
QWi
WATER IS OUR CONCERN
Produced Water Society
Middle East
PRODUCED WATER
MIDDLE EAST 2019
23 - 24 October, 2019
Sheraton Oman Hotel | Muscat, Oman
www.producedwatermiddleeast.com

Produced Water and Waste Streams Utilization

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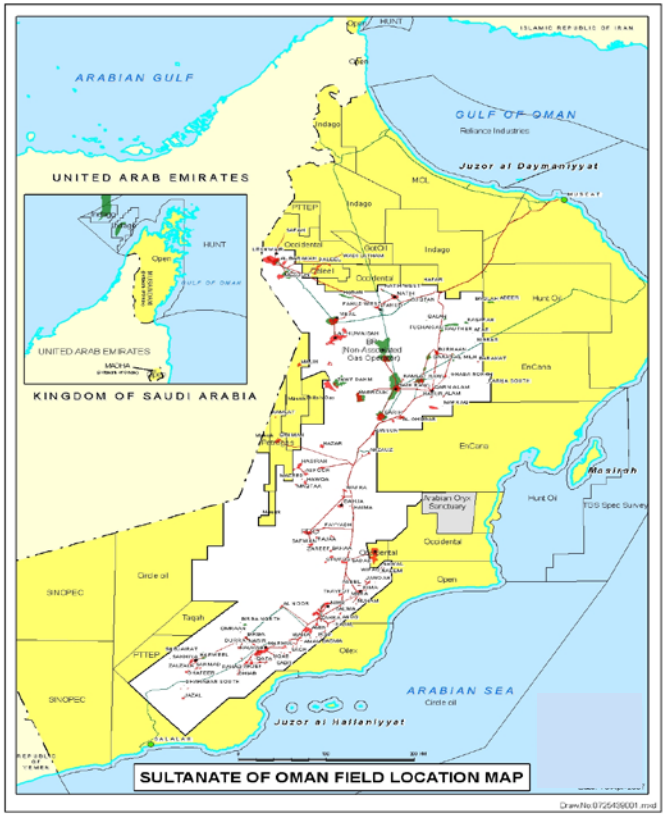
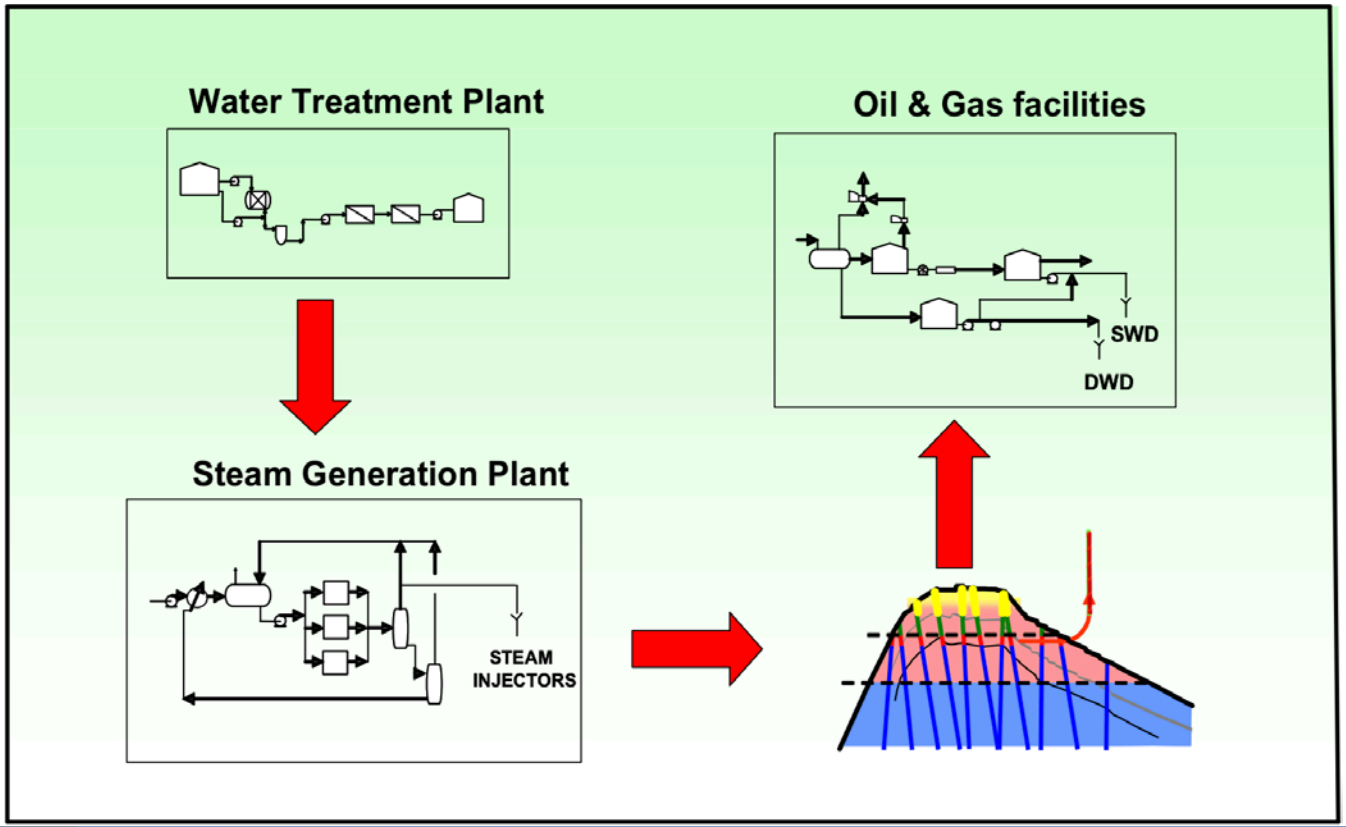
PDO

