmentation

Other Purposes 25%



Irrigation 75%

- Agriculture Irrigation
- Landscape Irrigation

Wastewater Treatment Plants

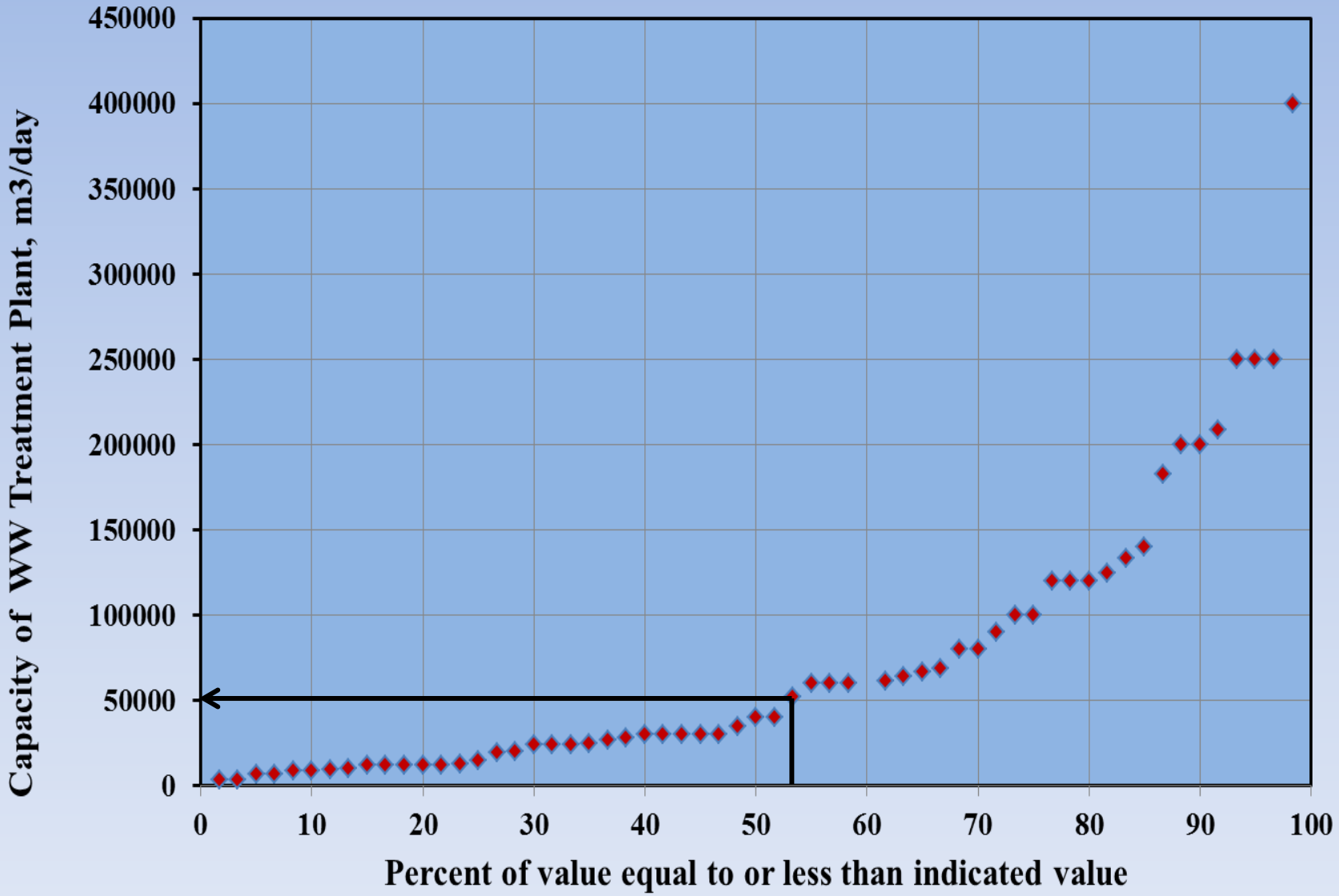
- Approximately 73 plants
- Design Capacity ≈ 5.0 million m^3/day

