Designing a Sea Water Intake System for Reverse Osmosis

Chapter 1:

Introduction to Sea Water Intake Systems

1.1 Importance of sea water intake systems for reverse osmosis desalination

The sea water intake system plays a crucial role in various industries, particularly in the context of reverse osmosis desalination plants. Here are some key reasons highlighting the importance of a well-designed sea water intake system:

Source of Water Supply:
Sea water intake systems provide access to an abundant source of water, primarily for desalination purposes. With freshwater scarcity becoming a global concern, sea water serves as an alternative and potentially limitless supply for regions facing water shortages.

Reverse Osmosis Desalination:
Sea water intake systems are integral components of reverse osmosis desalination plants. These systems allow for the extraction of salt and impurities from seawater, producing clean and potable water suitable for various applications, including drinking water, agriculture, and industrial processes.

Sustainable Water Resource:
The utilization of sea water through proper intake systems reduces the strain on freshwater sources, preserving them for other essential uses. It promotes sustainable water management practices by diversifying the water supply portfolio and reducing dependence on limited freshwater resources.

Environmental Impact:
Designing sea water intake systems with careful consideration for environmental factors is crucial. By implementing appropriate measures, such as intake screens and fish protection systems, the impact on marine ecosystems can be minimized. Protecting marine life and maintaining the ecological balance is essential for long-term environmental sustainability.

Engineering and Design Challenges:
Designing an efficient and reliable sea water intake system involves overcoming engineering challenges. Factors such as wave action, currents, corrosion, and fouling require careful consideration to ensure the longevity and effectiveness of the system. Proper engineering design and material selection help mitigate these challenges.

Economic Benefits:
Sea water intake systems contribute to economic growth by enabling the establishment and operation of desalination plants. These plants can provide a stable and sustainable source of freshwater, supporting industries, agriculture, tourism, and residential communities in regions with limited access to freshwater resources.

Water Security:
Sea water intake systems enhance water security by diversifying water sources and reducing dependence on rainfall and surface water supplies. This is particularly important in arid and

water-stressed regions, where sea water desalination can serve as a reliable and resilient water supply option.

Global Impact:
Sea water intake systems have a significant impact on addressing global water scarcity and improving access to clean water. They provide a viable solution for regions facing water stress, promoting sustainable development, and improving the quality of life for communities around the world.

In summary, the proper design and operation of sea water intake systems are critical for sustainable water management, reverse osmosis desalination, environmental protection, and ensuring access to clean water in regions where freshwater resources are limited. The importance of these systems extends beyond individual industries, making them key contributors to global water security and sustainable development.

1.2 Overview of the Sea Water Intake design process and considerations

When designing a sea water intake system, it is essential to follow a comprehensive design process and consider various factors to ensure its effectiveness and efficiency. Here is an overview of the sea water intake design process and key considerations:

Project Requirements:
Begin by understanding the specific requirements of the project. Consider factors such as the desired water flow rate, water quality parameters, system capacity, and any regulatory or environmental constraints.

<u>Example</u>
Need to design a sea water intake for 3x400,000 IGPD SWRO project.
Product flow rate : 5400M3/day
Recovery : 40%
Feed flow rate : 13,500M3/day or 562 M3/h
MMF backwash flow : 197M3/hr x(20 min) = 65M3 each MMF
Total MMF: 6 nos
Total BW flow : 390M3/day
Rinse MMF : 390M3/day
Total feed flow =(562*24 + 390+390)= 14,268 M3/day = 594M3/hr
Future expansion = 1.5 Times
Total feed flow = 891M3/hour flow rate

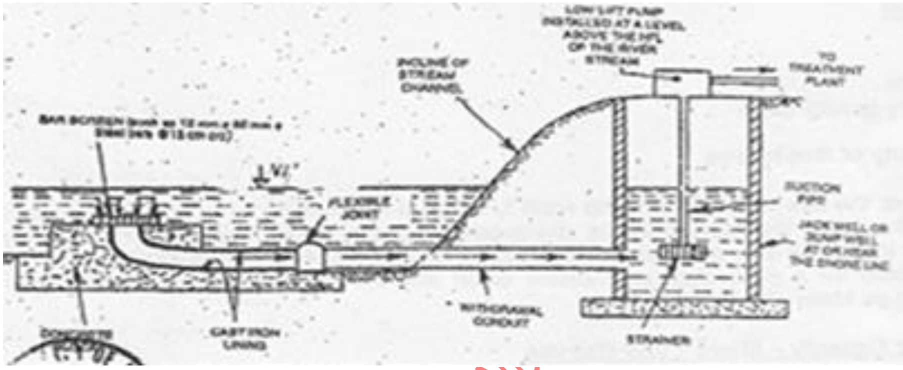
<u>Sufficient future expansion should be considered as sea water intake design is one time activity and involves a lot of cost.</u>

Intake System Configurations:
Evaluate different intake system configurations, such as surface intakes, submerged intakes, or beach well intakes. Each configuration has its advantages, challenges, and suitability based on site conditions, water quality, and project requirements.

Example

Intake structure for open sea intake generally designed with the screen inside the sea water at a depth of 3 meter from low tide level. Water is generally drawn in to the intake tank by gravity or intake pumps are connected directly to the screen to suck the water.

Option – 1 – Intake connected to the underground tank and water is lifted with submesible or turbine pumps



Option – 2 – intake screen is directly connected to the intake pumps and underground pumping station is created to have a positive suction at the intake pumps.

Source Water Analysis:
Conduct a thorough analysis of the source water to determine its characteristics, including salinity, temperature, turbidity, and potential contaminants. This analysis helps in selecting appropriate intake screen types, materials, and filtration processes.

Example

- Sea water profile is important to access the type of intake selected.
- 90% cases, you will have sea water depth of 7-11 meter at a distance of 200 – 300 meter
- In such cases, passive screen with hydro burst system is excellent choice.
- In case 7 – 11 meter depth is achieved in more then 600 meter, intake tower type structure with gravity flow is preferred.
- Water at depth of 3 – 4 meter to be collected every after 15 days and temperature, salinity, SDI and turbidity to be analysed.
- In case SDI and turbidity is higher side (SDI >5 and Turbidity more then 10 NTU), check the intake system feasibility again.
- If not possible to get lower SDI or turbidity value, proper pre-treatment system with DAFF and gravity media filter should be used.

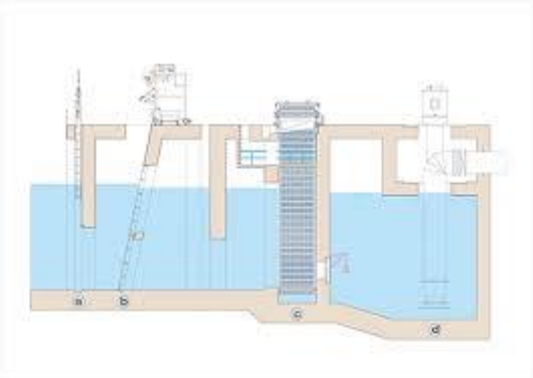
Intake Structure Design:
Design the intake structure to withstand environmental forces such as wave action, currents, and corrosion. Consider factors such as the selection of materials, structural stability, and minimizing the impact on marine ecosystems.

- In case of passive screen, a block should be designed with minimum 2M x 2M x 2M size and screen should be mounted on the top of the block.
- Structure should be installed minimum 1 meter below the sea bed.
- All the pipeline should be minimum 2 meter inside the sea bed.

Intake Screen Selection and Design:
Choose the appropriate type of intake screen (mesh, drum, or wedge wire) based on the source water analysis and the desired level of debris removal. Consider factors such as screen mesh size, hydraulic performance, fouling potential, and maintenance requirements.

- Passives screen with 2 mm slot side (wedge wire) should be selected along with the hydro burst system for the intake design up to 500 meter length and 5 meter depth.


- If system is large capacity (more then 10 MIGPD), travel bed screen are preferred.

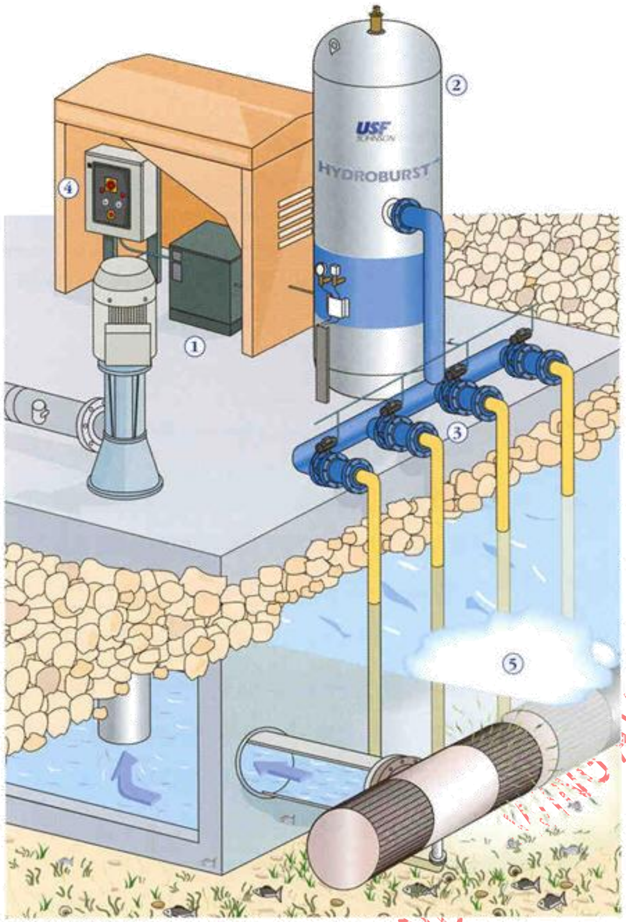


Pumping System Design:
Select pumps that can handle sea water and provide the required flow rate and pressure. Consider factors such as pump type (centrifugal, positive displacement), efficiency, energy consumption, and redundancy to ensure reliable operation.

Example

- Pumping system can be under the ground pump room, gravity flow , positive suction and intake pump directly connected to the intake screen via intake pipeline. Advantage of the design is that, pipeline can be operated with the suction velocity of 1.2 M/sec also, when connected with the pump suction.

- Intake screen and intake pipe is connected to the underground tank and it is always fill with the water. Submersible or turbine type pump is installed in the tank to pump the water from the tank. Disadvantage with the set up is that pipeline will fill the tank by gravity and maximum 0.8 M/hr velocity is possible. Bigger pipe size is required.



Pipeline Design and Layout:
Design the pipeline system to transport the sea water from the intake structure to the treatment facility. Consider factors such as pipe material selection, sizing, hydraulic calculations, and layout to minimize friction losses, pressure drop, and maintenance requirements.

Example

- For 3x400,000 IGPD sea water desalination, designed inlet water flow is water flow is 891M3/hour.
- Intake piping with the gravity flow is designed with 0.8M/sec velocity whereas piping connected with the intake pump can be designed with 1.5M/sec velocity.
- Intake pipe size, if V suction (1.5M/sec) = 458MM – next selected size is 500NB HDPE pipe
- Intake pipe size, if V suction (0.8M/sec) = 627 MM – next selected size is 700NB

Monitoring and Control Systems:
Implement real-time monitoring systems to track key parameters such as flow rate, pressure, water quality, and system performance. Integrate control systems to optimize operational efficiency and respond to any deviations or alarms.
Example

- Flow rate should be as per the demand

- Intake pumps should be operational as per demand
- Pre chlorination as per the actual flow rate
- Hydro burst system should operate 2 times in 24 hours to clean the screen from fouling
- Turbidity and temperature should be monitored continuously and should feed to SCADA and in case of high turbidity (rough sea) , intake system should be closed.

Maintenance and Fouling Prevention:
Develop a comprehensive maintenance plan to ensure the long-term performance of the intake system. Implement strategies to prevent fouling, such as chlorine dosing, anti-fouling coatings, and regular cleaning procedures.

- Hydro burst system 2 times in 24 hour
- Screen injected with shock chlorination to avoid biological growth
- Pre chlorination
- Screen cleaning once in 6 month

Environmental and Regulatory Compliance:

Consider environmental impact assessments and regulatory requirements related to marine ecosystems, fish protection, and water discharge. Implement necessary mitigation measures to minimize the ecological impact and ensure compliance.
Example

- Environmental study is required to obtain a permit from the ministry of environment
- Topographic survey is required
- Marine survey is required which includes depth of the sea at various distance.
- Outfall and intake should be located minimum 500 meter apart
- Always prefer breakwater for the intake and outfall to avoid permissions.
- Terminal velocity on the tip of screen should be lower then 0.2M/ hour and this will avoid fish to come close to screen
- Reject water should be diffused at a minimum 4 meter depth to keep the temperature and salinity balanced.

Cost Analysis and Feasibility:

Evaluate the economic feasibility of the proposed sea water intake system. Consider the capital costs, operational costs (including energy consumption), and life-cycle costs to determine the overall viability and return on investment.

- Most economical option is passive screen with intake pipe and pumps directly connected to the intake pipe.
- This method is good up to a flow rate of 4500M3//hour maximum

Throughout the design process, collaboration with multidisciplinary teams, including engineers, environmental experts, and regulatory authorities, is essential to ensure a well-rounded and successful sea water intake system design.

By following these considerations and steps, you can develop a robust and efficient sea water intake system that meets the project requirements, minimizes environmental impact, and provides a sustainable source of water for various applications.

1.3 Environmental and Ecological Factors Specific to Sea Water Intake

When designing a sea water intake system, it is essential to consider the environmental and ecological factors associated with extracting water from the sea. Here are some specific factors that need to be taken into account:

Marine Ecosystem Impact:

Sea water intake systems have the potential to affect marine ecosystems by entraining or impinging upon marine organisms. The intake process may inadvertently draw in fish, larvae, plankton, and other organisms, which can have ecological consequences. Minimizing the impact on marine life through the use of proper intake screens, fish exclusion devices, and velocity-reducing measures is crucial.

- Environment study should be carried out by agency
- Environmental permit is required

Habitat Disturbance:

The construction and operation of sea water intake structures can cause habitat disturbance in the surrounding areas. This disturbance may include dredging, sedimentation, and alteration of flow patterns. Careful site selection and design considerations should be made to minimize disruption to sensitive habitats, such as coral reefs, seagrass beds, and coastal wetlands.

- Environment study should be carried out by agency
- Environmental permit is required

Water Quality Effects:

Intake systems can influence water quality in the vicinity of the intake. Changes in salinity, temperature, and turbidity can occur due to the extraction process. Understanding the potential impacts on the local hydrodynamics and water quality parameters is important to ensure compliance with environmental standards and to mitigate any adverse effects.

- Environment study should be carried out by agency
- Environmental permit is required
- High salinity discharge due to reject water discharge and disperse in the sea should also be considered.

Impacts on Larval Dispersal:

The entrainment of larvae and planktonic organisms into the intake system can disrupt natural larval dispersal patterns, potentially affecting marine population dynamics and biodiversity. Mitigation measures, such as larval return systems or bypass mechanisms, can be implemented to minimize these impacts.

- Environment study should be carried out by agency
- Environmental permit is required

Algal Blooms and Harmful Algal Species:

Certain coastal areas are prone to algal blooms and the presence of harmful algal species. These blooms can affect water quality and pose risks to marine life and human health. Intake systems should be designed to anticipate and address the challenges associated with algal blooms, such as clogging of intake screens and the potential need for pre-treatment processes.

- Red tide is common phenomena in certain area of middle east.
- Additional pre-treatment should be considered for those area which should be operational when such situation arises.

Coastal and Nearshore Processes:

Sea water intake systems must consider coastal and nearshore processes, including tidal fluctuations, wave action, and currents. These processes can influence the siting, design, and operation of the intake system. Understanding the local hydrodynamics is crucial for determining the optimal location, orientation, and configuration of the intake structure.

Regulatory Compliance:

Compliance with environmental regulations and permits is essential when designing and operating sea water intake systems. Environmental impact assessments, fishery regulations, water quality standards, and protected area designations should be taken into account to ensure legal compliance and minimize environmental harm.

- Environment study should be carried out by agency
- Environmental permit is required

It is crucial to engage with environmental experts, ecologists, and regulatory bodies during the design process to assess and address these environmental and ecological factors. By incorporating appropriate mitigation measures and monitoring protocols, sea water intake systems can be designed to minimize their impact on the marine environment while efficiently extracting water for various applications.

Chapter 2:

Determining System Requirement

2.1 Importance of sea water intake systems for reverse osmosis desalination

Sea water intake systems play a vital role in reverse osmosis (RO) desalination, making them of utmost importance for the efficient production of freshwater from seawater. Here are some key reasons highlighting the significance of sea water intake systems in RO desalination:

Access to Abundant Water Source:
Sea water intake systems provide access to an abundant source of water, as approximately 97.5% of the world's water resources are seawater. This allows RO desalination plants to tap into an almost limitless supply of water, particularly in coastal regions where freshwater resources are scarce.

Reliable Water Supply:
RO desalination plants, powered by sea water intake systems, offer a reliable and continuous supply of freshwater. They are not dependent on rainfall or surface water sources, which may be subject to seasonal variations, droughts, or contamination. This reliability is crucial for ensuring a stable water supply for various applications, including drinking water, irrigation, and industrial processes.

Addressing Water Scarcity:
With growing populations, urbanization, and climate change, many regions around the world are facing water scarcity. Sea water intake systems provide a viable solution for these water-stressed areas by harnessing the abundant seawater resource and converting it into freshwater through the RO desalination process. They help alleviate water scarcity challenges and contribute to sustainable water management.

Diversification of Water Sources:
By incorporating sea water intake systems, RO desalination plants offer a means to diversify water sources. This reduces reliance on limited freshwater supplies, such as rivers, lakes, and underground aquifers, which are often overexploited and vulnerable to depletion. Diversification helps in balancing water resources, ensuring resilience, and mitigating the risks associated with single-source dependency.

Mitigating Freshwater Stress on Ecosystems: Excessive extraction of freshwater from natural sources can harm ecosystems and disrupt the balance of ecosystems dependent on freshwater inflows. By utilizing sea water intake systems for RO desalination, the pressure on freshwater sources is reduced, allowing ecosystems to maintain their natural water flows and supporting the ecological health of rivers, estuaries, and wetlands.

Global Water Security:
Sea water intake systems, in conjunction with RO desalination, contribute to global water security by providing a sustainable and reliable source of freshwater. They enable regions with limited access to freshwater resources to meet their water demands, supporting human well-being, economic growth, and social development.

Sustainable Development:
Sea water intake systems align with the principles of sustainable development by utilizing a renewable and abundant resource. They offer a long-term solution for water supply, reducing dependence on finite freshwater resources and promoting water resource management practices that are environmentally sound, socially equitable, and economically viable.

In summary, sea water intake systems are crucial for RO desalination, providing a sustainable and abundant water source to address water scarcity, diversify water supplies, support water security, and promote sustainable development. They play a pivotal role in ensuring access to clean and reliable freshwater, particularly in regions facing water stress or limited freshwater resources.

2.2 Estimating the Required Sea Water Flow Rate for the Reverse Osmosis System

Estimating the required sea water flow rate for a reverse osmosis (RO) system involves considering several factors and parameters. Here's an overview of the process:

Feed Water Parameters:
Start by determining the required water production rate or permeate flow rate for the RO system. This is typically based on the desired capacity or demand for treated water.

For example,
if the RO system needs to produce 3x400,000 IGPD SWRO project.
= 1,200,000 Imperial Gallon per day = 5400 M3/day treated water flow

Recovery Rate:
Determine the desired recovery rate, which is the percentage of feed water that is converted into permeate or freshwater. Recovery rates for RO systems typically range between 30% and 75%, depending on factors like water quality, membrane characteristics, and system design. The recovery rate affects the overall sea water flow rate needed.

2.2.1 Table indicating % recovery

Sno	Water Type	Salinity	% Recovery range
1	Sea water – Beach well	18,000PPM – 30,000PPM	45- 50%
2	Sea water – Beach well / intake	32,000 – 38000PPM	42% - 45%
3	Sea water – Beach well / Intake	38,000 – 42,000PPM	40%
4	Sea water – Beach well / Intake	42,000 – 45,000PPM	38% - 40%
5	Sea water – Beach well / Intake	45,000 – 48,000PPM	35% - 38%
6	Sea water – Beach well / Intake	48,000 – 52,000PPM	30% - 35%
7	Sea water	55,000PPM	30%

Concentrate or Reject Flow:

Calculate the concentrate flow rate or the reject flow rate, which is the portion of the feed water that is not converted into permeate but is instead discharged as concentrated brine. The concentrate flow rate is typically a percentage (100% - recovery rate) of the feed water flow rate.