Overview of PDO

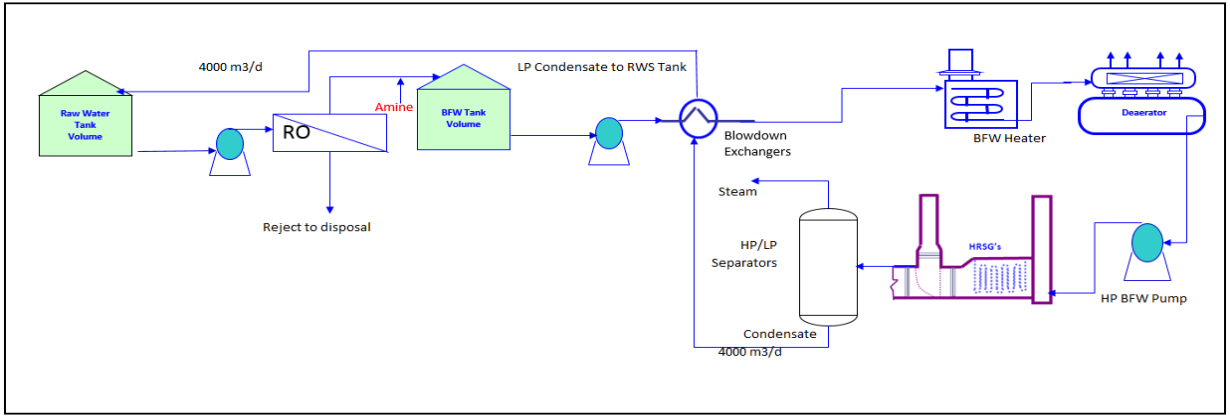
- Petroleum Development Oman (PDO) is the leading exploration and production company in the Sultanate of Oman
- PDO delivers the majority of the country's crude oil production and natural gas supply
- Production of produced water is increasing along with oil production
  - ✓ Current ratio is 9 bbl Produced Water (PW) / bbl Oil
- PDO has different configurations of PW treatments to meet specifications for WI/DWD/other re-uses



Facility Overview



Design Case Operation and Problem Statement



Previous Case:

- Low Pressure Steam Condensate was recycled to Raw Water tank.

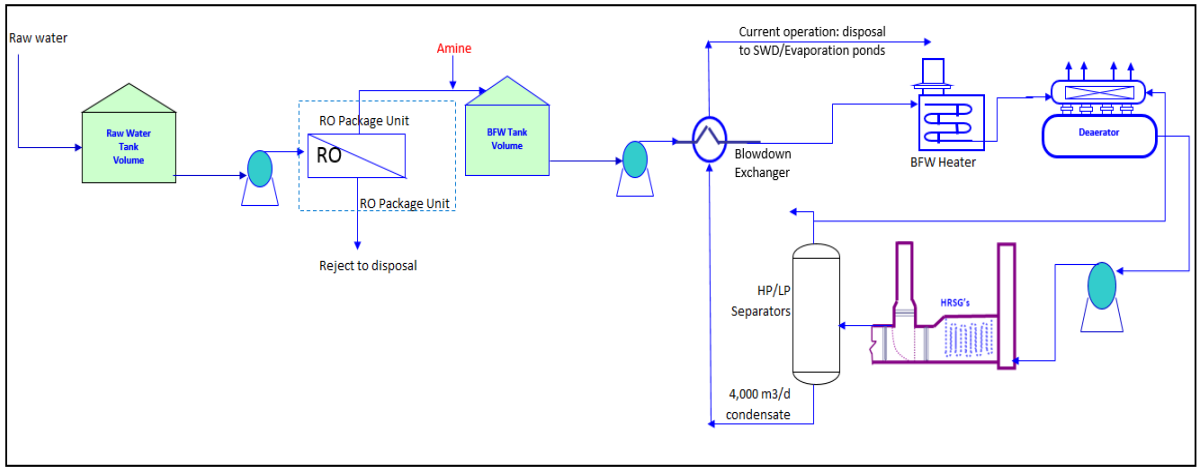
Modification:

