

## **APPENDIX V: Water Treatment Modeling**

# Technical Memo



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**Date:** May 2, 2017  
**To:** Tintina Resources, Inc.  
**From:** Bob Kimball, Amec Foster Wheeler  
**Subject:** Water Treatment Plant Modeling for Black Butte Copper Project

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This appendix provides a summary of the mass balance modeling results for the water treatment system for the Black Butte Copper Project. This includes:

**Appendix V-1. Site Wide Mass Balance:** Amec Foster Wheeler used an iterative spreadsheet-based model to conduct a site-wide material balance around the entire mine water circuit. Figure V-1 shows the flow diagram for the water circuit and Table V-1 shows a summary of the flows and chemistry of each stream in the circuit. The numbers on the figure refer to the stream numbers in the Table V-1. Using all known inputs of flow and water chemistry, the model predicts the flow and water quality resulting from specific unit operations and treatment steps, such as mixing of different streams, pH adjustment and water treatment. Recycle streams are also included, which causes the model to be iterative. The model uses chemical equilibrium equations and constants to complete water chemistry calculations for each stream in the model. A key requirement for accurately estimating the resultant water chemistry is to begin with a complete and electrically balanced feed water. Minor adjustments to balance the water were made by adding calcium or sulfate ions when necessary to complete the charge balance of the water. The calculations utilize appropriate activity coefficients, pK values, ionization fractions, solubility constants, and appropriate temperature corrections. All calculations are made using a Microsoft® EXCEL-based spreadsheet.

The mass balance around the PWP was then checked using the PHREEQC (pH-REdox- EQUilibrium-C {computer language}) model and found to be very similar with only minor differences. The differences are largely the result of the iterative nature of the calculations. PHREEQC (Parkhurst and Appelo, 1999) is a thermodynamic equilibrium program designed to model chemical speciation in aqueous solutions, determine the saturation states of solutions with minerals and gases, and predict the results of various reactions, such as dissolution of minerals and oxidation.

**Appendix V-2. Water Treatment Plant Mass Balance:** Amec Foster Wheeler used the same iterative spreadsheet-based model described above to prepare a detailed mass balance model for the water treatment plant. Figure V-2 shows the flow diagram for the water treatment process and Table V-2 shows a summary of the flows and chemistry of each stream in the water treatment system. Please note that the numbers on the figure refer to the stream numbers in the Table V-2.

**Appendix V-3. RO and Antiscalant Vendor Software Projections:** Using the feed water chemistry to the RO system from Table V-2, RO vendor software from Dow Process and Water Solutions was used to evaluate and model the full-scale design of a two-pass RO system. This was conducted for a single skid

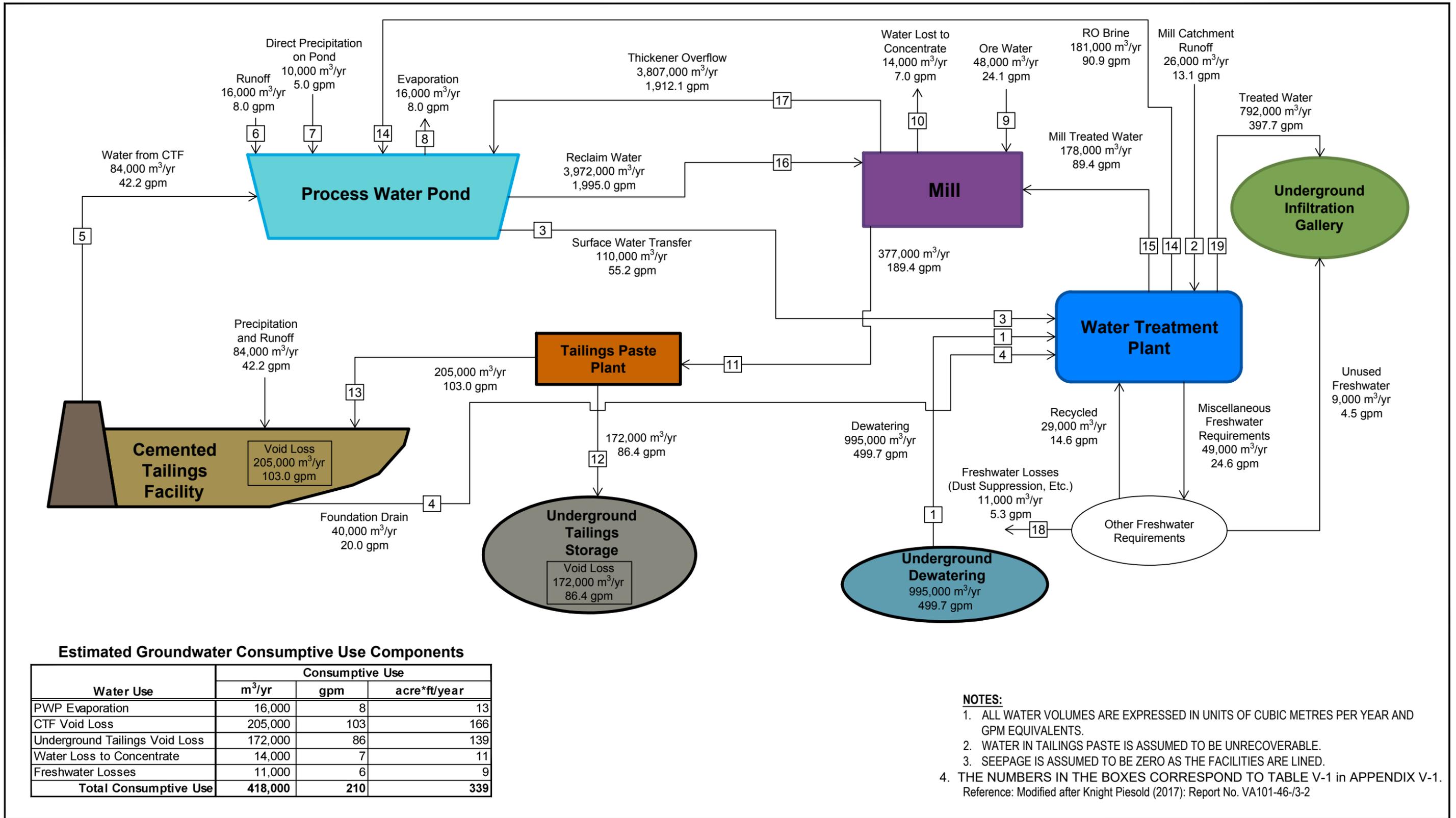
at both 10 Deg C and 25 Deg C to calculate the anticipated operating pressures, fluxes, brine water quality and effluent water quality produced by the RO system. The selected membrane and overall configuration was selected and optimized to achieve all discharge limits, especially for total nitrogen. In addition, vendor software from Avista Chemical was used to evaluate various antiscalants for use in the RO system to minimize/prevent membrane scaling. The software uses the feed water chemistry and RO configuration to predict the type of dosage of antiscalant required to ensure that sparingly soluble salts do not exceed their solubility limits. This analysis was conducted at the two operating temperatures. The results of this analysis show that a small dose of Vitec 3000 will prevent salts from precipitating in the membrane system.

**Appendix V-4. VSEP Vendor Software Projections:** VSEP software was used to perform a similar evaluation on RO concentrate. The results of vendor software in this section shows the design configuration, operating pressure, and water quality of the final brine concentrate and treated effluent.

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**APPENDIX V-1**

Overall Site Material Balance



Prepared by Tetra Tech Inc. (March 2017)

FIGURE V-1  
**Annual Water Balance Schematic for Mean Case - Year 6**  
**Black Butte Copper Project**  
Meagher County, Montana