Example

if the RO system needs to produce 3x400,000 IGPD SWRO project.

= 1,200,000 Imperial Gallon per day = 5400 M3/day treated water flow

Sea Water Salinity designed = 45,000PPM

Rate of recovery : 40% (as per the above table)

Reject flow = 5400/40% = 13,500 M3/day

Concentrate of reject flow = 60%

Salt Passage and System Efficiency:

Consider the salt passage rate of the RO membranes and the desired system efficiency. The salt passage rate refers to the percentage of salts that pass through the membrane and end up in the permeate. Lower salt passage rates result in higher salt rejection and better water quality. System efficiency accounts for losses due to fouling, membrane degradation, and system recovery rate.

Example

Sea water salinity : 45,000PPM

Sea water membrane sale rejection is " 99.5%

Salt passes = 100% - 99.5% = 0.5%

= 45,000X0.5% = 225PPM

Membrane Flux and Pressure:

Determine the specific membrane flux and pressure requirements for the RO system. Membrane flux is the amount of water that passes through the membrane per unit area and time, typically measured in liters per square meter per hour (LMH). The required flux depends on the membrane type, water quality, and system design. The operating pressure of the RO system also affects the flow rate and determines the energy consumption.

Example

<u>2.2.2 Table showing membranes and surface area</u>

Sno	Membrane Mfg	Membrane model	Membrane Type	Area – Ft2	Area – M2
1	Filmtech	BW30-365	Brackish water	365	33.9
		BW30- 400	Brackish water	400	37.16
		BW30-LE-440	Brackish water Low energy	440	40.87
		SW30HR 380	Sea water	380	35.3
		SW30HR 400	Sea water	400	37.16
		SW30HR LE 400	Sea water low energy	400	37.16
2	LG membranes	LG BW 400	Brackish water	400	37.16
		LG BW 440	Brackish water	440	40.88
		LG SW 400	Sea water	400	37.16
		LG SW 440	Sea water	440	40.88

3	Hydraunautics	CPA 3	Brackish water	400	37.16
		SWC5LD	Sea water	400	37.16
		SWC6LD	Sea water	400	37.16
4	Torrey	TM720-400	Brackish water	400	37.16
		TM 720-440	Brackish water	440	40.88
		TM820 – 400	Sea water	400	37.16
		TM 820- 440	Sea water	440	40.88

2.2.3 - Table between TDS – membrane type and flux selection

Sno	Membrane Type	TDS of water	% recovery	Recommended flux-LMH	*Expected system pressure	*Expected product TDS-PPM
1	Brackish water	<500	85%	26-28	12- 15Bar	<10
		500 - 1500	75%-80%	26-28	12-15 Bar	10 – 50
		1500 – 5000	75% - 80%	22-24	15- 20 Bar	50 – 150
		5000 – 7500	65% - 75%	20-22	18-22Bar	100- 200
		7500 – 10,000	60% - 65%	18-20	20 – 25Bar	150-250
		10,000- 12,000	50%-60%	18-20	23- 28Bar	200- 500
		12,000 – 15000	50%	18	25-30Bar	300 - 600
2	Sea water	<1000	80%	22-24	15-20Bar	<5
		1000 – 5000	75%	22-24	15-20Bar	5 – 15
		5000 – 10,000	65%	22-24	20 – 25Bar	20 – 50
		10,000 –15000	60%	22-24	25- 30Bar	30 – 80
		15,000 – 20,000	50%-55%	22-24	30 – 35bar	100 - 150
		20,000 – 25,000	50%	18-20	42- 50Bar	150-300
		25,000 – 30,000	45%-50%	16-18	50 – 60 Bar	150-300
		30,000 – 36,000	45%	15-16	62-65Bar	200- 350
		36,000 – 42,000	40%-42%	14-16	68-72Bar	<500
		45,000	35%-40%	13-14	75-80Bar	<500
		50,000	32%	11.5-12.5	80Bar	<700

*Run membrane projection via selected membrane software at actual temperature to obtain correct system pressure and expected TDS. Above tables are for quick guidance for design purpose.

Calculate production with LMH and surface area of membranes

Product water each membranes = flux * surface area of membranes
If flux is 16 LMH and area of membranes is 37.16 M2
Flow each membrane = 16* 37.16 = 594 L / Hour = 14.25 M3/day

Design Considerations:

Consider any additional factors that may impact the required sea water flow rate, such as pretreatment processes (filtration, sedimentation, chemical dosing) or the need for system

Example

1. If TDS is 1000PPM, as per the design table, recovery can be 75% - 80%, but if this is river water – High fouling water source, recovery will be maximum 60%
2. If TDS is 1000PPM, as per the design table, recovery can be 75%-80%, but if hardness is too high or silica presence is too high, recovery can be between 50-60%.
   Advised to run the membrane projection with a full water analysis result and check which recovery rate, we have no warning and accordingly recovery rate and flux rate to be designed.

redundancy or standby capacity.
These factors will influence the overall design and sizing of the RO system.

Example
If we are designing a plant for 1000M3/day capacity and standby for future for the another 1000M3/day, intake system must be suitable for the future also and overall plant layout should have provision to incorporate additional streams.

It's important to note that estimating the required sea water flow rate is a complex process that requires detailed analysis and consideration of site-specific conditions, water quality parameters, and system design parameters.
Consulting with experienced engineers or water treatment professionals is highly recommended to ensure accurate estimation and optimal system design for the specific application.

2.3 Understanding the Desired water quality parameters

Understanding the desired water quality parameters is crucial when designing a sea water intake system for reverse osmosis (RO) desalination. The water quality parameters determine the level of treatment required and help ensure the production of high-quality freshwater. Here are some key water quality parameters to consider:

Total Dissolved Solids (TDS):
TDS refers to the concentration of dissolved salts and minerals in water. It is an essential parameter for desalination processes. The desired TDS level depends on the intended use of the freshwater and can vary for different applications such as drinking water, irrigation, or industrial processes.

Example :
Refer table 1.2.1, it is evident that salinity and rejection plays an important role. The higher is TDS, lower is the recovery and hence more is feed water requirement.

Turbidity:
Turbidity measures the clarity or cloudiness of water caused by suspended particles. It is an important parameter to consider as high turbidity levels can negatively impact the performance

and efficiency of the RO system. Clear water with low turbidity is generally desired for optimal RO operation.

pH:

pH is a measure of the acidity or alkalinity of water. It affects the stability and performance of the RO system. The desired pH range for RO systems is typically between 6.5 and 8.5, as extremes in pH can affect the lifespan of the membranes and overall system performance.

Temperature:

Water temperature influences the viscosity of water and affects the efficiency and production rate of the RO system. The desired temperature range for optimal RO performance depends on the specific membrane and system design but is typically between 10°C and 35°C.

Example

- If water temperature is high from ground water (some area ground water is 55 – 60DegC), water temperature must be reduced before feed to RO plant
- For industrial application, condensate water temperature is very high (50 -75DegC) and it must be cooled down before pushing for polishing units.

Chlorine and other disinfection byproducts:

If the seawater source contains residual disinfectants like chlorine or disinfection byproducts, it is important to consider their levels and their potential impact on the RO system and membrane performance. Pre-treatment processes may be required to remove or neutralize these chemicals.

Suspended Solids:

Suspended solids refer to solid particles that are present in the water, such as sediment, silt, or organic matter. High levels of suspended solids can lead to fouling and reduced performance of the RO system. Proper pre-treatment, such as sedimentation or filtration, may be necessary to remove these solids.

Alkalinity:

Alkalinity is a measure of the water's buffering capacity or its ability to resist changes in pH. It is important to consider alkalinity as it can affect the stability and performance of the RO system, particularly in controlling pH variations during the desalination process.

Hardness:

Hardness is a measure of the concentration of calcium and magnesium ions in the water. Elevated levels of hardness can lead to scaling on the membrane surface, reducing its efficiency. Pre-treatment processes like water softening may be required to remove or reduce hardness.

Silica:

Silica is a common element found in seawater and can cause scaling on the membrane surface, impacting RO performance. Silica levels need to be monitored and controlled through appropriate pre-treatment methods, such as silica removal or antiscalant dosing.

Total Organic Carbon (TOC):

TOC represents the concentration of organic compounds in the water. High levels of TOC can contribute to fouling, bacterial growth, and reduced membrane performance. Pre-treatment processes, such as activated carbon filtration or oxidation, may be necessary to remove or reduce TOC.

Bicarbonate and Carbonate Alkalinity:
Bicarbonate and carbonate alkalinity contribute to the overall alkalinity of the water and can affect the pH stability during RO treatment. Controlling these parameters is important for maintaining proper pH levels and preventing scaling or precipitation.

Heavy Metals and Trace Contaminants:
Depending on the specific application and regulatory requirements, the presence of heavy metals, trace contaminants, and specific ions such as arsenic, lead, mercury, or nitrates may need to be monitored and controlled to ensure the desired water quality.

Microbial Contaminants: In addition to general biological contaminants, specific microbial parameters like coliform bacteria, E. coli, or other pathogens may need to be considered, especially if the treated water is intended for drinking or sensitive applications. Appropriate disinfection methods or microbial control measures may be necessary.

It's important to note that the specific water quality parameters of concern may vary depending on the local regulations, application requirements, and desired water quality standards. Conducting a comprehensive water analysis and consulting with water treatment experts will help identify the relevant parameters and guide the design and treatment processes for the sea water intake system.

Specific ions and contaminants:
Depending on the intended use of the freshwater, specific ions and contaminants may need to be monitored and controlled. For example, levels of specific ions like calcium, magnesium, sulfate, or heavy metals might need to be considered based on the application and water quality standards.

<u>1.3.1 - Water Analysis Sample Report</u>

Date of Analysis:
Sample Source:

Physical Parameters:

pH:
Temperature:
Turbidity:
Suspended particles

Chemical Parameters:

Total Dissolved Solids (TDS):
Total Hardness:
Alkalinity:
Chlorine:

Silica:
Nitrate:
Sulfate:
Carbonate:
Iron :
Microbiological Parameters:

Total Coliform:
E. coli:
Other Pathogens:
BOD:
COD:

Additional Parameters:

Heavy Metals:
Lead:
Arsenic:
Mercury:
Other Heavy Metals:
Conclusion:

When obtaining a water analysis report, it is important to consult with a certified laboratory or water testing service to ensure accurate and reliable results. They can provide a comprehensive analysis of the water sample, including the desired parameters specific to your project or application.

2.4 Analysing Seasonal Variation and Tidal influence

Analyzing seasonal variation and tidal influence is an important aspect when designing a sea water intake system. Understanding these factors helps in assessing the potential impact on the intake system's performance, water quality, and operational efficiency. Here are some key points to consider when analyzing seasonal variation and tidal influence:

Seasonal Variation:

Water Temperature:
Seasonal changes can significantly affect water temperature, which can impact the efficiency of the intake system and subsequent water treatment processes. Higher temperatures may increase biological activity and require additional pre-treatment measures.

Precipitation and Runoff:
Seasonal rainfall and runoff can introduce changes in water quality parameters such as turbidity, suspended solids, and organic matter. These variations can affect the design and operation of the intake system, requiring appropriate pre-treatment to manage these fluctuations.

Nutrient Levels:
Seasonal changes can influence nutrient concentrations in the seawater. High nutrient levels may lead to algal blooms or increased biological activity, requiring careful monitoring and potential adjustments in the intake system design or treatment processes.

Storm Events:
Intense storm events can introduce high turbidity, sedimentation, and debris into the seawater. Proper design considerations, such as intake location and protection mechanisms, should be implemented to minimize the impact of storms on the intake system.

Tidal Influence:

Flow Variation:
Tides cause fluctuations in water flow rates and directions. Analyzing tidal patterns is essential for determining the optimal intake location and designing appropriate intake structures to capture seawater during different tidal conditions.

Salinity Variation:
Tidal cycles affect the salinity of seawater, particularly in estuarine or coastal areas. Understanding the salinity variations helps in evaluating the suitability of the intake location, intake depth, and the need for pre-treatment processes to address potential salinity changes.

Sediment Transport:
Tidal currents play a role in sediment transport and deposition. Intake structures should be designed to minimize the intake of sediment and debris, which can impact the efficiency of the intake system and the subsequent water treatment processes.

Water Exchange:
Tidal movements contribute to water exchange and circulation. This can influence the dispersion of pollutants and the overall water quality in the vicinity of the intake. Evaluating the water exchange patterns aids in designing an intake system that minimizes the intake of pollutants or contaminants.

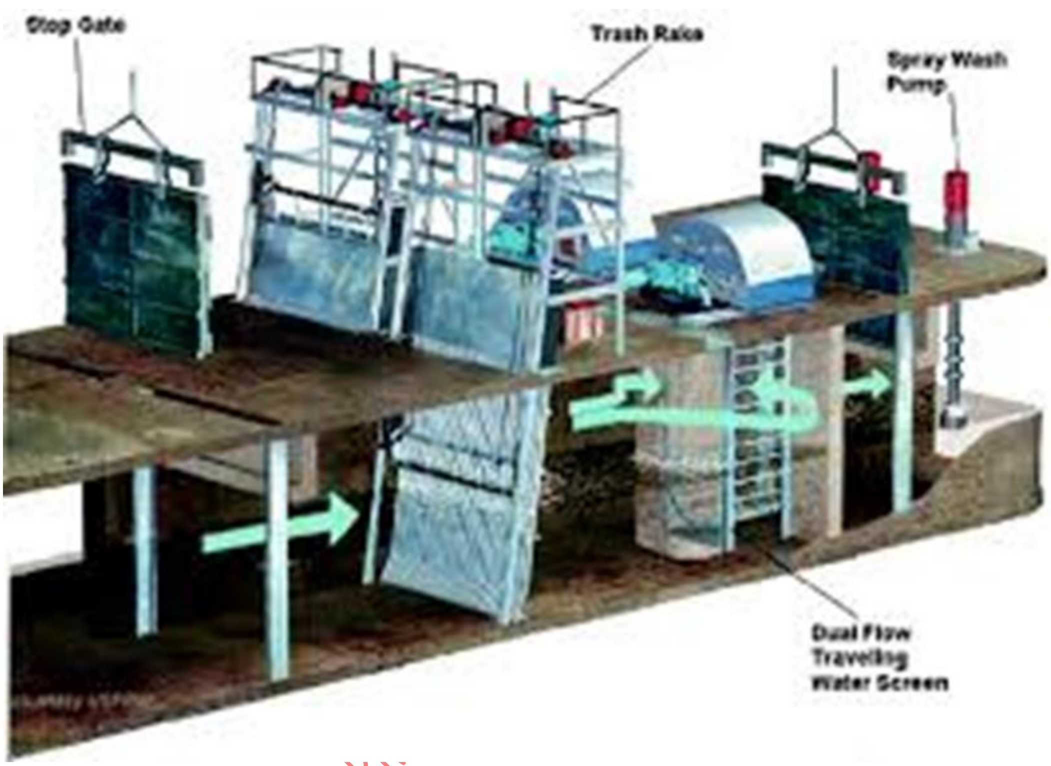
Analyzing seasonal variation and tidal influence requires careful assessment of historical data, hydrological modeling, and field observations. It is recommended to work with experts in coastal engineering, hydrology, and water treatment to ensure the intake system is designed to effectively handle these variations and provide consistent and high-quality seawater for the reverse osmosis process.

Chapter 3:

Intake System Configuration

3.1 Surface Intake System: Design consideration and Challenges

A surface intake system is a type of water intake system that takes water from the surface of a water body, such as a river, lake, or reservoir. Surface intake systems are typically used to provide water for drinking, irrigation, and industrial purposes.



Surface intake system also used for collection of sea water for the desalination plants. Generally surface intakes are used when water to be collected are huge and pipeline installation has limitations.

There are a number of design considerations that must be taken into account when designing a surface intake system. These include:

- The type of water body from which the water will be taken.
- The amount of water that will be needed.
- The quality of the water.
- The cost of construction and operation.
- The environmental impact of the system.

Once the design considerations have been taken into account, the next step is to select the appropriate type of surface intake system. There are a number of different types of surface intake systems available, which essentially including:

1. Intake channel

Will bring the sea water inside the treatment area. Design is based on a open channel design with 0.5 – 0.8M/sec velocity and width should be according to the water quantity required

2. Coarse screen

   Coarse screen is installed inside the channel with duty and standby working principal and having a provision of weir gate as inlet and outlet to isolate the water flow during the maintenance. Coarse screen are made of suitable material for the application.

3. Fine screen

   Fine screen is the next section after the coarse screen and purpose is to remove the fine particles from the intake water. Fine screens also are with duty and standby provision with the isolation weirs for the maintenance purpose.

4. Cleaning pumps for the screen

   Cleaning pumps take the clean water and sprey on the screen on regular basis to clean the screen whenever it is cocked automatically.

5. Electro chlorination

   Duty and standby electro chlorination systems are installed in the intake system which takes salt water from the sea and convert it with 2- 8 % of chlorine solution and inject it in the incoming sea water for pre chlorination purpose.

6. Intake sump

   Chlorinated Sea water is stored in the intake sump which is basically an enlargement of the intake channel and capacity of the sump will be equal to the minimum 1 hour storage volume. Since the intake sump is connected to the sea directly, level is maintained automatically as per the tide level and will never empty regardless of water consumption.

7. Intake pumps

   Intake pumps are submersible type with motor installed on the surface (out of water) (turbine type pumps). purpose of pumps is to deliver the water to the pre-treatment system as per the process requirement

Once the type of surface intake system has been selected, the next step is to install the system. The installation process will vary depending on the type of system that is being installed. However, all surface intake systems must be properly installed in order to ensure that they operate effectively and safely.

Once the surface intake system has been installed, it is important to monitor the system to ensure that it is operating properly. The system should be inspected regularly for signs of damage or wear. Any problems that are identified should be repaired as soon as possible to prevent the system from failing.

Surface intake systems can be a reliable and cost-effective way to provide water for a variety of purposes specially when the inlet flow of the water is high (capacity of RO plants are over 50

MIGPD) . However, it is important to carefully consider the design considerations and challenges involved before installing a surface intake system.

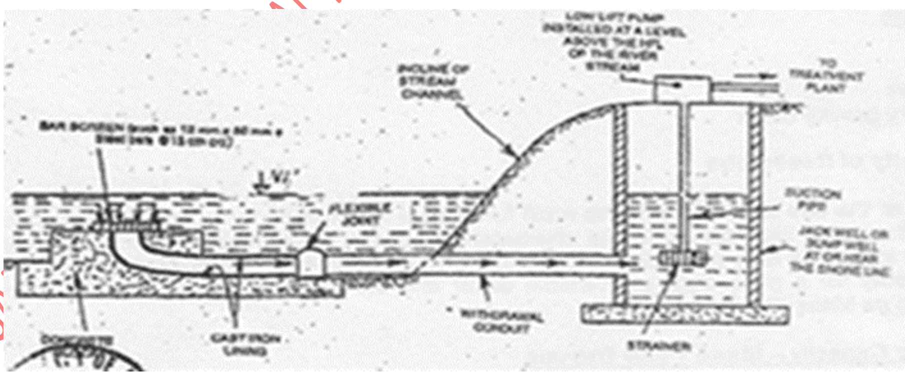
Here are some of the challenges that may be encountered when designing and installing a surface intake system:

- Water quality: The quality of the water from the surface water body must be suitable for the intended use.
- Sediment: Sediment can clog intake screens and pipes, reducing the amount of water that can be drawn from the water body.
- Ice: In cold climates, ice can form on the surface of the water body, blocking the intake system.
- Storms: Storms can cause waves and currents that can damage intake systems.
- Wildlife: Wildlife, such as fish and birds, can be injured or killed by intake systems.
- Red tide
- Pollutants from the nearby industries

It is important to carefully consider these challenges and design the intake system to minimize their impact.

3.2 Submerged Intake System: Advantage, design principal and considerations

Designing a submerged intake system for seawater has its considerations and challenges. Submerged intakes are commonly used in coastal or offshore locations for reverse osmosis desalination plants. Here are some design considerations and challenges to keep in mind when designing a surface intake system:



As name suggest, submerged intake is inside the water completely and both intake screen and pump rooms are below the ground.

Main advantage of submerged intake system as below

- Since intake screen is located minimum 2 meter below the water level and hence water quality is consistent

- Surface pollutant does not affect it adversely
- Oil spillage will not affect until it is mixed with water
- More effective during red tide situation
- Less maintenance

Water Quality:

<u>Intake Location</u>:
Selecting an appropriate location is crucial to ensure access to clean seawater with desirable water quality parameters. Factors such as distance from pollution sources, currents, and tidal influence should be considered.