- The HRSG tubes failure issue recommended that caustic injection is to be replaced by neutralizing Amine chemical.

Problems Experienced:

- Process upsets such as high SDI and biomass formation (Amines are nutrients for bacteria).
- Increased frequency of MMF backwash cycle leading to more water consumption.
- Increased frequency of cartridge filters replacement.
- Increased frequency of RO membranes Cleaning In Place.

Post Problem Operation



To mitigate the biomass formation issues, LP condensate was diverted to blowdown for disposal, (waste of 4000 m3/d of LP condensate ~ 6700m3/d of aquifer water).

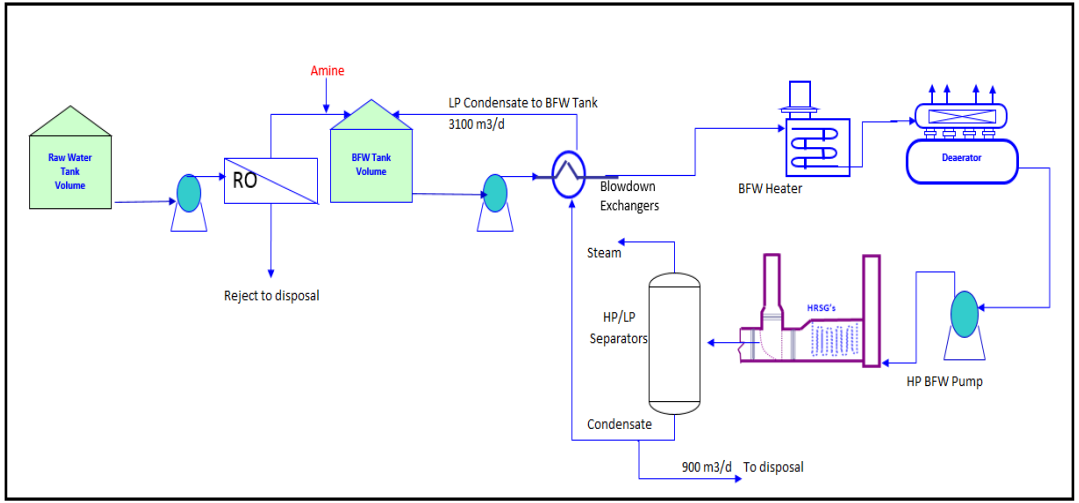
- A study was conducted and optimum solution proposed to route LP condensate to BFW
  - With water treatment.
  - Without water treatment.

