

May 19

Water!Pro

2025

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*Water!Pro is a specialized Excel spreadsheet used by professionals in the drinking water industry to model chemical and physical water treatment processes. Water!Pro was developed to provide comprehensive and immediate technical assistance to public drinking water utilities.*

Drinking  
Water  
Modeling  
Program

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Disclaimer

# MAIN MENU

Overview

## **Water!Pro™** *Treating Drinking Water* **Version 9.00**

<b>Sections</b>	<b>Program Subject Selections</b>
<b>Section 1</b>	<b>General Water Treatment and Corrosion Control Modeling Programs</b>
<b>Section 2</b>	<b>Corrosion Control Modeling Programs</b>
<b>Section 3</b>	<b>Lead and Copper Interactive Graphs</b>
<b>Section 4</b>	<b>Limestone Contactor and Post RO Treatment</b>
<b>Section 5</b>	<b>Blending Programs</b>
<b>Section 6</b>	<b>Ion Exchange and Isotherm</b>
<b>Section 7</b>	<b>Lime/Soda Ash Softening</b>
<b>Section 8</b>	<b>Aeration Programs</b>
<b>Section 9</b>	<b>Advanced Oxidation Process (AOP) program</b>
<b>Section 10</b>	<b>pH Targeting and the Carbonate System</b>
<b>Section 11</b>	<b>Filter Media, LRV Membrane and Pipeline Head Loss/Gt Programs</b>
<b>Section 12</b>	<b>UV Disinfection Reactor Modeling</b>
<b>Section 13</b>	<b>Disinfection, Pre-cursors, Clearwell Baffle Factors, and Dosing Programs</b>
<b>Section 14</b>	<b>Jar Testing and Video Training</b>
<b>Section 15</b>	<b>Arsenic and Iron/Manganese Treatment</b>
<b>Section 16</b>	<b>Anion/Cation Balance Program and ICA</b>
<b>Section 17</b>	<b>General - References</b>

**Water!Pro** is a specialized Excel spreadsheet used by professionals in the drinking water industry to model chemical and physical water treatment processes.

Listed below are programs within Water!Pro followed by a brief description:

**List of Programs:**

Water!Pro Program Listing					
	Section 1		Section 7		Section 15
1	Water!Pro	31	Water Soft 1	61	Ar(V) - TP
2	Pb, Cu & Zn Solids	32	Water Soft 2	62	Ar(V) - Arsenate
3	WaterPro Scenarios	33	Water Soft 3	63	IronMang
4	Coagulants, Acid, Base		<b>Section 8</b>	64	Fe(III) Diagram
5	WP-Coag & Cost Input	34	Packed Tower		<b>Section 16</b>
6	WP-Results	35	Spray Aeration TTHMs	65	Anion-Cation Balance!Pro
7	WP-Input-Storage	36	Aeration TTHM Graph	66	Anion-Cation Balance Lab Sheet
8	Pb Diagram	37	Single-Pass Aeration TTHMs		<b>Section 17</b>
9	Pb Contours		<b>Section 9</b>	67	Definition & Settings
10	3D Pb, DIC & pH	38	AOP (UV – H <sub>2</sub> O <sub>2</sub> )	68	References
11	Al Diagram		<b>Section 10</b>		
	<b>Section 2</b>	39	pH Targeting & Graphing		
12	Corrosion Modeling	40	Carbonate System		
13	CCT Scenarios	41	Acid - Irrigation		
14	Indices & Corrosion Modeling		<b>Section 11</b>		
15	Pb and Copper Guidance	42	Filter Media Evaluation		
15	Fid-an-Fix LCRR	43	LRV – Membranes		
	<b>Section 3</b>		<b>Section 12</b>		
16	Pb Diagram Equilibrium	44	UV Trojan D06		
17	C-Phosphate	45	Xyelm Wedeco		
18	Cu(II) - f(pH, Alk)	46	Uv Trojan 4L12		
19	Cu(II) Diagram	47	UV 24in Sentinel		
20	Buffer Intensity/Cu(II)		<b>Section 13</b>		
	<b>Section 4</b>	48	Pathogen Log Inact		
21	Limestone Contactor	49	Giardia Log Inact (Cl <sub>2</sub> )		
22	Limestone Target 1	50	Baffling Factors		
23	Limestone Target 2	51	Cyanotoxins		
24	Limestone Scenarios	52	Super Chlorination/Acid Cleaning		
25	SAR (Sodium Adsorption Ratio)	53	ChemDose(FR)		
	<b>Section 5</b>	54	ChemDose (PS)		
26	Blend	55	ChemDose (Dry)		
27	BlendingPro	56	TTHMs, HAAs, CH		
28	Blend Scenarios	57	Br and O <sub>3</sub>		
	<b>Section 6</b>		<b>Section 14</b>		
29	IX NO <sub>3</sub> <sup>-</sup> , As <sup>+5</sup>	58	Jar Testing		
30	NO <sub>3</sub> <sup>-</sup> - Cl <sup>-</sup> Isotherm	60	Jar Testing - Laboratory		

1. **Water!Pro** - The primary worksheet that models the changes in water characteristics based on the application of common chemicals used in the drinking water industry. The lists of chemicals are coagulants, acids, bases, orthophosphate, fluorites and disinfectants. The effects of these chemicals are seen by the changes in water characteristics such as pH, alkalinity, acidity, carbon dioxide, DIC, corrosion indices and the solubility of lead and copper. If water

constituents such as dissolved organic carbon (DOC) and turbidity are entered, then sludge production and the predicted reduction in DOC are determined based on coagulant dose and pH. The primary initial water characteristics entered into Water!Pro are TDS, pH, alkalinity, calcium and temperature. For modeling enhanced coagulation and sludge production, source water inputs for UV-254, DOC and turbidity are required. Once entered, the user can model various treatment processes such as coagulation, pH and corrosion control or a combination thereof.

Water!Pro is laid out into successive "Steps" to be an easy-to-use intuitive program. Water!Pro is commonly utilized by engineers within the California State Water Resources Control Board – Division of Drinking Water, private consultants, utilities, State Regulatory Agencies and Educational institutions throughout the U.S and other countries. Its user-friendly interface makes it an invaluable tool for any water industry professional.

### Example of enhanced coagulation, corrosion control, disinfection and fluoridation:

A utility has a lake source that is treated through a conventional water treatment plant. The user inputs the initial water characteristics in Step 1 and the calculated water characteristics and corrosion indices are displayed in Step 2:

<b>Step 1: Initial Water Characteristics</b>			
<b>Enter source water characteristics.</b>			Save Steps 1, 3 & 5 Data
Client ID:	1210	Retrieve Steps 1, 3 & 5 Data	
Customer Info: Mara River			
Plant Flow Rate:	594	gpm	855,360 gal/day
TDS:	200	mg/L	0.00500 mol/L, Ionic Strength
pH:	8.10	field pH is recommended	
Total Alkalinity:	130.0	mg/L as CaCO <sub>3</sub>	2.598 meq/L
Water Temperature:	15.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	15.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	30.0	mg/L	74.9 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	19.0	mg/L	78.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	21.0	mg/L	45.7 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	28.0	mg/L	39.5 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>-2</sup> ):	30.0	mg/L	31.3 mg/L as CaCO <sub>3</sub>
Cations/Anions Percent Difference:	-0.49%	$(\sum \text{cations} - \sum \text{anions}) / (\sum \text{cations} + \sum \text{anions})$	
If alkalinity is unknown, then enter target DIC and click " <b>Find Alk</b> " button.			
<b>Find Alk</b>	Target DIC	30.0	mg/L as C
<b>Enter source water characteristics (optional)</b>			
UVA-254:	0.124	1/cm, UV Absorption	%UVT: 75.2
DOC:	6.00	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	12.0	NTU	SUVA = 2.07 L/(m*mg)

