WATER RECYCLING PLANT IN WAFRA

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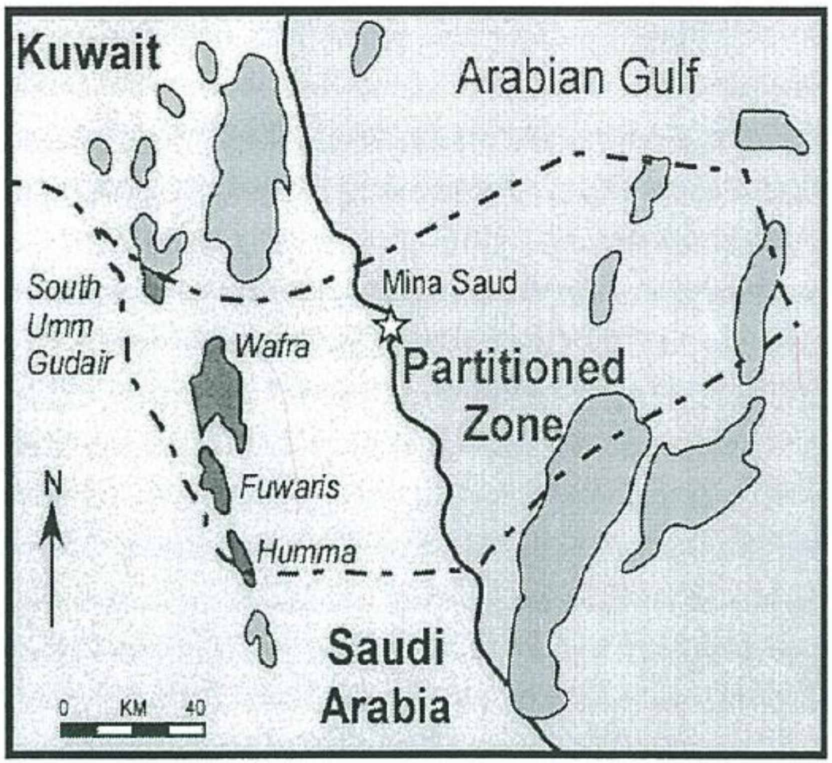
Introduction

- The Joint Operations (JO) was born in 1960 when the two oil companies formed a joint committee to oversee and supervise their operations with the resultant productions divided equally to both parties: the Kuwait Gulf Oil Company (KGOC), which operates the Kuwaiti concession and Chevron, Saudi Arabian Chevron (SAC) that operates the Saudi Arabian concession across the 3,600 Km2 partitioned neutral zone.

Location



The Wafra Oilfield is located in the Partitioned Zone near Kuwait's southern border with Saudi Arabia.

Wafra Oil Field

- Here produced water was historically managed in open, above-ground evaporation ponds. This was a normal and accepted practice not only in Gulf Cooperation Council (GCC) states but in many oilfields worldwide.
- At Wafra, with water cuts increasing from decades of oil production, the size of the pond area needed for effective evaporation also increased significantly.

Projects Mission

Mission Statement

- To be a leading project in providing innovative waste management services to residents, businesses and visitors of Kuwait in an efficient, effective and considerate manner, creating environmental sustainability.

Why should we recycle water?

- **Population growth & Resource Scarcity:** The global population has grown from 3.5 billion in 1970, to 7 billion in 2012. This along with increased purchasing capacity of people in emerging economies is placing a significant strain on our planet's limited resources. Oil, Natural gas, water, metals etc. are experiencing record levels of demand. Kuwait and other GCC economies rely significantly on oil and natural gas. Although these industries have provided extraordinary growth and prosperity in the region, We recognizing that these are non-renewable natural resources, even the water consumed in the region comes mostly from desalinated sea water, which is the on the most energy intensive form of water souring. For all these reasons, it makes perfect sense to use these natural resources as efficiently as possible, guaranteeing both short and long term prosperity.

Why should we recycle water?

- **Climate change:** Sound scientific evidence links climate change to increasing levels of CO2 and other Green House (GHGs) in the atmosphere. Climate change is a global problem that requires a global solution. We recognize that we exist within a global ecosystem and share the responsibility to do our utmost to cause minimal harm to our planet, and set an example of responsible environmental stewardship.

Why should we recycle water?