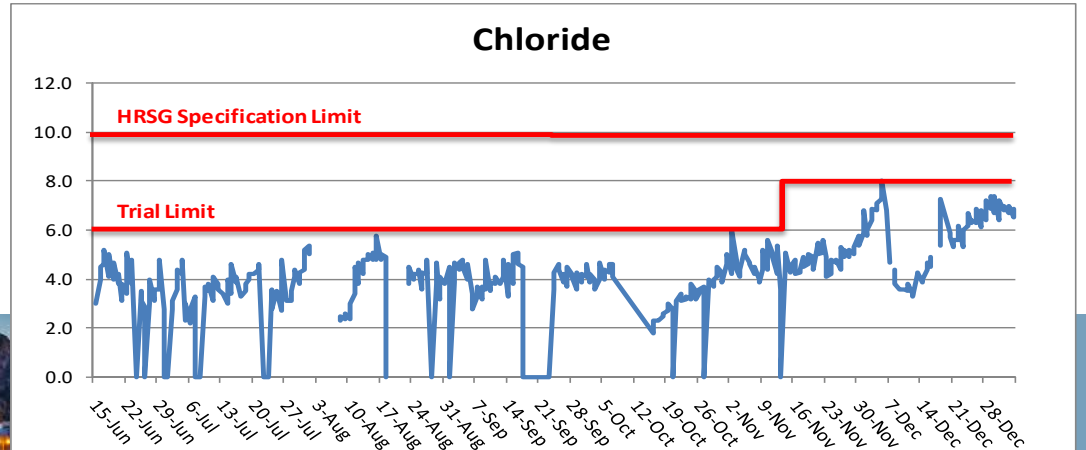
Solution

	Unit	HRSG BFW specification	LP Condensate water analysis	Permeate to BFW tank analysis (current analysis)
pH		9 - 10	9.4	8.58
Conductivity	µS/cm	750	42	18.45
Silica	mg/l	0.7	0.042	0.01
Total Iron	mg/l	<0.1	0.001	-
Total Chloride	mg/l	<10	3.8	2.7
Total Hardness	mg/l	<1	0.32	0.18

- LP condensate specification is well below the HRSG specification.
- Typical LP condensate concentration is 3-5 times the concentration of the boiler feed water.
- Its acceptable to re-route the LP condensate to the BFW tank without treatment.
- Optimum LP condensate recycle rate calculated is 75% to avoid HRSG integrity issues.
- Governing element is the chloride.

Conclusion





- Proposed and conducted a 6 months trail.
- Trail results were positive (water within the specs) for the selected duration.
- Concluded total success, and implemented continuously.
- PDO always striving to make effective use of the water and protect the aquifers water for the future generation.

Re-use of 4,000 m3/d reflects:

✓ **Additional 4,000 ton/d of steam generation**

✓ **8,000 m3/d of Aquifer savings**

✓ **Water for 16,000 people**


Thank you
Questions?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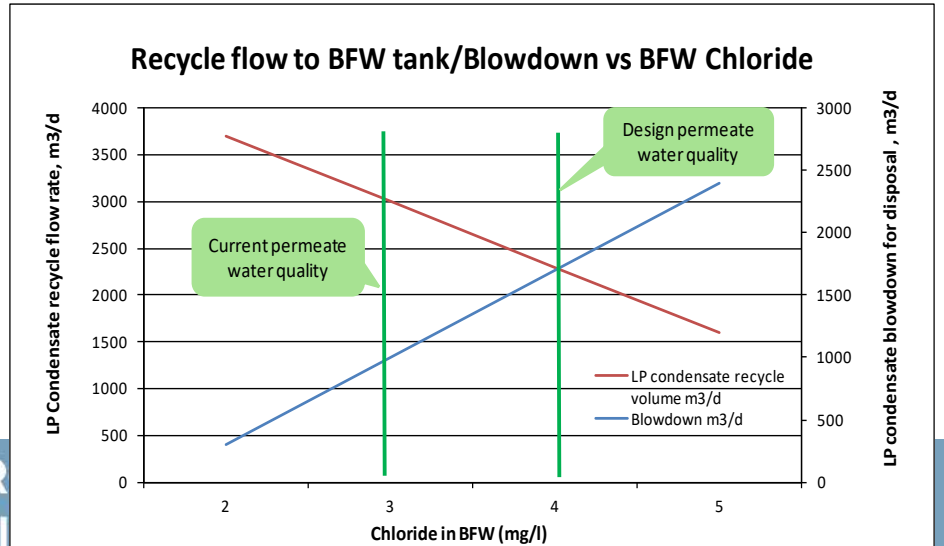
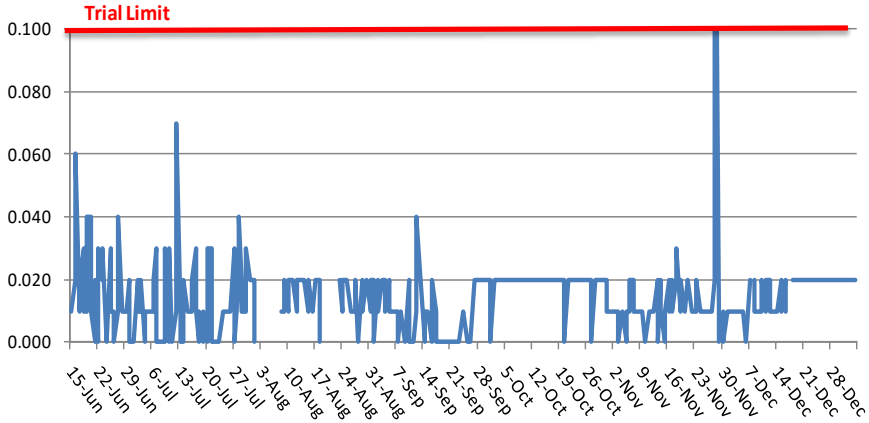
Back up