<u>Intake Depth:</u>
Determining the optimal intake depth is important to capture seawater with t
he desired quality, considering factors such as salinity stratification, sedimentation, and temperature variation with depth.

Example – minimum criteria for the consistent water quality for the intake

- Intake should be minimum 200 to 400 meter distance from the sea shore
- Minimum sea depth must be 7- 8 meter from the lowest tide level
- Shore line should not have stagnant water and must have tidal currents in the location
- Must not have pollutant on the surface like oil, grease, paint or industrial waste
- Reject water current should not be mixed with the sea.
- Check TDS and turbidity reading daily basis for 15 days (low tide and high tide situation)

Intake Structure:

<u>Screening:</u>
Installing effective screens or filters to prevent the entry of debris, marine life, and suspended solids into the intake system. These screens should be designed to minimize pressure drop and allow for easy maintenance and cleaning.
<u>Intake Velocity:</u>
Designing the intake structure to maintain an adequate intake velocity to prevent sedimentation and biofouling while avoiding excessive velocities that can cause erosion or damage to the structure.
<u>Intake Size:</u>
Proper sizing of the intake structure and its components to handle the required flow rate and to accommodate potential future increases in water demand.

Example – following should be considered

- Screen size should be 2mm and tip velocity must be lower then 0.2 m/sec
- Screen should be installed minimum 2 meter from the low tide level
- Intake screen must be installed on the block with min 2mx2mx2M
- Intake screen must have provision for air burst and shock chlorination pipe connection
- Intake pipe line should be designed with 0.8M/sec for gravity line and 1.2- 1.5 M/sec if directly connected to the pump

- Intake pipe size should be considered based on maximum flow and minimum design velocity

Marine Environment:

Marine Ecology:
Assessing the potential impact on marine life and ecosystems is crucial. Designing intake structures that minimize harm to marine organisms by incorporating fish-friendly screens, flow diversion, or other measures to reduce impingement and entrainment.

Coastal Dynamics:
Considering the local coastal dynamics, including wave action, tides, currents, and sediment transport, to ensure the intake structure is designed to withstand and adapt to these environmental forces.

Corrosion and Fouling:
Implementing appropriate materials and coatings to protect the intake structure from corrosion caused by seawater and to minimize biofouling that can reduce flow rates and increase maintenance requirements.

Example

- Marine and environmental team must be consulted to understand the ecological system around the area.
- Area under the consideration must not have high fatal tidal currents. Marine team can provide the data for the last 10 years for highest and lowest tide history

Maintenance and Operation:

Accessibility:
Ensuring the intake system is easily accessible for regular inspection, maintenance, and cleaning activities. This includes providing adequate platforms, walkways, and safety features for personnel to carry out necessary tasks.

Monitoring:
Installing monitoring systems to continuously assess water quality parameters, intake flow rates, and any changes in the intake system performance. This allows for proactive maintenance and troubleshooting to ensure efficient operation.

Example

- It should be close to the sea shore to reach easily for the maintenance
- Turbidity, flow and pressure transmitter to be installed in intake like to understand the variation on water quality

Environmental Regulations:

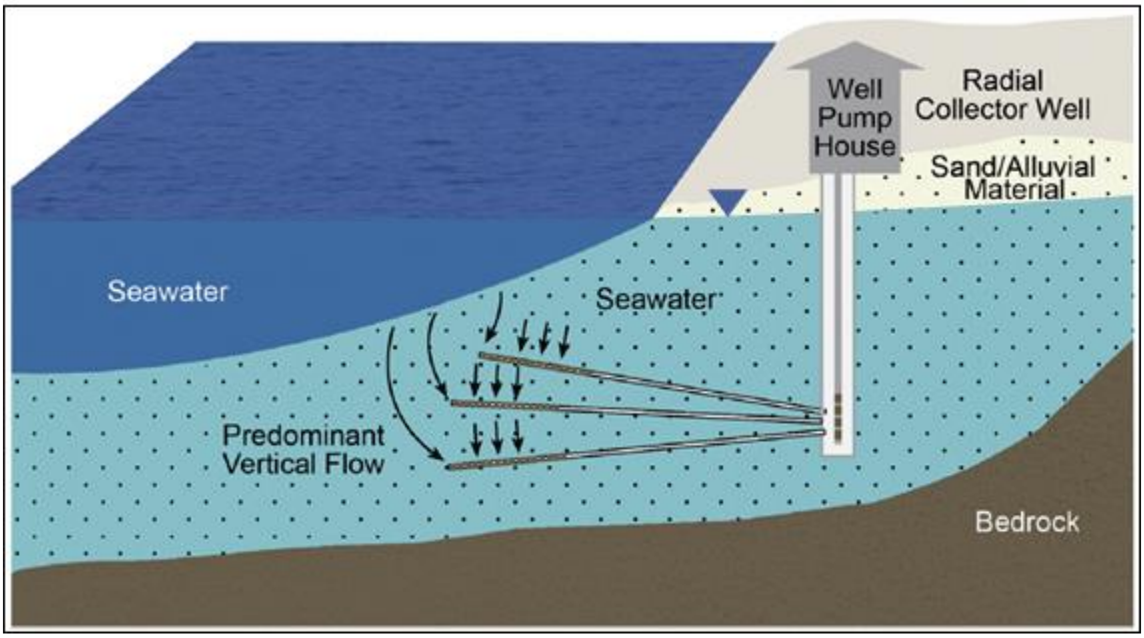
Compliance:

Adhering to local environmental regulations and obtaining necessary permits for the design, construction, and operation of the surface intake system. This includes conducting environmental impact assessments and addressing any concerns raised by regulatory authorities.

Designing a surface intake system requires a multidisciplinary approach, involving coastal engineers, marine biologists, and water treatment experts. By considering these design considerations and addressing the associated challenges, a well-designed surface intake system can provide a reliable and sustainable source of seawater for reverse osmosis desalination.

3.3 Beach Well Intake System: Suitability, Design Guideline and Challenges

Beach well intake systems are an alternative method for seawater intake in coastal areas. They involve drilling wells on the beach or nearshore region to access the underlying saline aquifers. Here are the suitability factors, design guidelines, and challenges associated with beach well intake systems:



Suitability:

Aquifer Availability:
Assessing the presence and characteristics of a suitable saline aquifer near the beach. The aquifer should have sufficient permeability and yield to provide the required seawater quantity.

Water Quality:

Conducting hydrogeological studies and water quality analysis to ensure the salinity and other water quality parameters meet the requirements for reverse osmosis desalination.

Environmental Impact:

Evaluating the potential impact on the coastal environment, including groundwater-surface water interaction, saltwater intrusion, and impacts on adjacent ecosystems.

Examples – suitability

- Turbidity from the well water is always better then open sea intake
- Fluctuation on water turbidity is also minimum
- Low biological load on beach well water
- Water quality is a major challenge to obtain water from beach well as sometime salinity is higher then the sea water and beach well becomes higher in operation cost of reverse osmosis system due to low recovery and high power consumption. This challenge makes beach well unsuitable and hence we must operate the well with maximum capacity for 24 hours and check the TDS reading before deciding the beach wells.
- Soil permeability also affects the beach well. Once well is opened and operated, check the well with the full flow and check drawn down level. (with 8" well, 80 – 90 M3/hour water flow is possible with the drawn down level of 3 meter). If this condition is met, soil has permeability and we can consider beach wells.

Design Guidelines:

Well Location:

Selecting the optimal location for beach wells, considering factors such as aquifer characteristics, proximity to the shoreline, and potential impacts on sensitive coastal areas or infrastructure.

Example

Well should be located very near to the sea shore in order to get unlimited source of inlet water and well will not dry up.

Well Depth:

Determining the appropriate well depth to access the saline aquifer while considering the depth of the freshwater-saltwater interface and potential impacts on coastal groundwater resources.

Well depth should be 20 – 30 meter near the sea shore and should hit the sea water line. Top 10 – 15 meter of the well must be sealed with firm pipe to avoid mixing with surface water

Well Construction:

Designing the well construction to ensure proper casing and screen installation, gravel packing, and sealing materials to prevent sand or debris from entering the well.

Normally 12 " well is drilled with the casing of 8" with 20 – 30 meter depth for the test well and check

- **Flow : > 80 m3/hr**
- **TDS: equal to sea water 38,000 o 42,000PPM**
- **Draw down level at 80m3/hr flow : maximum 3 meter**

<u>Pumping System:</u>

Designing an efficient pumping system to extract seawater from the wells, considering factors such as flow rate, pumping depth, and energy requirements.

Pump should be submersible pumps of duplex or super duplex or titanium series with non metallic pipeline

<u>Brine Discharge:</u>

Planning for the discharge of brine generated from the desalination process, ensuring proper dilution and minimizing environmental impacts.

Brine should be disposed off to the nearby sea or pond or by reject wells. Check the suitability to dispose off the reject water first as huge quantity of reject water is generated with sea water desalination

Challenges:

Saltwater Intrusion:

Monitoring and managing the potential for saltwater intrusion into freshwater aquifers due to the extraction of seawater. Proper hydrogeological studies and modeling can help mitigate this risk.

Aquifer Contamination:

Ensuring the integrity of the well construction to prevent cross-contamination between the saline aquifer and adjacent freshwater aquifers, which could impact local water resources.

Hydrological Variability:

Accounting for seasonal variations, tides, and storm events that may affect the groundwater levels and quality in the beach well intake system.

Environmental Impact:

Assessing and mitigating any potential environmental impacts, such as changes in coastal hydrology, disturbance to beach ecosystems, or impacts on nearby infrastructure.

Maintenance and Operation:

Planning for regular monitoring, maintenance, and cleaning of the beach well intake system, including potential challenges associated with sand, sediment, or biofouling.

Designing a beach well intake system requires collaboration between hydrogeologists, coastal engineers, and water treatment specialists. Thorough site investigations, hydrogeological studies, and environmental assessments are crucial to ensure the suitability and sustainability of the beach well intake system while minimizing environmental impacts. Compliance with local regulations and obtaining necessary permits is also essential throughout the design and operation phases.

Beach well is always preferred system of water intake due to

- Less capital cost
- Easy maintenance
- Easy control
- Easy operation
- Consistent water quality
- Less biological contamination
- Minimum pre-treatment cost

Limitations are

- Local governing law
- High salinity of well water then the sea water
- Low permeability of ground resulting well dry up or deep well or high draw down level

Chapter 4:

Intake Structure Design

4.1 Designing Intake Structure to Withstand Wave Action, Current, and Corrosion

Designing intake structures that can withstand wave action, currents, and corrosion is essential for ensuring the reliability and longevity of sea water intake systems. Here are some key considerations for designing intake structures to address these challenges:

Wave Action:

Intake Location:

Select a location that minimizes exposure to high wave energy, such as locating the intake in a sheltered area or behind natural or artificial barriers.

Breakwaters or Seawalls:

Incorporate breakwaters or seawalls to provide protection against wave action and reduce the impact of waves on the intake structure.

Intake Orientation:

Align the intake structure to minimize the direct impact of waves and currents, reducing the chances of structural damage or disruption of flow.

Currents:

Hydraulic Modeling:

Conduct hydraulic modeling studies to understand the local current patterns and design the intake structure accordingly, ensuring optimal alignment and configuration.

Flow Diversion:

Implement flow diversion mechanisms, such as angled or curved intake screens, to redirect and guide the water flow effectively while minimizing the impact of strong currents on the intake structure.

Stabilization Measures:

Incorporate appropriate stabilization measures, such as submerged breakwaters or flow diffusers, to reduce the effect of strong currents on the intake structure.

Corrosion:

Material Selection:

Choose corrosion-resistant materials for the construction of the intake structure, such as duplex or super duplex stainless steel, fiberglass-reinforced plastic (FRP), or coated materials that are specifically designed for marine environments.

Protective Coatings:

Apply protective coatings or paints on the intake structure's surfaces to prevent corrosion caused by exposure to saltwater and atmospheric conditions.

Sacrificial Anodes:

Install sacrificial anodes, which are made of more reactive metals, to attract corrosion and protect the intake structure from damage. Regular inspection and replacement of sacrificial anodes are necessary.

This method is generally adopted in case of coarse and fine screen – travelling bed screens

Maintenance and Inspection:

Regular Inspections:

Establish a routine inspection program to monitor the condition of the intake structure, including checking for signs of corrosion, damage, or wear and tear. Prompt repairs or maintenance should be carried out when necessary.

Cleaning and Debris Removal:

Implement strategies for regular cleaning and debris removal to prevent blockages or fouling of the intake structure. This may involve the use of screens, filters, or mechanical cleaning systems.

Cathodic Protection:

Consider implementing cathodic protection systems, such as impressed current or galvanic anodes, to provide additional corrosion protection to the intake structure.

By carefully considering wave action, currents, and corrosion in the design phase and implementing appropriate mitigation measures, the intake structure can be designed to withstand these challenges and ensure the long-term effectiveness and reliability of the sea water intake system. Consulting with experienced coastal engineers, corrosion specialists, and marine construction experts is recommended to ensure the intake structure is designed to withstand the specific environmental conditions of the location.

4.2 Material Selection for Intake Structure Components

When designing intake structures for sea water intake systems, selecting the appropriate materials for various components is crucial to ensure durability, corrosion resistance, and overall performance. Here are some key considerations for material selection in intake structure components:

Structural Components:

Reinforced Concrete:

Reinforced concrete is commonly used for the construction of structural components due to its strength, durability, and resistance to corrosion. It can withstand the forces exerted by waves, currents, and tidal fluctuations.

Steel:

High-quality stainless steel, such as 316L or duplex stainless steel, is suitable for structural elements that require superior strength and corrosion resistance. It is commonly used in areas exposed to harsh marine environments.

Example

If sacrifice cathode protection is utilized, SS316L can be used for sea water screens. But the usage is limited to the surface type intake screen where regular maintenance and observation is possible.

In case of submerged intake, duplex, super duplex or titanium is used due to non-corrosive property

Intake Screens:

Stainless Steel:

Stainless steel is widely used for intake screens due to its excellent corrosion resistance and mechanical strength. It can withstand the corrosive effects of seawater and resist biofouling. For submerged intake screen, we must use duplex or super duplex only.

Fiber-Reinforced Plastic (FRP):

FRP screens offer corrosion resistance, lightweight properties, and can be custom-designed for specific intake requirements. They are suitable for applications where weight reduction is essential or where corrosion resistance is a primary concern.

Piping and Fittings:

High-Density Polyethylene (HDPE):

HDPE pipes and fittings are commonly used in sea water intake systems due to their excellent resistance to corrosion, chemicals, and marine organisms. They are lightweight, durable, and easy to install.

Ductile Iron:

Ductile iron pipes and fittings offer high strength, durability, and resistance to corrosion. They are suitable for applications that require larger diameters or higher pressure ratings.

Coatings and Linings:

Epoxy Coatings:

Epoxy coatings are commonly used to protect steel or concrete components from corrosion. They provide an impermeable barrier to prevent direct contact between the substrate and corrosive elements.

Rubber Linings:

Rubber linings can be used to protect the inner surfaces of pipes, fittings, and other components from corrosion and abrasion. They offer chemical resistance and can withstand the turbulent flow conditions.

Fasteners and Hardware:

Duplex / Super duplex Stainless Steel:

DSS or SDSS Stainless steel fasteners and hardware are preferred due to their corrosion resistance and strength. They should be selected based on the specific grade and corrosion resistance required for the application.

When selecting materials, it is essential to consider the specific environmental conditions, including salinity, temperature, wave action, and exposure to chemicals or marine organisms. Additionally, compliance with local regulations, industry standards, and codes is critical to ensure the chosen materials meet the required standards for safety and performance.

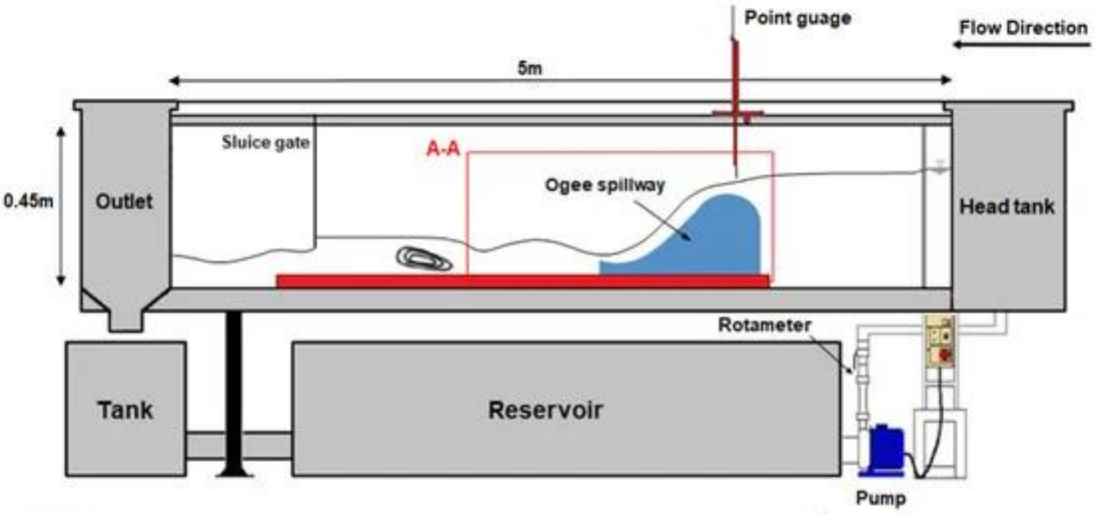
Consulting with materials engineers, corrosion specialists, and industry experts can provide valuable guidance in selecting the appropriate materials for intake structure components, considering the specific needs and challenges of the sea water intake system.

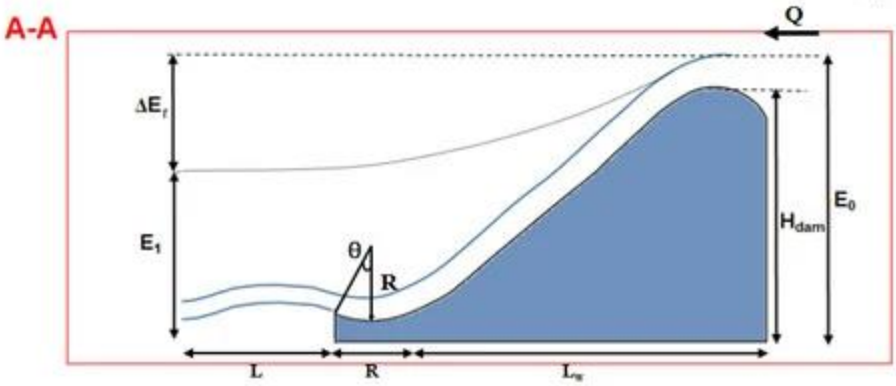
4.3 Incorporating Energy Dissipation Measures to Minimize Environmental Impact

Incorporating energy dissipation measures into sea water intake systems is crucial to minimize the environmental impact of the intake structures. These measures help to reduce the negative effects of excessive energy dissipation, such as erosion, sedimentation, and disturbance to marine ecosystems. Here are some key considerations for incorporating energy dissipation measures:

Flow Deflectors:

Flow deflectors, such as baffles or guide walls, can be strategically placed around the intake structure to redirect the incoming flow and reduce its energy. These deflectors help to dissipate the energy and prevent excessive turbulence near the intake, minimizing erosion and sedimentation.