- **Social Responsibility:** Organizations have a significant role to play to address social and economic issues of country of operation. Using the financial and organizational strength, organizations have played a significant role addressing social issues that have a long term impact. A sustainability strategy should be made to address these economic and social issues in a transparent and systematic way.

Why should we recycle water?

A. Causes health problems		
Category	**Examples**	**Sources**
1. Infectious agents	Bacteria, viruses, parasites	Human and animal excreta
2. Organic chemicals	Pesticides, plastics, detergents, oil, and gasoline	Industrial, household, and farm use
3. Inorganic chemicals	Acids, caustics, salts, metals	Industrial effluents, household cleansers, surface runoff.
4. Radioactive materials	Uranium, thorium, cesium, iodine, radon	Mining and processing of ores, power plants, weapons production, natural sources

Why should we recycle water?

- The recycled water could reduce the investments needed for the infrastructure in Wafra by supplying the water from the close by oil field rather than having it pumped from a far away water desalination plant.

- The excess water could be used by the close by farms in Wafra.

JO Response

- The intent of this multi-faceted Zero Discharge Initiative was to decommission the pits with minimal impact to the environment, human health, and operations.

Therefore a Pressure Management Plant was made to handle the injected water and disposal wells.

Water Handling Facilities at JO

- Key elements of this complex initiative involves:

1) Altering oilfield operations by re-injecting produced water for formation pressure maintenance as well as disposal.
2) Construction of necessary produced water injection wells.
3) Water management facilities and pipeline networks