Riyadh Plants

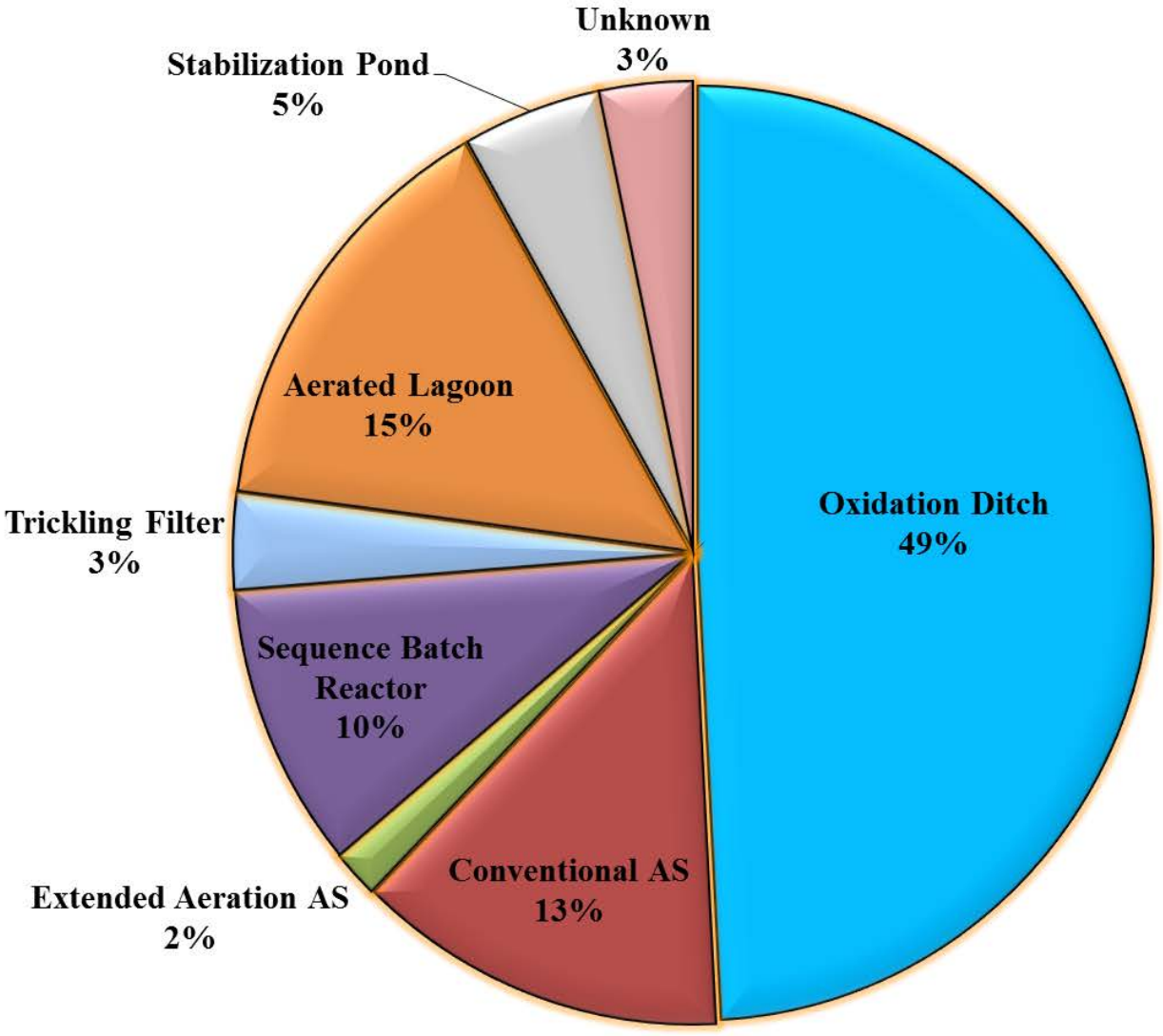
A Plant in Khateef

A Plant in Hafouf

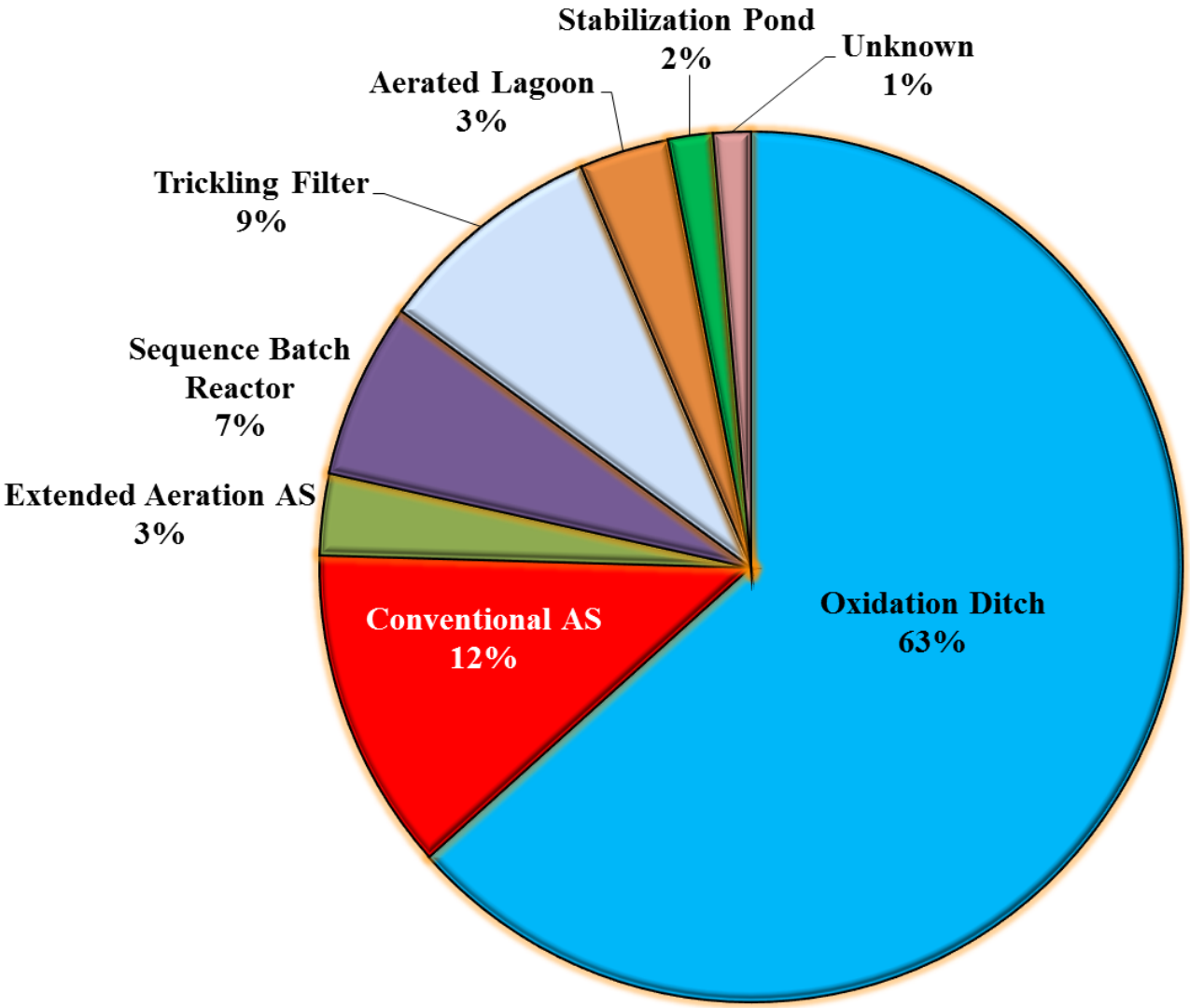
Cumulated Capacity of Wastewater Treatment Plants in SA



Types of Wastewater treatment Plants



Percent of Wastewater Treated by Different Systems



Evaluation of the Oxidation Ditch Process for the Biological Treatment of Municipal Wastewater in Saudi Arabia

Research Project Sponsored by the Science & Technology Program – King Saud University