Point guage
Flow Direction
5m
0.45m
Outlet
Sluice gate
A-A
Ogee spillway
Head tank
Rotameter
Tank
Reservoir
Pump


A-A
Q
ΔE_f
E_1
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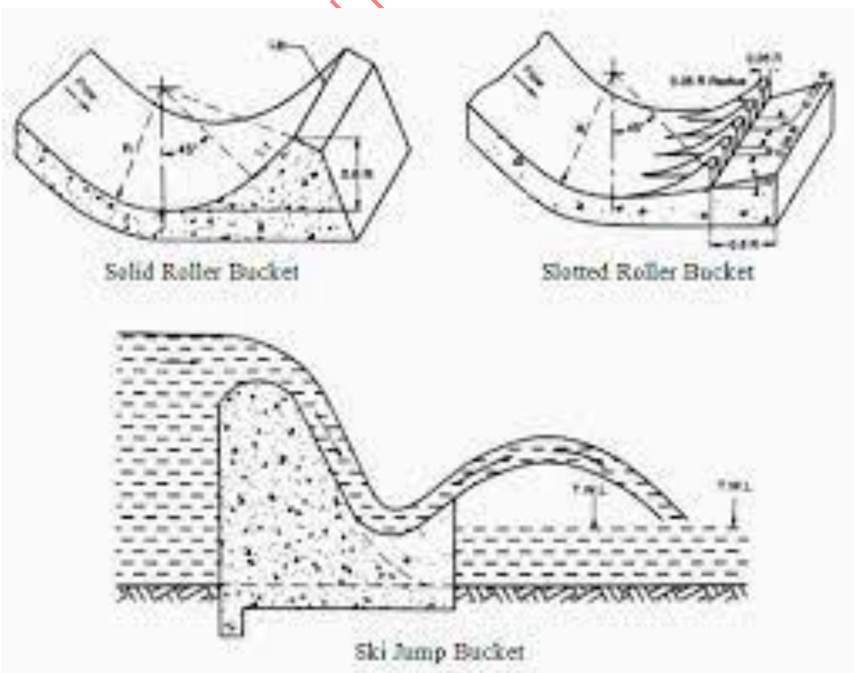
H_dam
E_0
L
R
L_s


Solid Roller Bucket
Slotted Roller Bucket
Ski Jump Bucket

Flow Diffusers:

Flow diffusers are designed structures that are installed at the outlet of the intake system to distribute the discharged water over a larger area and in a controlled manner. They help to minimize the velocity and energy of the discharged water, reducing its impact on the receiving water body.

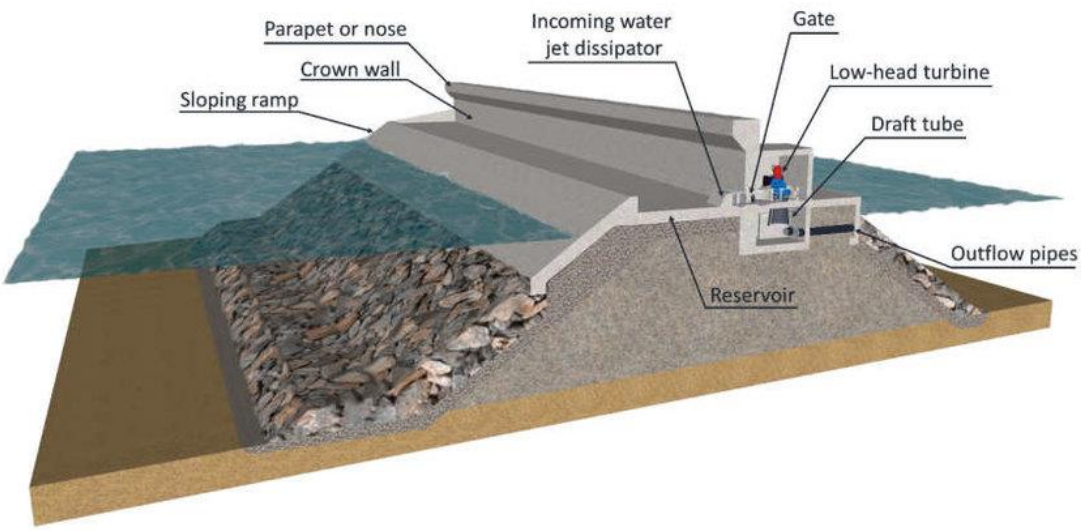


Sedimentation Basins:

Sedimentation basins can be incorporated into the intake system design to allow sediment-laden water to settle before entering the intake structure. These basins provide a space for sediment to settle out, reducing the potential for sedimentation within the intake system and the associated negative impacts.

Jetty or Breakwater Structures:

Jetty or breakwater structures can be constructed around the intake system to provide protection from wave action and currents. These structures help to dissipate wave energy and create calmer conditions near the intake, reducing the risk of erosion and improving the stability of the intake structure.



Environmental Monitoring and Adaptation:

It is important to continuously monitor the environmental impacts of the intake system and be prepared to adapt the design or incorporate additional measures if necessary. Regular monitoring of water quality, sedimentation levels, and marine ecosystems can help identify any adverse impacts and guide the implementation of appropriate mitigation measures.

Computational Fluid Dynamics (CFD) Modeling:

CFD modeling can be used to simulate and analyze the flow patterns, velocity distribution, and energy dissipation within the intake system. This allows for a better understanding of potential issues and helps optimize the design of energy dissipation measures.

By incorporating these energy dissipation measures, the environmental impact of the sea water intake system can be significantly reduced.

It is important to work closely with coastal engineers, environmental experts, and regulatory authorities to ensure that the design and implementation of these measures align with environmental regulations and best practices.

Regular monitoring and maintenance of the intake system are also crucial to assess its ongoing environmental performance and make any necessary adjustments.

Chapter 5:

Intake Screen Selection and Design

5.1 Purpose of Intake Screen and Importance in Protecting the System

The intake screen is a critical component of a sea water intake system, serving the purpose of filtering out debris, marine organisms, and suspended solids from the incoming water. It plays a vital role in protecting the system and maintaining the efficiency and reliability of the reverse osmosis desalination process. Here are the key purposes and importance of intake screens in a sea water intake system:

<u>Debris Removal:</u>

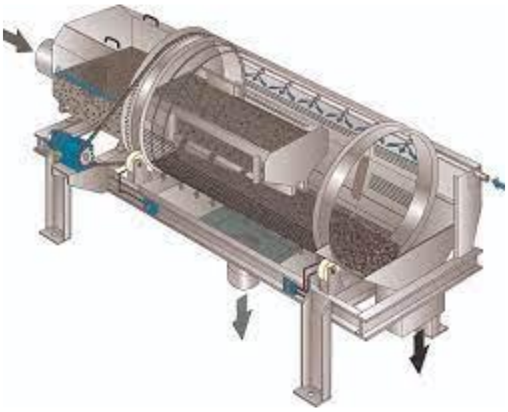
The intake screen prevents large debris such as rocks, branches, seaweed, and trash from entering the system. Without the intake screen, these objects could clog pumps, damage equipment, or cause blockages in the piping system.

<u>Marine Organism Exclusion:</u>

Intake screens are designed to prevent marine organisms, including fish, algae, jellyfish, and shellfish, from entering the intake system. These organisms can cause fouling, clogging, and damage to the system components, affecting the performance and efficiency of the desalination process.

Suspended Solids Removal:

Intake screens are effective in removing suspended solids, such as silt, sediment, and fine particles, from the incoming water. By filtering out these solids, the intake screen helps prevent their accumulation in the system, reducing the risk of fouling, scaling, or abrasive wear on equipment.



Protection of Equipment:

The intake screen acts as a protective barrier for pumps, valves, membranes, and other sensitive equipment within the sea water intake system. By preventing debris, marine organisms, and solids from entering, it helps prolong the operational life of these components, reducing maintenance costs and downtime.

Maintenance and Cleaning:

Intake screens are designed to be removable or cleanable, allowing for regular maintenance and cleaning. This ensures that the screens remain clear and free from blockages, optimizing the flow of water and minimizing pressure drop across the intake system.

Environmental Considerations:

Intake screens also play an important role in minimizing the impact on marine ecosystems. By preventing the entry of marine organisms, including protected or endangered species, they help preserve the biodiversity and ecological balance of the surrounding marine environment.

The proper design, sizing, and maintenance of intake screens are crucial for their effectiveness in protecting the sea water intake system. Factors such as the size of the screen openings, screen material, flow velocity, and screen cleaning mechanisms need to be carefully considered to ensure optimal performance. Regular inspection, cleaning, and replacement of the intake screens, as needed, are necessary to maintain their efficiency and prevent potential issues.

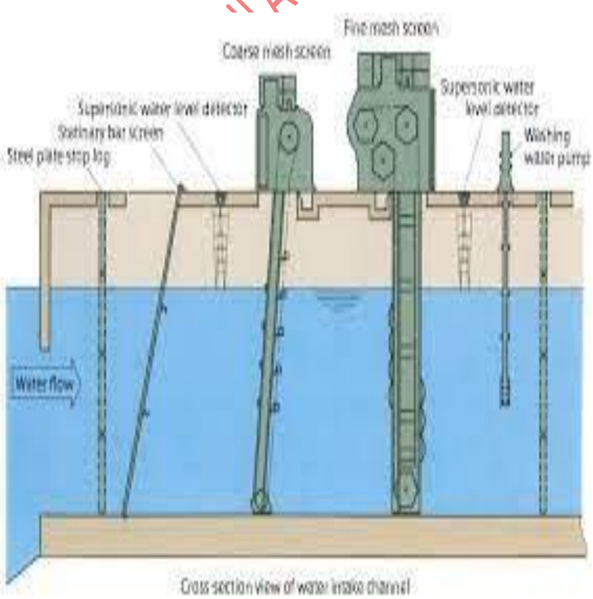
Overall, the intake screen is an essential component that safeguards the sea water intake system, preventing damage, fouling, and operational disruptions. It helps maintain the overall system

5.2 Type of Intake Screens

There are various types of intake screens used in sea water intake systems, each designed to suit different operating conditions and filtration requirements. The selection of the intake screen type depends on factors such as water source characteristics, environmental considerations, maintenance requirements, and the size and type of debris to be filtered. Here are some commonly used types of intake screens:

Bar Screens:

Bar screens consist of vertical or inclined bars or rods placed parallel to each other. They are effective in filtering out large debris and preventing them from entering the system. Bar screens can be manually or mechanically cleaned by raking or brushing off the accumulated debris.

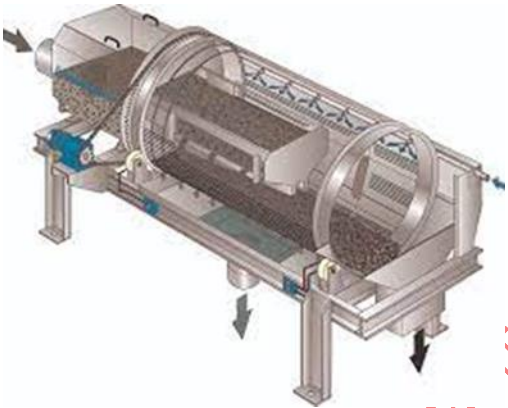


Mesh Screens:

Mesh screens are constructed with a woven wire mesh or perforated plate, forming a fine barrier that filters out debris of various sizes. The mesh size can be customized based on the specific filtration requirements. Mesh screens are often used to protect sensitive equipment and prevent the entry of marine organisms.

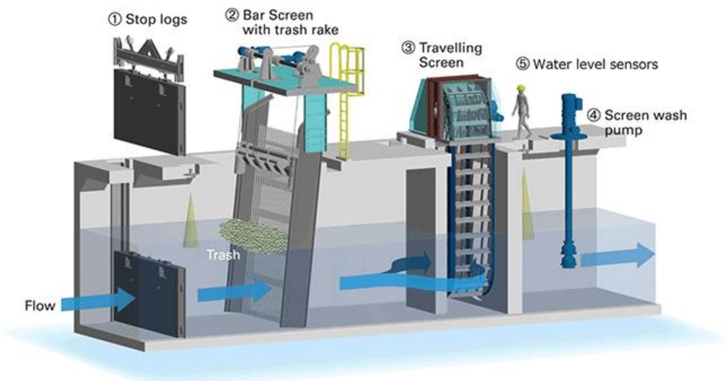
Drum Screens:

Drum screens are cylindrical-shaped screens with rotating drums that have fine mesh or perforated panels. As the water flows through the drum, debris is captured on the screen surface and subsequently removed by a rotating cleaning mechanism or by backwashing.



Traveling Screens:

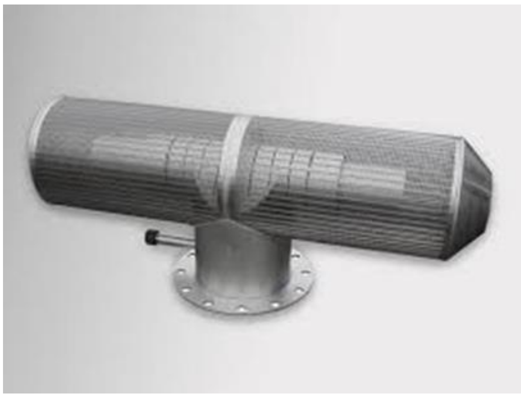
Traveling screens are composed of multiple panels or bars that continuously move or travel across the intake opening. Debris is intercepted by the screens and lifted out of the water. Traveling screens are particularly useful in areas with high debris concentrations and can be cleaned by rotating or backwashing the panels.



Overall Water Intake Screening System

Passive Screens:

Passive screens are fixed or stationary screens that rely on the flow dynamics to separate debris from the water. They are often placed at an angle to the flow to enhance the separation process. Passive screens are simple in design and require minimal maintenance.



Self-Cleaning Screens:

Self-cleaning screens incorporate mechanisms such as brushes, jets, or air bubbles to dislodge debris from the screen surface. These screens are designed to reduce clogging and minimize the need for manual cleaning or maintenance.

Mostly for large intakes, bar screen, drum screen or traveling bed screen are auto self-cleaning screens

The choice of intake screen type depends on the specific requirements and conditions of the sea water intake system. Factors such as the size and type of debris, flow rate, maintenance capabilities, and available space for installation should be considered when selecting the appropriate type of intake screen. It is essential to consult with experienced professionals and screen manufacturers to determine the most suitable screen type for a given application.

5.3 Sizing and Placement Consideration for Efficient Debris Removal

When sizing and placing intake screens in a sea water intake system, careful consideration is required to ensure efficient debris removal and optimal performance. Improper sizing or placement can result in reduced flow rates, increased pressure drop, and decreased effectiveness in removing debris. Here are some key considerations for sizing and placing intake screens for efficient debris removal:

Intake Screen Opening Size:

The size of the screen openings should be selected based on the anticipated debris size in the water source. It should be small enough to prevent the entry of unwanted debris while allowing sufficient water flow. The screen opening size can be determined by analyzing the characteristics of the water source and considering the maximum allowable particle size for the system.

Coarse Screens sizes:

Coarse screens are typically designed to capture debris with larger sizes, such as leaves, branches, and larger aquatic organisms.

- The openings in coarse screens can range from 10 to 50 millimeters or even larger, depending on the expected debris size in the water source.
- The size of the coarse screen openings is selected to prevent the entry of unwanted debris while allowing sufficient water flow through the intake system.
- Coarse screens are often placed as the primary filtration stage in the intake system, and they are followed by finer screens to provide additional filtration.
- Recommended size of coarse screen is 10mm.

Fine Screens:

Fine screens are used to filter out smaller particles and organisms, such as sand, silt, algae, and smaller aquatic organisms.

- The openings in fine screens are typically smaller than those in coarse screens, ranging from 0.1 to 5 millimeters (0.004 to 0.2 inches), depending on the desired level of filtration.
- The size of the fine screen openings is selected to effectively capture the targeted particles and organisms while minimizing pressure drop and maintaining sufficient flow rates.
- Fine screens are often placed downstream of the coarse screens in the intake system, providing a secondary level of filtration for finer debris removal.
- Recommended size of fine screen is 2mm.

Flow Velocity:

The flow velocity through the intake screens should be optimized to ensure efficient debris removal. It is generally recommended to maintain a velocity range of 0.2 to 0.5 meters per second (0.65 to 1.6 feet per second) to avoid excessive turbulence or clogging. Adjustments in screen size and design may be necessary to achieve the desired flow velocity.

Recommend flow velocity at tip of screen should be 0.2M/sec maximum

Screen Area:

The total screen area should be properly sized to accommodate the anticipated flow rate and prevent excessive pressure drop. It should be sufficient to handle the maximum expected debris load without significantly impeding water flow. The screen area can be calculated based on the desired flow velocity and the required screen open area.

Screen Configuration:

The configuration of the intake screens, such as the number of screens, their arrangement, and the spacing between them, should be designed to maximize debris removal efficiency. Factors such as the hydraulic profile, water flow patterns, and anticipated debris distribution should be considered.

Multiple screens with appropriate spacing can help distribute the flow evenly and increase the debris capture efficiency.

Approach Velocity:

The approach velocity refers to the velocity of the water approaching the intake screens. It is important to design the intake structure in a way that minimizes the approach velocity to prevent excessive sedimentation or resuspension of particles. Baffles or flow deflectors can be used to reduce the approach velocity and promote effective debris removal.

Maintenance and Accessibility:

Consideration should be given to the accessibility of the intake screens for maintenance and cleaning purposes. Screens should be easily removable or cleanable to facilitate regular inspection and debris removal. Adequate space around the screens should be provided to ensure safe and efficient maintenance operations.

Environmental Considerations:

The placement of intake screens should take into account environmental factors, such as the protection of sensitive habitats or species. Screens should be positioned to minimize any negative impacts on marine ecosystems and comply with regulatory requirements.

It is important to consult with experienced engineers, screen manufacturers, and professionals familiar with the specific water source and intake system design. Computational fluid dynamics (CFD) modeling can also be utilized to analyze flow patterns, optimize screen placement, and evaluate the efficiency of debris removal. Regular monitoring and maintenance of the intake screens are essential to ensure continued efficiency and performance of the sea water intake system.

Chapter 6:

Pumping System Design

6.1 Selecting Appropriate Pump for Sea Water Intake

Selecting the appropriate pump for a sea water intake system is crucial to ensure efficient and reliable operation. Sea water poses specific challenges due to its corrosive nature and the need to overcome the high density and resistance to flow. Here are some key considerations when choosing a pump for a sea water intake system:

Corrosion Resistance:

Sea water contains high levels of salt and other corrosive elements, which can accelerate the deterioration of pump components. It is important to select a pump made of corrosion-resistant materials, such as stainless steel or materials specifically designed for sea water applications. This helps to minimize maintenance requirements and extend the lifespan of the pump.

We recommend super duplex stainless steel, duplex stainless steel, titanium, nickel aluminium bronze or FRP pumps for the application

Sea Water Compatibility:

The pump should be specifically designed and rated for sea water applications. This includes considering factors such as sea water temperature, salinity, and the presence of abrasive particles. Choosing a pump with sea water compatibility ensures optimal performance and minimizes the risk of damage or failure.

Efficiency and Flow Rate:

The pump selected should be capable of providing the required flow rate for the sea water intake system. Consider factors such as the desired capacity of the reverse osmosis system and any potential future expansions. Additionally, choose a pump that offers high efficiency to minimize energy consumption and operating costs.

- Pump should have highest efficiency 85% and above and motor should be IE4 , suitable for VFD operation.
- Motor should be outside the water preferably.

Submersible or Surface Pump:

Depending on the intake system design, you may need to decide between a submersible pump or a surface pump. Submersible pumps are designed to be submerged in water, often used in deep sea water intakes. Surface pumps are installed above the water surface and draw water through suction. Consider the specific requirements of the intake system and consult with experts to determine the most suitable pump type.

Pump must have standby provision available, as failure of the pump can stop the complete facility down the line.

Reliability and Maintenance:

Select a pump known for its reliability and durability. Consider factors such as the availability of spare parts, ease of maintenance, and the reputation of the manufacturer. Regular maintenance and servicing are essential to ensure the pump's long-term performance and prevent unexpected downtime.

Energy Efficiency:

Energy efficiency is an important consideration to reduce operating costs and minimize environmental impact. Look for pumps with high energy efficiency ratings, such as pumps with advanced motor technologies, adjustable speed drives, or variable frequency drives (VFDs) that can optimize energy consumption based on the system's demand.

Safety Considerations:

Safety features such as overload protection, leakage detection, and fail-safe mechanisms should be considered when selecting a pump. These features help to protect the pump, prevent damage, and ensure safe operation.

Pump Impeller Design:

The impeller design plays a crucial role in the pump's ability to handle sea water effectively. Consider pumps with impellers specifically designed for sea water applications, such as those with a robust construction and optimized hydraulic profiles. This helps to minimize the risk of clogging, improve efficiency, and enhance the pump's performance.

NPSH Requirements:

Net Positive Suction Head (NPSH) is the available pressure head at the pump suction. Sea water intake systems often operate at relatively low pressures, so it is important to select a pump that has low NPSH requirements. This ensures that the pump can operate without cavitation or other issues related to insufficient suction pressure.

Saltwater Cooling:

Sea water can serve as a cooling medium for pumps that generate heat during operation. Consider pumps that have provisions for saltwater cooling, such as a built-in cooling jacket or a separate heat exchanger. This helps to maintain optimal operating temperatures and prevent overheating of the pump.

Variable Speed Operation:

Depending on the variability of the sea water intake conditions, a pump with variable speed operation may be beneficial. Variable frequency drives (VFDs) or adjustable speed drives can allow for the adjustment of pump speed to match the changing flow requirements. This improves energy efficiency and provides better control over the intake system.