Future Potential

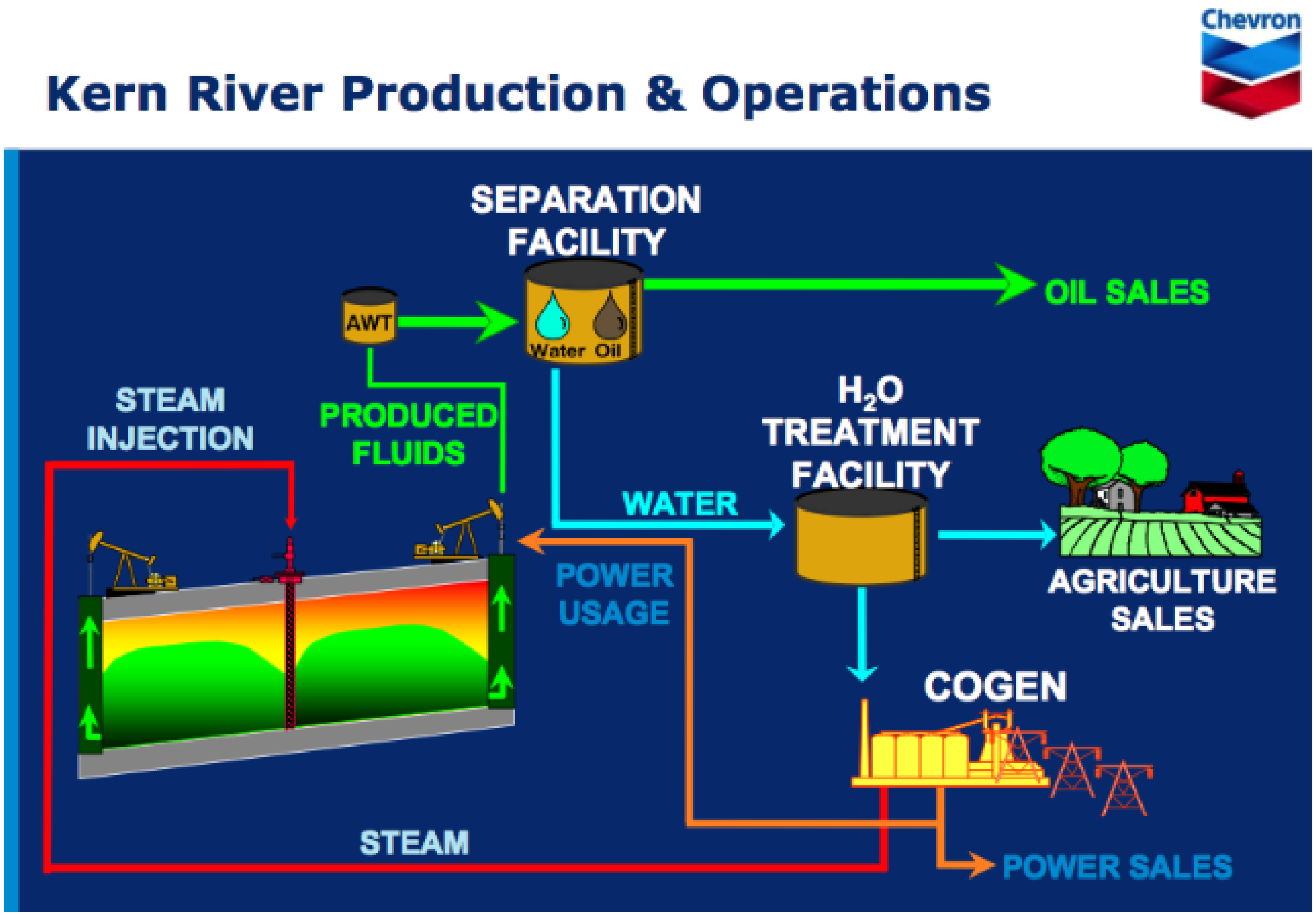
Water from Steam Flooding Facilities

- Steam Injection or steam injection is an "enhanced oil recovery" (EOR) technology.
- It uses up very large quantities of water, by injecting it into the earth to increase production using injection wells in order to decrease the viscosity of the oil in the reservoir and therefore increase the oil productivity of the reservoir.

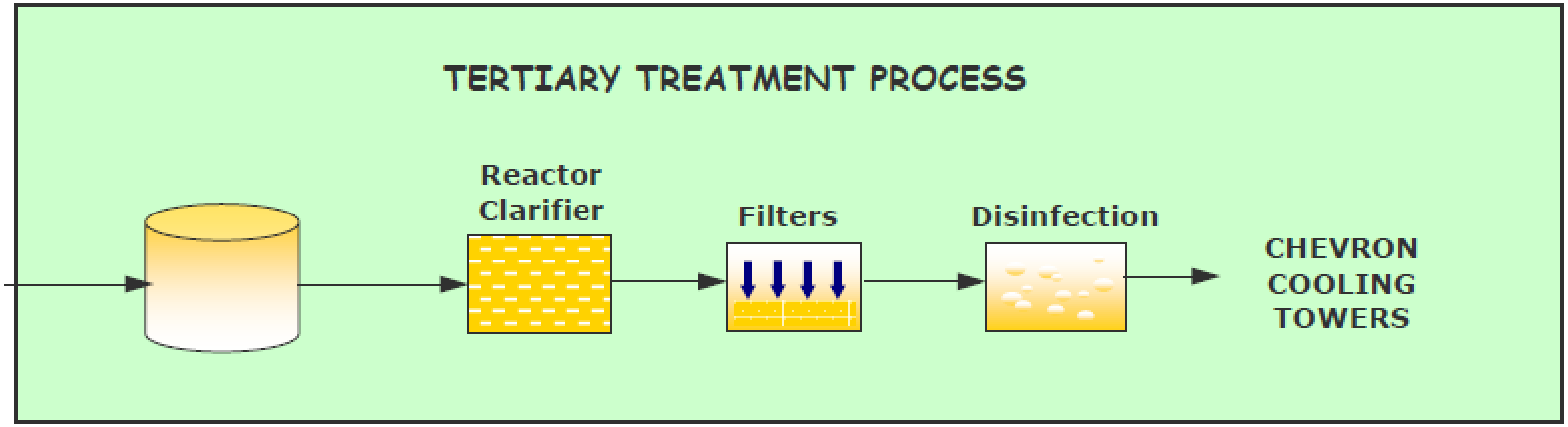
Solutions

- Due to the high water production rates the Oil industry engineers and water quality specialists say it is technically feasible to treat and recycle all of the produced water, and use it for steam flooding. There is so much produced water that such a closed loop treatment and recycling system could supply one-and-a-half times the amount of water needed for all of the industry’s steam flood operations.