**Table V-1**  
**Site Wide Mass Balance**

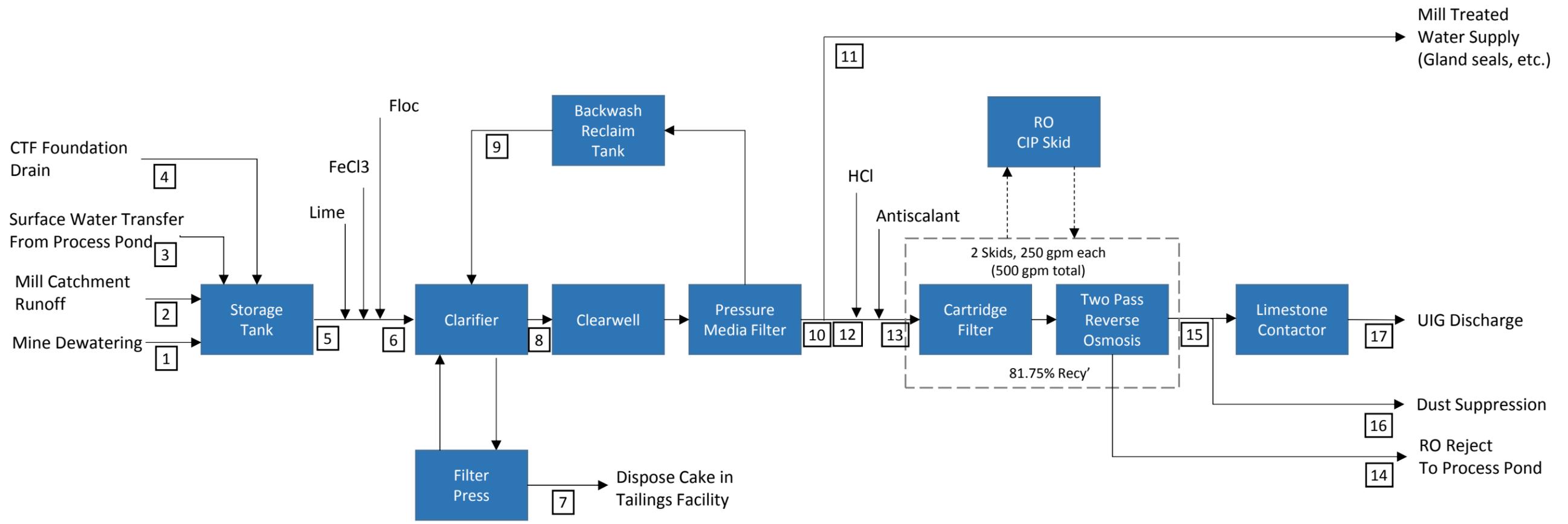
Stream ID (See Figure V-1)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Description	Underground Dewatering	Mill Catchment Runoff	Surface Water Transfer	CTF Foundation Drain	Water From CTF to PWP	Runoff to PWP	Direct Precip	PWP Evap	Ore Water to Mill	Water Loss to Conc	Cement/Paste Void Loss	Underground Tailings Storage	Cement Tailings	RO Brine Conc.	Mill Treated Water	Reclaim Water to Mill	Mill Thickener OF to PWP	Dust Suppression	Treated Water Discharge (combined)
<b>Flow, gpm</b>	<b>499.7</b>	<b>13.1</b>	<b>55.2</b>	<b>20.0</b>	<b>42.2</b>	<b>8.0</b>	<b>5.0</b>	<b>7.0</b>	<b>24.1</b>	<b>7.0</b>	<b>189.4</b>	<b>86.4</b>	<b>103.0</b>	<b>90.8</b>	<b>89.4</b>	<b>1,995.8</b>	<b>1,912.9</b>	<b>5.3</b>	<b>402.3</b>
lb/min	4,170.78	109.33	461.3	166.8	352.4	66.7	41.7	58.5	201.2	58.5	1,582.5	1,582.5	1,582.5	761.4	746.3	16,678.6	15,982.9	44.2	3,355.5
Specific Gravity	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.0	1.01	1.00	1.00	1.00	1.00	1.00
Temperature, Deg C	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.0	25.0	25.00	25.00	25.00	25.00	25.00	25.00
<b>Commons</b>																			
pH	6.7	7.1	6.0	7.4	4.1	7.0	7.0	6.0	6.7	10.4	10.4	10.4	10.4	6.7	8.4	6.0	10.4	5.9	8.1
Total Alkalinity	183.0	218.0	120.7	212.0	97.0	25.0	-	120.7	183.0	76.7	76.7	76.7	76.7	1,066.7	252.9	120.7	76.7	0.20	100.23
Nitrogen, Ammonia	4.40	-	11.40	-	-	-	-	11.40	4.40	11.04	11.04	11.04	11.04	25.83	4.81	11.40	11.04	0.10	0.10
Nitrogen, Nitrate	33.0	0.0	86.8	0.2	-	-	-	86.8	33.0	84.0	84.0	84.0	84.0	197.6	36.2	86.8	84.0	0.22	0.22
Silica	1.55	-	0.38	-	2.45	-	-	0.38	1.55	-	-	-	-	7.39	1.35	0.38	<0.001	<0.001	<0.001
Phosphorus	0.00	-	0.06	-	0.26	-	-	0.06	0.00	0.06	0.06	0.06	0.06	0.04	0.0	0.1	0.1	0.00	0.00
<b>Anions</b>																			
Bicarbonate	223	266	147	258	118	30	-	147	223	4	3.6	3.6	3.6	1,299.1	293	147	4	0	120
Carbonate	0.08	0.22	0.01	0.41	0.00	0.02	-	0.01	0.08	8.44	8.44	8.44	8.44	0.85	5.9	0.0	8.4	0.00	0.87
Chloride	1.38	1.28	135.59	-	34.30	-	-	135.59	1.38	129.15	129.15	129.15	129.15	337.43	20	136	129	0.01	0.01
Fluoride	1.14	0.70	0.52	0.10	0.66	-	-	0.52	1.14	0.28	0.3	0.3	0.3	5.7	1.0	0.5	0.3	<0.001	<0.001
Nitrate	146	0.09	384.2	0.66	-	-	-	384.2	146.1	372.0	372.00	372.00	372.00	875.17	160.3	384.2	372.0	0.98	0.98
Sulfate	304	265	904	12	765	5	-	904	304	865	864.90	864.90	864.90	1,917.88	350	904	865	<0.001	<0.001
<b>Cations</b>																			
Calcium	89	85	521	59	132	-	-	521	89	516	515.58	515.58	515.58	887.48	162	521	516	0.08	40.18
Magnesium	79	55	19	18	92	-	-	19	79	0.01	0.01	0.01	0.01	389.19	71	19	0.01	0.04	0.04
Potassium	11	3	29	-	-	-	-	29	11	28	28.17	28.17	28.17	66.29	12	29	28	0.08	0.08
Sodium	15	16	43	2	13	14	-	43	15	42	41.89	41.89	41.89	92.84	17	43	42	0.08	0.08
Ammonium	5.64	-	14.65	-	-	-	-	14.65	5.64	0.87	0.87	0.87	0.87	33.10	5.38	14.65	0.87	0.13	0.13
Aluminum	0.012	-	0.374	-	17.700	-	-	0.374	0.012	0.001	0.001	0.001	0.001	0.249	0.045	0.374	0.001	<0.001	<0.001
Arsenic	0.004	0.067	0.045	-	0.031	-	-	0.045	0.004	0.045	0.045	0.045	0.045	0.050	0.009	0.045	0.045	<0.001	<0.001
Barium	0.001	0.011	0.004	0.050	0.004	-	-	0.004	0.001	0.003	0.003	0.003	0.003	0.018	0.003	0.004	0.003	<0.001	<0.001
Cadmium	-	-	0.000	-	0.001	-	-	0.000	-	-	-	-	-	0.000	0.000	0.000	-	<0.001	<0.001
Chromium	-	-	0.004	-	0.012	-	-	0.004	-	0.004	0.004	0.004	0.004	0.002	0.000	0.004	0.004	<0.001	<0.001
Copper	-	-	4.003	-	61.300	-	-	4.003	-	2.930	2.930	2.930	2.930	0.549	0.100	4.003	2.930	<0.001	<0.001
Iron (+2)	0.002	1.130	0.000	-	-	-	-	0.000	0.002	-	-	-	-	0.005	0.001	0.000	-	<0.001	<0.001
Iron (+3)	-	-	0.014	-	0.636	-	-	0.014	-	-	-	-	-	0.027	0.005	0.014	-	<0.001	<0.001
Lead	-	-	0.092	-	0.027	-	-	0.092	-	0.096	0.096	0.096	0.096	0.048	0.009	0.092	0.096	<0.001	<0.001
Manganese	0.165	0.025	0.093	-	2.730	-	-	0.093	0.165	0.001	0.001	0.001	0.001	0.820	0.150	0.093	0.001	<0.001	<0.001
Nickel	0.007	0.001	0.195	-	8.500	-	-	0.195	0.007	0.016	0.016	0.016	0.016	0.133	0.024	0.195	0.016	<0.001	<0.001
Strontium	10.500	14.500	4.247	0.140	2.620	-	-	4.247	10.500	2.000	2.000	2.000	2.000	52.905	9.650	4.247	2.000	0.010	0.010
Zinc	0.030	0.010	0.259	-	0.826	-	-	0.259	0.030	0.248	0.248	0.248	0.248	0.275	0.050	0.259	0.248	<0.001	<0.001
<b>Gases</b>																			
Ammonia	0	-	0.01	-	-	-	-	0.01	0.01	12.59	12.59	12.6	12.6	0.11	0.76	0.01	12.59	0.00	0.01
Carbon Dioxide	60	30	170	14	10,421	5	-	170	60	0	0	0.0	0.0	247	1	170	0	1	1
<b>Other</b>																			
TSS	150	10	7	26	150	150	-	7	-	4	4	4.0	4.0	1	0	7	4	<0.001	<0.001
TDS (sum of ions)	889	708	2,209	350	1,258	49	-	2,209	889	1,979	1,979	1,978.7	1,978.7	5,973	1,110	2,209	1,979	1.7	163
TDS (180 Deg C)	777	575	2,136	221	1,199	34	-	2,136	777	1,977	1,977	1,976.9	1,976.9	5,323	963	2,136	1,977	1.6	103
Total Hardness, mg/L CaCO3	560.3	458.6	1,382.5	220.7	715.7	-	-	1,382.5	560.3	1,288.1	1,288.1	1,288.1	1,288.1	3,876.7	706.8	1,382.5	1,288.1	0.4	100.4
<b>Scaling Indices</b>																			
Langelier Saturation Index	(0.7)	(0.2)	(0.9)	0.0	(3.4)	-	-	(0.9)	(0.7)	1.9	1.9	1.9	1.9	0.9	1.4	(0.9)	1.9	(7.1)	0.3

All values in mg/L, unless noted otherwise

**APPENDIX V-2**

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Water Treatment Plant Material Balance (Operational Phase)



**Figure V-2**  
**Water Treatment Operational Phase Flow Diagram**  
**Black Butte Copper Project**  
**Meagher County, Montana**