Redundancy and Backup Systems:

For critical sea water intake systems, it is advisable to consider redundancy and backup pump systems. Having multiple pumps or backup pumps ensures continuous operation in case of pump failure or maintenance requirements. Redundancy can help minimize downtime and maintain the desired flow rate.

Environmental Considerations:

Consider the environmental impact of the pump selection. Choose pumps that have low noise emissions, comply with environmental regulations, and minimize any potential harm to marine life. This can include features such as low vibration, efficient hydraulic designs, and the use of environmentally friendly lubricants.

Integration with Control Systems:

Ensure that the selected pump is compatible with the control and automation system of the sea water intake system. This allows for seamless integration and centralized control, enabling effective monitoring, operation, and maintenance of the pump.

Budget and Total Cost of Ownership:

Consider the initial cost of the pump as well as the long-term operating and maintenance costs. Evaluate the pump's efficiency, durability, and expected lifespan to determine the total cost of ownership over the system's lifecycle. Opting for a higher quality, more efficient pump may result in lower operating costs and better overall performance in the long run.

Remember to consult with pump manufacturers, system designers, or experienced professionals in the field to ensure the pump selection aligns with the specific requirements and conditions of your sea water intake system. Their expertise and insights can help you make an informed decision and optimize the performance of your system.

6.2 Pump Characteristics, Efficiency and Energy Consumption Consideration

When selecting a pump for a sea water intake system, it is important to consider pump characteristics, efficiency, and energy consumption. These factors play a significant role in the performance, operating costs, and environmental impact of the system. Here are some key considerations:

Pump Characteristics:

Head:

Consider the pump's head or total dynamic head (TDH) requirement, which is the combination of static head (elevation) and dynamic head (friction losses, pipe fittings, etc.). Ensure that the selected pump can provide the required head to overcome the resistance in the sea water intake system.

Flow Rate:

Determine the desired flow rate based on the capacity of the reverse osmosis system and the water demand. The pump should be capable of delivering the required flow rate while maintaining efficiency.

Pump Type: Evaluate different pump types such as centrifugal pumps, positive displacement pumps, or axial flow pumps. Each type has its own advantages and considerations in terms of performance, efficiency, and suitability for sea water applications.

For Example

RO plant capacity : 1000M3/day

Recovery : 40%

Feed flow Required for RO plant : 2500M3/Day or 104.16 M3/hr

Safety margin – 40%

Feed flow of the intake pump = 145M3/hr

Pump flow rate should be 145 M3/hr and Head to be calculated based on pipe distance , elevation and pressure available at the end point. Suppose pressure drop is equal to 25 Meter head and hence pump should be selected for 145M3/hr @ 3 Bar pressure

Efficiency:

Pump Efficiency:

Consider the pump's efficiency, which is the ratio of the pump's hydraulic power output to the electrical power input. Higher pump efficiency results in lower energy consumption and operating costs. Look for pumps with high-efficiency ratings to minimize energy waste.

Specific Energy Consumption (SEC):

Calculate the specific energy consumption of the pump, which is the amount of energy consumed per unit volume of water pumped. Lower SEC values indicate higher energy efficiency. Compare the SEC values of different pumps to determine the most energy-efficient option.

Energy Consumption Consideration:

Motor Efficiency:

Evaluate the efficiency of the pump motor, as it is a significant contributor to overall energy consumption. Select motors with high-efficiency ratings, such as those meeting international energy efficiency standards (e.g., IE4 or NEMA Premium efficiency).

Variable Speed Operation:

Consider pumps with variable frequency drives (VFDs) or adjustable speed drives that allow for adjusting the pump speed to match the required flow rate. Variable speed operation can optimize energy consumption by reducing motor speed during periods of lower demand.

Pump Control Systems:

Integrate pump control systems that use sensors and automation to optimize pump operation based on demand. This helps to avoid unnecessary energy consumption and ensure efficient performance.

Life Cycle Cost Analysis:

Consider the life cycle cost of the pump, which includes the initial cost, energy consumption, maintenance, and replacement costs over the system's lifespan. Compare different pump options based on their total cost of ownership to make an informed decision.

Environmental Impact:

Assess the environmental impact of the pump selection, including factors such as noise emissions, carbon footprint, and compliance with environmental regulations. Choose pumps that are environmentally friendly and meet applicable standards to minimize the system's ecological footprint.

Manufacturer Support and Warranty:

Consider the reputation of the pump manufacturer, their after-sales support, and the warranty offered. A reputable manufacturer provides technical assistance, spare parts availability, and reliable warranty coverage, ensuring long-term performance and support.

It is recommended to consult with pump manufacturers, system designers, or knowledgeable professionals in the field to evaluate the specific pump characteristics, efficiency, and energy consumption considerations based on your sea water intake system requirements. They can help you select the most suitable pump that balances performance, energy efficiency, and cost-effectiveness for your application.

6.3 Designing the Pump Station and Auxiliary Equipment for Optimal Performance

Designing the pump station and selecting appropriate auxiliary equipment is crucial to ensure optimal performance and reliability of the sea water intake system. Here are key considerations for designing the pump station and auxiliary equipment:

Pump Station Layout:

- Determine the layout of the pump station, considering factors such as available space, accessibility for maintenance, and ease of operation.
- Position the pumps and auxiliary equipment to minimize piping distances, pressure losses, and potential flow disruptions.
- Provide adequate space for pump maintenance, including clearance for pump removal and installation.

Piping Design:

- Size the piping appropriately to minimize friction losses and maintain the desired flow rates.
- Use corrosion-resistant materials for the piping system, considering the corrosive nature of sea water.
- Ensure proper pipe supports and anchors to prevent excessive movement or vibrations.

Valves and Control Systems:

- Install valves at strategic locations to control flow, isolate pumps for maintenance, and facilitate system operation.
- Consider the use of check valves to prevent backflow and pressure surges.
- Implement a comprehensive control system to monitor and control pump operation, including features such as pressure sensors, flow meters, and automation capabilities.

Filtration Systems:

- Incorporate appropriate filtration systems to remove debris and protect the pumps from damage.
- Consider the use of pre-filters, strainers, or screens to prevent large particles and debris from entering the pumps.
- Implement regular maintenance and cleaning procedures for the filtration systems to ensure their effectiveness.

Pressure and Flow Control:

- Install pressure control devices, such as pressure regulators or pressure relief valves, to maintain stable operating conditions and prevent excessive pressure.
- Implement flow control mechanisms, such as flow meters or flow control valves, to monitor and adjust the flow rate as required.

Instrumentation and Monitoring:

- Install instrumentation and monitoring equipment to track various parameters, including flow rates, pressure, temperature, and electrical parameters.
- Implement an alarm system to alert operators of any abnormal conditions or equipment failures.
- Integrate the monitoring system with a central control room or remote monitoring capabilities for efficient operation and maintenance.

Electrical Systems:

- Ensure proper electrical design, including appropriate wiring, grounding, and protection measures.
- Size the electrical components, such as cables, motor starters, and control panels, to meet the power requirements of the pumps and auxiliary equipment.
- Implement electrical safety measures, such as circuit breakers and grounding systems, to protect against electrical hazards.

Emergency Backup Systems:

- Consider incorporating backup systems, such as standby generators or alternative power sources, to ensure continuous operation during power outages or emergencies.
- Include backup pumps or redundant systems to minimize downtime in case of pump failures or maintenance requirements.

Maintenance and Access:

- Design the pump station and auxiliary equipment with easy access for maintenance and repair activities.
- Include proper drainage systems to remove any accumulated water and prevent flooding.
- Implement a preventive maintenance program to regularly inspect and maintain the pumps and auxiliary equipment for optimal performance and longevity.

Compliance and Regulations:

- Ensure that the pump station design complies with relevant industry standards, local regulations, and environmental requirements.
- Consider any specific regulations or guidelines related to sea water intake systems in your location.

Vibration and Noise Control:

- Implement measures to minimize vibration and noise generated by the pumps and auxiliary equipment. This can include the use of vibration isolators, soundproof enclosures, or acoustic barriers.
- Consider the placement of the pump station in relation to nearby structures or residential areas to mitigate potential noise disturbances.
- Consider using low RPM pumps to reduce the noise level specially if pump room is under ground and in case of submersed intake.

Cooling Systems:

- Incorporate cooling systems to maintain optimal operating temperatures for the pumps and auxiliary equipment. This can include the use of cooling water circuits, heat exchangers, or dedicated cooling towers.
- Ensure proper ventilation and airflow within the pump station to prevent overheating and ensure efficient operation.

Corrosion Protection:

- Select corrosion-resistant materials for the pump station and auxiliary equipment, considering the corrosive nature of sea water.
- Implement protective coatings, such as epoxy or anti-corrosion paints, on exposed surfaces to enhance durability and prevent corrosion.

Instrumentation and Control Integration:

- Integrate the instrumentation and control systems of the pump station with the overall control system of the reverse osmosis desalination plant.
- Ensure seamless communication and data exchange between different components for efficient monitoring, operation, and troubleshooting.

Spare Parts and Maintenance Strategy:

- Develop a comprehensive spare parts inventory for critical components of the pump station and auxiliary equipment.
- Establish a maintenance strategy that includes routine inspections, preventive maintenance, and prompt repair or replacement of faulty components.
- Maintain documentation of maintenance activities, including equipment logs, service records, and performance data.

Safety Considerations:

- Incorporate safety features and protocols into the design, such as emergency shutdown systems, safety signage, and proper lighting.
- Ensure compliance with safety standards and regulations related to electrical systems, machinery, and personnel safety.

Future Expansion and Flexibility:

- Anticipate future growth or changes in water demand and design the pump station to accommodate potential expansion.
- Allow for flexibility in the layout and equipment selection to adapt to future upgrades or modifications.

Environmental Considerations:

- Evaluate the environmental impact of the pump station design and auxiliary equipment, considering factors such as energy consumption, emissions, and waste management.
- Incorporate eco-friendly practices, such as energy-efficient equipment, renewable energy integration, and water conservation measures.

Remember to engage with experienced engineers, pump manufacturers, and industry professionals to ensure that the design of the pump station and auxiliary equipment aligns with the specific requirements, regulations, and best practices for sea water intake systems. Their expertise will help optimize the performance, reliability, and longevity of the system.

Chapter 7:

Pipeline Design And Layout

7.1 Pipeline Material Selection

When it comes to selecting pipeline materials for a sea water intake system, several factors need to be considered, including corrosion resistance, durability, and cost-effectiveness. Here are some common materials used for sea water pipelines and their key characteristics:

Duplex & Super Duplex Stainless Steel:

Corrosion Resistance:

Stainless steel, particularly grades like 2505 and 2507, offers excellent corrosion resistance in sea water environments. It resists both general corrosion and localized corrosion, such as pitting and crevice corrosion.

Durability:

Duplex stainless steel is highly durable and can withstand harsh conditions, making it suitable for long-term use in sea water intake systems.

Cost-effectiveness:

While duplex and super duplex stainless steel can be more expensive upfront compared to some other materials, its durability and corrosion resistance often make it a cost-effective choice in the long run, as it requires minimal maintenance and replacement.

HDPE (High-Density Polyethylene):

Corrosion Resistance:

HDPE is highly resistant to corrosion, including corrosion caused by sea water and various chemicals. It does not rust or degrade when exposed to corrosive environments.

Durability:

HDPE is known for its high durability, toughness, and resistance to impact and abrasion. It can withstand both high and low temperatures.

Cost-effectiveness:

HDPE pipes are generally cost-effective due to their long service life, low maintenance requirements, and ease of installation.

Fiberglass Reinforced Plastic (FRP):

Corrosion Resistance:

FRP pipes offer excellent corrosion resistance, making them suitable for sea water applications. They are resistant to both internal and external corrosion.

Durability:

FRP pipes have high strength-to-weight ratios and are lightweight yet durable. They can withstand extreme temperatures, UV exposure, and various chemicals.

Cost-effectiveness:

FRP pipes may have higher upfront costs compared to some other materials, but their long lifespan, low maintenance requirements, and resistance to corrosion can result in cost savings over time.

PVC (Polyvinyl Chloride):

Corrosion Resistance:

PVC pipes have good resistance to corrosion from sea water. However, they may not be suitable for highly aggressive environments with high temperatures or certain chemicals.

Durability:

PVC pipes are lightweight, durable, and have a long lifespan. They are resistant to impact, abrasion, and biological fouling.

Cost-effectiveness:

PVC pipes are generally cost-effective and offer competitive pricing compared to other materials. They are easy to install and require minimal maintenance.

Ductile Iron:

Corrosion Resistance:

Ductile iron pipes have moderate corrosion resistance in sea water environments. Proper external coating and cathodic protection may be necessary to enhance their corrosion resistance.

Durability:

Ductile iron pipes are known for their strength, durability, and impact resistance. They can handle high pressures and are suitable for underground applications.

Cost-effectiveness:

Ductile iron pipes can provide good cost-effectiveness, especially for larger diameter pipelines. However, ongoing maintenance and the need for corrosion protection should be considered.

Carbon Steel:

Corrosion Resistance:

Carbon steel pipes can be susceptible to corrosion in sea water environments. Proper coating and cathodic protection are typically required to enhance their corrosion resistance.

Durability:

Carbon steel pipes are known for their strength and durability. They can withstand high pressures and temperatures.

Cost-effectiveness:

Carbon steel pipes are often cost-effective compared to some other materials. However, ongoing maintenance and corrosion protection measures should be considered.

Copper Nickel:

Corrosion Resistance:

Copper nickel alloys, such as Cu-Ni 90/10 and Cu-Ni 70/30, offer excellent corrosion resistance in sea water. They are highly resistant to both general and localized corrosion.

Durability:

Copper nickel pipes have good mechanical properties and can withstand high velocities and pressures. They are resistant to biofouling and marine organisms.

Cost-effectiveness:

Copper nickel pipes may have higher upfront costs compared to some other materials, but their long service life, low maintenance requirements, and corrosion resistance make them cost-effective in the long run.

Titanium

Corrosion Resistance:

Titanium is renowned for its exceptional corrosion resistance in sea water, even in aggressive environments. It is highly resistant to both general and localized corrosion.

Durability:

Titanium pipes have excellent strength-to-weight ratios, high durability, and resistance to erosion and biofouling. They can withstand high temperatures and pressures.

Cost-effectiveness:

Titanium pipes can be more expensive compared to other materials, primarily due to the cost of titanium itself. However, their long lifespan, minimal maintenance requirements, and corrosion resistance make them a cost-effective choice in certain applications.

When selecting the pipeline material, it is essential to consider the specific requirements of the sea water intake system, including the expected lifespan, operating conditions, water chemistry, and budgetary constraints. Consulting with engineers and industry experts can help in choosing the most suitable material that balances corrosion resistance, durability, and cost-effectiveness for the specific application. Additionally, adhering to relevant industry standards and guidelines is crucial for the successful implementation of the pipeline system.

7.2 Pipe sizing and Hydraulic Consideration for Sea Water Flow

When designing a sea water intake system, pipe sizing and hydraulic considerations are crucial to ensure optimal flow rates and minimize pressure losses. Here are some key factors to consider:

Flow Rate:

Determine the desired flow rate for the sea water intake system based on the water demand and system requirements. This will serve as the basis for pipe sizing calculations.

For Example

RO plant capacity : 1000M3/day

Recovery : 40%

Feed flow Required for RO plant : 2500M3/Day or 104.16 M3/hr

Safety margin – 40%

Feed flow of the intake pump = 145M3/hr

Velocity:

Select an appropriate velocity for sea water flow within the pipes. For sea water intake systems, velocities typically range from 1.5 to 3 meters per second (5 to 10 feet per second) to prevent sedimentation and maintain efficient flow.

Pressure Loss:

Consider the pressure loss along the length of the pipeline. Pressure losses can occur due to friction within the pipe, fittings, and other components. It is important to calculate and minimize these losses to ensure adequate pressure at the desired points of use.

Pipe Material and Roughness:

Take into account the roughness of the pipe material and its impact on flow resistance. Different pipe materials have varying roughness coefficients, which affect the friction factor used in pressure loss calculations.

Pipe Diameter:

Calculate the required pipe diameter based on the flow rate and velocity requirements. Larger diameter pipes can accommodate higher flow rates with lower velocities, resulting in reduced pressure losses.

Example

Flow rate : 145M3/hour

Velocity : 2M/sec & 3 M/Sec

Pipe area : Flow /3600/Velocity in M2 = 0.0201 M2 (2m/sec Velocity) and 0.0134M2 (3M/sec velocity)

Pipe Diameter : Sqrt(area*4/3.142)

Pipe diameter : 160mm @ 2M/sec Velocity

: 115.8mm@ 3M/sec velocity

Selected diameter can be DN 125 or DN 150

Pipe Layout:

Consider the layout and configuration of the pipe network, including the number of bends, fittings, and elevation changes. These factors can affect flow patterns, pressure distribution, and overall system performance.

Pressure drop is calculated based on the pipe layout and depends on no of valves, check valve, bend etc.

Pump System:

Coordinate the pipe sizing with the pump system to ensure compatibility and efficient operation. The pipe diameter should be selected to match the pump's capacity and characteristics, taking into account the required head and flow rate.

Expansion and Future Needs:

Anticipate future expansion or changes in water demand and design the pipe system to accommodate potential growth. Allow for flexibility in the layout and consider the potential need for additional pumps or pipe branches.

Pressure Regulation:

Incorporate appropriate pressure regulation devices, such as pressure reducing valves or control valves, to maintain stable and controlled pressure throughout the sea water intake system.

Compliance with Standards:

Ensure that the pipe sizing and hydraulic design adhere to relevant industry standards and regulations, such as those related to water distribution systems or specific codes for sea water intake systems.

By carefully considering these factors and conducting hydraulic calculations, engineers can determine the appropriate pipe sizes and layout for the sea water intake system. This ensures efficient flow, minimizes pressure losses, and supports the overall performance of the reverse osmosis desalination process.

7.3 Determining the Pipeline Route and Layout for Efficient Operation and Maintenance

Determining the pipeline route and layout for a sea water intake system is essential to ensure efficient operation and ease of maintenance. Here are some considerations for pipeline route and layout design:

Site Survey:

Conduct a thorough site survey to assess the topography, soil conditions, existing infrastructure, and any potential obstacles or constraints that may impact the pipeline route.

Source Location:

Determine the optimal location for the sea water intake source, considering factors such as water quality, accessibility, depth, tidal influences, and environmental considerations.

Pipeline Alignment:

Identify the most direct and efficient route for the pipeline while considering any geographical features, such as hills, rivers, or existing structures. Minimize the length of the pipeline to reduce pressure losses and construction costs.

Elevation Changes:

Account for any elevation changes along the pipeline route and incorporate appropriate measures, such as slope adjustments or pumping stations, to maintain the desired flow rate and pressure.

Environmental Impact:

Minimize environmental impact by avoiding sensitive areas, protected habitats, or areas of high ecological significance. Consider the potential for marine life disturbance and the need for mitigation measures during construction.

Construction and Maintenance Accessibility:

Ensure that the pipeline route allows for easy access during construction, inspection, and maintenance activities. Consider factors such as equipment access, right-of-way permissions, and safety considerations for personnel.

Crossings and Obstacles:

Identify any potential crossings, such as roads, rivers, or utility lines, along the pipeline route. Determine the most suitable crossing methods, such as trenchless techniques or bridge crossings, and obtain necessary permits and approvals.

Pipe Material Compatibility:

Consider the compatibility of the chosen pipe material with the surrounding environment and soil conditions. Certain pipe materials may require additional protective measures or coatings in specific environments.

Expansion and Redundancy:

Design the pipeline layout to accommodate future expansion or redundancy needs. Allow for the addition of extra pipelines or branches to support increased water demand or system resilience.

Documentation and Mapping:

Create detailed documentation and mapping of the pipeline route, including accurate measurements, elevation profiles, and geospatial data. This information is vital for ongoing maintenance, repairs, and future modifications.

Regulatory Compliance:

Ensure compliance with local regulations, permits, and environmental impact assessments throughout the pipeline route and layout design process.

By considering these factors and engaging with experienced engineers and environmental specialists, you can determine the optimal pipeline route and layout for your sea water intake system. This will ensure efficient operation, minimize environmental impact, and facilitate effective maintenance and future expansion.

Chapter 8:

Intake System Monitoring and Control

8.1 Implementing Real Time Monitoring of sea water intake Parameters

Implementing real-time monitoring of sea water intake parameters is essential for ensuring the efficient and reliable operation of the intake system. It allows for timely detection of any deviations or abnormalities in the water quality and system performance. Here are some key considerations for implementing real-time monitoring:

<u>Parameter Selection:</u>

Determine the critical parameters that need to be monitored to assess the quality and condition of the sea water intake. This may include parameters such as temperature, salinity, pH, turbidity, total dissolved solids (TDS), and levels of specific contaminants or impurities.