Water Recycling Process



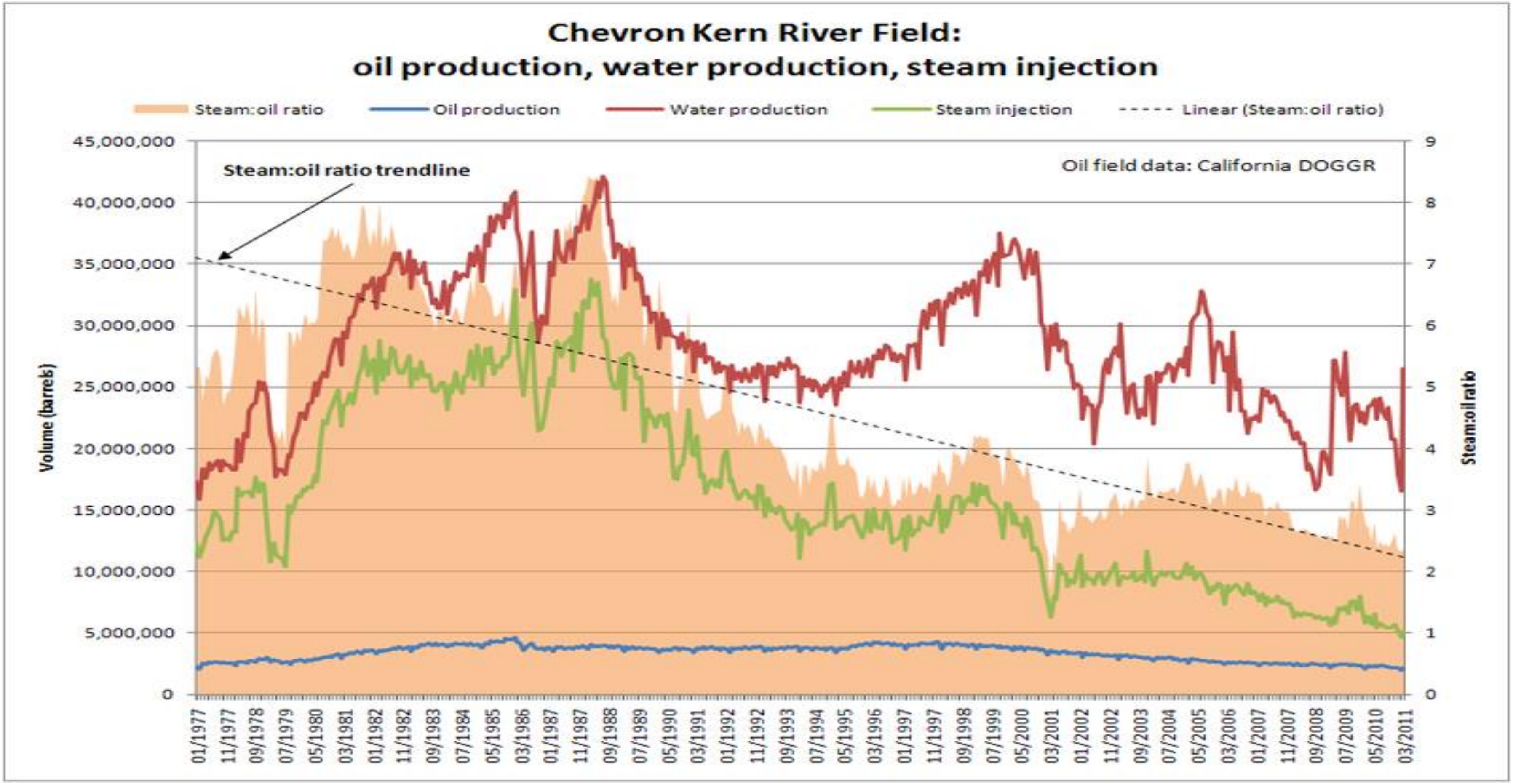
Water Recycling Process



Kern River Project in numbers

Kern River Field current statistics	
Oil production	75,000 bpd
Water production	780,000 bpd
Steam injection	180,000 bpd
Clean water shipped to agriculture (regulated)	550,000 bpd
Water lease usage	50,000 bpd
Active injection wells	~700

Kern River Project in numbers



Chevrons Target from the project

- Equipment Renewal Projects identified to improve safety, environment and reliability CEQA requirement – recycled water.

- Chevron Way – protect people and the environment

Project Objectives

- Use all of the resources available to get the maximum benefit from them in every aspect possible.
- Reduce large investments for the water transportation pipelines and desalination plants for the new projects.
- The proposed project could act as an emergency water tap where the water production is used when necessary.
- Diversify our water resources.