**Table V-2  
Water Treatment Plant Mass Balance**

Stream ID (See Figure V-2)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Description	Underground Dewatering	Mill Catchment Runoff	Surface Water Transfer	CTF Foundation Drain	Combined WTP Feed	Clarifier Feed	Filter Press Cake	Clarifier Overflow	Sand Filter Backwash	Sand Filter Effluent	Mill Treated Water	Filtered Effluent to RO	RO Feed Water	RO Brine Conc.	Treated Effluent (RO Perm)	Dust Suppression	Treated Water Discharge (combined)
<b>Flow, gpm</b>	<b>499.7</b>	<b>13.1</b>	<b>55.2</b>	<b>20.0</b>	<b>588.0</b>	<b>588.0</b>	<b>0.15</b>	<b>587.7</b>	<b>21.8</b>	<b>587.7</b>	<b>89.4</b>	<b>498.3</b>	<b>498.4</b>	<b>90.8</b>	<b>407.4</b>	<b>5.3</b>	<b>402.3</b>
lb/min	4,170.78	109.33	461.3	166.8	4,908.2	4,908.7	1.5	4,906.5	182.2	4,906.5	746.3	4,160.1	4,160.6	761.4	3,398.0	44.2	3,355.5
Specific Gravity	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00
Temperature, Deg C	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
<b>Commons</b>																	
pH	6.7	7.1	6.0	7.4	6.6	8.4	8.4	8.4	8.4	8.4	8.4	8.4	6.8	6.7	5.9	5.9	8.1
Total Alkalinity	183.0	218.0	120.7	212.0	178.9	262.1	252.9	252.9	252.9	252.9	252.9	252.9	194.6	1,066.7	0.2	0.2	100.2
Nitrogen, Ammonia	4.40	-	11.40	-	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81	25.83	0.12	0.10	0.10
Nitrogen, Nitrate	33.0	0.0	86.8	0.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	197.6	0.22	0.22	0.22
Silica	1.55	-	0.38	-	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	7.39	<0.001	<0.001	<0.001
Phosphorus	0.00	-	0.06	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	<0.001	0.00	0.00
<b>Anions</b>																	
Bicarbonate	223	266	147	258	218	304	293	293	293	293	293	293	237	1,299	1.2	0.3	120.4
Carbonate	0.08	0.22	0.01	0.41	0.07	6.09	5.87	5.87	5.87	5.87	5.87	5.87	0.12	0.85	0.00	0.00	0.87
Chloride	1.38	1.28	135.59	-	13.93	20.49	20.49	20.49	20.16	20.16	20.16	20.16	61.49	337.43	0.01	0.01	0.01
Fluoride	1.14	0.70	0.52	0.10	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	5.69	<0.001	<0.001	<0.001
Nitrate	146	0.09	384.2	0.66	160.3	160.3	160.3	160.3	160.3	160.3	160.3	160.3	160.3	875.2	0.98	0.98	0.98
Sulfate	304	265	904	12	350	350	350	350	350	350	350	350	349	1,918	-	-	-
<b>Cations</b>																	
Calcium	89	85	521	59	128	162	162	162	162	162	162	162	162	887	0.08	0.08	40.18
Magnesium	79	55	19	18	71	71	71	71	71	71	71	71	71	389	0.04	0.04	0.04
Potassium	11	3	29	-	12	12	12	12	12	12	12	12	12	66	0.08	0.08	0.08
Sodium	15	16	43	2.0	17	17	17	17	17	17	17	17	17	93	0.08	0.08	0.08
Ammonium	5.64	-	14.65	-	6.17	5.38	5.38	5.38	5.38	5.38	5.38	5.38	6.16	33.10	0.13	0.13	0.13
Aluminum	0.012	-	0.374	-	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.249	<0.001	<0.001	<0.001
Arsenic	0.004	0.067	0.045	-	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.050	<0.001	<0.001	<0.001
Barium	0.001	0.011	0.004	0.050	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.018	<0.001	<0.001	<0.001
Cadmium	-	-	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	<0.001	<0.001	<0.001
Chromium	-	-	0.004	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	<0.001	<0.001	<0.001
Copper	-	-	4.003	-	0.376	0.376	1,090	0.100	0.100	0.100	0.100	0.100	0.100	0.549	<0.001	<0.001	<0.001
Iron (+2)	0.002	1.130	0.000	-	0.027	0.027	101	0.001	0.001	0.001	0.001	0.001	0.001	0.005	<0.001	<0.001	<0.001
Iron (+3)	-	-	0.014	-	0.001	3.438	13,567	0.005	0.005	0.005	0.005	0.005	0.005	0.027	<0.001	<0.001	<0.001
Lead	-	-	0.092	-	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.048	<0.001	<0.001	<0.001
Manganese	0.165	0.025	0.093	-	0.149	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.149	0.820	<0.001	<0.001	<0.001
Nickel	0.007	0.001	0.195	-	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.133	<0.001	<0.001	<0.001
Strontium	10.500	14.500	4.247	0.140	9.650	9.650	9.650	9.650	9.650	9.650	9.650	9.650	9.649	52.905	0.010	0.010	0.010
Zinc	0.030	0.010	0.259	-	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.275	<0.001	<0.001	<0.001
<b>Gases</b>																	
Ammonia	0	-	0.01	-	0.01	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.02	0.11	0.00	0.00	0.01
Carbon Dioxide	60	30	170	14	68	1	1	1	1	1	1	1	46	247	1	1	1
<b>Other</b>																	
TSS	150	10	7	26	129	129	477,899	15	400	0.1	0.1	0.1	0.0	0.8	<0.001	<0.001	<0.001
TDS (sum of ions)	889	708	2,209	350	990	1,127	1,110	1,110	1,110	1,110	1,110	1,110	1,090	5,973	2.6	1.7	163
TDS (180 Deg C)	777	575	2,136	221	881	975	964	964	963	963	963	963	971	5,323	2.0	1.6	103
Total Hardness, mg/L CaCO3	560.3	458.6	1,382.5	220.7	623.6	706.9	706.8	706.8	706.8	706.8	706.8	706.8	706.7	3,876.7	0.4	0.4	100.4
<b>Scaling Indices</b>																	
Langelier Saturation Index	(0.7)	(0.2)	(0.9)	0.0	(0.6)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	(0.3)	0.9	(7.1)	(7.1)	0.3

All values in mg/L, unless noted otherwise

**APPENDIX V-3**

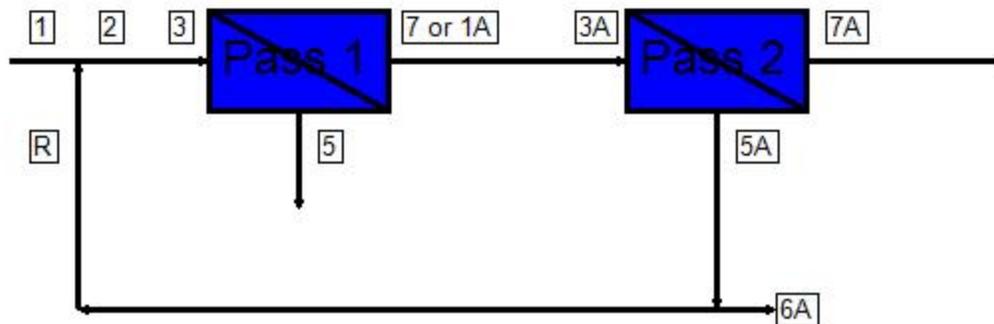
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Reverse Osmosis and Antiscalant Model Outputs (Operational Phase)

Project: Tintina Reject to Pond rev22  
 Prepared By:

ROSA 9.1 ConfigDB u399339\_282  
 Case: 1  
 9/15/2015

### System Design Overview



Raw Water TDS	1088.19 mg/l	% System Recovery (7A/1)	81.84 %
Water Classification	Surface Supply SDI < 5	Flow Factor (Pass 1)	0.85
Feed Temperature	25.0 C	Flow Factor (Pass 2)	0.85

Pass #	Pass 1			Pass 2	
	1	2	3	1	2
Stage #	1	2	3	1	2
Element Type	ECO-440i	ECO-440i	ECO-440i	ECO-440i	ECO-440i
Pressure Vessels per Stage	5	3	1	4	2
Elements per Pressure Vessel	6	6	6	6	6
Total Number of Elements	30	18	6	24	12
Pass Average Flux	14.70 gfd			18.57 gfd	
Stage Average Flux	15.53 gfd	14.49 gfd	11.14 gfd	19.52 gfd	16.67 gfd
Permeate Back Pressure	50.00 psig	30.00 psig	15.00 psig	15.00 psig	15.00 psig
Booster Pressure	0.00 psig	0.00 psig	0.00 psig	0.00 psig	0.00 psig
Chemical Dose	-			-	
Energy Consumption	1.54 kWh/kgal			1.12 kWh/kgal	

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Project: Tintina Reject to Pond rev22  
Prepared By:

ROSA 9.1 ConfigDB u399339\_282  
Case: 1  
9/15/2015

Pass 1				Pass 2			
Stream #	Flow (gpm)	Pressure (psig)	TDS (mg/l)	Stream #	Flow (gpm)	Pressure (psig)	TDS (mg/l)
1	249.62	0.00	1088.19	1A	242.49	-	16.36
2	287.81	0.00	0.00	3A	242.49	119.20	16.36
3	287.81	143.38	958.67	5A	38.19	86.45	94.36
5	44.58	88.18	6079.27	6A	1.60	0.00	0.00
7	242.49	-	16.36	7A	204.29	-	2.56
7/2	% Recovery	84.25		R	37.32	0.00	0.00
				7A/1A	% Recovery	84.25	