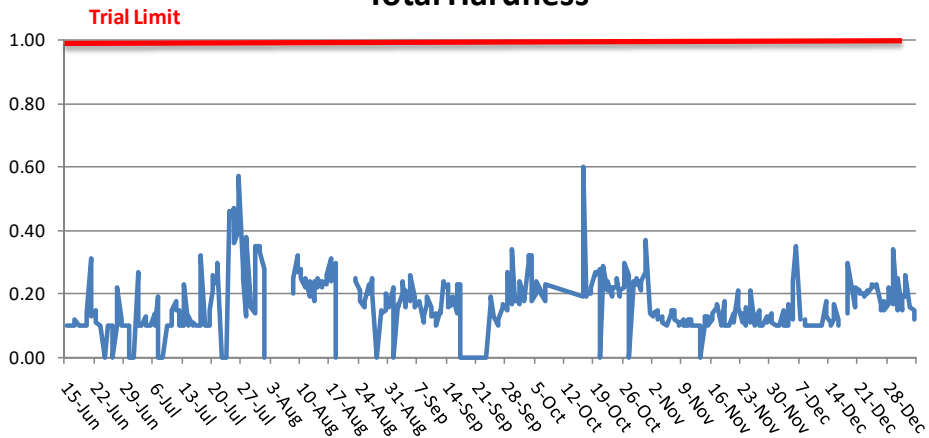
Chloride (mg/l) in RO permeate water (inlet to BFW tank)	LP condensate Recycle Volume to BFW tank (m3/day)	LP condensate Blowdown to disposal (m3/d)	BFW tank Chloride (after mixing with LP condensate) (mg/l)
2	3700 (93%)	300	<7.0
3 (current operation of WTP)	3000 (75%)	1000	<7.0
4 (design of WTP)	2300 (58%)	1700	<7.0
5	1600 (40%)	2400	<7.0