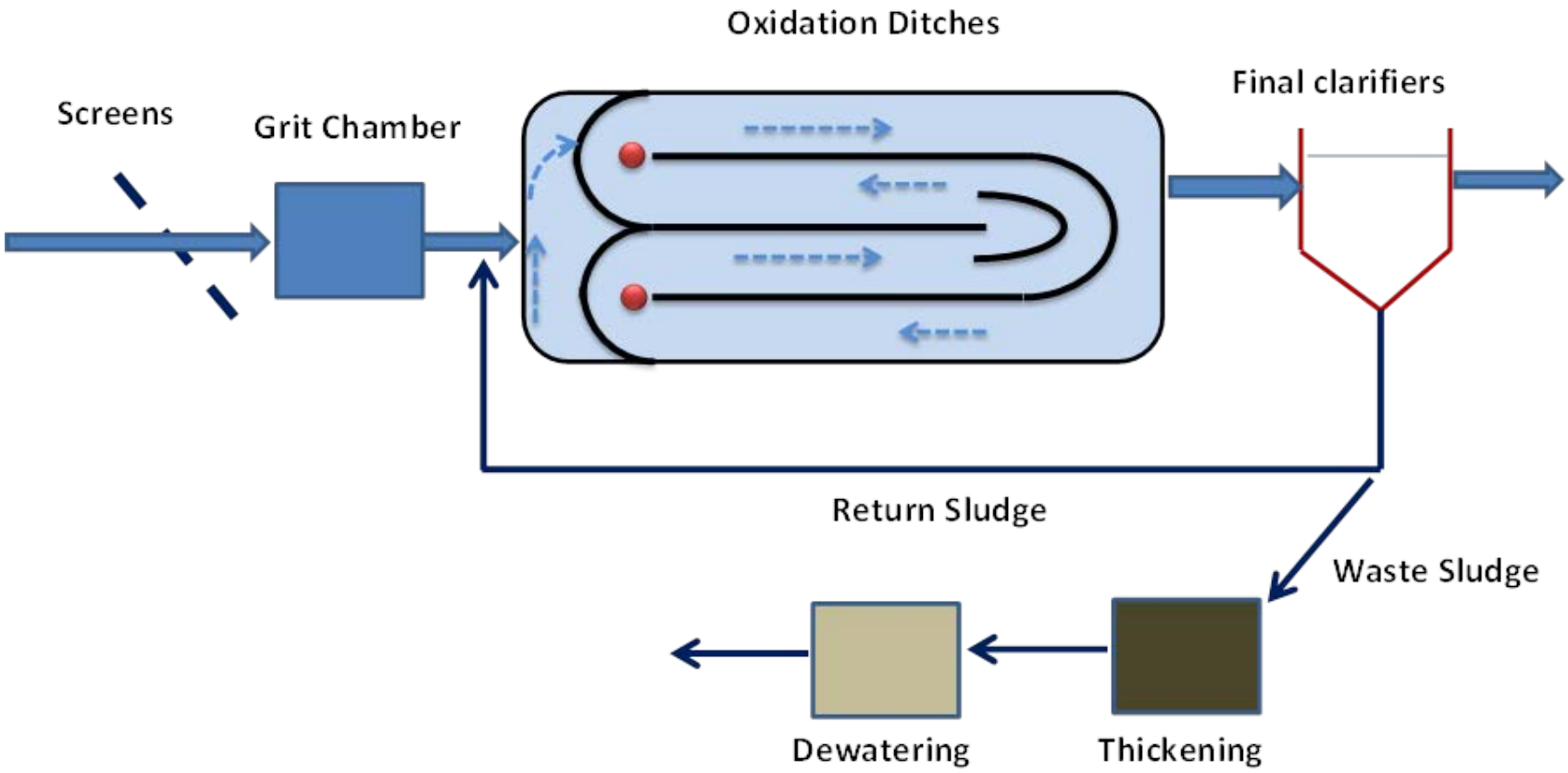
Objectives

- **Evaluate the treatment efficiency of the main oxidation-ditch wastewater treatment plants in Saudi Arabia**
- **Assess major operation concerns associated with oxidation ditch process**
- **Compare the OD with other biological treatment processes in terms of cost effectiveness**

Oxidation Ditch Process

Solids Retention Time: up to 48 days

Typical Oxidation Ditch Plant



Nitrification

De-Nitrification

Advantages

- Less Sludge due to Extended Solids Retention Time
- Resistance to Shock Loads & Hydraulic Surges Due to Long Hydraulic Detention Time

Disadvantages

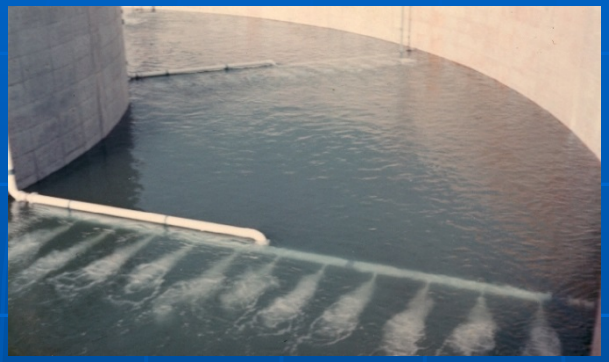
- Requires a Large Land Area (Costly)
- Effluent SS Concentrations are Relatively High

The First Oxidation Ditch

Pasveer Ditch – 1954 in Netherland

Modifications to Oxidation Ditch

Jet Aeration Channel



Orbal Process

Modifications to Oxidation Ditch

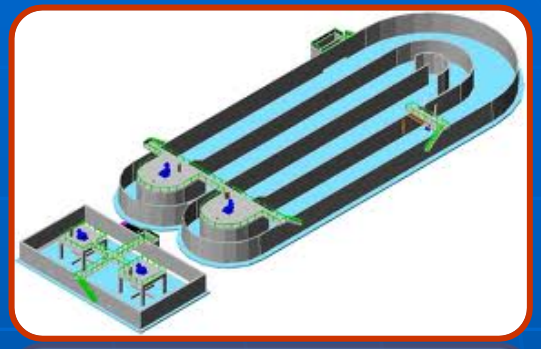
Carrousel System

Vertical Shaft Surface Aerator

Modifications to Oxidation Ditch

Carrousel 1000

- Compact System for Small-Scale WWTPs



Carrousel 2000

- Standard Carrousel System + Pre-Denitrification Tank
- + Anaerobic Tank for Phosphorus Removal

Carrousel 3000

- Deep Unit (up to 8 m)