**Project Information:**

Tintina Black Cloud WTP

**Design Warnings:**

-- Pass 1

-None-

-- Pass 2

-None-

**Solubility Warnings:**

-- Pass 1

Langelier Saturation Index > 0

Stiff & Davis Stability Index > 0

CaSO4 (% Saturation) > 100%

SrSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

-- Pass 2

-None-

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

ROSA 9.1 ConfigDB u399339\_282

Project: Tintina Reject to Pond rev22

Case: 1

9/15/2015

**Project Information:** Tintina Black Cloud WTP

**Case-specific:** Temp = 25 C 50% Capacity x 2 81.75% Recovery Reject to Paste Plant

**System Details -- Pass 1**

Feed Flow to Stage 1	287.81 gpm	Pass 1 Permeate Flow	242.49 gpm	Osmotic Pressure:	
Raw Water Flow to System	249.62 gpm	Pass 1 Recovery	84.25 %	Feed	0.00 psig
Feed Pressure	143.38 psig	<b>Feed Temperature</b>	<b>25.0 C</b>	Concentrate	32.15 psig
Flow Factor	0.85	Feed TDS	0.00 mg/l	Average	16.08 psig
Chem. Dose	None	Number of Elements	54	Average NDP	109.37 psig
Total Active Area	23760.00 ft²	Average Pass 1 Flux	14.70 gfd	Power	22.38 kW
Water Classification: Surface Supply SDI < 5				Specific Energy	1.54 kWh/kgal
<b>System Recovery</b>	<b>81.84 %</b>			Conc. Flow from Pass 2	38.19 gpm

Stage	Element	#PV	#Ele	Feed Flow (gpm)	Feed Press (psig)	Recirc Flow (gpm)	Conc Flow (gpm)	Conc Press (psig)	Perm Flow (gpm)	Avg Flux (gfd)	Perm Press (psig)	Boost Press (psig)	Perm TDS (mg/l)
1	ECO-440i	5	6	287.81	138.38	0.00	144.71	125.40	142.36	15.53	50.00	0.00	7.60
2	ECO-440i	3	6	144.71	120.40	0.00	65.00	110.52	79.71	14.49	30.00	0.00	21.61
3	ECO-440i	1	6	65.00	105.52	0.00	44.58	88.18	20.42	11.14	15.00	0.00	58.38

Pass Streams (mg/l as Ion)										
Name	Feed	Adjusted Feed		Concentrate			Permeate			
		Initial	After Recycles	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Total
NH4+ + NH3	6.13	6.15	5.65	11.04	23.82	33.97	0.22	0.61	1.65	0.47
K	12.00	12.00	10.85	21.29	46.47	66.81	0.24	0.75	2.09	0.56
Na	17.00	17.00	15.31	30.07	65.80	94.78	0.30	0.93	2.53	0.70
Mg	71.00	71.00	62.28	123.26	273.29	397.34	0.29	0.91	2.49	0.68
Ca	162.00	162.00	142.08	281.21	623.55	906.62	0.65	2.04	5.61	1.52
Sr	9.65	9.65	8.46	16.75	37.14	54.00	0.04	0.12	0.33	0.09
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO3	0.16	0.16	0.12	0.56	3.46	8.16	0.00	0.00	0.00	0.00
HCO3	237.00	237.00	208.69	412.09	908.07	1312.76	2.04	4.34	10.98	3.43
NO3	160.10	160.10	144.59	283.75	619.85	891.63	3.13	9.67	26.56	7.25
Cl	61.00	61.00	53.39	105.74	234.71	341.49	0.18	0.57	1.61	0.43
F	1.00	1.00	0.88	1.74	3.85	5.60	0.00	0.01	0.04	0.01
SO4	349.75	349.75	305.15	604.83	1344.46	1958.29	0.52	1.66	4.49	1.23
SiO2	1.40	1.40	1.22	2.42	5.38	7.84	0.00	0.01	0.02	0.01
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	43.33	43.33	43.36	43.56	44.85	46.86	42.85	43.56	45.34	43.38
TDS	1088.19	1088.21	958.67	1894.74	4189.83	6079.27	7.60	21.61	58.38	16.36
pH	6.80	6.80	6.75	7.00	7.27	7.37	4.89	5.20	5.57	5.10

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Reverse Osmosis System Analysis for FILMTEC™ Membranes  
 Project: Tintina Reject to Pond rev22

ROSA 9.1 ConfigDB u399339\_282

Case: 1

9/15/2015

**Design Warnings -- Pass 1**

-None-

**Solubility Warnings -- Pass 1**

Langelier Saturation Index &gt; 0

Stiff &amp; Davis Stability Index &gt; 0

CaSO4 (% Saturation) &gt; 100%

SrSO4 (% Saturation) &gt; 100%

CaF2 (% Saturation) &gt; 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

**Stage Details -- Pass 1**

Stage 1 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.09	5.21	5.03	57.41	958.67	138.38
2	0.10	5.00	5.78	52.20	1053.95	135.45
3	0.10	4.81	6.71	47.20	1165.00	132.86
4	0.11	4.64	7.91	42.40	1296.35	130.57
5	0.12	4.48	9.48	37.76	1454.57	128.58
6	0.13	4.34	11.60	33.28	1649.21	126.86
Stage 2 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.11	5.13	11.78	48.24	1894.74	120.40
2	0.11	4.87	14.40	43.11	2118.80	118.06
3	0.12	4.60	17.93	38.23	2386.87	116.03
4	0.13	4.31	22.82	33.63	2710.93	114.28
5	0.14	4.00	29.71	29.32	3106.24	112.80
6	0.14	3.65	39.68	25.32	3591.85	111.55
Stage 3 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.06	4.11	39.60	65.00	4189.83	105.52
2	0.06	3.80	46.31	60.89	4469.75	102.04
3	0.06	3.52	54.14	57.08	4764.20	98.82
4	0.06	3.25	63.24	53.57	5072.92	95.85
5	0.06	2.99	73.82	50.32	5395.53	93.10
6	0.06	2.75	86.06	47.33	5731.27	90.55

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

ROSA 9.1 ConfigDB u399339\_282

Project: Tintina Reject to Pond rev22

Case: 1

9/15/2015

**Project Information:** Tintina Black Cloud WTP

**Case-specific:** Temp = 25 C 50% Capacity x 2 81.75% Recovery Reject to Paste Plant

**System Details -- Pass 2**

Feed Flow to Stage 1	242.49 gpm	Pass 2 Permeate Flow	204.29 gpm	Osmotic Pressure:	
Raw Water Flow to System	249.62 gpm	Pass 2 Recovery	84.25 %	Feed	0.12 psig
Feed Pressure	119.20 psig	Feed Temperature	25.0 C	Concentrate	0.00 psig
Flow Factor	0.85	Feed TDS	16.36 mg/l	Average	0.06 psig
Chem. Dose	None	Number of Elements	36	Average NDP	102.01 psig
Total Active Area	15840.00 ft²	Average Pass 2 Flux	18.57 gfd	Power	13.74 kW
Water Classification: RO Permeate SDI < 1				Specific Energy	1.12 kWh/kgal
System Recovery	81.84 %				

Stage	Element	#PV	#Ele	Feed Flow (gpm)	Feed Press (psig)	Recirc Flow (gpm)	Conc Flow (gpm)	Conc Press (psig)	Perm Flow (gpm)	Avg Flux (gfd)	Perm Press (psig)	Boost Press (psig)	Perm TDS (mg/l)
1	ECO-440i	4	6	242.49	114.20	0.00	99.31	101.27	143.17	19.52	15.00	0.00	2.28
2	ECO-440i	2	6	99.31	96.27	0.00	38.19	86.45	61.12	16.67	15.00	0.00	3.20

Pass Streams (mg/l as Ion)									
Name	Feed	Adjusted Feed		Concentrate		Permeate			
		Initial	After Recycles	Stage 1	Stage 2	Stage 1	Stage 2	Total	
NH4+ + NH3	0.47	0.45	0.45	0.98	2.29	0.11	0.17	0.13	
K	0.56	0.56	0.56	1.28	3.16	0.07	0.11	0.08	
Na	0.70	0.70	0.70	1.61	4.01	0.07	0.12	0.08	
Mg	0.68	0.68	0.68	1.62	4.12	0.03	0.05	0.04	
Ca	1.52	1.52	1.52	3.62	9.23	0.07	0.11	0.08	
Sr	0.09	0.09	0.09	0.22	0.55	0.00	0.01	0.00	
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
CO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
HCO3	3.43	3.43	3.43	7.77	19.66	1.13	1.27	1.17	
NO3	7.25	7.25	7.25	16.52	40.77	0.82	1.37	0.98	
Cl	0.43	0.43	0.43	1.04	2.68	0.01	0.01	0.01	
F	0.01	0.01	0.01	0.03	0.07	0.00	0.00	0.00	
SO4	1.23	1.23	1.23	3.01	7.82	0.00	0.00	0.00	
SiO2	0.01	0.01	0.01	0.01	0.04	0.00	0.00	0.00	
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
CO2	43.38	43.38	43.38	43.57	43.67	42.74	42.84	42.77	
TDS	16.36	16.36	16.36	37.69	94.36	2.28	3.20	2.56	
pH	5.10	5.10	5.10	5.44	5.82	4.65	4.70	4.66	