<b>Step 2: Initial Water Characteristics Results (before chemical addition)</b>						
(water characteristics, corrosion indices, hardness, & lead/copper solubilities after temperature correction)						
pH:	8.10		312.5	uS/cm (Electrical Conductivity)		
Acidity:	133.4	mg/L as CaCO <sub>3</sub>	2.666	meq/L	CO <sub>2</sub> : 0.635	mg/L atm
Bicarbonate (HCO <sub>3</sub> <sup>-</sup> ):	156.6	mg/L as HCO <sub>3</sub> <sup>-</sup>	2.567	meq/L	30.83	mg/L as C
Carbonate (CO <sub>3</sub> <sup>2-</sup> ):	0.900	mg/L as CO <sub>3</sub> <sup>2-</sup>	0.030	meq/L	0.180	mg/L as C
Carbon Dioxide (CO <sub>2</sub> ):	2.19	mg/L as CO <sub>2(aq)</sub>	0.050	meq/L	0.60	mg/L as C
DIC:	31.61	mg/L as C	2.632	meq/L	31.61	mg/L as C (DIC sum)
Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> ):	153.2	mg/L as CaCO <sub>3</sub>	3.06	meq/L	Ca <sup>2+</sup> : 1.50 meq/L	Mg <sup>2+</sup> : 1.56 meq/L
Carbonate Hardness:	128.5	mg/L as CaCO <sub>3</sub>	2.57	meq/L	Ca <sup>2+</sup> : 1.50 meq/L	Mg <sup>2+</sup> : 1.07 meq/L
Non-Carbonate Hardness:	24.69	mg/L as CaCO <sub>3</sub>	0.49	meq/L	Ca <sup>2+</sup> : 0.00 meq/L	Mg <sup>2+</sup> : 0.49 meq/L
<b>Corrosion Indices</b>		Calcite	<b>&lt;Select Crystalline Form</b>		<b>Recommended</b>	
Aggressive Index (AI):	12.1	Non-aggressive water for asbestos cement piping				>12
Ryznar Index (RI):	7.71	Tendency to dissolve CaCO <sub>3</sub> (for steel piping)				6.5-7.0
Langelier Index, Calcite:	0.19	Tendency for deposition of CaCO <sub>3</sub> (for steel and cast iron piping)				>0
CCPP:	2.88	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential				4-10 mg/L
B <sub>H2O</sub> + B <sub>CO3</sub> :	0.148	mM/pH, Buffer intensity from water and carbonate species				
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk:	0.54	Mid metal tendency towards mild steel				< 0.5
<b>Select water temp. for Pb &amp; Cu and select copper solid(s) for calculations</b>						
<input checked="" type="radio"/> Field Temperature	<input type="radio"/> Temperature @ 25C	<input checked="" type="checkbox"/> Cupric Hydroxide	<input type="checkbox"/> Malachite	<input type="checkbox"/> Tenorite	<input checked="" type="checkbox"/> Cupric Phosphate	
Copper II at Field Temp.:	0.385	mg/L as copper II at dissolution; Cupric Hydroxide, light blue/blue-green				
Lead II at Field Temp.:	0.166	mg/L as lead II at dissolution; Lead Carbonate (cerussite)				
pH <sub>25</sub> :	8.02	pH of water if measured at 25°C				
					CSMR:	0.93

The utility uses 5% Acid Aluminum Sulfate (Alum) for coagulation. The targeted reduction of dissolved organic carbon (DOC) is 35%. Determine the amount of Alum to achieve the goal of 35 % reduction in DOC.

<b>Step 3: Chemical Interim Addition</b>				
<b>Source Water Treatment - Pre-Oxidation/ Acid/Base Addition</b>				
Sodium Hypochlorite (NaOCl):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Chlorine Gas (Cl <sub>2</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Hydrochloric Acid (HCl):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ) ±:		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Ca(OH) <sub>2</sub> (100% hydrated Lime):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
CaO (100% Quicklime):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Soda Ash (Na <sub>2</sub> CO <sub>3</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Caustic Soda (NaOH):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Sodium Bicarbonate (NaHCO <sub>3</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
<b>Source Water Treatment - Coagulant Addition</b>				
<b>Primary Coagulant</b>		<b>Secondary Coagulant</b>		
5% Acid Alum*14.3H <sub>2</sub> O		ACH (12.5% Al, 83% Basicity)		
5% Acid Alum*14.3H <sub>2</sub> O	70.0	mg/L	44.01	mg/L as CaCO <sub>3</sub>
ACH (12.5% Al, 83% Basicity)		mg/L	0.00	mg/L as CaCO <sub>3</sub>

In Step 3 above, the user has a selection of coagulants, base, and acid chemicals to choose from for the coagulation process and or pH adjustment. Based on the goal of 35% reduction of DOC, 70 mg/L of Alum is added. The dosage is based on dry Alum\*14.3 H<sub>2</sub>O. The amount of acid (H<sub>2</sub>SO<sub>4</sub>) added to the Alum is automatically calculated and processed within the program. The changes in water characteristics are displayed in Step 4 below:

<b>Step 4: Interim Results (after chemical addition)</b>					
pH:	6.66	pH of water after chemical addition and before release of CO <sub>2</sub>			
Total Alkalinity:	85.99	mg/L as CaCO <sub>3</sub>	1.718	meq/L	
Acidity:	177.4	mg/L as CaCO <sub>3</sub>	3.545	meq/L	
Carbon Dioxide (CO <sub>2</sub> ):	40.22	mg/L as CO <sub>2(aq)</sub>	1.828	meq/L	10.98 mg/L as C
Calcium (Ca <sup>2+</sup> ):	30.0	mg/L Ca <sup>2+</sup>	1.497	meq/L	75 mg/L as CaCO <sub>3</sub>
CCPP:	-69.3	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential			
<b>DOC Reduction after Coagulant/Acid/Base Addition</b>					
DOC:	3.90	mg/L as C	DOC Removed =	2.10	mg/L as C
% of DOC Reduced:	35.0%	after coagulant/acid/base treatment			
Nonsorbable DOC:	2.43	mg/L as C	1.4 mg TSS/NTU removed		
Aluminum Added:	0.234	mMol/L, 6.30 mg/L	\$33.97	\$ per million gallons	
Ferric Added :	0.000	mMol/L, 0.00 mg/L	\$0.00	\$ per million gallons	
Sludge Production:	409	lbs per MG	49.0 Kg/1000 m <sup>3</sup>	350 lb/day	159 Kg/day

After filtration, the water system disinfects with sodium hypochlorite to 1.5 mg/L; adds hydrofluosilicic acid for fluoridation with a dose of 0.95 mg/L as F; and raises pH for corrosion control using caustic soda. The targeted pH goal of the water leaving the treatment plant is 8.0. Step 5 below displays the chemical dosages and Step 6 displays the changes in water characteristics and corrosion indices.

<b>Step 5: Chemical Addition: Finished Water Treatment</b>				
Soda Ash (Na <sub>2</sub> CO <sub>3</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Potash (K <sub>2</sub> CO <sub>3</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Caustic Soda (NaOH):	35.7	mg/L	44.67	mg/L as CaCO <sub>3</sub>
Potassium Hydroxide (KOH):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Sodium Bicarbonate (NaHCO <sub>3</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
CaCO <sub>3</sub> (Limestone):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Ca(OH) <sub>2</sub> (100% hydrated Lime):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Calcium Chloride (CaCl <sub>2</sub> ):		mg/L	0.00	mg/L as Ca <sup>2+</sup>
Orthophosphate as PO <sub>4</sub> <sup>3-</sup> :		mg/L	0.00	mg/L as P <sup>3+</sup>
Carbon Dioxide (CO <sub>2</sub> ) ±:		mg/L	0.00	mg/L as CaCO <sub>3</sub>
<b>Disinfection &amp; Fluoridation</b>				
Chlorine Gas (Cl <sub>2</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Sodium Hypochlorite (NaOCl):	1.5	mg/L	0.59	mg/L as CaCO <sub>3</sub>
Calcium Hypochlorite (Ca(OCl) <sub>2</sub> ):		mg/L	0.00	mg/L as CaCO <sub>3</sub>
Hydrofluosilicic Acid (H <sub>2</sub> SiF <sub>6</sub> ):	1.2	mg/L	0.95	mg/L as F <sup>-</sup>
Sodium Silicofluoride (Na <sub>2</sub> SiF <sub>6</sub> ):		mg/L	0.00	mg/L as F <sup>-</sup>