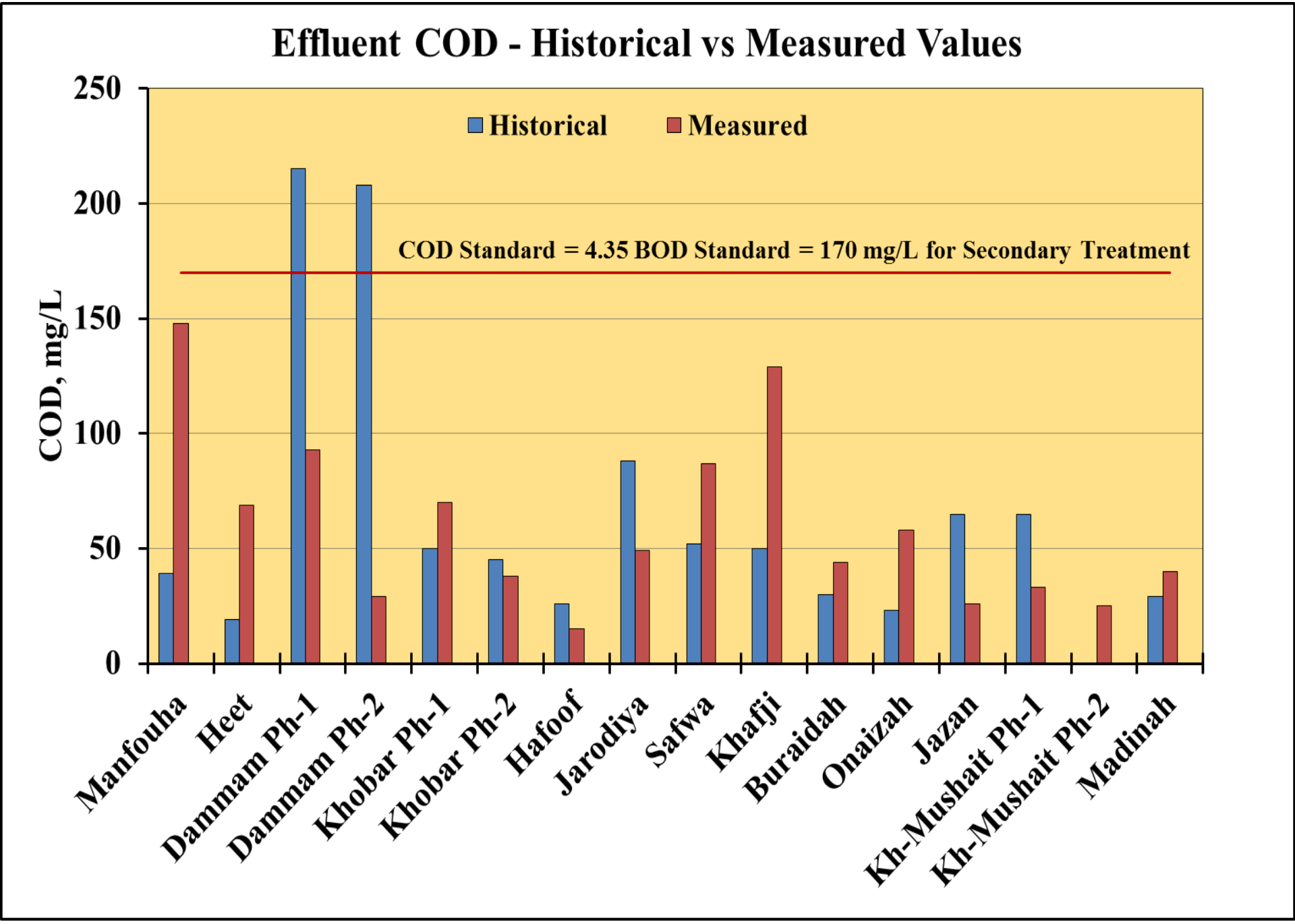
History of Oxidation Ditch in SA

Khamees-Meshait	1981	Oxidation Ditch	
Dammam phase-1	1982	Carrousel	DHV
Al-khobar phase-1	1982	Carrousel	DHV
Al-Jarodiah	1988	Carrousel	DHV+Other
.			
.			
.			
Dammam phase-2	2008	Carrousel 2000	DHV
Al-khobar phase-2	2008	Carrousel 2000	DHV
.			
.			

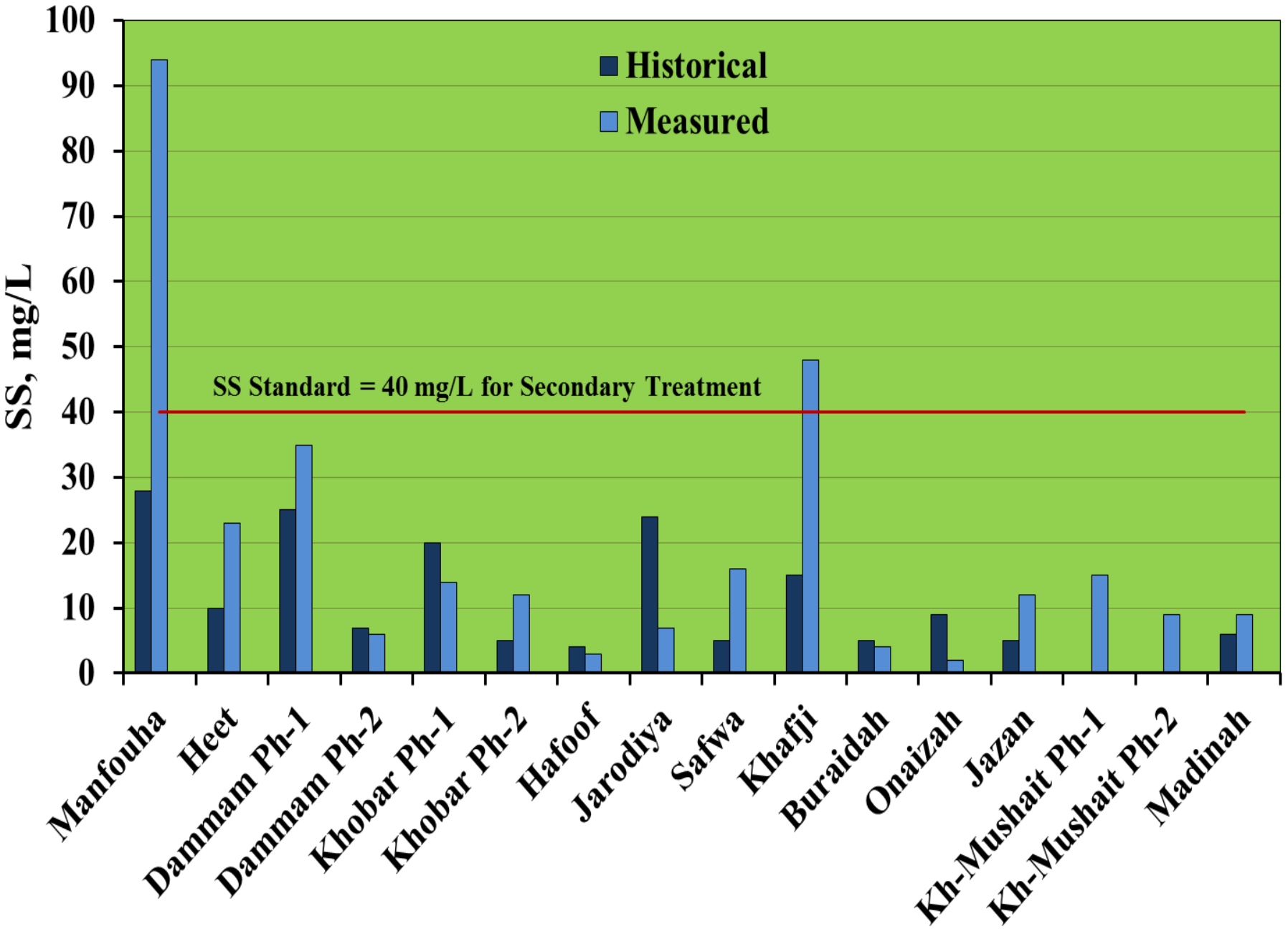
Old Oxidation Ditch in Khamees-Meshait (built 1981)