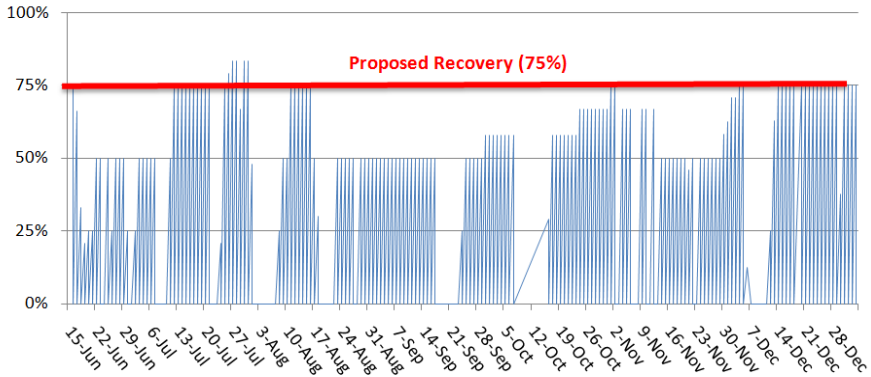
Total Iron



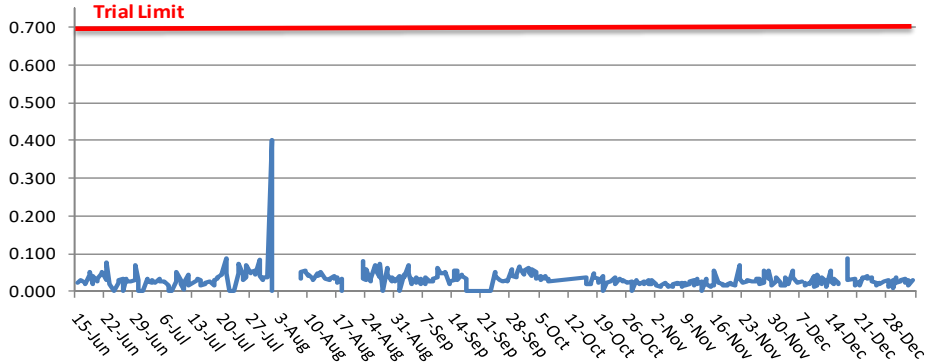
Total Hardness

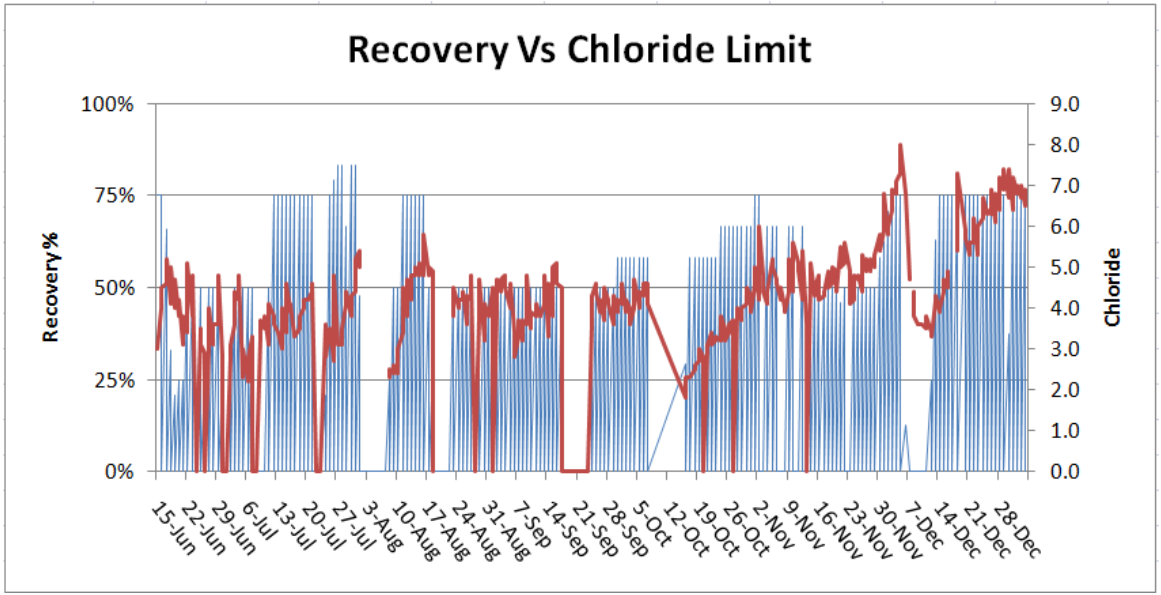


% Recovery



Silica




Recovery Vs Chloride Limit
Recovery %
100%
75%
50%
25%
0%
Chloride
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
15-Jun
22-Jun
29-Jun
6-Jul
13-Jul
20-Jul
27-Jul
3-Aug
10-Aug
17-Aug
24-Aug
31-Aug
7-Sep
14-Sep
21-Sep
28-Sep
5-Oct
12-Oct
19-Oct
26-Oct
2-Nov
9-Nov
16-Nov
23-Nov
30-Nov
7-Dec
14-Dec
21-Dec
28-Dec

Chloride Operating case	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
RO discharge water (m3/d)	20300	20300	20300	20300	20300	20300	20300	20300
Ro discharge water chloride (PPM)	3	3	3	3	3	3	3	3
LP condensate (m3/d)	4000	4000	4000	4000	4000	4000	4000	4000
LP condensate (ppm) Chloride	15	24.87654	33.005	39.69579	45.2023	49.7344	53.46453	56.53459
	100%							
Mixing water BFW tank; ppm	4.9753	6.601077	7.9392	9.040459	9.94688	10.69291	11.30692	11.81228

Exceeding HRSG spec 10mg/l

Chloride Operating case	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	
RO discharge water (m3/d)	21300	21300	21300	21300	21300	21300	21300	21300	21300	21300	21300	21300	21300		
Ro discharge water chloride (PPM)	3	3	3	3	3	3	3	3	3	3	3	3			
LP condensate (m3/d)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000			
LP condensate (ppm) Chloride	15	22.40741	26.98	29.8024	31.54469	32.62018	33.28406	33.69386	33.94683	34.10298	34.19937				
	75%														
Mixing water BFW tank; ppm	4.4815	5.395976	5.9605	6.308938	6.524036	6.656812	6.738773	6.789366	6.820596	6.839874	6.851774	6.85912	6.863654	6.866453	6.868181

With 75% recycle Chloride levels maintained <10mg/l

- Based on the theoretical calculations, it is recommended that 75% condensate recycle to the Boiler Feed Water Tank considering the RO permeate chloride level of 3 ppm.
- This will result in a slightly higher chloride level of 7 ppm.