<u>Sensor Selection:</u>

Choose appropriate sensors and instrumentation capable of accurately measuring the selected parameters. Consider factors such as sensor accuracy, reliability, durability, compatibility with sea water, and the ability to provide real-time data.

<u>Sensor Placement:</u>

Install sensors at strategic locations within the sea water intake system to capture representative data. Consider placing sensors at the intake point, pre-treatment stages, post-treatment stages, and critical points along the pipeline to monitor changes in water quality.

<u>Data Logging and Transmission:</u>

Implement a data logging system to collect and store real-time monitoring data. Utilize a reliable communication system to transmit the data from the sensors to a central monitoring system. This can be achieved through wired or wireless communication technologies, depending on the project requirements.

<u>Central Monitoring System:</u>

Establish a central monitoring system that receives and analyzes the real-time data from the sensors. This can be a dedicated computer system or cloud-based platform that provides visualization, data analysis, and alert notifications for abnormal conditions or threshold exceedances.

Alarm and Alert Systems:

Set up alarm and alert systems within the monitoring system to notify operators or relevant personnel in case of deviations or critical conditions. This allows for prompt response and remedial actions to maintain the integrity of the intake system.

Integration with Control Systems:

Integrate the real-time monitoring system with the overall control system of the sea water intake system. This enables automated control actions or adjustments based on the monitored parameters, ensuring optimal operation and performance.

Data Analysis and Reporting:

Utilize data analysis techniques to identify trends, patterns, and anomalies in the monitored parameters. Generate regular reports summarizing the data and highlighting any significant observations or deviations from the desired water quality standards.

Calibration and Maintenance:

Regularly calibrate the sensors and instruments to maintain their accuracy and reliability. Implement a maintenance program to ensure the proper functioning of the monitoring system and address any potential issues promptly.

Regulatory Compliance:

Ensure that the real-time monitoring system meets the regulatory requirements and standards for sea water intake systems. Adhere to any specific monitoring guidelines or protocols outlined by relevant authorities or regulatory bodies.

By implementing real-time monitoring of sea water intake parameters, operators can gain valuable insights into the performance of the system and take proactive measures to address any issues promptly. This enhances operational efficiency, reduces downtime, and ensures the production of high-quality desalinated water.

8.2 Control System Integration and Automation for Optimized Operation

Control system integration and automation play a crucial role in optimizing the operation of a sea water intake system. By integrating various components and automating processes, operators can enhance efficiency, reliability, and overall system performance. Here are some considerations for implementing control system integration and automation:

Centralized Control:

Establish a centralized control system that allows operators to monitor and control various aspects of the sea water intake system from a single location. This includes monitoring parameters, adjusting operational settings, and receiving real-time data and alerts.

SCADA (Supervisory Control and Data Acquisition) System:

Implement a SCADA system that collects data from sensors, instruments, and other system components. The SCADA system provides a graphical interface for operators to monitor the system, visualize data, and make informed decisions.

Process Automation:

Automate routine processes and tasks within the sea water intake system to reduce human error, improve efficiency, and ensure consistent operation. This can include automated valve controls, pump sequencing, and backwash cycles for filtration systems.

Feedback Control:

Utilize feedback control loops to maintain desired parameters and optimize system performance. This involves continuously monitoring key variables, comparing them to setpoints, and making automatic adjustments to maintain optimal conditions.

Integration with Instrumentation and Actuators:

Integrate control systems with the instrumentation and actuators of the sea water intake system. This allows for seamless communication and control of pumps, valves, flow meters, and other equipment to achieve desired operational goals.

Alarm and Event Management: Implement an alarm management system that promptly notifies operators of abnormal conditions, equipment failures, or deviations from desired operating parameters. This enables operators to take immediate action and prevent potential issues or system failures.

Data Logging and Analysis:

Capture and store operational data in a centralized database for analysis and reporting. Utilize data analysis techniques to identify trends, optimize system performance, and predict maintenance needs.

Remote Monitoring and Control:

Enable remote access to the control system, allowing operators to monitor and control the sea water intake system from off-site locations. This enhances flexibility, reduces response time, and enables 24/7 system monitoring.

Integration with External Systems:

Integrate the control system with other external systems, such as energy management systems or weather monitoring systems, to optimize energy consumption, take advantage of renewable energy sources, and respond to changing environmental conditions.

Training and Support:

Provide adequate training to operators and maintenance personnel to ensure they have the necessary skills to operate and maintain the integrated control system effectively. Establish a support system to address any technical issues or software updates.

By integrating control systems and automating processes, operators can achieve optimized operation, improved energy efficiency, reduced downtime, and enhanced system reliability for sea water intake systems. This integration allows for better control, monitoring, and decision-making, leading to overall operational excellence.

8.3 Alarm and Safeguard for Protection Against System Failure or Anomalies

Implementing alarm and safeguard systems is crucial for protecting against system failure or anomalies in a sea water intake system. These systems provide early warning notifications and initiate protective measures to prevent further damage or operational disruptions. Here are some considerations for implementing alarm and safeguard systems:

Risk Assessment:

Conduct a thorough risk assessment of the sea water intake system to identify potential failure scenarios, critical parameters, and abnormal operating conditions that require monitoring and protection.

Alarm Setpoints:

Define appropriate alarm setpoints for key parameters such as flow rate, pressure, temperature, salinity, and levels of specific contaminants. Setpoints should be based on design specifications, operational limits, and regulatory requirements.

Alarm Types:

Determine the types of alarms to be used, including visual alarms (such as flashing lights or indicator panels), audible alarms (such as sirens or alarms sounds), and remote notifications (such as SMS or email alerts) for immediate response.

Alarm Hierarchy:

Establish an alarm hierarchy or priority levels to differentiate between critical alarms that require immediate attention and less urgent alarms. This helps operators prioritize their response and focus on the most critical issues.

Alarm Acknowledgement:

Implement an alarm acknowledgement system that requires operators to acknowledge and respond to alarms promptly. This ensures that alarms are not overlooked or ignored, and appropriate actions are taken in a timely manner.

Safeguard Measures:

Define safeguard measures that are automatically triggered in response to certain alarm conditions. These measures may include shutting down specific equipment, activating backup systems, or initiating emergency procedures to prevent further damage or mitigate risks.

Redundancy and Backup Systems:

Incorporate redundancy and backup systems, such as redundant pumps or power supplies, to ensure continuous operation even in the event of a failure or malfunction. This helps maintain system reliability and minimize downtime.

Emergency Shutdown Procedures:

Develop and communicate clear emergency shutdown procedures to operators in the event of severe system failures, safety hazards, or abnormal conditions that pose risks to personnel or the environment. Regular drills and training should be conducted to ensure preparedness.

Data Logging and Analysis:

Log and store alarm data for analysis and review. This helps identify recurring issues, patterns, or trends that may require further investigation or system improvements.

Maintenance and Testing:

Regularly maintain and test the alarm and safeguard systems to ensure their proper functioning. Conduct routine checks, calibration, and performance verification to verify the reliability and effectiveness of the alarm system.

By implementing robust alarm and safeguard systems, operators can detect and respond to system failures or anomalies in a timely manner, preventing further damage and ensuring the continuous operation of the sea water intake system. These systems help safeguard equipment, protect personnel and the environment, and maintain the integrity of the desalination process.

Chapter 9:

Maintenance and Fouling Prevention

9.1 Preventive Maintenance Strategy for Sea Water Intake System

Implementing a preventive maintenance strategy for a sea water intake system is essential to ensure its reliable and efficient operation. A well-planned maintenance approach can help identify and address potential issues before they escalate into major failures, minimize downtime, and extend the lifespan of equipment. Here are key considerations for developing a preventive maintenance strategy for a sea water intake system:

<u>Equipment Inventory:</u>

Create an inventory of all equipment and components within the sea water intake system, including pumps, motors, valves, filters, screens, and instrumentation. This provides a comprehensive view of the assets that require maintenance.

<u>Manufacturer Guidelines:</u>

Consult the manufacturer's guidelines and recommendations for maintenance schedules, procedures, and specific requirements for each equipment component. Adhering to these guidelines ensures proper maintenance and preserves warranty coverage.

<u>Maintenance Schedule:</u>

Develop a maintenance schedule that includes regular inspections, preventive maintenance tasks, and equipment servicing. The frequency of maintenance activities will depend on factors such as equipment type, operating conditions, and manufacturer recommendations.

<u>Inspection and Testing:</u>

Conduct routine inspections to assess the condition of equipment, identify signs of wear, corrosion, or damage, and detect any abnormalities. Perform testing and calibration of instruments and sensors to ensure accurate measurements and reliable performance.

<u>Lubrication and Fluid Analysis:</u>

Regularly lubricate moving parts such as pumps, motors, and valves as per manufacturer recommendations. Additionally, analyze fluid samples, including oil and coolant, to monitor contamination levels, detect potential issues, and determine the need for fluid replacement.

<u>Cleaning and Debris Removal:</u>

Implement a regular cleaning schedule for intake screens, filters, and other components prone to fouling or clogging. Remove accumulated debris, sediment, or marine growth to maintain optimal flow rates and prevent system inefficiencies.

Corrosion Protection:

Implement corrosion protection measures for metal components exposed to sea water, such as coatings, sacrificial anodes, or cathodic protection systems. Regularly inspect and maintain corrosion protection systems to prevent equipment degradation and failures.

Spare Parts Inventory:

Maintain an inventory of critical spare parts for quick replacement and minimize downtime in case of equipment failure. Identify critical components prone to frequent failures or longer lead times for replacement and ensure sufficient stock availability.

Documentation and Records:

Maintain comprehensive records of maintenance activities, including inspection reports, servicing records, component replacements, and any repairs performed. This documentation helps track maintenance history, identify recurring issues, and supports future decision-making.

Staff Training and Competency:

Provide training and development opportunities for maintenance staff to ensure they have the necessary skills and knowledge to perform maintenance tasks effectively and safely. Stay updated with emerging technologies, industry best practices, and advancements in maintenance techniques.

Continuous Improvement:

Regularly review and evaluate the effectiveness of the preventive maintenance strategy. Identify areas for improvement, consider feedback from maintenance personnel, and implement changes or adjustments to optimize the strategy.

By implementing a preventive maintenance strategy, operators can proactively address potential issues, minimize unplanned downtime, and optimize the performance and longevity of the sea water intake system. This approach ensures reliable operation, reduces maintenance costs, and enhances the overall efficiency of the desalination process.

9.2 Fouling Management Techniques

Fouling management techniques are essential for maintaining the efficiency and performance of a sea water intake system. Fouling refers to the accumulation of organic and inorganic materials on surfaces, such as intake screens, pipes, and membranes, which can impede flow and reduce system effectiveness. Here are some common fouling management techniques:

Chlorine Dosing:

Chlorine dosing is a widely used method for controlling biological fouling in sea water intake systems. Chlorine, in the form of sodium hypochlorite or chlorine gas, is added to the sea water to disinfect and inhibit the growth of marine organisms, such as algae, bacteria, and biofilm. Proper dosing and monitoring are crucial to maintain an effective chlorine residual without causing adverse effects on the environment or downstream processes.

We recommend shock and intermediate chlorination to avoid biological growth and keep system clean.

Anti-fouling Coatings:

Applying anti-fouling coatings to intake screens, pipes, and other system components can help minimize fouling. These coatings create a smooth and resistant surface that inhibits the attachment of organisms and reduces the accumulation of deposits. Various types of coatings, such as silicone-based or fluoropolymer-based coatings, are available and should be selected based on compatibility with sea water, durability, and effectiveness against specific fouling organisms.

Mechanical Cleaning:

Regular mechanical cleaning is essential for removing accumulated fouling deposits from intake screens, pipes, and other system components. Methods may include high-pressure water jetting, brushing, or scraping to dislodge and remove fouling materials. The frequency of cleaning depends on the severity of fouling and should be determined through monitoring and inspection.

Chemical Cleaning:

Chemical cleaning involves the use of specific cleaning agents or solutions to dissolve or remove fouling deposits from surfaces. Acidic or alkaline cleaning solutions are commonly used, depending on the nature of the fouling material. Chemical cleaning should be performed carefully, considering the compatibility of cleaning agents with system materials and environmental regulations.

Backwashing or hydro burst :

Backwashing is a technique used in filtration systems and hydro burst is used in intake screens to remove accumulated particulate fouling from filters or intake screens. By reversing the flow of sea water through the filtration media, dislodged particles are flushed out, restoring the filtration efficiency. Backwashing should be conducted at regular intervals or triggered based on pressure differentials or performance indicators.

Monitoring and Control:

Implement real-time monitoring of key parameters, such as pressure differentials, flow rates, and water quality parameters, to detect early signs of fouling. This allows for timely intervention and maintenance actions to prevent further fouling and ensure optimal system performance.

Fouling Evaluation and Analysis:

Regularly assess and analyze the fouling patterns and characteristics to identify the root causes and optimize fouling management strategies. This may involve analyzing fouling samples, conducting laboratory tests, or utilizing data analytics to understand the fouling mechanisms and develop targeted mitigation approaches.

It is important to note that the selection and application of fouling management techniques should be based on the specific requirements of the sea water intake system, the nature of fouling organisms, and environmental considerations. A comprehensive fouling management strategy may involve a combination of these techniques to effectively control fouling and maintain the performance of the sea water intake system.

9.3 Inspection and Repair Procedure for Intake Screens, pumps and pipeline

Inspection and repair procedures for intake screens, pumps, and pipelines in a sea water intake system are crucial for ensuring their proper functioning and preventing potential failures. Here are some general guidelines for inspection and repair:

Intake Screens:

Regular Inspection:

Conduct routine visual inspections of intake screens to check for fouling, debris accumulation, or damage. Inspect for any signs of corrosion, structural integrity issues, or clogging.

Cleaning:

Remove accumulated debris and fouling from intake screens using appropriate cleaning methods such as high-pressure water jetting, brushing, or scraping. Ensure that the cleaning method does not damage the screen material.

Screen Replacement:

If intake screens are severely damaged, corroded, or cannot be effectively cleaned, consider replacing them with new screens. Follow manufacturer guidelines for screen replacement and ensure proper installation.

Pumps:

Visual Inspection:

Regularly inspect pumps for any signs of leaks, corrosion, abnormal vibrations, or unusual noises. Check motor and pump alignment to ensure proper functioning.

Performance Monitoring:

Monitor pump performance parameters such as flow rate, pressure, and power consumption. Compare the measured values with the expected performance specifications to identify any deviations.

Lubrication:

Follow manufacturer recommendations for lubrication of pump bearings, shafts, and other moving parts. Ensure proper lubricant selection and application.

Seal Inspection:

Check the condition of pump seals and gaskets. Replace worn-out or damaged seals to prevent leaks and maintain pump efficiency.

Motor Maintenance:

Inspect motor components, including wiring, insulation, and cooling systems, to ensure they are in good condition. Clean motor vents and cooling fins regularly to prevent overheating.

Pipelines:

Visual Inspection:

Conduct regular visual inspections of pipelines to check for signs of corrosion, leaks, cracks, or structural damage. Pay attention to pipe supports, joints, and fittings.

Leak Detection:

Monitor pipeline sections for potential leaks using pressure monitoring or leak detection systems. Perform pressure tests periodically to identify and address any leaks.

Cathodic Protection:

If pipelines are made of metal, implement appropriate cathodic protection measures to prevent corrosion. Regularly inspect and maintain cathodic protection systems.

Corrosion Monitoring:

Utilize corrosion monitoring techniques such as ultrasonic thickness measurement or corrosion rate monitoring to assess the condition of the pipeline. Address any detected corrosion promptly.

Repair and Replacement:

If pipeline damage is identified, repair or replace the affected sections as per industry standards and guidelines. Consider factors such as material compatibility, pipeline integrity, and environmental conditions during repair or replacement.

It is important to note that specific inspection and repair procedures may vary depending on the design, materials, and operating conditions of the sea water intake system. It is recommended to consult the system's design specifications, manufacturer guidelines, and industry best practices when developing inspection and repair procedures for intake screens, pumps, and pipelines. Regular and thorough inspections, along with proactive maintenance and timely repairs, are key to ensuring the longevity and reliable operation of the sea water intake system.

Chapter 10:

Case Study and Lesson Learned

10.1 Real World Example of Successful Sea Water Intake System Design

Implementing a preventive maintenance strategy for a sea water intake system is essential to ensure its reliable and efficient operation. A well-planned maintenance approach can help identify and address potential issues before they escalate into major failures, minimize downtime, and extend the lifespan

10.2 Challenges Encountered and Innovation solution implemented

When designing sea water intake systems for reverse osmosis desalination, various challenges can arise. However, innovative solutions have been implemented to address these challenges. Here are some examples:

Intake Screen Fouling:

One of the main challenges in sea water intake systems is the fouling of intake screens due to the accumulation of marine organisms, algae, or debris. This can reduce the flow rate and efficiency of the system. To tackle this, innovative solutions such as advanced screen materials with anti-fouling properties have been developed. These materials can resist biofouling and reduce the need for frequent cleaning.

Environmental Impact:

Sea water intake systems can have environmental implications, including the entrainment or impingement of marine organisms. To mitigate this, innovative solutions have been implemented, such as the use of low-velocity intake designs that minimize the impact on marine life. Additionally, the development of fish-friendly screens and intake structures that allow for the safe passage of marine organisms has been explored.

Corrosion and Material Compatibility:

Sea water is corrosive, and selecting appropriate materials for intake system components is crucial. Innovative solutions involve the use of corrosion-resistant materials such as stainless steel, fiberglass-reinforced polymers, or specialized coatings that can withstand the harsh sea water environment. Advancements in material science have led to the development of more durable and corrosion-resistant options.

Energy Efficiency:

Sea water intake systems often require significant energy to pump large volumes of water. To address this challenge, innovative solutions include the integration of energy recovery devices such as pressure exchangers or turbines. These devices harness the energy from the high-pressure seawater flow, reducing the overall energy consumption of the system and improving efficiency.

Water Quality Variability:

Sea water quality can vary based on factors such as tides, seasons, and weather conditions. This can pose challenges in maintaining consistent water quality for desalination. Innovative solutions involve the implementation of real-time monitoring and control systems that adjust the operation of the intake system based on water quality parameters. This ensures that the desalination process can adapt to changing conditions and maintain optimal performance.

Intake System Reliability:

Sea water intake systems need to be reliable and resistant to extreme weather conditions, wave action, and other external factors. Innovative solutions include robust intake structure designs that can withstand high-velocity flows and turbulent conditions. Computational modeling and simulations are also utilized to optimize the intake system's performance and ensure its reliability under various scenarios.

Intake System Efficiency:

Achieving high efficiency in sea water intake systems can be challenging due to factors such as pressure losses, turbulence, and frictional resistance along the intake path. Designing the intake system to minimize these losses and optimize the flow characteristics requires careful consideration of pipe sizing, flow velocities, and hydraulic design principles.

Intake System Scalability:

Designing a sea water intake system that can accommodate future expansion or increased water demand can be a challenge. Anticipating future growth and incorporating provisions for system scalability, such as oversized pipelines or additional intake structures, is crucial to avoid retrofitting or significant modifications in the future.

Reducing Environmental Impact:

While sea water intake systems are essential for desalination, their operation can have potential ecological impacts. It is important to minimize the environmental footprint by considering factors such as the location and design of intake structures, flow velocities to prevent entrainment or impingement of marine life, and the use of environmentally friendly materials and coatings.

Compliance with Regulatory Requirements:

Sea water intake systems must comply with environmental regulations and permits governing the extraction of seawater. These regulations often include restrictions on intake velocities, protection of marine habitats, and water quality standards. Designing the intake system to meet these regulatory requirements and obtaining necessary permits can be a complex process.

Cost Optimization:

Designing a sea water intake system that balances performance, efficiency, and cost can be challenging. Balancing the use of high-quality materials, advanced technologies, and energy-efficient components with the overall project budget is important. Identifying cost-effective solutions and optimizing the design while ensuring long

By addressing these challenges with innovative solutions, the design and operation of sea water intake systems for reverse osmosis desalination can be enhanced, leading to more efficient, sustainable, and reliable water production.

10.3 Lesson Learned and Best Practices for Future project

When reflecting on past sea water intake system projects, several lessons learned and best practices can guide future projects. Here are some key lessons and best practices:

Comprehensive Site Assessment:

Conduct a thorough site assessment that considers environmental conditions, water quality parameters, tidal influence, seasonal variations, and potential impacts on marine ecosystems. This assessment forms the basis for designing an intake system that is tailored to the specific site conditions.