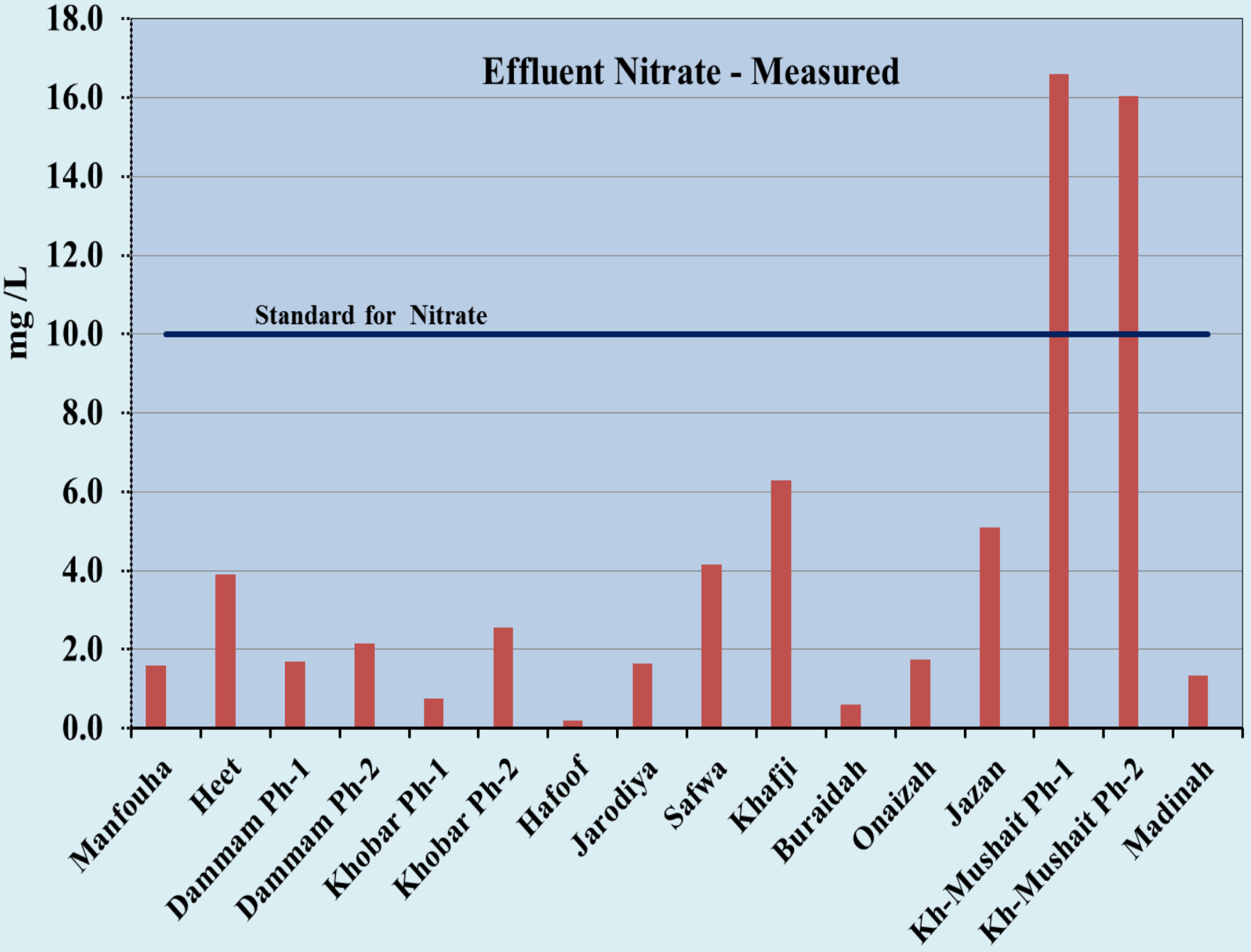
Oxidation Ditch WWTPs Studied

Region	Plant	Capacity, m^3/day	Oxidation Ditch Type	System Configuration
Riyadh (2)	Manfoha East	200,000	Carousel	Pre-anoxic
	Heet	200,000	Carousel	Pre-anoxic
Al-Qaseem (2)	Buraidah	69,000	Carousel	Post-anoxic
	Onayzah	35,500	Carousel	
Al-Sharqiyah (8)	Dammam Ph-1	208,810	Carousel	Post-anoxic
	Dammam Ph-2	61,500	Carousel 2000	Pre-anaerobic & anoxic
	Khobar Ph-1	133,330	Carousel	Post-anoxic
	Khobar Ph-2	60,000	Carousel 2000	Pre-anaerobic & anoxic
	Hafoof	183,000	Carousel	Post-anoxic
	Jarodiya	90,000	Carousel	Post-anoxic
	Safwa	15,000	Carousel	
	Khafji	15,600	Carousel	
Madinah (1)	Madinah	120,000	Carousel + EA	Pre-anaerobic
Aseer (2)	Kh-Mushait Ph-1	9,000	Oxidation Ditch	
	Kh-Mushait Ph-2	30,000	Carousel	
Jazan (1)	Jazan	20,000	Carousel	


Effluent COD - Historical vs Measured Values
Historical
Measured
COD Standard = 4.35 BOD Standard = 170 mg/L for Secondary Treatment
COD, mg/L
250
200
150
100
50
0
Manfouha
Heet
Dammam Ph-1
Dammam Ph-2
Khobar Ph-1
Khobar Ph-2
Hafoof
Jarodiya
Safwa
Khafji
Buraidah
Onaizah
Jazan
Kh-Mushait Ph-1
Kh-Mushait Ph-2
Madinah

Effluent SS - Historical vs Measured Values




Effluent Nitrate - Measured
mg /L
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Standard for Nitrate
Manfouha
Heet
Dammam Ph-1
Dammam Ph-2
Khobar Ph-1
Khobar Ph-2
Hafoof
Jarodiya
Safwa
Khafji
Buraidah
Onaizah
Jazan
Kh-Mushait Ph-1
Kh-Mushait Ph-2
Madinah