Project Objectives

- Decrease the subsurface water aquifer pollution as a result of re injecting unclean water.
- Introduce new technology and methods in the local area for more flexibility and strategic issues (water security).
- Provide an outlet for the extra water production in case of any unexpected trip which could save us from having to shut down any high oil productivity wells which would cause losses.

Project Proposed Steps

- Pretreatment:

- Pumping and containment – The majority of water must be pumped from its source or directed into pipes or holding tanks. To avoid adding contaminants to the water, this physical infrastructure must be made from appropriate materials and constructed so that accidental contamination does not occur.

Project Proposed Steps

- Sludge storage and removal in tanks:

- As particles settle to the bottom of a sedimentation basin, a layer of sludge is formed on the floor of the tank. This layer of sludge must be removed and treated. The amount of sludge that is generated is significant, often 3 to 5 percent of the total volume of water that is treated. The cost of treating and disposing of the sludge can be a significant part of the operating cost of a water treatment plant.

Project Proposed Steps

- Disinfection:

- Disinfection is accomplished both by filtering out harmful micro-organisms and also by adding disinfectant chemicals. Water is disinfected to kill any pathogens which pass through the filters and to provide a residual dose of disinfectant to kill or inactivate potentially harmful micro-organisms in the storage and distribution systems. Possible pathogens include viruses, bacteria.

Project Proposed Steps

- Desalination

  Is a process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis. Desalination is currently expensive compared to most alternative sources of water, and only a very small fraction of total human use is satisfied by desalination. It is only economically practical for high-valued uses (such as household and industrial uses) in arid areas.

Project Proposed Steps

- Distillation

  Involves boiling the water to produce water vapor.

  The vapor contacts a cool surface where it condenses as a liquid. Because the solutes are not normally vaporized, they remain in the boiling solution.

Project Proposed Steps

- Boiling

  Bringing it to its boiling point at 100 °C (212 °F), is the oldest and most effective way since it eliminates most microbes causing intestine related diseases, but it cannot remove chemical toxins or impurities.

Project Proposed Steps

- Maximum water recovery

- To determine maximum water recovery there are various techniques that have been developed by researchers; for maximum water reuse/reclamation/recovery strategies such as water pinch analysis. The techniques help a user to target the minimum freshwater consumption and wastewater target. It also helps in designing the network that achieves the target.

Essential HC recovery equipment

1. Oil skimmers.
2. Oil Scrubbers.
3. Gas Scrubbers.
4. Secondary Separators.
5. Knock out drums.
6. Vertical Deaerators.