Step 6: Final Results (after chemical additions in Steps 3 and 5)					Recommended	
pH:	7.95	pH of water after chemical addition and before release of CO <sub>2</sub>			6.8-8.0 or 8.5-9.3	
Total Alkalinity:	128.7	mg/L as CaCO <sub>3</sub>	2.57	meq/L		
Acidity:	134.7	mg/L as CaCO <sub>3</sub>	2.69	meq/L		
Bicarbonate ( HCO <sub>3</sub> <sup>-</sup> ):	155.7	mg/L as HCO <sub>3</sub> <sup>-</sup>	2.55	meq/L	30.64	mg/L as C
Carbonate ( CO <sub>3</sub> <sup>2-</sup> ):	0.631	mg/L as CO <sub>3</sub> <sup>2-</sup>	0.021	meq/L	0.126	mg/L as C
Carbon Dioxide (CO <sub>2</sub> ):	3.08	mg/L as CO <sub>2(aq)</sub>	0.070	meq/L	0.84	mg/L as C
DIC:	31.61	mg/L as C	2.632	meq/L	Sum: 31.61	mg/L as C
Sodium (Na <sup>+</sup> ):	41.98	mg/L Na <sup>+</sup>	1.83	meq/L	91.4	mg/L as CaCO <sub>3</sub>
Calcium (Ca <sup>2+</sup> ):	30.0	mg/L Ca <sup>2+</sup>	1.50	meq/L	74.9	mg/L as CaCO <sub>3</sub>
Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> ):	153.2	mg/L as CaCO <sub>3</sub>	3.06	meq/L	0.01%	Δ Cation/Anion
Corrosion Indices & Theoretical Lead/Copper Solubilities					Recommended	
Aggressive Index (AI):	11.9	Moderately aggressive conditions for asbestos cement piping			>12	
Ryznar Index (RI):	7.89	Tendency to dissolve CaCO <sub>3</sub> (for steel piping)			6.5-7.0	
Langelier Index, Calcite:	0.03	Tendency for deposition of CaCO <sub>3</sub> (for steel and cast iron piping)			>0	
CCPP:	0.56	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential			4-10 mg/L	
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk:	0.89	Mid metal tendency towards mild steel			< 0.5	
B <sub>H2O</sub> + B <sub>CO3</sub> + B <sub>PO4</sub> :	0.182	mM/pH, Buffer intensity from water, carbonate, and PO <sub>4</sub> species				
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	72.2	mg/L	75.3	mg/L as CaCO <sub>3</sub>	1.50	meq/L
Chloride (Cl <sup>-</sup> ):	28.7	mg/L	40.5	mg/L as CaCO <sub>3</sub>	0.81	meq/L
CSMR:	0.40	Chloride-to-sulfate mass ratio; recommend <0.6 to reduce lead solder acceleration				
Copper II at Field Temp.:	0.53	mg/L as copper II at dissolution; Cupric Hydroxide, light blue/blue-green				
Lead II at Field Temp.:	0.166	mg/L as lead II at dissolution; Lead Carbonate (cerussite)				
pH <sub>25</sub> :	7.87	pH of water if measured at 25°C				

**Note:** The calculated stoichiometry changes in water characteristics are based on complete chemical reactions with alkalinity. Field research on measured alkalinity before and after treatment has shown that the addition of coagulants and/or base chemicals do not necessarily show full reaction with alkalinity (acid) or the addition of alkalinity (base). This may be the results of chemical reactions (<100% reaction), minor errors in dose calculation related to chemical feed drawn down measurements, chemical strength and weight, and plant flow meter. For best results in matching the measured plant's pH and alkalinity to the output results in Water!Pro, measured alkalinity of source and treated water is required. For example, after coagulant treatment the plant's alkalinity is 50 mg/L and pH is 6.5. However, Water!Pro outputs show alkalinity to be 45 mg/L and pH at 6.2. The user is advised to adjust the coagulant dose to match up with the physical measurement of the plant's alkalinity. When adjusted, the calculated pH should closely match that of the plant's pH.

2. **Water!Pro Scenarios:** This program is similar to the program "Water!Pro" but allows the user to model up to 25 sets of data. It also has the option to allow the program to determine the chemical dosages based on constraints (Alkalinity, pH and corrosion indices) or dosages may be manual inputted. After all pertinent information is entered, the user is required to input what data set to be processed before clicking on the "Process Data" button.

**Water!Pro Scenarios - Water Treatment Modeling**

Range of Data Sets for complete Processing (max 25)  
 Start Set#: 1  
 End Set#: 3  
 Process Data  
**For data inputs, complete Steps 1 - 3**

This program expands on the worksheet tab "WaterPro" that allows the user to model simultaneously up to 25 sets of data. Select choice of chemical via drop-down list. User may manually input dose or allow computer generated dose based on targeted or constraint values.  
**Set Numbers**

	1	2	3	4	5
<b>Step 1: Initial Water Characteristics Input</b>	<b>Project #:</b> CA1710001				
1 Plant Flow (gpm):	147	147	147	147	
2 TDS (mg/L):	120	50	75	200	
3 pH:	7.00	6.00	6.50	9.00	
4 Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	600	20.00	50.00	100	
5 Temperature (°C, at which pH was measured):	10.0	10.0	10.0	10.0	
6 Field Temperature (°C, operating temperature):	10.0	10.0	10.0	10.0	
7 Calcium (mg/L as Ca <sup>2+</sup> ):	5.0	5.0	5.0	15.0	
8 Magnesium (mg/L as Mg <sup>2+</sup> ):	6.0	2.0	2.0	2.0	
9 Sodium (mg/L as Na <sup>+</sup> ):	8.0	25.0	30.0	15.0	
10 Chloride (mg/L as Cl <sup>-</sup> ):	5.0	5.0	5.0	5.0	
11 Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):	1.2	1.2	1.2	1.2	
<b>Optional:</b>					
13 UV <sub>A</sub> -254/cm (filtered thru a 0.4 um absolute filter):	0.011	0.011	0.011		
14 Dissolved Organic Carbon (DOC), mg/L:	5.0	5.0	5.0		
15 Source Water Turbidity (NTU):	32.0	32.0	32.0		

	1	2	3	4	5
<b>Step 2: Interim Chemical Addition:</b>	<b>Set#</b>				
17 Pre-Oxidation/Disinfection, Gas Chlorine (Cl <sub>2</sub> , mg/L):					
18 Pre-Oxidation/Disinfection, Sodium Hypochlorite (NaOCl, mg/L):					
19 <b>Select Acid to Lower pH:</b>	None	None	None	None	None
20 Chemical Dose, mg/L (computer generated):					
21 Targeted pH:					
22 Chemical Dose, mg/L (manually inputted):					
23 <b>Select Base/CO<sub>2</sub> Stripping to Raise pH:</b>	CO <sub>2</sub>	CO <sub>2</sub>	None	None	None
24 Chemical Dose, mg/L (computer generated):	0.0	-33.8			
25 Targeted pH:	6.5	6.5			
26 Targeted Alkalinity, mg/L as CaCO <sub>3</sub> :					
27 Chemical Dose, mg/L (manually inputted):					
<b>Coagulant Addition</b>					
29 <b>Select Primary Coagulant:</b>	9990 (10% Al 83% Basicity)	9990 (10% Al 83% Basicity)	9990 (10% Al 83% Basicity)	9990 (10% Al 83% Basicity)	9990 (10% Al 83% Basicity)
30 Primary Coagulant (mg/L):					
31 <b>Select Secondary Coagulant:</b>	No Secondary Coagulant	No Secondary Coagulant	No Secondary Coagulant	No Secondary Coagulant	No Secondary Coagulant
32 Secondary Coagulant (mg/L):					