Collaboration and Stakeholder Engagement:

Involve relevant stakeholders, including local communities, environmental agencies, and experts in the field, throughout the design and implementation process. Collaborative decision-making and engagement foster transparency, address concerns, and enhance the overall success of the project.

Environmental Impact Mitigation:

Implement robust measures to minimize the environmental impact of the intake system. This may include selecting the appropriate intake technology, incorporating fish-friendly screens, employing real-time monitoring systems, and regularly assessing the impact on marine life and ecosystems.

Material Selection and Corrosion Protection:

Select materials that are corrosion-resistant, durable, and suitable for the marine environment. Consider the life cycle cost of materials, their compatibility with seawater, and the need for protective coatings or cathodic protection systems to prevent corrosion and extend the lifespan of the intake system.

Energy Efficiency and Optimization:

Design the intake system with a focus on energy efficiency. Incorporate energy recovery devices, optimize pump selection and operation, and consider the potential for renewable energy integration to minimize energy consumption and operational costs.

Robust Maintenance and Monitoring:

Develop a comprehensive maintenance plan that includes regular inspections, cleaning of intake screens, and monitoring of water quality and system performance. Implement proactive measures to address issues such as fouling, corrosion, and mechanical failures to ensure the long-term reliability and efficiency of the intake system.

Compliance with Regulations:

Stay updated on regulatory requirements and permits related to sea water intake systems. Engage with regulatory authorities early in the design process to ensure compliance and avoid potential delays or conflicts during project implementation.

Continual Improvement and Knowledge Sharing:

Foster a culture of continual improvement by capturing lessons learned from past projects and sharing best practices within the industry. Encourage knowledge sharing among project teams, industry associations, and research institutions to drive innovation and advancements in sea water intake system design and operation.

Robust Design Considerations:

Consider the potential impacts of extreme weather events, such as storms or hurricanes, on the intake system design. Incorporate measures to ensure the resilience and stability of the intake structure, pipelines, and associated equipment in the face of such events.

Water Quality Monitoring and Treatment:

Implement a comprehensive water quality monitoring program that includes regular sampling and analysis of intake water. This helps identify any changes or trends in water quality parameters and allows for timely adjustments in treatment processes, if needed.

Operational Flexibility:

Design the intake system to accommodate variations in seawater quality and quantity. Incorporate flexibility in the design to adjust intake depths, intake rates, or treatment processes to ensure consistent production of high-quality water, even under changing conditions.

Data Management and Analysis:

Establish a robust data management system to collect, store, and analyze data related to the intake system's performance, maintenance activities, and water quality parameters. This data can provide valuable insights for optimizing system operation, identifying trends, and making informed decisions.

Training and Knowledge Transfer:

Ensure that the project team and operators receive adequate training on the operation, maintenance, and troubleshooting of the sea water intake system. Facilitate knowledge transfer through comprehensive documentation, standard operating procedures, and regular communication channels to ensure effective and efficient system operation.

Early Engagement of Experts:

Engage experienced consultants, engineers, and specialists in sea water intake system design early in the project. Their expertise can help identify potential challenges, provide innovative solutions, and ensure compliance with industry standards and best practices.

Environmental Monitoring and Mitigation Plans:

Develop comprehensive environmental monitoring and mitigation plans to assess and mitigate the potential impacts of the intake system on marine ecosystems. Regular monitoring and adaptive management practices can help identify any unforeseen impacts and implement timely measures to minimize environmental harm.

Regular System Evaluation and Performance Audits:

Conduct periodic evaluations and performance audits of the sea water intake system to assess its efficiency, reliability, and compliance with operational targets. Identify areas for improvement, implement corrective actions, and continuously monitor system performance to ensure optimal operation.

Knowledge Exchange and Collaboration:

Participate in industry conferences, workshops, and forums to share experiences and learn from other sea water intake system projects. Collaborate with industry peers, researchers, and technology providers to stay updated on emerging technologies, best practices, and advancements in sea water intake system design and operation.

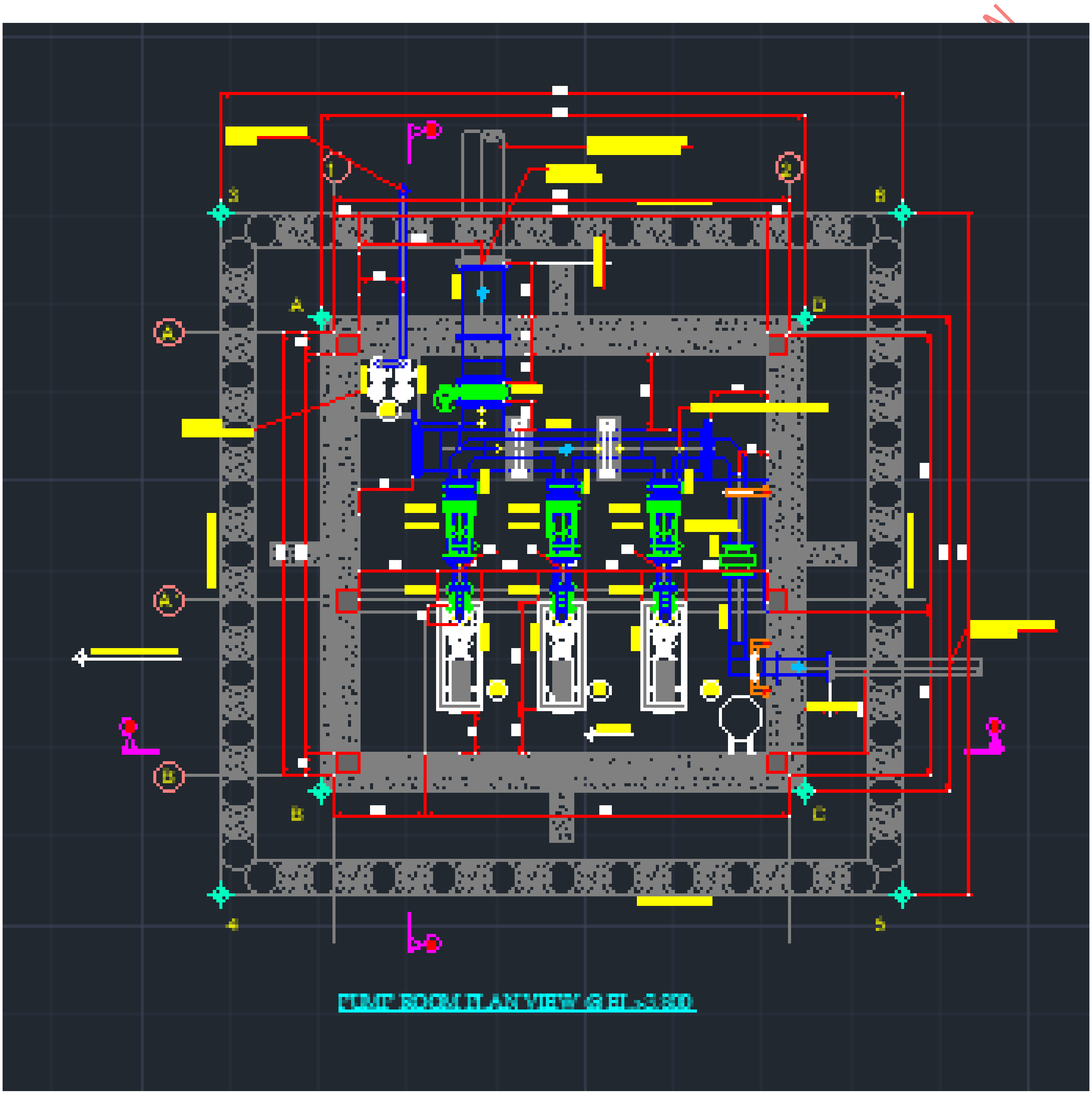
By incorporating these additional lessons learned and best practices into future projects, sea water intake systems can be designed, implemented, and operated more effectively, resulting in sustainable and reliable water supply for communities and industries.

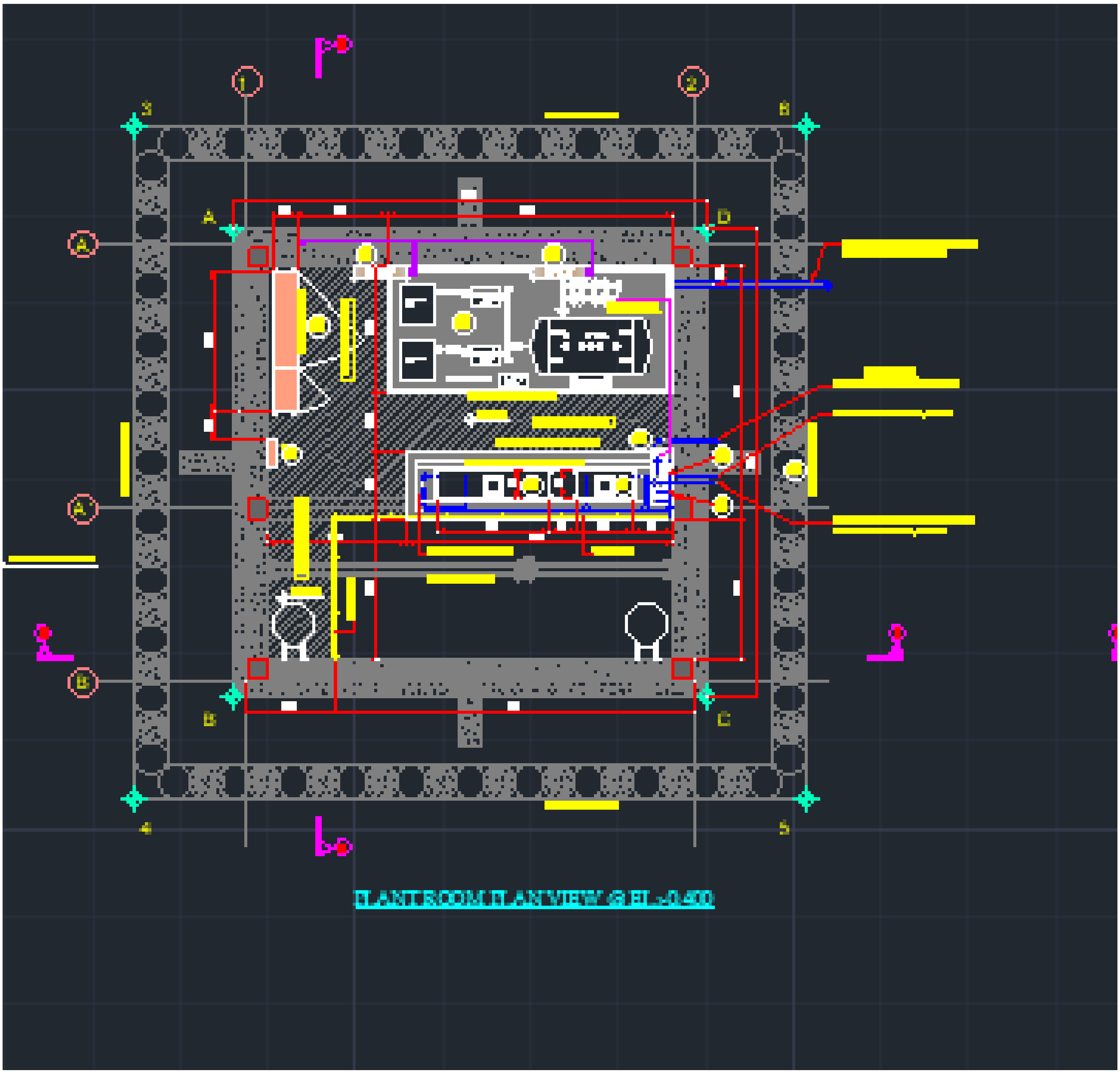
Chapter 11:

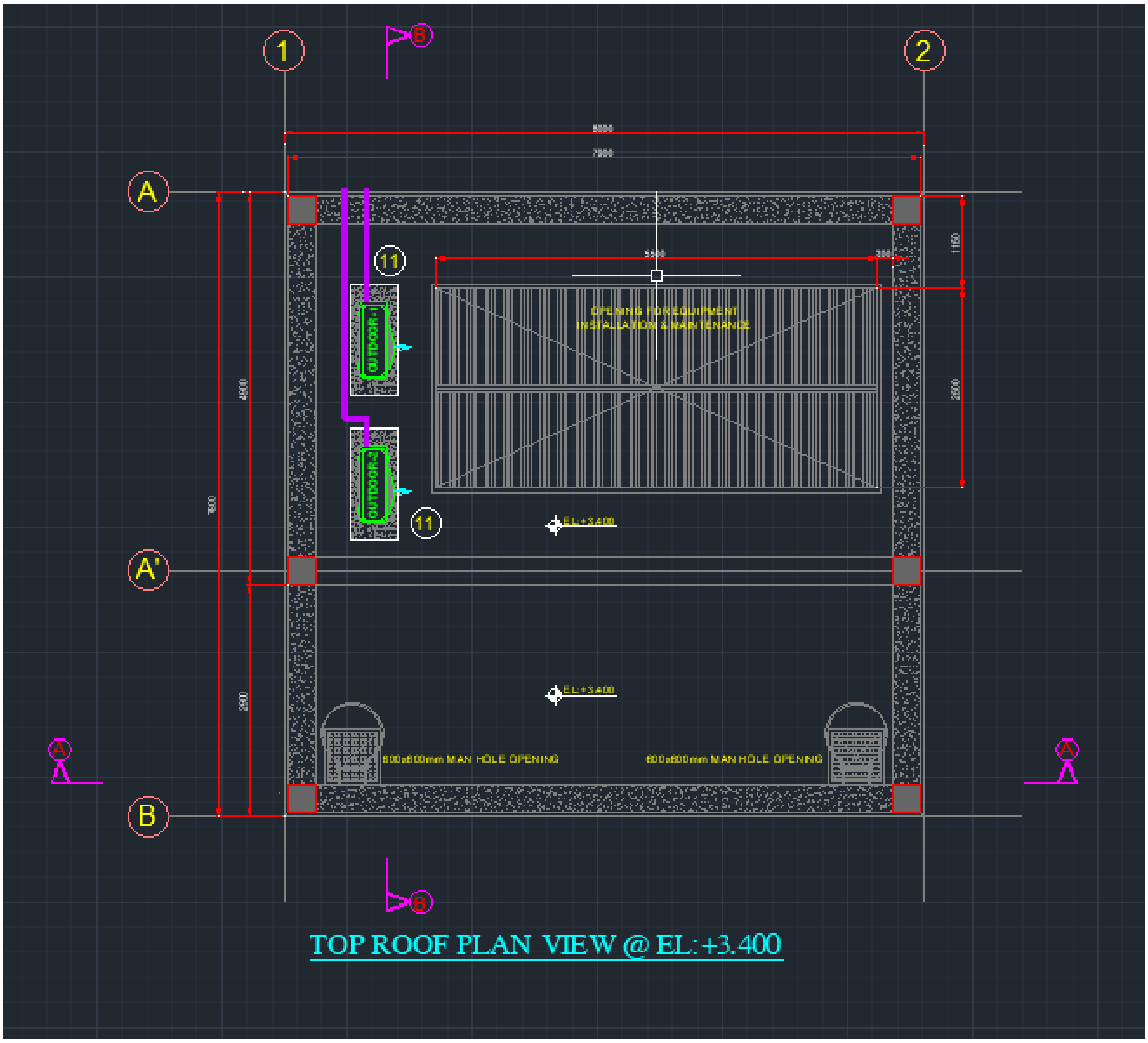
DRAWINGS FOR THE INTAKE PUMP ROOM AND INTAKE PIPING

Drawing intake pumps Option – 1

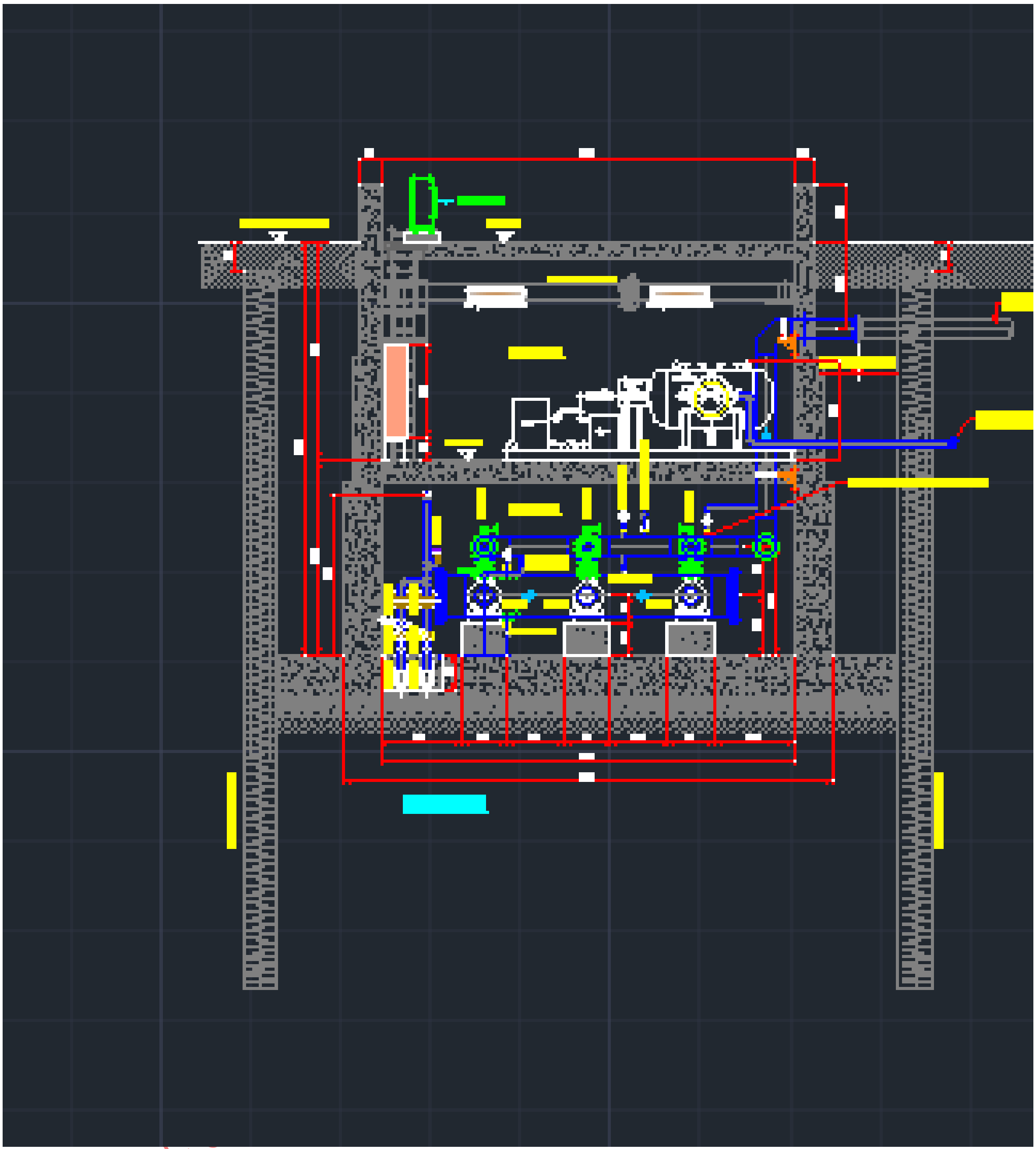
(full pump room under the ground)