Common Features of Oxidation Ditch Plants in Saudi Arabia

- **No primary Sedimentation except in Madinah Plant**

- **Surface aerators with fixed speed (some are manufactured locally) > difficulty in controlling oxygen requirements for variable organic loading**

Common OD plants Operational Problems

Sand deposition in OD If not properly removed in preliminary treatment. (at dead ends of aeration tanks)

Operational Problems

Splashing around surface aerators (endanger health of workers)

Operational Problems

Foam & Floating Scum (oil and grease, & others) in Ditches

Operational Problems

If the Surface Aerator is Broken Down!!, or If the Operator Decides to Safe the Mechanical Aerator

Operational Problems

Sludge & Scum Floating in Final Clarifiers

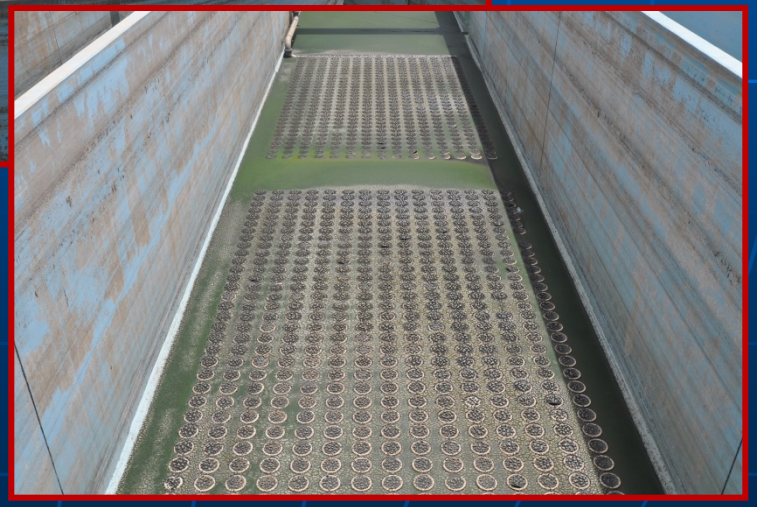
(Insufficient time for de-nitrification in oxidation ditches)

Operational Problems

Design Error!,, Aerators are Fully Covered!

Operational Problems

Regular Maintenance of Diffused Aeration Systems



Other Operational Problems

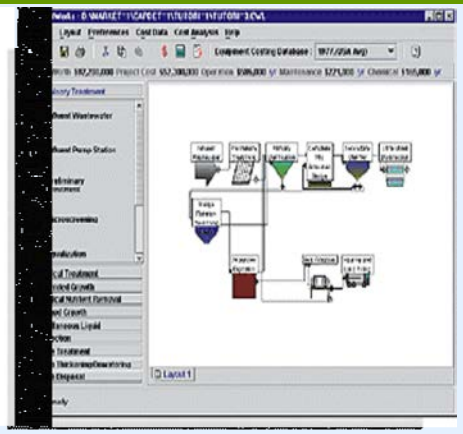
Excessive and variable organic loadings due to discharge of industrial wastewater and septage into some plants

Insufficient capacity of scum collection systems in final clarifiers

Cost Estimation and Analysis

The CapdetWorks (A cost-estimating program for wastewater-treatment construction projects)

- **Calculates the design of each unit process based on the process influent and then cost that design**
- **It estimates costs using the U.S July 2000 data base, and uses *"Cost Indices"* to adjust costs to the present**

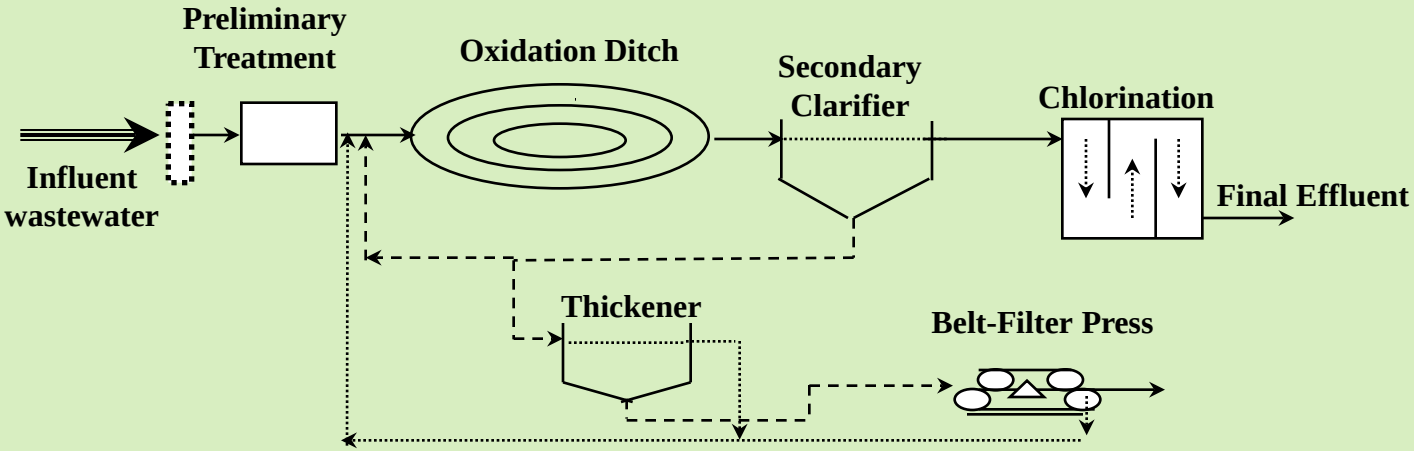


	2010 values
▪ The Marshall & Swift Equipment Cost Index	1302
▪ The Pipe, Valve, & Fitting Cost Index	656
▪ The Engineering News Record Construction Cost Index	7751

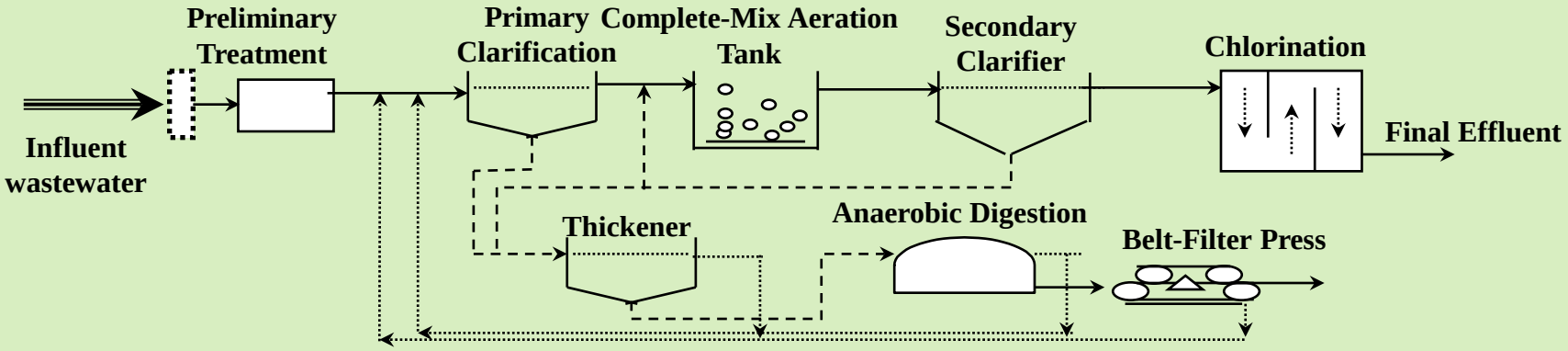
Unit costs for some construction activities & materials, chemicals, and supplies were acquired from local markets