	1	2	3	4	5
<b>Step 3: Chemical Addition: Finished Water Treatment</b>	<b>Project #:</b> CA1710001				
<b>Corrosion Control</b>	<b>Set#</b>				
35 <b>Select Base/CO<sub>2</sub> Stripping to Raise pH:</b>	NaOH	CO <sub>2</sub>	CaCO <sub>3</sub>	Ca(OH) <sub>2</sub>	Na <sub>2</sub> CO <sub>3</sub>
36 Chemical Base/CO <sub>2</sub> Stripping Dose, mg/L (computer generated):	71.8		0.0	0.0	31.3
37 Upper bound pH:	7.40	7.40	7.40	7.40	7.20
38 Upper bound Langelier Saturation Index, Calcite (LSI):	0.12	0.12	0.12	0.12	0.02
39 Upper bound Calcium Carbonate Precipitation (CCPP, mg/L as CaCO <sub>3</sub> ):	1.00	1.00	1.00	1.00	0.50
40 Chemical Dose, mg/L (manually inputted):		-20.0			
<b>Other Chemical Additions - Input Manually</b>					
42 Calcium Chloride (CaCl <sub>2</sub> , mg/L)					
43 Orthophosphate as PO <sub>4</sub> <sup>3-</sup> , mg/L)					
44 Carbon Dioxide (mg/L as CO <sub>2(gas)</sub> ):					
<b>Disinfection &amp; Fluoridation</b>	<b>Set#</b>				
46 Chlorine Gas (Cl <sub>2</sub> , mg/L)					
47 Sodium Hypochlorite (NaOCl, mg/L)					
48 Calcium Hypochlorite (Ca(OCl) <sub>2</sub> , mg/L)					
49 Hydrofluosilicic Acid (H <sub>2</sub> SiF <sub>6</sub> , mg/L)					
50 Sodium Silicofluoride (Na <sub>2</sub> SiF <sub>6</sub> , mg/L)					

Results					
	1	2	3	4	5
<b>1. Initial Water Characteristics</b>	<b>Project #:</b> CA1710001				
Electrical Conductivity (uS/cm):	187.5	78.1	117.2	312.5	229.7
pH (field water temperature):	7.00	6.00	6.50	9.00	6.85
Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	600	20	50	100	100
Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	731	24	61	113	122
Carbonate (mg/L as CO <sub>3</sub> <sup>2-</sup> ):	0.278	0.001	0.007	4.474	
Acidity (mg/L as CaCO <sub>3</sub> ):	928.6	132.3	137.8	92.7	169.5
Carbon Dioxide (CO <sub>2</sub> , mg/L):	144.68	49.32	38.59	0.22	30.60
DIC (dissolved inorganic carbon, mg/L as C):	183.43	18.27	22.53	23.13	32.30
<b>Hardness - Initial</b>	<b>Set#</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Magnesium Hardness (mg/L as CaCO <sub>3</sub> ):	25	8	8	8	132
Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	12	12	12	37	37
Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	37	21	21	46	169
Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	37	20	21	46	100
Non-Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	0	1	0	0	69
Cations/Anions Percent Difference, (Σcations-Σanions) + (Σcations+Σanions):	-83.53%	45.20%	19.20%	-12.48%	
<b>Corrosion Indices</b>	<b>Set#</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Aggressive Index (AI):	10.8	8.4	9.3	12.5	10.4
Ryznar Index (RI):	9.13	12.93	11.67	7.87	9.72
Langelier Index (LI):	-1.07	-3.46	-2.59	0.57	-1.44
CCPP (Calcium Carbonate Precipitation Potential, mg/L as CaCO <sub>3</sub> ):	-71.75	-100.27	-77.72	6.27	-54.70
Buffer Intensity (mM/pH):	5.95	0.682	1.08	0.2	1.19
Larson's Ratio ((Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk):	0.01	0.42	0.17	0.08	0.71
CSMR (Chloride to Sulfate Mass Ratio):	4.17	4.17	4.17	4.17	0.84
<b>Lead and Copper</b>	<b>Project #:</b> CA1710001				
pH at field water temperature:	7.00	6.00	6.50	9.00	6.85
Field water temperature (°C):	10.0	10.0	10.0	10.0	15.0
Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):	31.22	164.39	24.06	0.07	6.99
Copper II (mg/L), Tenorite, black, CuO(s):	2.87	13.87	2.09	0.01	0.64
Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):	0.45	3.74	0.64	0.03	0.24
Lead II (mg/L), Lead Carbonate (PbCO <sub>3</sub> , cerussite):	0.137	1.169	0.282	0.165	0.199
<b>Lead &amp; Copper and pH Results (at 25°C water temperature):</b>	<b>Set#</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
pH (at 25°C water temperature):	6.89	5.89	6.39	8.82	6.78
Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):	14.86	66.01	10.21	0.04	4.07
Copper II (mg/L), Tenorite, black, CuO(s):	1.37	5.98	0.93	0.00	0.37
Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):	0.31	2.31	0.41	0.02	0.18
Lead II (mg/L), Lead Carbonate (PbCO <sub>3</sub> , cerussite):	0.211	1.628	0.406	0.244	0.258
Lead II (mg/L), Basic Lead Carbonate (Pb <sub>3</sub> (CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2</sub> , hydrocerussite):	1.104	5.964	1.370	0.155	0.805