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Reverse Osmosis System Analysis for FILMTEC™ Membranes  
 Project: Tintina Reject to Pond rev22

ROSA 9.1 ConfigDB u399339\_282

Case: 1

9/15/2015

### Design Warnings -- Pass 2

-None-

### Solubility Warnings -- Pass 2

-None-

### Stage Details -- Pass 2

Stage 1 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.10	6.25	1.96	60.62	16.36	114.20
2	0.11	6.08	2.07	54.37	18.09	111.10
3	0.12	5.95	2.19	48.30	20.18	108.40
4	0.14	5.87	2.33	42.34	22.81	106.09
5	0.16	5.82	2.49	36.48	26.22	104.14
6	0.19	5.83	2.68	30.65	30.88	102.54
Stage 2 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.11	5.47	2.78	49.66	37.69	96.27
2	0.12	5.32	2.93	44.18	42.12	93.86
3	0.13	5.17	3.09	38.87	47.61	91.78
4	0.15	5.02	3.28	33.70	54.57	90.02
5	0.17	4.87	3.49	28.68	63.71	88.55
6	0.20	4.72	3.74	23.81	76.21	87.37

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**Scaling Calculations**

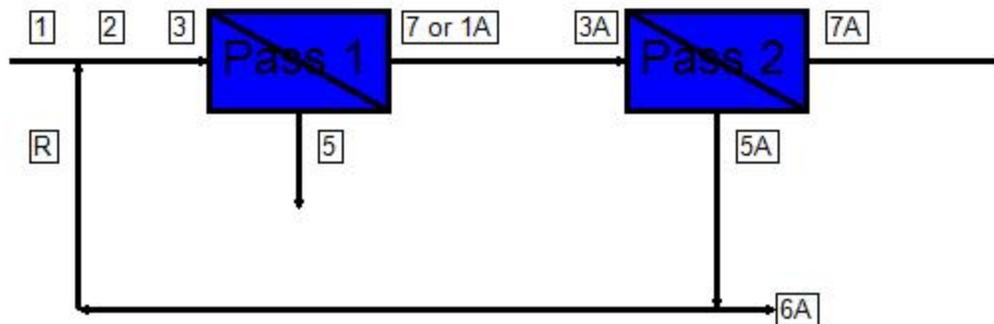
	Raw Water	Pass 1 Adjusted Feed	Pass 1 Concentrate	Pass 2 Concentrate
pH	6.80	6.80	7.37	0.00
Langelier Saturation Index	-0.23	-0.23	1.78	0.00
Stiff & Davis Stability Index	0.03	0.03	1.40	0.00
Ionic Strength (Molal)	0.03	0.03	0.15	0.00
TDS (mg/l)	1088.19	1088.21	6079.27	0.00
HCO <sub>3</sub>	237.00	237.00	1312.76	0.00
CO <sub>2</sub>	43.32	43.32	46.85	0.00
CO <sub>3</sub>	0.16	0.16	8.16	0.00
CaSO <sub>4</sub> (% Saturation)	10.71	10.71	116.37	0.00
BaSO <sub>4</sub> (% Saturation)	0.00	0.00	0.00	0.00
SrSO <sub>4</sub> (% Saturation)	45.48	45.48	289.77	0.00
CaF <sub>2</sub> (% Saturation)	21.54	21.54	3775.48	0.00
SiO <sub>2</sub> (% Saturation)	1.09	1.09	6.27	0.00
Mg(OH) <sub>2</sub> (% Saturation)	0.00	0.00	0.01	0.00

To balance: 0.00 mg/l Na added to feed.

Project: Tintina Reject to Pond rev3  
 Prepared By:

ROSA 9.1 ConfigDB u399339\_282  
 Case: 2  
 5/1/2017

### System Design Overview



Raw Water TDS	1088.15 mg/l	% System Recovery (7A/1)	81.85 %
Water Classification	Surface Supply SDI < 5	Flow Factor (Pass 1)	0.85
Feed Temperature	10.0 C	Flow Factor (Pass 2)	0.85

Pass #	Pass 1			Pass 2	
	1	2	3	1	2
Element Type	ECO-440i	ECO-440i	ECO-440i	ECO-440i	ECO-440i
Pressure Vessels per Stage	5	3	1	4	2
Elements per Pressure Vessel	6	6	6	6	6
Total Number of Elements	30	18	6	24	12
Pass Average Flux	14.70 gfd			18.58 gfd	
Stage Average Flux	15.78 gfd	13.91 gfd	11.68 gfd	19.16 gfd	17.40 gfd
Permeate Back Pressure	40.00 psig	30.00 psig	15.00 psig	15.00 psig	15.00 psig
Booster Pressure	0.00 psig	0.00 psig	0.00 psig	0.00 psig	0.00 psig
Chemical Dose	-			-	
Energy Consumption	2.22 kWh/kgal			2.06 kWh/kgal	

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Project: Tintina Reject to Pond rev3  
Prepared By:

ROSA 9.1 ConfigDB u399339\_282  
Case: 2  
5/1/2017

Pass 1				Pass 2			
Stream #	Flow (gpm)	Pressure (psig)	TDS (mg/l)	Stream #	Flow (gpm)	Pressure (psig)	TDS (mg/l)
1	249.66	0.00	1088.15	1A	242.54	-	6.86
2	287.86	0.00	0.00	3A	242.54	206.62	6.86
3	287.86	206.15	949.33	5A	38.20	165.31	39.89
5	45.33	135.84	5991.20	6A	0.88	0.00	0.00
7	242.54	-	6.86	7A	204.34	-	1.27
7/2	% Recovery	84.26		R	37.32	0.00	0.00
				7A/1A	% Recovery	84.25	

**Project Information:**

Tintina Black Cloud WTP

**Design Warnings:**

-- Pass 1

-None-

-- Pass 2

-None-

**Solubility Warnings:**

-- Pass 1

Langelier Saturation Index > 0

Stiff & Davis Stability Index > 0

CaSO4 (% Saturation) > 100%

SrSO4 (% Saturation) > 100%

CaF2 (% Saturation) > 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

-- Pass 2

-None-

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

ROSA 9.1 ConfigDB u399339\_282

Project: Tintina Reject to Pond rev3

Case: 2

5/1/2017

**Project Information:** Tintina Black Cloud WTP

**Case-specific:** Temp = 10 C 50% Capacity x 2 81.84% Recovery

**System Details -- Pass 1**

Feed Flow to Stage 1	287.86 gpm	Pass 1 Permeate Flow	242.54 gpm	Osmotic Pressure:	
Raw Water Flow to System	249.66 gpm	Pass 1 Recovery	84.26 %	Feed	0.00 psig
Feed Pressure	206.15 psig	<b>Feed Temperature</b>	<b>10.0 C</b>	Concentrate	30.13 psig
Flow Factor	0.85	Feed TDS	0.00 mg/l	Average	15.06 psig
Chem. Dose (100% H2SO4)	0.00	Number of Elements	54	Average NDP	168.16 psig
Total Active Area	23760.00 ft²	Average Pass 1 Flux	14.70 gfd	Power	32.27 kW
Water Classification: Surface Supply SDI < 5				Specific Energy	2.22 kWh/kgal
<b>System Recovery</b>	<b>81.85 %</b>			Conc. Flow from Pass 2	38.20 gpm

Stage	Element	#PV	#Ele	Feed Flow (gpm)	Feed Press (psig)	Recirc Flow (gpm)	Conc Flow (gpm)	Conc Press (psig)	Perm Flow (gpm)	Avg Flux (gfd)	Perm Press (psig)	Boost Press (psig)	Perm TDS (mg/l)
1	ECO-440i	5	6	287.86	201.15	0.00	143.22	183.58	144.64	15.78	40.00	0.00	3.63
2	ECO-440i	3	6	143.22	178.58	0.00	66.74	165.04	76.48	13.91	30.00	0.00	9.05
3	ECO-440i	1	6	66.74	160.04	0.00	45.33	135.84	21.41	11.68	15.00	0.00	21.47

Name	Feed	Adjusted Feed		Concentrate			Permeate			
		Initial	After Recycles	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Total
NH4+ + NH3	6.14	6.15	5.48	10.94	23.20	33.87	0.08	0.24	0.61	0.18
K	12.00	12.00	10.59	21.19	45.14	66.10	0.09	0.29	0.76	0.21
Na	17.00	17.00	14.97	29.98	63.90	93.64	0.12	0.37	0.94	0.27
Mg	71.00	71.00	61.80	124.09	265.88	391.05	0.11	0.36	0.89	0.26
Ca	162.00	162.00	140.99	283.13	606.64	892.25	0.25	0.80	2.00	0.58
Sr	9.65	9.65	8.40	16.86	36.13	53.14	0.01	0.05	0.12	0.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO3	0.11	0.11	0.08	0.39	2.21	5.38	0.00	0.00	0.00	0.00
HCO3	237.00	237.00	206.91	414.93	885.79	1298.04	1.52	2.27	4.30	1.94
NO3	160.10	160.10	141.20	282.61	602.08	881.94	1.19	3.80	9.65	2.76
Cl	61.00	61.06	53.09	106.65	228.59	336.30	0.07	0.22	0.57	0.16
F	1.00	1.00	0.87	1.75	3.75	5.51	0.00	0.01	0.01	0.00
SO4	349.75	349.75	303.73	610.26	1308.78	1926.27	0.20	0.65	1.61	0.47
SiO2	1.40	1.40	1.22	2.44	5.24	7.71	0.00	0.00	0.01	0.00
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	56.23	56.23	56.28	56.43	57.24	58.61	55.58	56.09	57.37	55.93
TDS	1088.15	1088.22	949.33	1905.21	4077.32	5991.20	3.63	9.05	21.47	6.86
pH	6.80	6.80	6.75	7.00	7.26	7.38	4.77	4.93	5.19	4.87