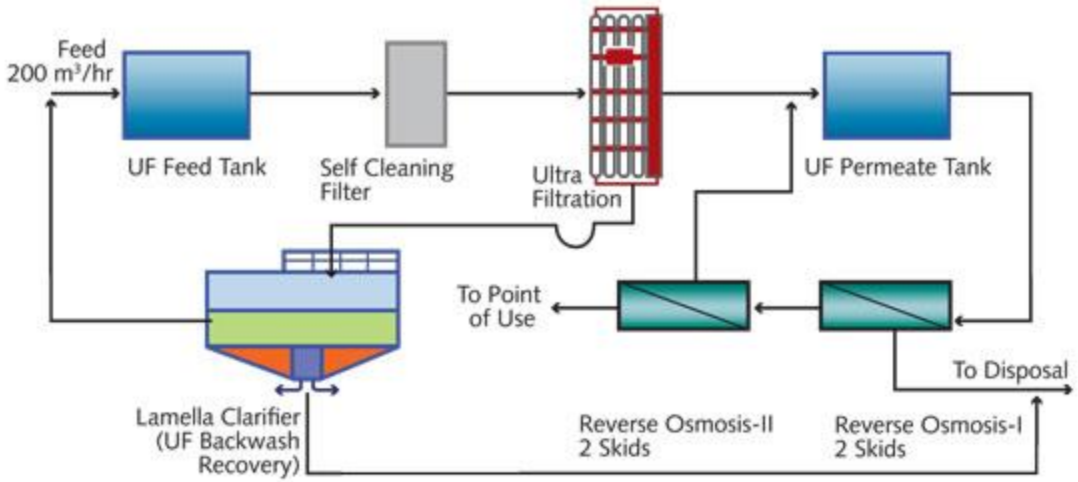
A closer look

- EQUATE Petrochemical Company in Kuwait, a manufacturer of ethylene, polyethylene and ethylene glycol, decided to explore the possibility of recycling treated wastewater for internal use in process requirements. To this end, the Kuwaiti firm signed a plant-based water recycle deal with Aquatech to develop and pilot a solution as part of a full-scale wastewater recycle project.
- The goal of the project – part of the EQUATE Green Initiative – is to reduce water consumption and decrease the carbon emission associated with purifying water by recycling and reusing treated wastewater for internal use in process requirements to the maximum possible extent.
- The project involves treating multiple waste streams contaminants such as oil and grease, volatile organic compounds and high dissolved solids levels with potentially high variation in constituents from the facility to maximum recovery. Since the quality requirements of process water are very stringent, EQUATE wanted to thoroughly examine the concept of reusing the treated wastewater before implementing the full-scale project, and therefore, the project involved piloting.

Facilities Network

- The facilities network should be similar to the following:

Figure 1. Process flow diagram



Water composition in a similar plant

The design analysis of the composite stream mixed in proportions is stated in Table 1 below:

Constituent/ Parameter	Unit	Design Basis	Expected Outlet Quality
Flow	m3/hr	200	160
pH		6.5-8.5	6.5-8.5
BOD	mg/l	30	<1
COD	mg/l	200	<3
Oil/Grease	mg/l	10	0
TSS	mg/l	10	0
TDS	mg/l	5000	65
Phosphate	mg/l	2	0
Ammonia	mg/l	5.5	<1
Nitrate NO3	mg/l	30	<5
TKN	mg/l	5	0
Total Nitrogen	mg/l	35	<6
Fluorides	mg/l	2	<0.02
Sulfides	mg/l	0.5	Traces
Chlorine	mg/l	0.5	0.5
Dissolved Oxygen	mg/l	>2	n/a
Turbidity		50	Traces
Aluminum	mg/l	5	0
Arsenic	mg/l	0.1	0
Barium	mg/l	0.1	0
Boron	mg/l	0.75	< 0.3
Beryllium	mg/l	0.1	0
Cyanides	mg/l	0.1	0
Cadmium	mg/l	0.01	0
Chromium	mg/l	0.2	0
Nickel	mg/l	0.2	0
Mercury	mg/l	0.001	0
Cobalt	mg/l	0.2	0
Iron	mg/l	5	0.1
Antimony	mg/l	1	0
Copper	mg/l	0.2	0
Manganese	mg/l	0.2	0
Zinc	mg/l	2	0
Lead	mg/l	0.5	0
Lithium	mg/l	2.5	Traces

Table 1: Design Water Analysis

Equate measurements

The process scheme

- An innovative scheme was designed to achieve maximum recovery of high quality water from a wastewater stream of 880 GPM (200 m^3/hr). The actual plant would recover 160 m^3/hr for reuse. This system combines membrane-based technologies to remove suspended, biological and inorganic impurities from the treated wastewater to make it fit for use in the process. It is designed to accommodate a wide range of operating parameters like flow, TDS and temperature without affecting the final treated water quality. This system also has an associated lamella-based unit to ensure further recovery of reusable water from some of the waste streams being generated from the plant. The scheme was expected to deliver: more than 80% recovery across Pass I; more than 90% recovery across Pass II and overall more than 80 % recovery. However, this design has to prove it could deliver the estimated recovery and quality treating wastewater onsite.

Process Elements

- **Feed Tank:** The treated effluent from the effluent treatment plant is collected in a feed tank before being fed to the downstream recycle plant.
- **Ultrafiltration:** Feed water from the feed tank shall be filtered for removal of suspended matter to < 3.0 SDI. This is also used to reduce organics and COD. Ultrafiltration membranes were supplied by QUA.
- **UF Backwash Recovery:** The backwash waste produced in the UF system is treated in an inline lamella system in order to maximize recovery of the system by avoiding any waste disposal from the UF system. Clear water from the lamella is taken back to the feed tank for further recovery.
- **RO Block:** The above water is then preconditioned and passed through cartridge filters, which act as a safeguard against media breakthrough from the preceding units, followed by the reverse osmosis equipment using RO membranes supplied by Dow. This system operates at very high efficiency in terms of recovery – i.e., about 80 - 85%. It removes the dissolved impurities from the stream and produces a permeate stream of lower TDS and a reject stream of higher TDS.
- Permeate is taken to the second pass RO for improvement in quality in terms of desired organics level and conductivity requirements. This permeate is used for the main process requirement.

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