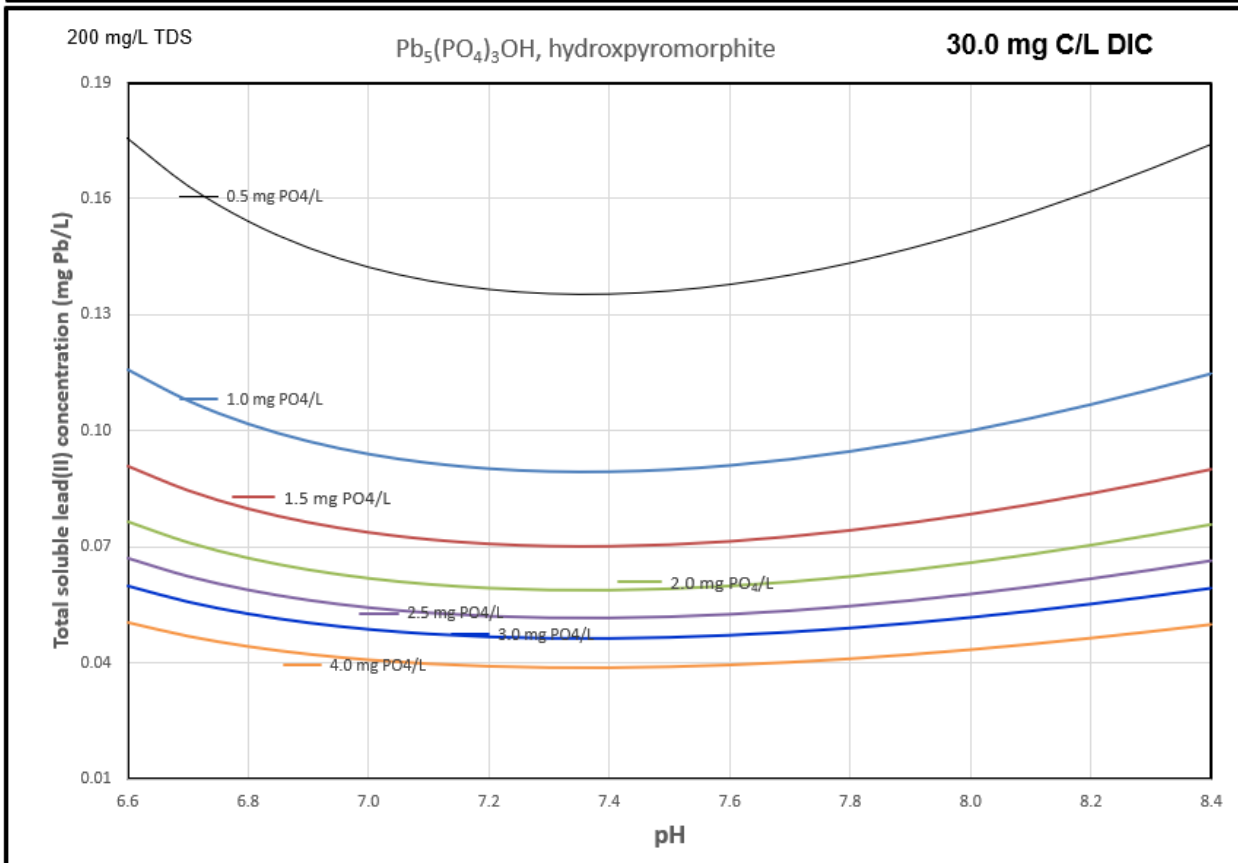
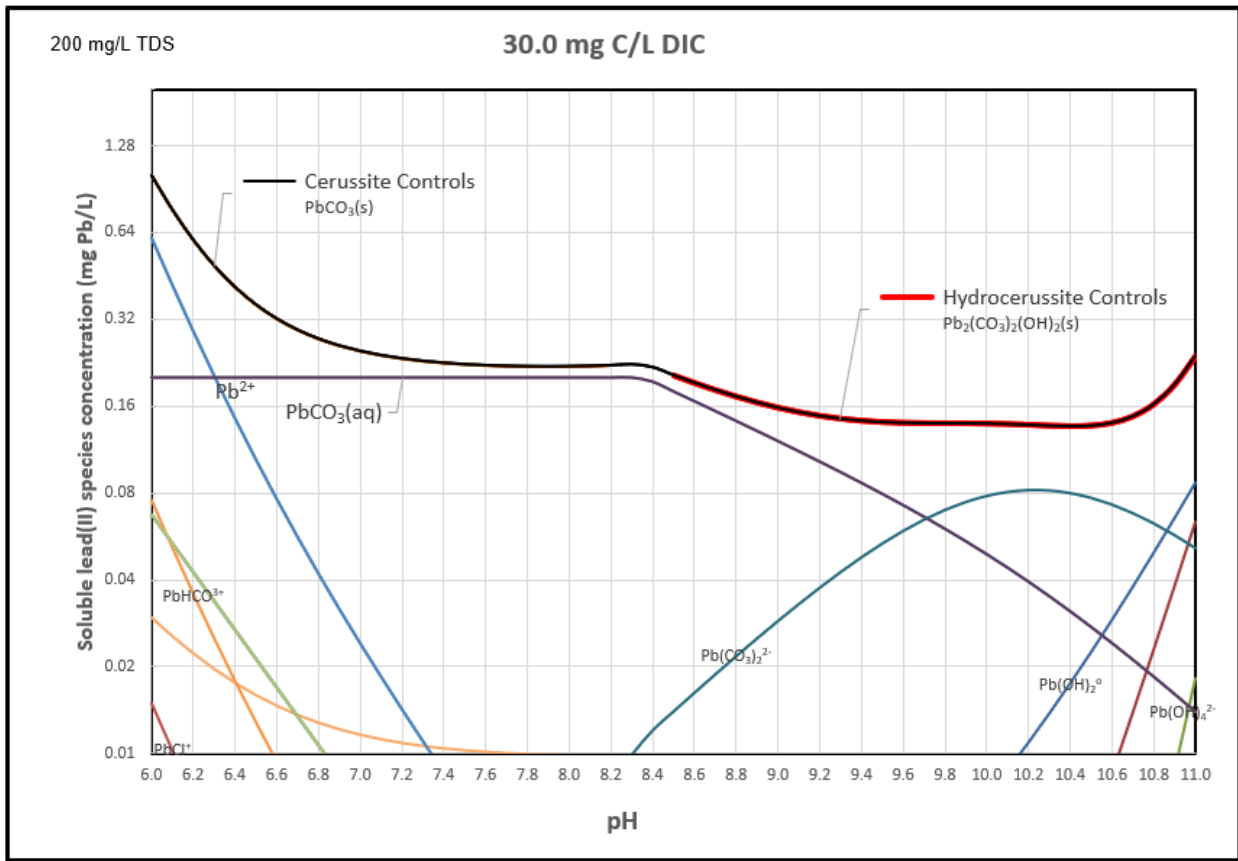
2. Results after Interim Chemical Addition					
	1	2	3	4	5
<b>Acid Chemical Added</b>	<b>Project #:</b> CA1710001				
Acid Chemical Added	None	None	None	None	None
Chemical Dose (mg/L):	0	0	0	0	0
<b>Base Chemical Added:</b>	<b>CO<sub>2</sub></b>	<b>CO<sub>2</sub></b>	<b>None</b>	<b>None</b>	<b>None</b>
Chemical Dose (mg/L):	0.0	-33.8	0.0	0.0	0.0
Primary Coagulant Added:	9890 (10% Al, 83% Basicity)	9890 (10% Al, 83% Basicity)	9890 (10% Al, 83% Basicity)	9890 (10% Al, 83% Basicity)	9890 (10% Al, 83% Basicity)
Chemical Dose (mg/L):					
Secondary Coagulant Added:	No Secondary Coagulant	No Secondary Coagulant	No Secondary Coagulant	No Secondary Coagulant	No Secondary Coagulant
Chemical Dose (mg/L):					
pH (at field water temperature):	7.00	6.50	7.40	10.60	6.85
Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	600	20	50	100	100
Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	731	24	61	27	122
Acidity (mg/L as CaCO <sub>3</sub> ):	929	55	61	16	169
Carbon Dioxide (mg/L as CO <sub>2(aq)</sub> ):	66	0	5	0	18
Calcium (mg/L as Ca <sup>2+</sup> ):	5	5	5	15	15
Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	12	12	12	37	37
<b>DOC Reduction and Sludge Production after Coagulant addition</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Dissolved Organic Carbon (DOC, mg/L as C):	5.00	5.00	5.00	-	27.00
% of DOC Reduced post coagulant/acid/base treatment:	0.0%	0.0%	0.0%	-	0.0%
Nonsorbable DOC (mg/L):	2.64	2.64	2.64	-	-
Aluminum Added (mg/L as Al):	0.00	0.00	0.00	0.00	0.00
Ferric Added (mg/L as Fe):	0.00	0.00	0.00	0.00	0.00
Sludge Production (lbs/MG):	0	0	0	0	0
Sludge Production (lbs/day):	0	0	0	0	0
Sludge Production (Kg/day):	0	0	0	0	0