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

ROSA 9.1 ConfigDB u399339\_282

Project: Tintina Reject to Pond rev3

Case: 2

5/1/2017

**Design Warnings -- Pass 1**

-None-

**Solubility Warnings -- Pass 1**

Langelier Saturation Index &gt; 0

Stiff &amp; Davis Stability Index &gt; 0

CaSO4 (% Saturation) &gt; 100%

SrSO4 (% Saturation) &gt; 100%

CaF2 (% Saturation) &gt; 100%

Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

**Stage Details -- Pass 1**

Stage 1 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.09	5.11	2.70	57.57	949.33	201.15
2	0.09	4.98	2.96	52.46	1041.66	197.19
3	0.10	4.86	3.29	47.48	1150.68	193.66
4	0.11	4.75	3.71	42.62	1281.62	190.56
5	0.12	4.66	4.27	37.87	1442.13	187.85
6	0.14	4.57	5.04	33.21	1643.84	185.53
Stage 2 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.10	4.63	5.63	47.74	1905.21	178.58
2	0.10	4.49	6.55	43.11	2109.45	175.44
3	0.11	4.34	7.74	38.62	2353.94	172.68
4	0.12	4.19	9.36	34.28	2651.08	170.29
5	0.13	4.02	11.58	30.09	3018.43	168.23
6	0.15	3.83	14.77	26.07	3481.49	166.49
Stage 3 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.06	4.02	15.53	66.74	4077.32	160.04
2	0.06	3.83	17.60	62.72	4337.67	155.18
3	0.06	3.65	19.99	58.89	4618.34	150.68
4	0.06	3.47	22.73	55.25	4921.50	146.52
5	0.06	3.30	25.89	51.78	5249.50	142.67
6	0.06	3.14	29.55	48.47	5605.09	139.12

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

ROSA 9.1 ConfigDB u399339\_282

Project: Tintina Reject to Pond rev3

Case: 2

5/1/2017

**Project Information:** Tintina Black Cloud WTP**Case-specific:** Temp = 10 C 50% Capacity x 2 81.84% Recovery**System Details -- Pass 2**

Feed Flow to Stage 1	242.54 gpm	Pass 2 Permeate Flow	204.34 gpm	Osmotic Pressure:	
Raw Water Flow to System	249.66 gpm	Pass 2 Recovery	84.25 %	Feed	0.05 psig
Feed Pressure	206.62 psig	Feed Temperature	10.0 C	Concentrate	0.00 psig
Flow Factor	0.85	Feed TDS	6.86 mg/l	Average	0.02 psig
Chem. Dose	None	Number of Elements	36	Average NDP	185.81 psig
Total Active Area	15840.00 ft <sup>2</sup>	Average Pass 2 Flux	18.58 gfd	Power	25.28 kW
Water Classification: RO Permeate SDI < 1				Specific Energy	2.06 kWh/kgal
System Recovery	81.85 %				

Stage	Element	#PV	#Ele	Feed Flow (gpm)	Feed Press (psig)	Recirc Flow (gpm)	Conc Flow (gpm)	Conc Press (psig)	Perm Flow (gpm)	Avg Flux (gfd)	Perm Press (psig)	Boost Press (psig)	Perm TDS (mg/l)
1	ECO-440i	4	6	242.54	201.62	0.00	102.00	183.98	140.54	19.16	15.00	0.00	1.16
2	ECO-440i	2	6	102.00	178.98	0.00	38.20	165.31	63.80	17.40	15.00	0.00	1.51

Pass Streams (mg/l as Ion)									
Name	Feed	Adjusted Feed		Concentrate		Permeate			
		Initial	After Recycles	Stage 1	Stage 2	Stage 1	Stage 2	Total	
NH4+ + NH3	0.18	0.17	0.17	0.39	0.98	0.02	0.04	0.03	
K	0.21	0.21	0.21	0.49	1.27	0.01	0.02	0.02	
Na	0.27	0.27	0.27	0.63	1.63	0.01	0.03	0.02	
Mg	0.26	0.26	0.26	0.61	1.60	0.01	0.01	0.01	
Ca	0.58	0.58	0.58	1.35	3.57	0.01	0.02	0.02	
Sr	0.03	0.03	0.03	0.08	0.21	0.00	0.00	0.00	
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
CO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
HCO3	1.94	1.94	1.94	3.96	10.07	0.96	1.12	1.01	
NO3	2.76	2.76	2.76	6.36	16.52	0.14	0.27	0.18	
Cl	0.16	0.16	0.16	0.39	1.03	0.00	0.00	0.00	
F	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	
SO4	0.47	0.47	0.47	1.12	2.98	0.00	0.00	0.00	
SiO2	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
CO2	55.93	55.93	55.93	56.23	56.41	55.38	55.54	55.42	
TDS	6.86	6.86	6.86	15.37	39.89	1.16	1.51	1.27	
pH	4.87	4.87	4.87	5.17	5.55	4.58	4.65	4.60	

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Reverse Osmosis System Analysis for FILMTEC™ Membranes

ROSA 9.1 ConfigDB u399339\_282

Project: Tintina Reject to Pond rev3

Case: 2

5/1/2017

**Design Warnings -- Pass 2**

-None-

**Solubility Warnings -- Pass 2**

-None-

**Stage Details -- Pass 2**

Stage 1 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.10	6.05	1.04	60.63	6.86	201.62
2	0.11	5.94	1.08	54.59	7.55	197.43
3	0.12	5.86	1.12	48.64	8.38	193.76
4	0.14	5.79	1.17	42.79	9.43	190.61
5	0.16	5.75	1.23	36.99	10.80	187.94
6	0.18	5.74	1.30	31.24	12.67	185.73
Stage 2 Element Recovery		Perm Flow (gpm)	Perm TDS (mg/l)	Feed Flow (gpm)	Feed TDS (mg/l)	Feed Press (psig)
1	0.11	5.55	1.35	51.00	15.37	178.98
2	0.12	5.45	1.40	45.45	17.17	175.61
3	0.13	5.36	1.46	40.00	19.42	172.70
4	0.15	5.27	1.52	34.64	22.31	170.24
5	0.18	5.18	1.60	29.38	26.19	168.20
6	0.21	5.10	1.70	24.20	31.65	166.57

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**Scaling Calculations**

	Raw Water	Pass 1 Adjusted Feed	Pass 1 Concentrate	Pass 2 Concentrate
pH	6.80	6.80	7.38	0.00
Langelier Saturation Index	-0.57	-0.57	1.44	0.00
Stiff & Davis Stability Index	-0.26	-0.26	1.12	0.00
Ionic Strength (Molal)	0.03	0.03	0.15	0.00
TDS (mg/l)	1088.15	1088.22	5991.20	0.00
HCO <sub>3</sub>	237.00	237.00	1298.04	0.00
CO <sub>2</sub>	56.23	56.23	58.59	0.00
CO <sub>3</sub>	0.11	0.11	5.38	0.00
CaSO <sub>4</sub> (% Saturation)	10.71	10.71	114.03	0.00
BaSO <sub>4</sub> (% Saturation)	0.00	0.00	0.00	0.00
SrSO <sub>4</sub> (% Saturation)	45.48	45.48	284.63	0.00
CaF <sub>2</sub> (% Saturation)	21.54	21.54	3598.05	0.00
SiO <sub>2</sub> (% Saturation)	1.44	1.44	8.12	0.00
Mg(OH) <sub>2</sub> (% Saturation)	0.00	0.00	0.01	0.00

To balance: 0.06 mg/l Cl added to feed.

## Project Details

Project: Tintina RO Plant Design  
Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
System Recovery: 82%

## Antiscalant

Vitec 3000 is the selected product at a dose of 2.08mg/l. Assuming the plant operates continuously, then this will require 4551lb of antiscalant per year. This may be supplied in 2 x 2500lb Totes, 10 x 500lb Drums, or 102 x 45lb Pails.

## Chemical Cleaning

The chemical cleaning calculation has not been completed for this project.

## Biocide

No biocide has been selected for this system. It is always recommended that a biocide injection point be included to allow for the retrofit of a biocide system at a later date.

## Coagulant

No coagulant has been selected for this system. It is always recommended that a coagulant injection point be included to allow for the retrofit of a coagulant system at a later date.

## Dechlorination

No dechlorination has been selected for this system.

## Project Details

Project: Tintina RO Plant Design  
 Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
 System Recovery: 82%

## Antiscalant Projection

The projection is based on the following feed water analysis. The adjusted feed is the analysis after pH correction, and any ions have been added to balance the analysis. The concentrate analysis has been manually input.