Cost Estimation and Analysis

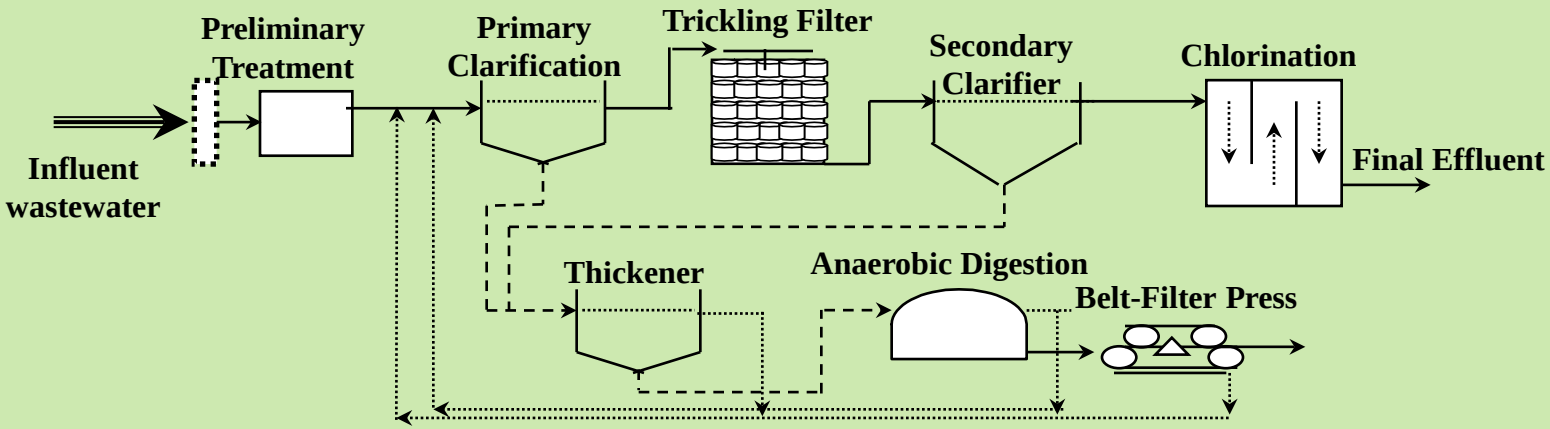
Treatment Schemes



(a) Oxidation Ditch Activated Sludge Plant



(b) Complete-Mix Activated Sludge Plant



(c) Trickling Filtration Plant

Data for design and Cost

- ✓ **Wastewater flows & Characteristics**

  Manfuha WW Treatment Plant (Riyadh)

  Average flow = 200,000 m^3/d, Peak flow = 320,000 m^3/day

  BOD_5 = 300 mg/L, COD = 500 mg/L, SS = 400 mg/L, TKN = 50 mg/L

- ✓ **Desired effluent quality**

  Reclaimed water quality criteria for un-restricted irrigation (Ministry of Water & Electricity)

- ✓ **Design Period = 30 years**

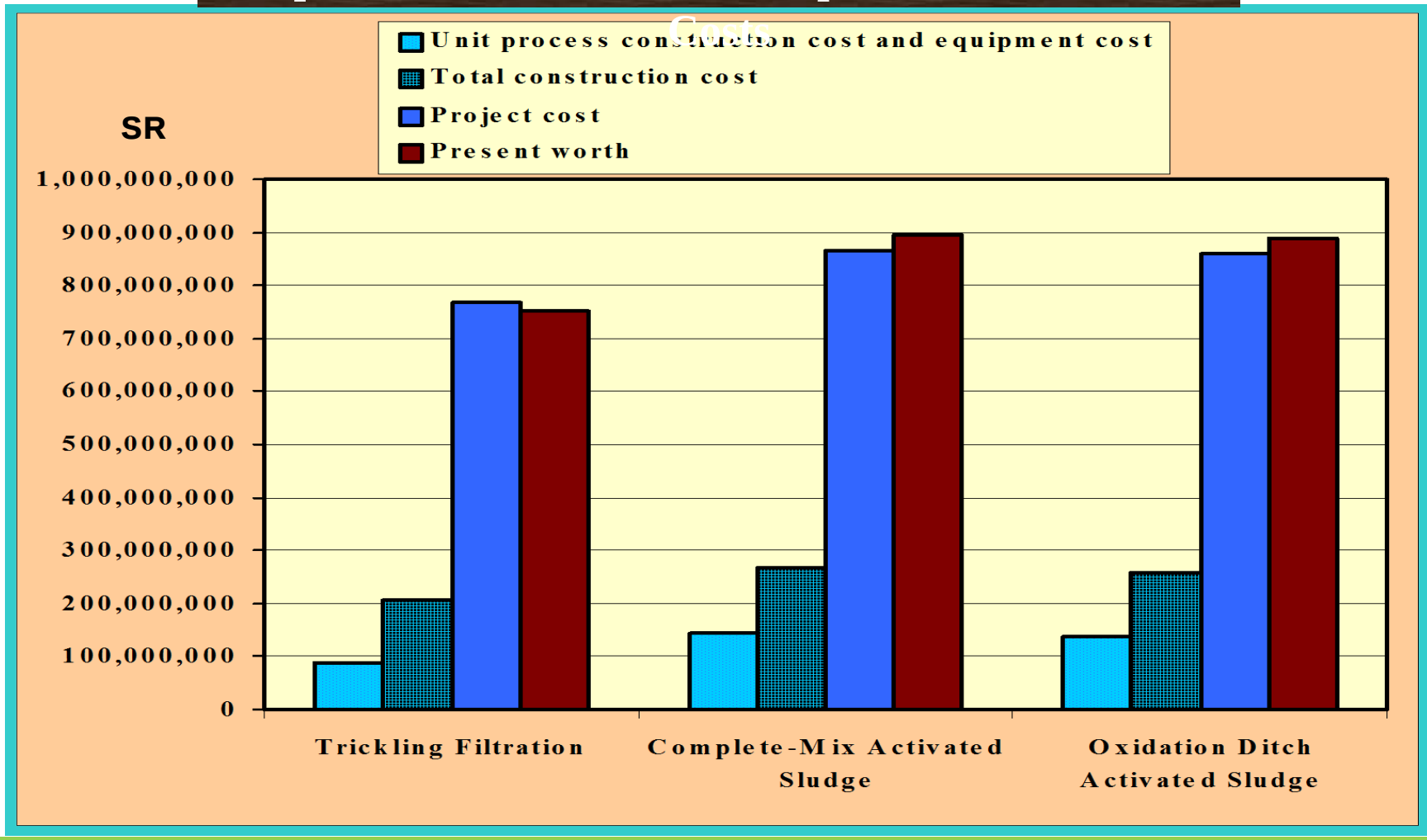
To determine the most cost-effective treatment scheme