116	<b>3. Final Results after Chemical Addition</b>	Project #	CA1710001				
117	Corrosion Control Chemicals Added:		NaOH	CO <sub>2</sub>	CaCO <sub>3</sub>	Ca(OH) <sub>2</sub>	Na <sub>2</sub> CO <sub>3</sub>
118	Chemical Dose (mg/L)		71.8	-20.0	0.0	0.0	31.3
119	Orthophosphate (as PO <sub>4</sub> <sup>3-</sup> , mg/L):						
120	pH (at field water temperature):		7.40	9.95	7.40	10.60	7.20
121	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):		690	20	50	100	130
122	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):		839	14	61	27	158
123	Carbonate (mg/L as CO <sub>3</sub> <sup>2-</sup> ):		0.80	4.41	0.06	43	
124	Acidity (mg/L as CaCO <sub>3</sub> ):		839	10	61	16	169
125	Carbon Dioxide (mg/L as CO <sub>2(gas)</sub> ):		66	0	5	0	18
126	DIC (dissolved inorganic carbon, mg/L as C):		183	4	13	14	36
127	Calcium (mg/L as Ca <sup>2+</sup> ):		5	5	5	15	15
128	Sodium (mg/L as Na <sup>+</sup> ):		49	25	30	15	22
129	Chloride (mg/L as Cl <sup>-</sup> ):		5	5	5	5	27
130	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):		1	1	1	1	32
131	<b>Hardness - Final</b>	Set#	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
132	Magnesium Hardness (mg/L as CaCO <sub>3</sub> ):		25	8	8	8	132
133	Calcium Hardness (mg/L as CaCO <sub>3</sub> ):		12	12	12	37	37
134	Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):		37	21	21	46	169
135	Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):		37	11	21	22	
136	Non-Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):		0	9	0	24	
137	Cations/Anions Percent Difference, (Σcations-Σanions) / (Σcations+Σanions):		-65.7%	58.7%	19.3%	44.0%	
138	<b>Corrosion Indices - Finished Water Characteristics</b>	Set#	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
139	Aggressive Index (AI):		11.29	12.32	10.19	14.01	10.86
140	Ryznar Index (RI):		8.63	9.59	10.78	7.90	9.15
141	Langelier Index (LI):		-0.61	0.18	-1.69	1.35	-0.97
142	CCPP (Calcium Carbonate Precipitation Potential, mg/L as CaCO <sub>3</sub> ):		-24.79	2.28	-12.65	24.11	-29.29
143	Buffer Intensity (mM/pH):		3.14	0.342	0.231	1.61	0.802
144	Larson's Ratio ((Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk):		0.01	0.42	0.17	0.08	0.55
145	CSMR (Chloride to Sulfate Mass Ratio):		4.17	4.17	4.17	4.17	0.84
146	<b>Lead and Copper - Finished Water Characteristics</b>	Set#	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
147	pH (at field water temperature):		7.40	9.95	7.40	10.60	7.20
148	Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):		14.28	0.01	1.26	0.01	3.23
149	Copper II (mg/L), Tenorite, black, CuO(s):		1.32	0.00	0.11	0.00	0.30
150	Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):		0.31	0.03	0.10	0.07	0.15
151	Lead II (mg/L), Lead Carbonate (PbCO <sub>3(s)</sub> , cerussite):		0.137	0.409	0.169	0.862	0.173
152	<b>Lead and Copper, and pH Results (at 25°C water temperature) - Finished</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
153	pH (at 25°C water temperature):		7.29	9.63	7.29	10.30	7.13
154	Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):		6.85	0.00	0.57	0.00	1.92
155	Copper II (mg/L), Tenorite, black, CuO(s):		0.63	0.00	0.05	0.00	0.18
156	Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):		0.21	0.01	0.07	0.02	0.11
157	Copper II (mg/L), Copper Phosphate, Cu <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O(s):		-	-	-	-	-
158	Lead II (mg/L), Lead Carbonate, PbCO <sub>3(s)</sub> , cerussite:		0.211	0.392	0.247	0.683	0.227
159	Lead II (mg/L), Basic Lead Carbonate, Pb <sub>3</sub> (CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2</sub> (s), hydrocerussite:		0.852	0.069	0.418	0.092	0.590
160	Lead II (mg/L), Hydroxy-pyromorphite, Pb <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> (OH) <sub>2</sub> (s):		-	-	-	-	-

3. **Theoretical Equilibrium Lead (II) & Cu (II) Solubility Program:** Allows the user to evaluate lead and copper solubility before and after the addition of orthophosphate for a given pH, DIC, chloride, sulfate, TDS, and orthophosphate dose at a temperature of 25°C. Plotted is the Cerussite and Hydrocerussite controlling solids for targeted TDS and DIC for a pH range from 6 to 11: Also plotted are the Hydroxypyromorphite curves for different dosages of orthophosphate for a pH range of 6.6 to 8.4.

### Theoretical Equilibrium Lead (II) & Cu (II) Solubility Program

<b>Step 1: Input values below in blue:</b>				
TDS (mg/L):	200	5.00	mMol/L, Ionic Strength	
Temperature (°C):	25	77.0	°F	
Sulfate (SO <sub>4</sub> <sup>2-</sup> , mg/L):	40	0.42	mMol/L	
Chloride (Cl <sup>-</sup> , mg/L):	30	0.85	mMol/L	
DIC (mg/L as C):	30	2.498	mMol/L	
pH (6-11):	7.20	unit		
Orthophosphate:	1.00	mg/l as PO <sub>4</sub> <sup>3-</sup>	0.0105	mMol/L
Alkalinity:	110.6	mg/L as CaCO <sub>3</sub>	2.2093 meq/L	
Carbon Dioxide (CO <sub>2</sub> ):	12.79	mg/L as CO <sub>2</sub>	3.49	mg/L as C
Bicarbonate (HCO <sub>3</sub> <sup>-</sup> ):	110.4	mg/L as CaCO <sub>3</sub>	26.49	mg/L as C
Carbonate (CO <sub>3</sub> <sup>2-</sup> ):	0.205	mg/L as CaCO <sub>3</sub>	0.02458	mg/L as C
Hydroxide (OH <sup>-</sup> ):	0.009	mg/L as CaCO <sub>3</sub>	30	mg/ as C
Hydrogen (H <sup>+</sup> ):	0.003	mg/L as CaCO <sub>3</sub>	Alk: HCO <sub>3</sub> <sup>-</sup> + CO <sub>3</sub> <sup>2-</sup> + OH <sup>-</sup> - H <sup>+</sup>	
CSMR:	1.33	Cl to SO <sub>4</sub> mass ratio		
<b>Step 2: Final Pb &amp; Cu Results - before and after PO<sub>4</sub> addition</b>				
Lead II (mg/L):	0.234	PbCO <sub>3</sub> (s), Cerussite		
Lead II (mg/L):	0.549	Pb(CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2</sub> (s), Hydrocerussite		
Copper II (mg/L):	1.40	Cupric Hydroxide, Cu(OH) <sub>2</sub> (s) light blue/blue-green		
Copper II (mg/L):	0.130	Tenorite, black, CuO(s)		
Copper II (mg/L):	0.070	Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):		
<b>When orthophosphate is added:</b>				
Lead II (mg/L):	0.090	Pb <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> (OH)(s), Hydroxypyromorphite		
Lead II (mg/L):	0.234	PbCO <sub>3</sub> (s), Cerussite		
Lead II (mg/L):	0.549	Pb(CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2</sub> (s), Hydrocerussite		
Copper II (mg/L):	0.909	Cupric Phosphate, blue, Cu <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> • 2H <sub>2</sub> O(s)		





5. **Arsenic and Corrosion Treatment:** A utility has a well source with 80 ug/L of arsenic. Ferric chloride followed by filtration is proposed to reduce arsenic below the maximum contamination level (MCL) of 10 ug/L. The initial water characteristics are displayed in Step 1:

<b>Step 1: Enter Source Water Characteristics</b>			
Total Dissolved Solids (TDS):	151	mg/L	0.00378 mol/L, Ionic Strength
pH:	8.10	unit (field pH is recommended)	
Total Alkalinity:	96.0	mg/L as CaCO <sub>3</sub>	1.92 meq/L
Water Temperature:	15.0	°C (temperature at which pH was analyzed)	
Field Temperature:	15.0	°C (operating temperature at facility)	
Calcium (Total, Ca <sup>2+</sup> ):	35.0	mg/L	87.41 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	37.0	mg/L	52.2 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	65.0	mg/L	67.7 mg/L as CaCO <sub>3</sub>
Iron (Fe <sup>+3</sup> ):	0	mg/L	0.00 mg/L as CaCO <sub>3</sub>
Arsenic:	80	ug/L (source water)	

In Step 2, the user may select an acid to reduce the source water pH to improve the performance of the addition of Ferric Chloride. If an acid is selected, the user inputs the targeted pH. Pre-oxidation of liquid sodium hypochlorite is optional for converting any As(III) to As(V). The user inputs the target treated water arsenic concentration.