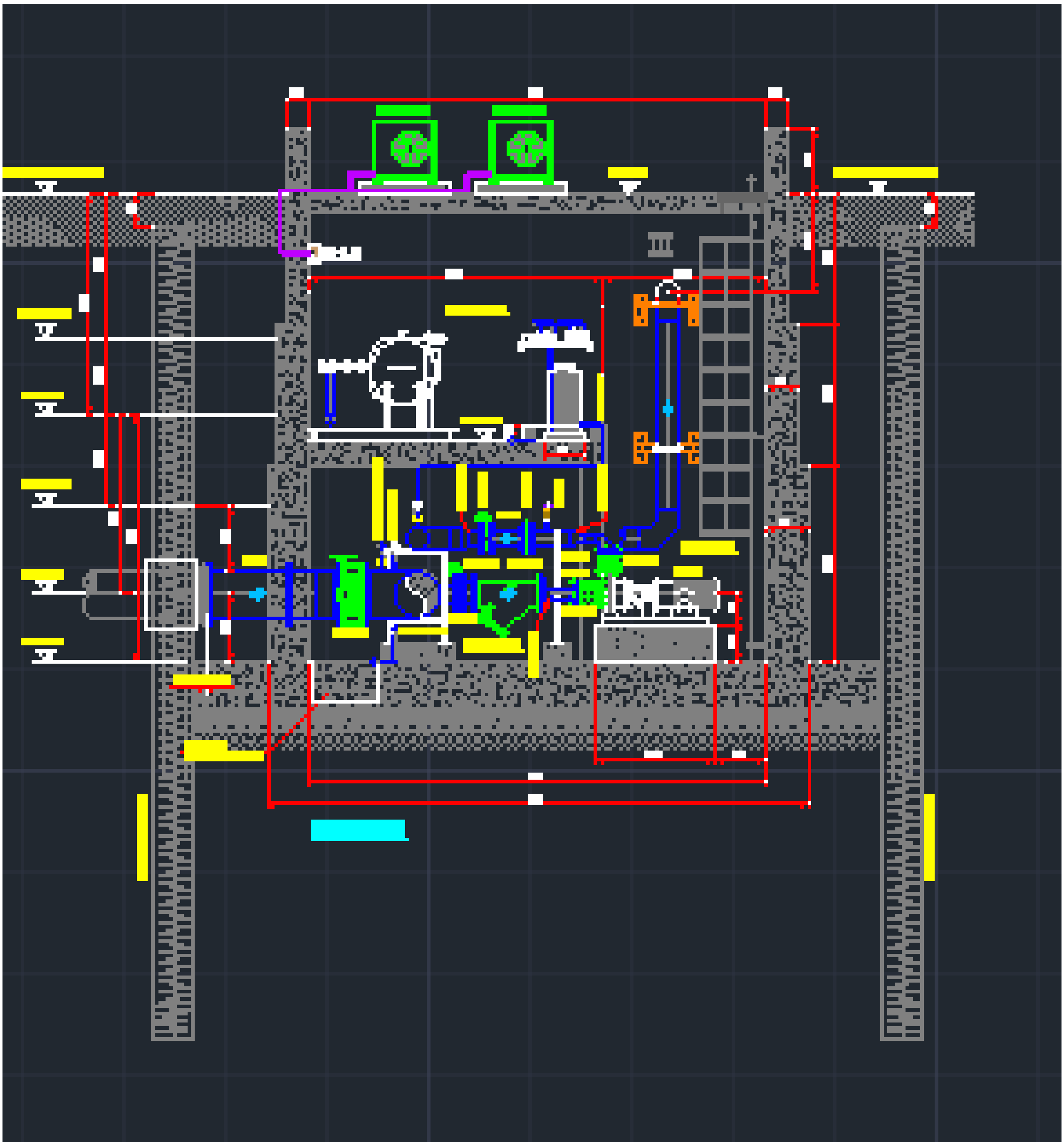



PLANT ROOM PLAN VIEW @ EL -0.400



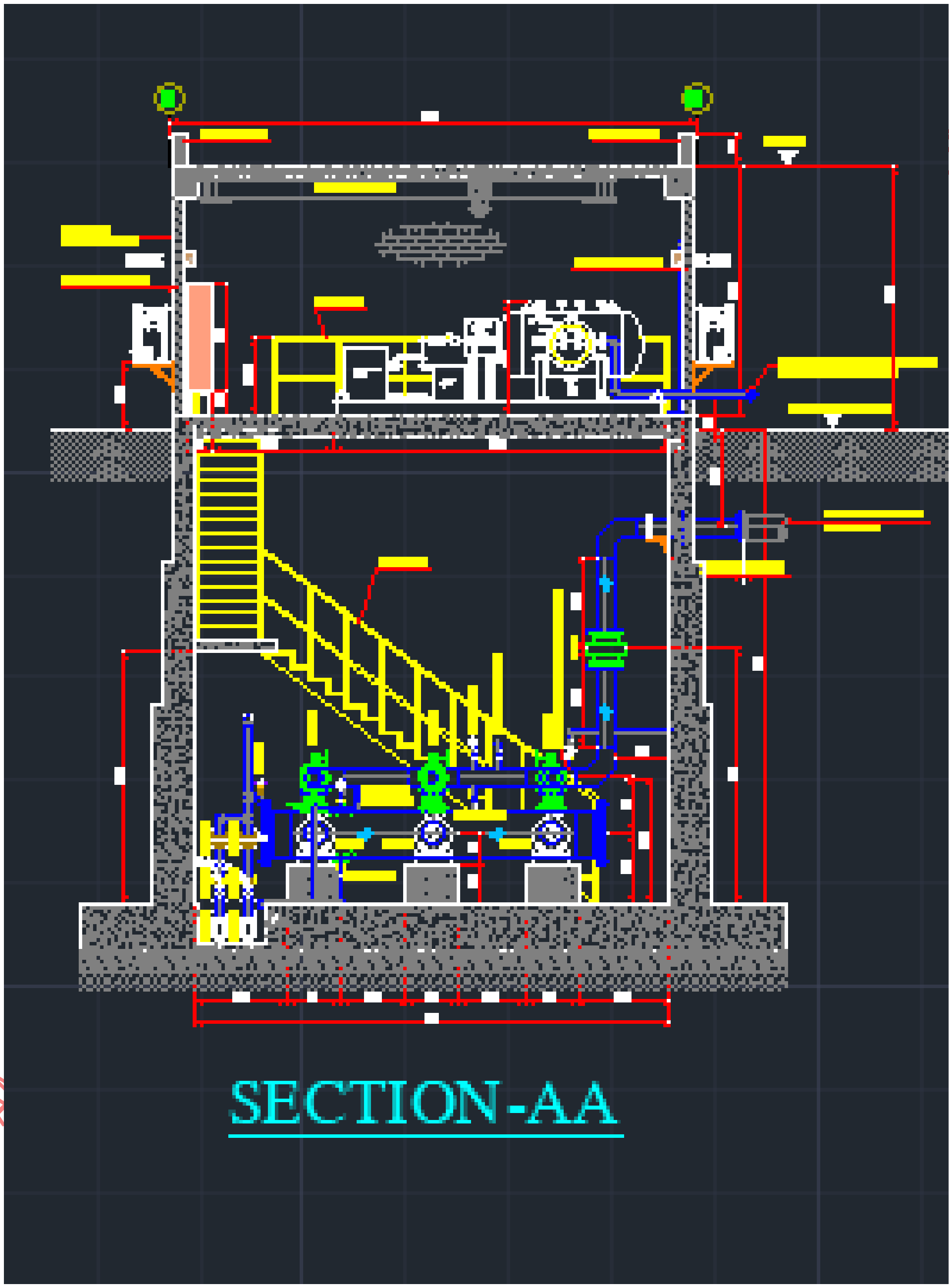
1
2
A
A'
B
11
OUTDOOR-1
OUTDOOR-2
OPENING FOR EQUIPMENT
INSTALLATION & MAINTENANCE
EL:+3.400
600x600mm MAN HOLE OPENING
600x600mm MAN HOLE OPENING
TOP ROOF PLAN VIEW @ EL:+3.400

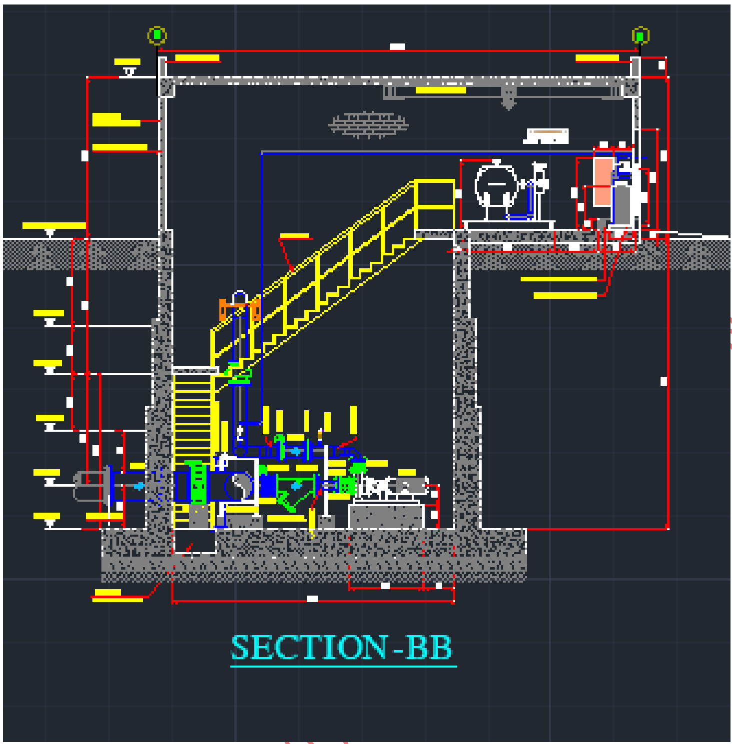


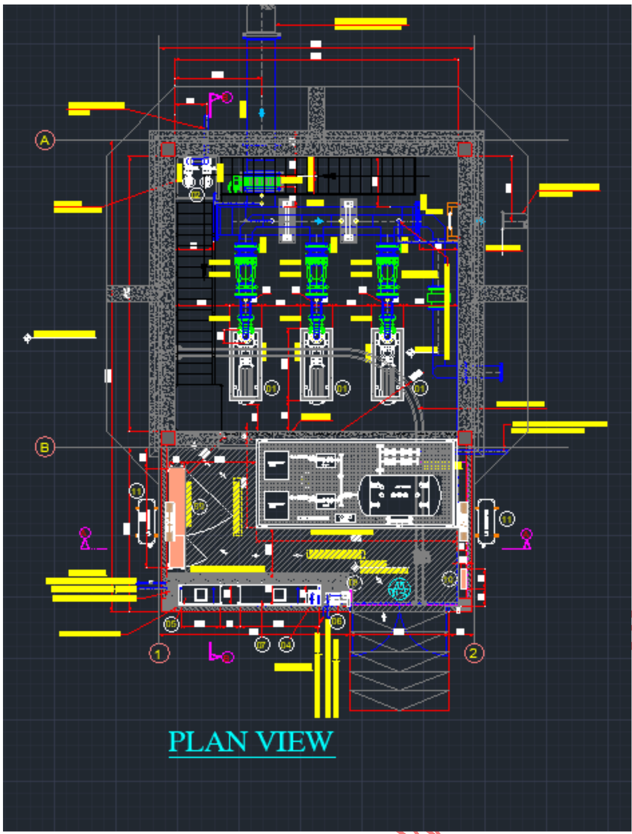


Drawing intake pumps Option – 2

(Pumps under the ground and hydro burst on ground level)

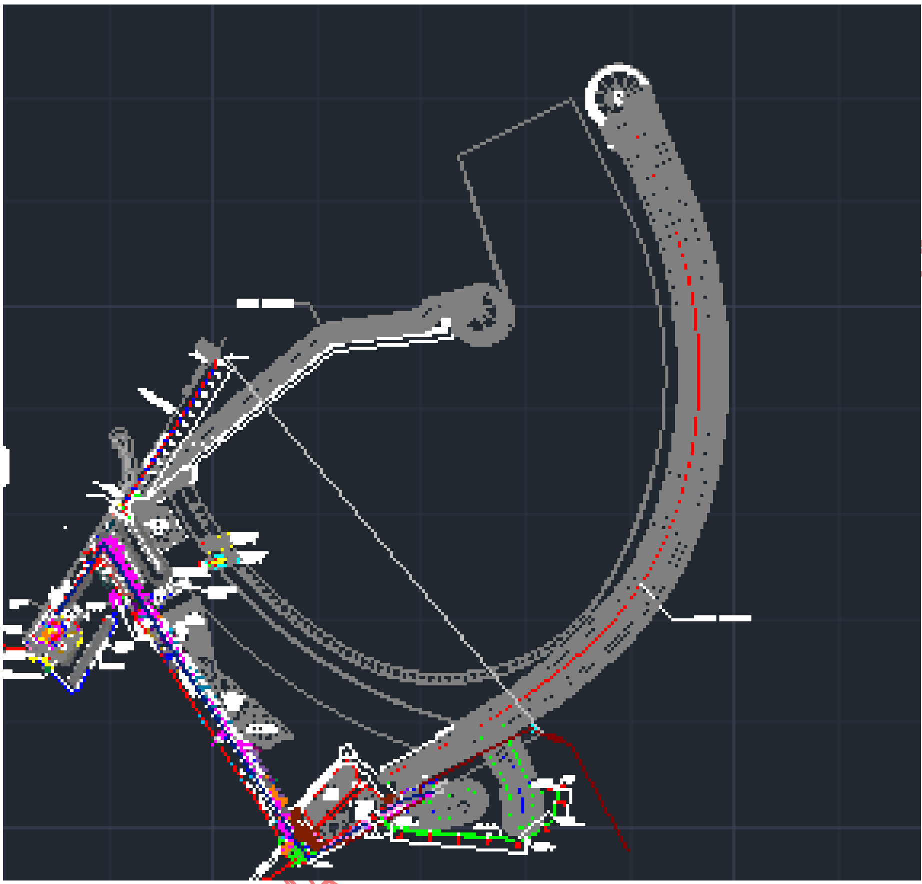


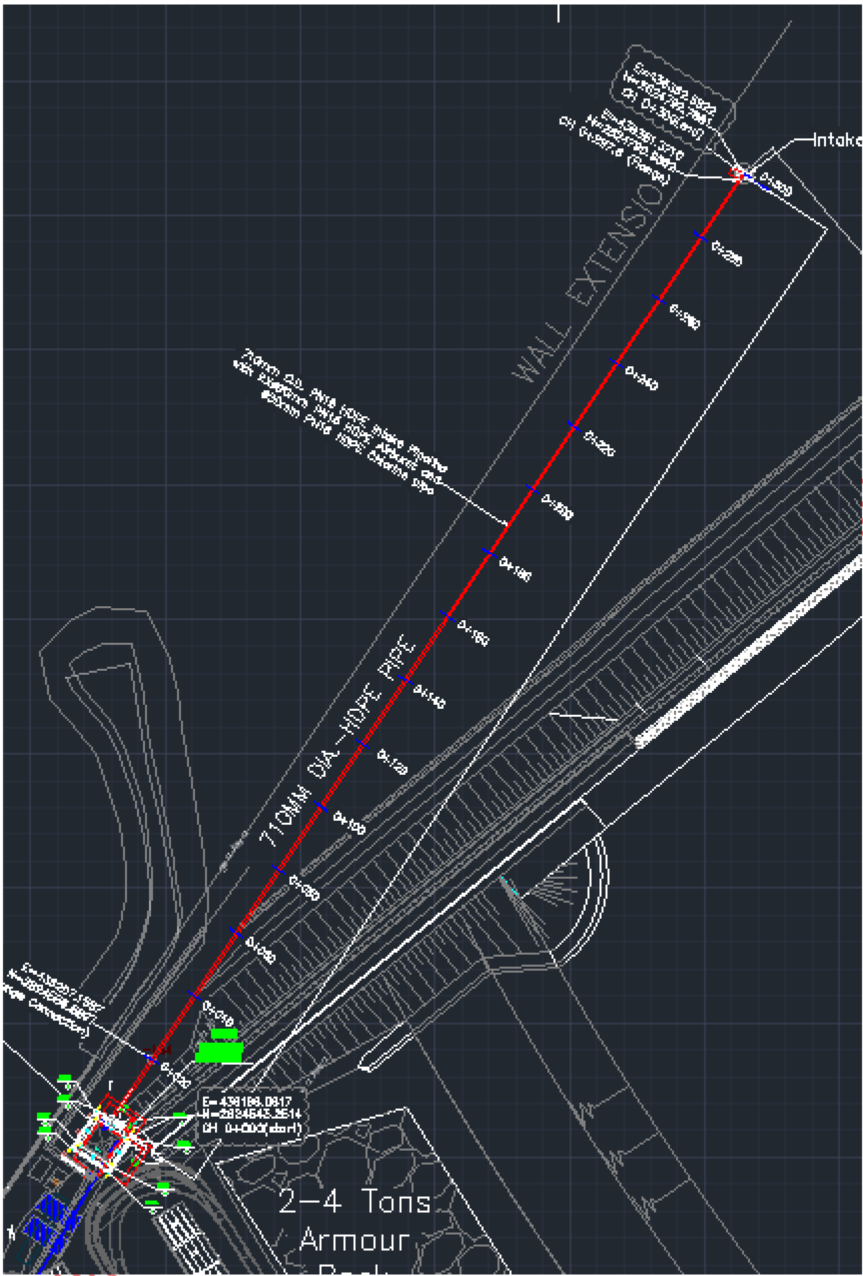

SECTION-BB

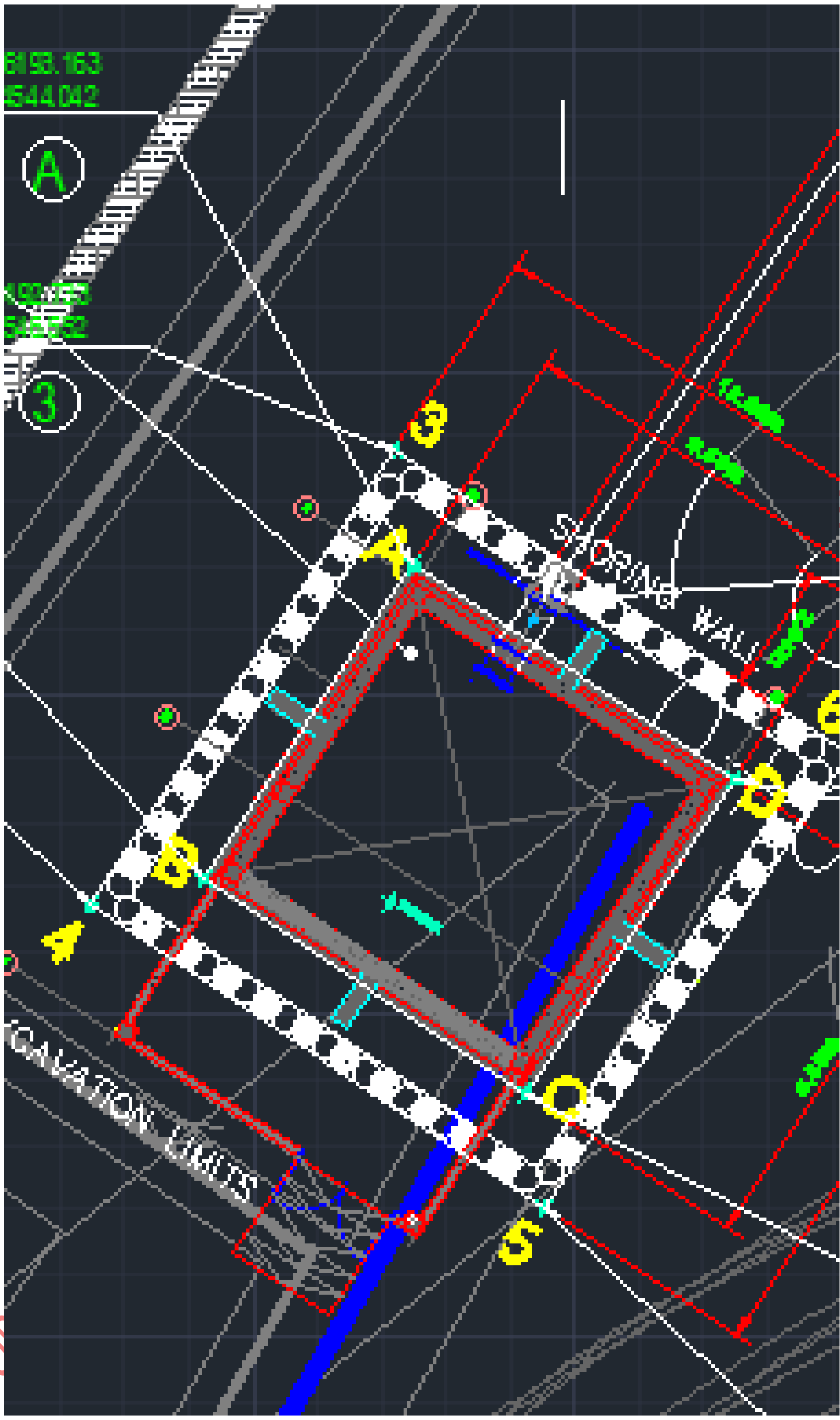


A
B
1
2
PLAN VIEW

Drawing intake and outfall piping




Intake
WALL EXTENSIO
710MM DIA.-HDPE PIPE
2-4 Tons
Armour


6193.163
4544.042
A
3
SHORING
WALL
CAVATION LIMITS
A
B
C
D
4
5