- ✓ **The Present Worth Cost**
- ✓ **The Unit Cost per m^3 of wastewater treated**

➢ **The Present Worth Cost**

The amount of money required at the beginning of the planning period to pay the project cost immediately *and* the present worth of the annual O & M costs for the entire planning period

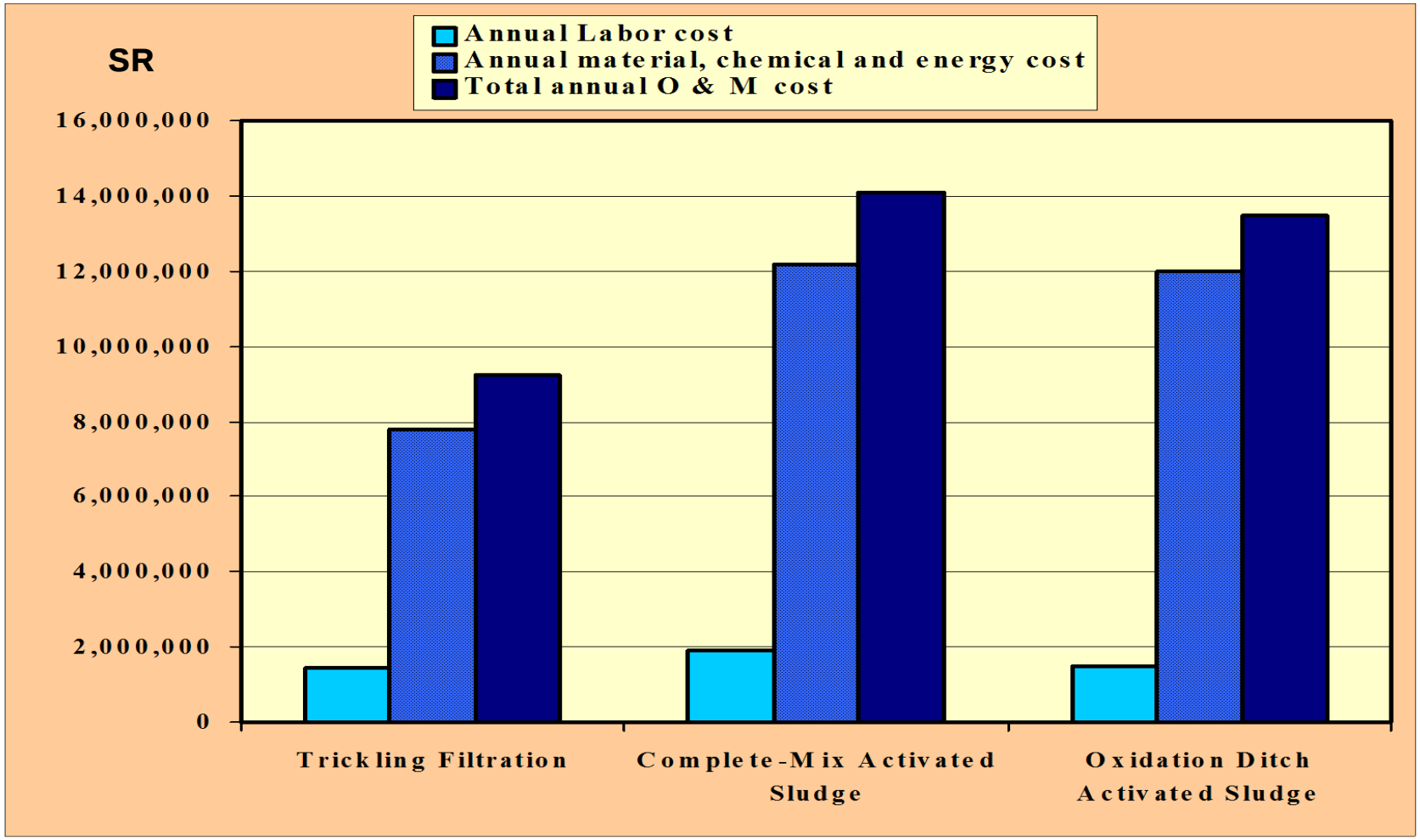
Comparison of Construction, Capital & Present Worth Costs



The capital and present worth costs for the complete-mix and oxidation-ditch AS plants are higher than those of TF

- **Total construction cost (27% - 31%)**
- **Project cost (12%)**
- **Present Worth Cost (18%)**

Comparison of Operation & Maintenance Costs



The O & M costs for the *complete-mix* and *oxidation ditch AS plants* are higher than those of *Tricking filter plant*

- ✓ **The annual material, chemical and energy cost (54% - 57%)**
- ✓ **The total annual O & M cost (46% - 52%)**

The per unit cost:

- Complete-mix AS: **SR 1.55/m^3**
- Oxidation-ditch AS: **SR 1.53/m^3**
- Trickling Filter: **SR 1.36/m^3**

Main Findings & Conclusions

- **Most Oxidation Ditch Plants Satisfy Effluent Standards for Restricted Irrigation in terms of SS, COD and Nitrate**
- **Tertiary Treatment is Needed to Satisfy Effluent Standards for Unrestricted Irrigation**
- **Some plants Experience Some Operational Problems and Need More Attention & Qualified Operators**
- **The Oxidation Ditch is Not the Most-Cost Effective Treatment Plant**

  (Does not satisfies effluent requirements with the lowest cost)

Main Findings & Conclusions

- **There are no typical best type and design for WW treatment plants that can be generalized for all rural and urban cities, and every case need to be studied separately according to the local conditions and circumstances**

Thanks