<b>Step 2: Source Water Chemical Treatment Inputs and Goals</b>		
<b>Pre-Oxidation/pH adjustment/Arsenic Treatment</b>		
To lower pH before FeCl <sub>3</sub> addition, select an acid or select none.		
Select Acid:	<input checked="" type="radio"/> Sulfuric Acid	<input type="radio"/> Hydrochloric Acid <input type="radio"/> Carbon Dioxide <input type="radio"/> None (no acid added)
pH will be adjusted with Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ).		
Input Target pH:	6.9	unit, before FeCl <sub>3</sub> addition
<b>Enter NaOCl pre-oxidation dose to convert As(III) to As(V), (optional)</b>		
Sodium Hypochlorite (NaOCl):	3.0	mg/L
<b>Enter Treated Water Goal for Arsenic</b>		
Target Treated Water Arsenic :	5.0	ug/L (finished water)

Step 3 allows the user to implement corrosion control. The user will decide if pH is to be raised via Sodium Hydroxide or Soda Ash and/or orthophosphate treatment. Disinfection is the last process the user may input dose. Once Steps 1-3 are completed, the user is to click on "Process Data" for the program to process the inputted data. The results are shown in Step 4-6. Step 4 shows the corrosion indices based on the initial water characteristics. Step 5 shows the chemical dosages of the chemicals added, changes in water characteristics and corrosion indices. Step 6 shows the final water characteristics and corrosion indices after corrosion treatment.

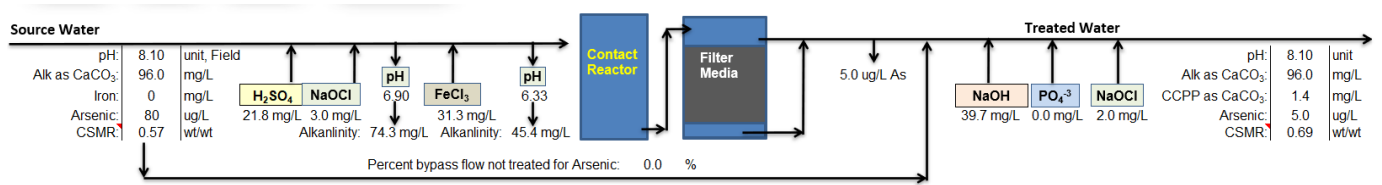
<b>Step 3: Corrosion Control and Disinfection - Finished Water Treatment</b>			
Raised pH for corrosion control?	<input checked="" type="radio"/> Yes <input type="radio"/> No		
Enter Target pH:	8.10	unit	<input checked="" type="radio"/> Sodium Hydroxide <input type="radio"/> Soda Ash
Please select base chemical for raising pH:			
<b>Enter Orthophosphate (PO<sub>4</sub><sup>3-</sup>) Dose if Applied</b>			
Orthophosphate as PO <sub>4</sub> <sup>3-</sup> :	0.0	mg/L	0.00 mg/L as P <sup>3+</sup>
<b>Enter NaOCl Dose if Disinfection is Applied</b>			
Sodium Hypochlorite (NaOCl):	2.0	mg/L	

<b>Step 4: Intial Results before Chemical Addition</b>		
<b>Theoretical Initial Water Characteristics after Temperature Correction</b>		
pH:	8.10	unit, based on field water temperature
DIC:	194.6	mg/L as CaCO <sub>3</sub> 23.3 mg/L as C
Langelier Index, Calcite (LSI):	0.14	Tendency for deposition of CaCO <sub>3</sub>
CCPP:	1.5	mg/L as CaCO <sub>3</sub>
Chloride/Sulfate Mass Ratio:	0.57	wt/wt, CSMR
Copper II (Temperature at 15°C):	0.29	mg/L, Cupric Hydroxide
Lead II (Temperature at 15°C):	0.169	mg/L, Lead Carbonate

<b>Step 5: Pre-FeCl<sub>3</sub> Chemical Addition/Water Charateristic Changes</b>		
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	22.90	mg/L      23.37 mg/L as CaCO <sub>3</sub>
Sodium Hypochlorite (NaOCl):	3.0	mg/L
pH:	6.90	unit
<b>Post-FeCl<sub>3</sub> Addition/Water Characteristics Changes before Corrosion Control</b>		
Total Fe added (Source + FeCl <sub>3</sub> ):	10.76	mg/L as Fe <sup>+2</sup>
FeCl <sub>3</sub> :	31.25	mg/L      10.76 mg/L as Fe <sup>+3</sup>
pH:	6.34	unit
Total Alkalinity:	45.8	mg/L as CaCO <sub>3</sub> 0.92 meq/L
Langelier Index, Calcite (LSI):	-2.0	Tendency to dissolve CaCO <sub>3</sub>
CCPP:	-84.6	mg/L as CaCO <sub>3</sub>

Step 6: Post Corrosion Control/Disinfection Water Characteristics				
Sodium Hydroxide (NaOH):	40.60	mg/L	50.80	mg/L as CaCO <sub>3</sub>
Orthophosphate as PO <sub>4</sub> <sup>3-</sup> :	0.0	mg/L	0.00	mg/L as P <sup>3+</sup>
Sodium Hypochlorite (NaOCl):	2.0	mg/L		
pH:	8.10	unit		
Total Alkalinity:	96.0	mg/L as CaCO <sub>3</sub>		1.92 meq/L
Langelier Index, Calcite (LSI):	0.1		Tendency for deposition of CaCO <sub>3</sub>	
CCPP:	1.4	mg/L as CaCO <sub>3</sub>		
Chloride/Sulfate Mass Ratio:	0.68	wt/wt, CSMR		
Copper II (Temperature at 15°C):	0.28	mg/L, Cupric Hydroxide		
Lead II (Temperature at 15°C):	0.169	mg/L, Lead Carbonate		

Below is a depiction of the treatment processes with source and final water characteristics:



6. **WP-Cost Input** – This worksheet allows the user to input the chemical cost and characteristics and information on sludge production. The information is used to calculate daily operating cost based on information inputted in the “WaterPro” worksheet. Below is an example of the worksheet entry form for selected chemicals. The sludge characteristics and process handling cost are not displayed.

**Enter chemical, operational and sludge cost and associated characteristics**  
**Note: Associated chemical & operating cost may be artificial. - All data is entered in "Blue".**

**Chemical & Operating Cost Input**

Aluminum Sulfate Coagulant	\$Cost per Dry Ton as Al <sub>2</sub> (O <sub>3</sub> )	Active % Strength as Al	\$Cost per lb as Al	Acids/Fluorides	\$Cost per Dry Ton	\$Cost per lb
Alum (Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> *18H <sub>2</sub> O)	\$450.00	8.10	\$0.43	Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> )	\$200	\$0.10
Alum (Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> *14.3H <sub>2</sub> O)	\$450.00	9.00	\$0.43	Hydrochloric Acid (HCl)	\$450	\$0.23
				Carbon Dioxide (CO <sub>2</sub> )	\$450	\$0.23
Iron Coagulant	\$Cost per Dry Ton	Active % Strength as Fe	\$Cost per lb as Fe	Hydrofluosilicic Acid (H <sub>2</sub> SiF <sub>6</sub> ) <th>\$2,600</th> <th>\$1.30</th>	\$2,600	\$1.30
Ferrous Sulfate (FeSO <sub>4</sub> *7H <sub>2</sub> O)	\$450.00	9.86	\$1.12	Sodium Silicofluoride (Na <sub>2</sub> SiF <sub>6</sub> )	\$2,500	\$1.25
Ferric Chloride (FeCl <sub>3</sub> )	\$450.00	34.43	\$0.65		\$Cost per Dry Ton	\$Cost per lb
Disinfectants	\$Cost per Ton Cylinder			Bases		
Chlorine Gas (Cl <sub>2</sub> )	\$550			Caustic Soda (NaOH)	\$550.00	\$0.28
Sodium Hypochlorite	Product % Strength	Product Specific Gravity (SG)	\$Product Cost per Gal	Potassium Hydroxide (KOH)	\$550.00	\$0.28
NaOCl (12.5%)	12.50	1.20	\$0.80	Soda Ash (Na <sub>2</sub> CO <sub>3</sub> )	\$550.00	\$0.28
Calcium Hypochlorite			\$Product/lb	Potash (K <sub>2</sub> CO <sub>3</sub> )	\$550.00	\$0.28
Ca(OCl) <sub>2</sub>	68.00	-	\$1.00	Sodium Bicarbonate (NaHCO <sub>3</sub> )	\$550.00	\$0.28
				CaCO <sub>3</sub> (Limestone)	\$150.00	\$0.08
				Ca(OH) <sub>2</sub> (100% hydrated Lime)	\$550.00	\$0.28
				CaO (100% Quicklime)	\$550.00	\$0.28
				Orthophosphate, liquid	\$/lb-PO <sub>4</sub> <sup>3-</sup>	
				Orthophosphate as PO <sub>4</sub> <sup>3-</sup>	\$2.00	