Ion	Feed Water	Adjusted Feed	Concentrate
Sodium	17.00	19.31	106.23 mg/l
Potassium	12.00	12.00	65.81 mg/l
Calcium	162.00	162.00	898.61 mg/l
Magnesium	71.00	71.00	393.70 mg/l
Iron	0.01	0.01	0.03 mg/l
Manganese	0.15	0.15	0.83 mg/l
Barium	0.00	0.00	0.02 mg/l
Strontium	9.65	9.65	53.53 mg/l
Aluminium	0.00	0.00	0.00 mg/l
Chloride	20.10	20.10	110.67 mg/l
Sulfate	350.00	350.00	1941.44 mg/l
Bicarbonate	293.00	293.00	1598.19 mg/l
Nitrate	160.20	160.20	851.85 mg/l
Fluoride	1.04	1.04	5.73 mg/l
Phosphate	0.01	0.01	0.07 mg/l
Silica	1.35	1.35	7.43 mg/l
CO2	74.80	74.80	74.80 mg/l
TDS		1099.82	6034.13
pH	6.80	6.80	6.70

Water Source: Surface Water

Water Temperature: 25° C

## Product Choice

Vitec Choice: Vitec 3000  
 Dosage: 2.08mg/l  
 Usage: 12.47 lb per day.

## Application

Dosed Solution Strength: 100%  
 Pump Rate: 1.20USGPD  
 3.15ml/m

There is one dosing pump per membrane train, using a common chemical tank for all trains.  
 With 2 trains, each pump will deliver 1.20USGPD

## Project Details

Project: Tintina RO Plant Design  
 Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
 System Recovery: 82%

## Scaling Potential.

### Langelier Saturation Index (LSI)

The reject stream has a LSI of 0.89.  
 Vitec 3000 has a limit of 3.00

### Calcium Carbonate Precipitation Potential (CCPP)

The concentrate has a CCPP of 599mg/l.  
 This is within the limits of Vitec 3000.

### Calcium Sulfate

The concentrate has a calcium sulphate saturation of 112.86%.  
 This is within the limits of Vitec 3000.

### Barium Sulfate

The concentrate has a barium sulphate saturation of 187.38%.  
 This is within the limits of Vitec 3000.

### Strontium Sulfate

The concentrate has a strontium sulphate saturation of 342.34%.  
 This is within the limits of Vitec 3000.

### Calcium Fluoride

The concentrate has a calcium fluoride saturation of 1386.18%.  
 This is within the limits of Vitec 3000.

### Silica

The concentrate has a silica level of 7.43mg/l.  
 Silica has a solubility of 141.9mg/l at this temperature and brine pH.

### Magnesium Hydroxide

The concentrate has a magnesium hydroxide saturation of 0.00%.

### Calcium Phosphate

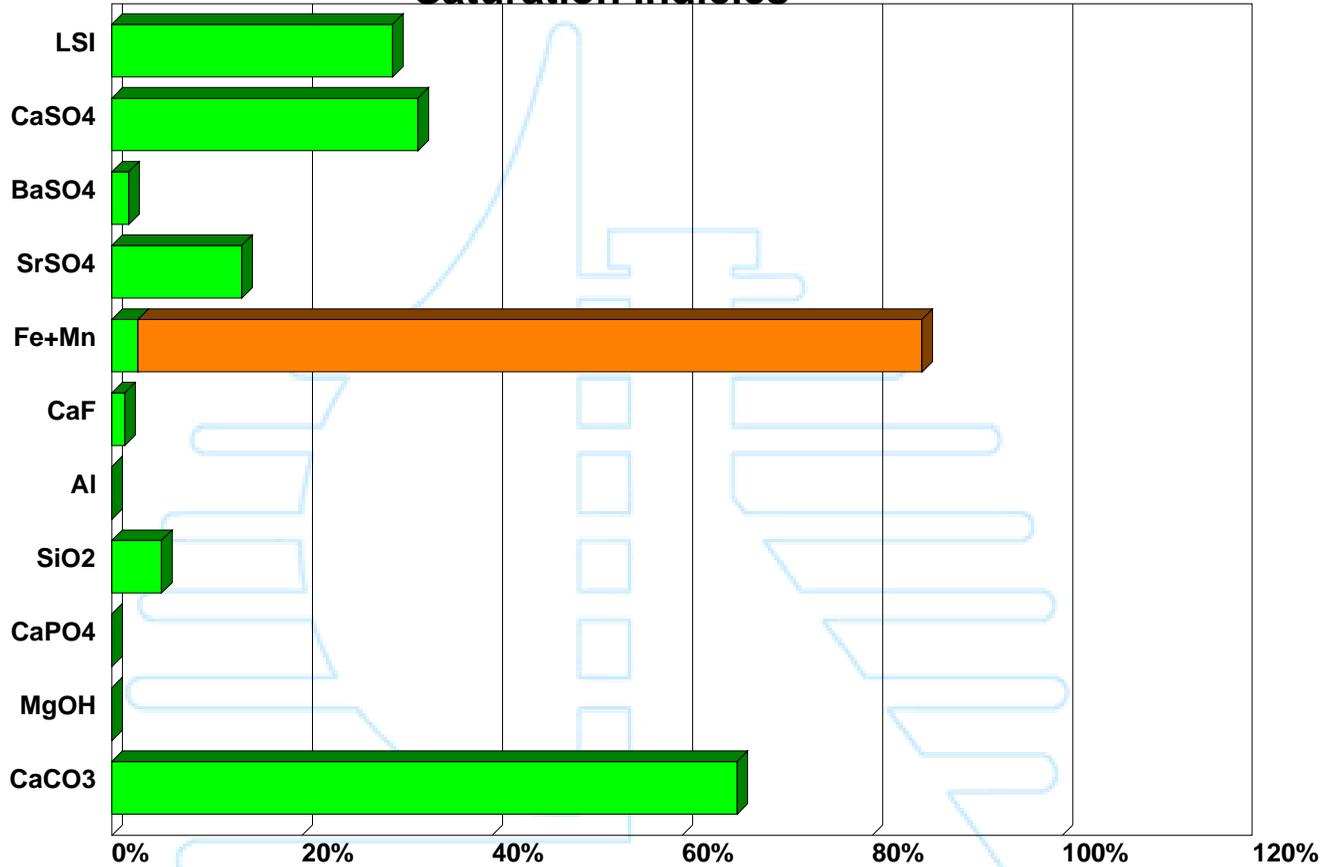
The concentrate has a calcium phosphate saturation of 0.00%.  
 This is within the limits of Vitec 3000.

*While every effort has been made to ensure the accuracy of this program, no warranty, expressed or implied, is given as actual application of the products is outside the control of Avista Technologies.*

## Project Details

Project: Tintina RO Plant Design  
 Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
 System Recovery: 82%

## Saturation Indices



## Product Choice

## Application

Vitec Choice: Vitec 3000 Dosed Solution Strength: 100%  
 Dosage: 2.08mg/l Pump Rate: 1.20USGPD  
 Usage: 12.47 lb per day. 3.15ml/m

There is one dosing pump per membrane train, using a common chemical tank for all trains.  
 With 2 trains, each pump will deliver 1.20USGPD

## Project Details

Project: Tintina RO Plant Design  
Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
System Recovery: 82%

## Antiscalant

Vitec 3000 is the selected product at a dose of 2.00mg/l. Assuming the plant operates continuously, then this will require 4375lb of antiscalant per year. This may be supplied in 2 x 2500lb Totes, 9 x 500lb Drums, or 98 x 45lb Pails.

## Chemical Cleaning

The chemical cleaning calculation has not been completed for this project.

## Biocide

No biocide has been selected for this system. It is always recommended that a biocide injection point be included to allow for the retrofit of a biocide system at a later date.

## Coagulant

No coagulant has been selected for this system. It is always recommended that a coagulant injection point be included to allow for the retrofit of a coagulant system at a later date.

## Dechlorination

No dechlorination has been selected for this system.

## Project Details

Project: Tintina RO Plant Design  
 Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
 System Recovery: 82%

## Antiscalant Projection

The projection is based on the following feed water analysis. The adjusted feed is the analysis after pH correction, and any ions have been added to balance the analysis. The concentrate analysis has been manually input.

Ion	Feed Water	Adjusted Feed	Concentrate
Sodium	17.00	19.31	106.23 mg/l
Potassium	12.00	12.00	65.81 mg/l
Calcium	162.00	162.00	898.61 mg/l
Magnesium	71.00	71.00	393.70 mg/l
Iron	0.01	0.01	0.03 mg/l
Manganese	0.15	0.15	0.83 mg/l
Barium	0.00	0.00	0.02 mg/l
Strontium	9.65	9.65	53.53 mg/l
Aluminium	0.00	0.00	0.00 mg/l
Chloride	20.10	20.10	110.67 mg/l
Sulfate	350.00	350.00	1941.44 mg/l
Bicarbonate	293.00	293.00	1598.19 mg/l
Nitrate	160.20	160.20	851.85 mg/l
Fluoride	1.04	1.04	5.73 mg/l
Phosphate	0.01	0.01	0.07 mg/l
Silica	1.35	1.35	7.43 mg/l
CO2	96.59	96.59	74.80 mg/l
TDS		1099.82	6034.13
pH	6.80	6.80	6.70

Water Source: Surface Water

Water Temperature: 10° C

## Product Choice

Vitec Choice: Vitec 3000  
 Dosage: 2.00mg/l  
 Usage: 11.99 lb per day.

## Application

Dosed Solution Strength: 100%  
 Pump Rate: 1.15USGPD  
 3.03ml/m

There is one dosing pump per membrane train, using a common chemical tank for all trains.  
 With 2 trains, each pump will deliver 1.15USGPD

## Project Details

Project: Tintina RO Plant Design  
Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
System Recovery: 82%

## Scaling Potential.

### Langelier Saturation Index (LSI)

The reject stream has a LSI of 0.56.  
Vitec 3000 has a limit of 3.00

### Calcium Carbonate Precipitation Potential (CCPP)

The concentrate has a CCPP of 440mg/l.  
This is within the limits of Vitec 3000.

### Calcium Sulfate

The concentrate has a calcium sulphate saturation of 131.35%.  
This is within the limits of Vitec 3000.

### Barium Sulfate

The concentrate has a barium sulphate saturation of 187.38%.  
This is within the limits of Vitec 3000.

### Strontium Sulfate

The concentrate has a strontium sulphate saturation of 342.34%.  
This is within the limits of Vitec 3000.

### Calcium Fluoride

The concentrate has a calcium fluoride saturation of 1386.18%.  
This is within the limits of Vitec 3000.

### Silica

The concentrate has a silica level of 7.43mg/l.  
Silica has a solubility of 107.8mg/l at this temperature and brine pH.

### Magnesium Hydroxide

The concentrate has a magnesium hydroxide saturation of 0.00%.

### Calcium Phosphate

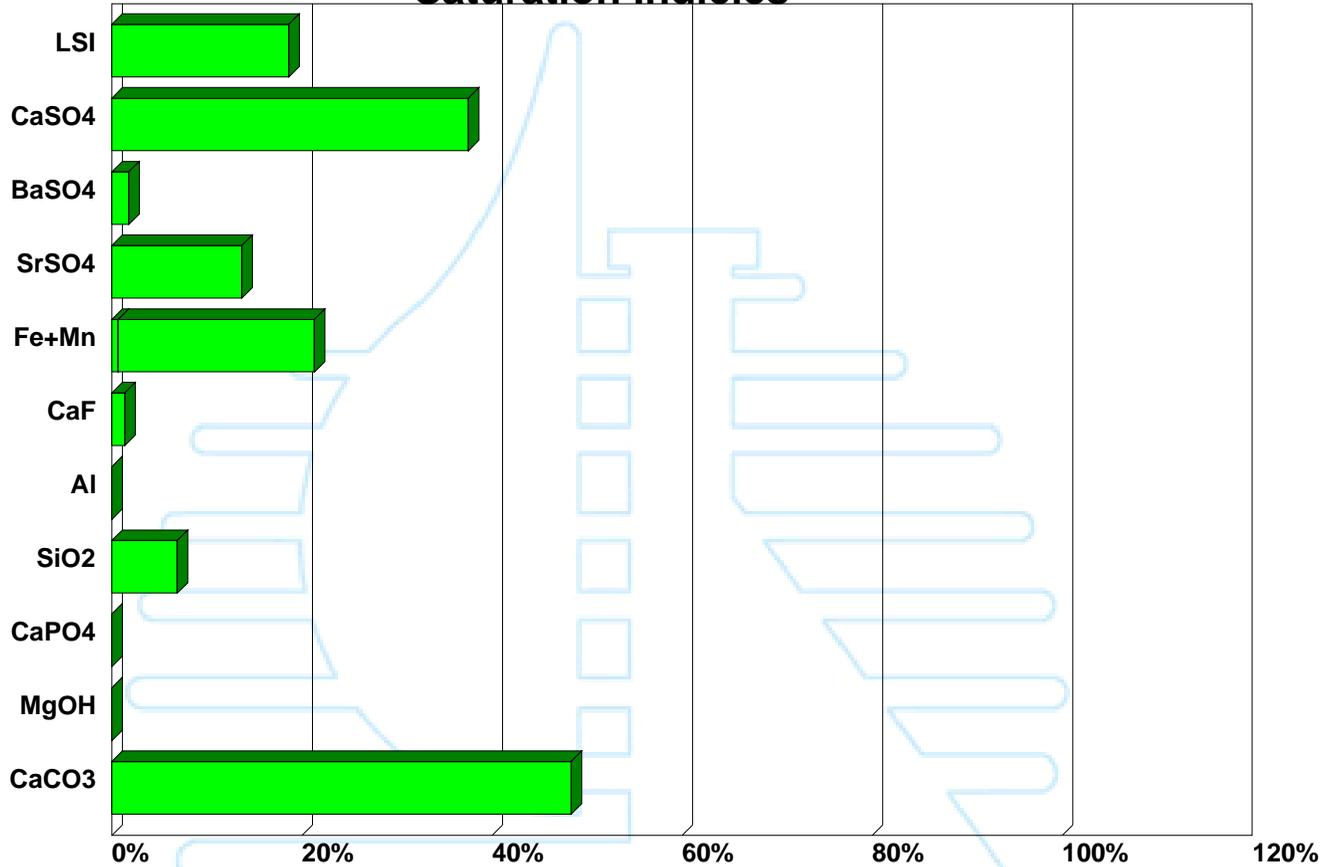
The concentrate has a calcium phosphate saturation of 0.00%.  
This is within the limits of Vitec 3000.

*While every effort has been made to ensure the accuracy of this program, no warranty, expressed or implied, is given as actual application of the products is outside the control of Avista Technologies.*

## Project Details

Project: Tintina RO Plant Design  
 Permeate Flowrate: 410USGPM This is split into 2 trains of 205.0USGPM  
 System Recovery: 82%

## Saturation Indices



## Product Choice

Vitec Choice: Vitec 3000  
 Dosage: 2.00mg/l  
 Usage: 11.99 lb per day.

## Application

Dosed Solution Strength: 100%  
 Pump Rate: 1.15USGPD  
 3.03ml/m

There is one dosing pump per membrane train, using a common chemical tank for all trains.  
 With 2 trains, each pump will deliver 1.15USGPD

**APPENDIX V-4**

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VSEP Projections (Closure Phase)

Customer:	AMEC		Project Information
Application:	RO reject		
Prepared by:	Josh Miller		
Date:	3/28/2017		
<b>Stage 1</b>			
Design Temperature	15 °C	<a href="#">Modify Values in Blue Only</a>	
Feed Flow	69 GPM		
Operating Pressure	550 PSI		
Estimated Recovery	85%		
Estimated Flux	18 GFD		
Membrane Area/Module	1400 FT2		
Estimated Membrane Life	2.5 Years		
Time Between Cleanings	2880 Minutes		

Customer: AMEC  
 Application: RO reject  
 Prepared by: Josh Miller  
 Date: 3/28/2017



Estimates of VSEP Performance\*

Design Basis Temp. °C	Stage	GPM Feed	Recovery	GPM Permeate	GPD Permeate	GPM Reject	GPD Reject	GPD Feed	GFD	Gal Perm/22 Hrs	Safe. Fac.	Total Area (ft2)	# of i84 Mods	Round up #	Eff. Safety Factor
15.00	1	69	0.85	59	84,456	10	14,904	99,360	18.00	5,100.00	0.30	6,630	5	5	0.36

\* All values are estimates only. No warranty is expressed or implied. Costs are budgetary and expressed as USD.

<b>Customer:</b>	AMEC				
<b>Application:</b>	RO reject				
<b>Prepared by:</b>	Josh Miller				
<b>Date:</b>	3/28/2017				
<b>Stage 1 Quality Estimates</b>					
<b>Membrane: RO</b>					
		<b>Initial Raw Feed</b>	<b>Estimated RO Permeate</b>	<b>Estimated Reject</b>	<b>Estimated % Reduction</b>
		ppm (mg/l)	ppm (mg/l)	ppm (mg/l)	
Silver	Ag	0.0800	0.0067	0.50	91.66%
Arsenic	As	0.0290	0.0019	0.18	93.50%
Barium	Ba	0.0010	0.0000	0.01	98.65%
Chromium	Cr	0.0080	0.0000	0.05	99.56%
Copper	Cu	7.9820	0.0111	53.15	99.86%
Molybdenum	Mo	0.0200	0.0004	0.13	98.20%
Nickel	Ni	1.0160	0.0192	6.66	98.11%
Lead	Pb	0.1680	0.0001	1.12	99.96%
Zinc	Zn	0.7630	0.0156	5.00	97.96%
Calcium	Ca	1824.0000	114.0000	11,514.0	93.75%
Fluoride	F	6.4000	0.7727	38.3	87.93%
Iron	Fe	24.1850	0.0117	161.2	99.95%
Magnesium	Mg	437.0000	21.5804	2,791.0	95.06%
Manganese	Mn	2.8900	0.1445	18.4	95.00%
Sodium	Na	112.0000	14.8400	662.6	86.75%
Potassium	K	80.0000	16.0000	442.7	80.00%
Phosphorous	P	0.1000	0.0140	0.6	86.00%
Chloride	Cl	2029.0000	70.8324	13,125.3	96.51%
Silica	SiO2	20.9000	1.0002	133.7	95.21%
Sulfate	SO4	2902.0000	10.2179	19,288.8	99.65%
Ammonia	NH4	26.8000	5.1257	149.6	80.87%
Total Nitrogen	TN	137.8000	26.9608	765.9	80.43%
Bicarbonate	HCO3	813.0000	32.5200	5,235.7	96.00%
Total Dissolved Solids	TDS	8867.0000	1057.6292	53,120.1	88.07%
Conductivity	µS	16762.0000	1508.5800	103,198.0	91.00%