Liquid Alum, Acidized Coagulant	Product % Strength of H <sub>2</sub> SO <sub>4</sub>	Product % Strength as Al	Product % Strength as Al <sub>2</sub> (O <sub>3</sub> )	Product Specific Gravity (SG)	Product Cost per Gal	Cost per lb (Al)	Product % Dry Weight of Aluminum Sulfate Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> *14.3H <sub>2</sub> O
0% Acid Alum*14.3H <sub>2</sub> O	0.00	4.30	8.20	1.335	\$0.21	\$0.43	48.20
0.5% Acid Alum*14.3H <sub>2</sub> O	0.50	4.11	7.90	1.310	\$0.22	\$0.48	46.44
1% Acid Alum*14.3H <sub>2</sub> O	1.00	4.05	7.70	1.300	\$0.22	\$0.50	45.26
1.5% Acid Alum*14.3H <sub>2</sub> O	1.50	4.05	7.60	1.300	\$0.22	\$0.50	44.67
2% Acid Alum*14.3H <sub>2</sub> O	2.50	3.95	7.50	1.300	\$0.23	\$0.53	44.09
2.5% Acid Alum*14.3H <sub>2</sub> O	3.00	3.95	7.40	1.300	\$0.23	\$0.54	43.50
3% Acid Alum*14.3H <sub>2</sub> O	4.00	3.85	7.20	1.300	\$0.23	\$0.56	42.32
4% Acid Alum*14.3H <sub>2</sub> O	4.00	3.75	7.00	1.290	\$0.23	\$0.58	41.15
5% Acid Alum*14.3H <sub>2</sub> O	5.00	3.60	6.80	1.290	\$0.25	\$0.65	39.97
7% Acid Alum*14.3H <sub>2</sub> O	7.00	3.25	6.20	1.280	\$0.28	\$0.80	36.44
10% Acid Alum*14.3H <sub>2</sub> O	10.00	2.85	5.30	1.270	\$0.30	\$1.01	31.15
15% Acid Alum*14.3H <sub>2</sub> O	15.00	2.25	4.20	1.270	\$0.30	\$1.27	24.69
20% Acid Alum*14.3H <sub>2</sub> O	20.00	1.65	3.10	1.260	\$0.35	\$2.03	18.22

Liquid Ferric Sulfate Coagulant	Product % Strength of H <sub>2</sub> SO <sub>4</sub>	Product % Strength as Fe	Product % Strength as Ferric Sulfate	Product Specific Gravity (SG)	Product Cost per Gal	Cost per lb (Fe)
Ferric Sulfate (Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> *8.8H <sub>2</sub> O)	0.00	12.00	60.0	1.600	\$0.30	\$0.48
3% Acid Ferric Sulfate*8.8H <sub>2</sub> O	3.00	11.50	57	1.560	\$0.50	\$0.75
5% Acid Ferric Sulfate*8.8H <sub>2</sub> O	5.00	10.90	54	1.550	\$0.50	\$0.70
7% Acid Ferric Sulfate*8.8H <sub>2</sub> O	7.00	9.70	48	1.500	\$0.50	\$0.61
10% Acid Ferric Sulfate*8.8H <sub>2</sub> O	10.00	8.30	41	1.450	\$0.50	\$0.50

Polyaluminum Chloride (PAC) Liquid Form (Product)	Product % Basicity	Product % as Al	Product \$Cost per lb	Cost per lb (Al)
PACI (5.3% Al, 90% Basicity)	90	5.3	\$8.00	\$0.42
PACI (17.2% Al, 80% Basicity)	80	17.2	\$10.00	\$1.72
PACI (12.2% Al, 70% Basicity)	70	12.2	\$5.00	\$0.61
PACI (5.3% Al, 50% Basicity)	50	5.3	\$5.00	\$0.27
PACI (8.5% Al, 40% Basicity)	40	8.5	\$5.00	\$0.43
PACI (9.5% Al, 35% Basicity)	35	9.5	\$5.00	\$0.48
PACI (5.3% Al, 30% Basicity)	30	5.3	\$5.00	\$0.27
Aluminum Chlorohydrate (ACH)				
ACH (12.5% Al, 80% Basicity)	80	12.5	\$5.00	\$0.63

7. **WP-Input-Storage** – Worksheet for storing and retrieving up to 100 sets of input data from “WaterPro” worksheet for evaluation. Data may also be directly inputted into this worksheet for storage and later retrieved into the “WaterPro” worksheet. Saving and retrieving is in Step 1 of “WaterPro” worksheet. This process allows the user to quickly go back and forth between data sets for evaluation without having to manually enter the data each time.

WaterPro Input Data from Steps 1, 3 and 5

Data is stored below from WaterPro or manually inputted by user

			Step 1 WaterPro Input Storage Data														Step 3 WaterPro									
Data Set #	Client ID	Customer Information	Plant Flow	Flow Units	TDS mg/L	Alkalinity CaCO <sub>3</sub> pH	Water Temperature °C	Field Water Temperature °C	Calcium Ca <sup>2+</sup> mg/L	Mg <sup>2+</sup> mg/L	Sodium Na <sup>+</sup> mg/L	Chloride Cl <sup>-</sup> mg/L	Sulfate SO <sub>4</sub> <sup>2-</sup> mg/L	UVA-254 1/cm	DOC mg/L	Turbidity NTU	Pre-NaOCl mg/L	Pre-Cl <sub>2</sub> mg/L	HCl mg/L	Sulfuric Acid mg/L	CO <sub>2</sub> mg/L	Ca(OH) <sub>2</sub> mg/L	CaO mg/L	Soda Ash Na <sub>2</sub> CO <sub>3</sub> mg/L		
1	1201	City of McFarland	100	gpm	210	9.20	15.0	15.0	7.0	0.0	22.0	97.0	1.5	0.100	4.00	0.08										
2	1202	City of Fresno, Table 1	100	gpm	210	7.33	34.0	15.0	15.0	7.0	22.2	97.0	1.5	0.100	4.00	0.08										
3	1203	Corrosion data2	100	gpm	210	9.40	33.0	25.0	20.0	0.0	97.0	1.5	0.100	4.00	0.08											
4	1204	City of McFarland, Problem 1	1,800	gpm	147	9.45	37.0	15.0	15.0	3.0	0.0	16.0	29.5	0.100	4.00	0.08										
5	1205	Corrosion data	100	gpm	210	9.40	33.0	25.0	20.0	0.0	97.0	1.5	0.100	4.00	0.08											
6	1206 - Tehachapi, WellA	CCI-Tehachapi, Well A, lead/Copper Treatment	100	L/min	410	7.50	160.0	15.0	15.0	74.0	10.0	27.0	74.0	0.100	4.00	0.08										
7	1207 - Tehachapi, WellB	CCI-Tehachapi, Well B, lead/Copper treatment	100	gpm	442	7.40	160.0	15.0	15.0	88.0	0.0	38.0	110.0	0.100	4.00	0.08										
8	5800844-001, Well	MJUSD Browns Valley School, Lead treatment	100	gpm	228	7.10	228.0	15.0	15.0	25.0	26.0	7.7	9.6													
9	1209	MJUSD Browns Valley School, Lead treatment	100	gpm	554	7.40	112.0	15.0	15.0	62.0	22.0	154.0	67.0													
10	1210	Blue Rock View Apartments, Well Data	100	gpm	2291	7.30	348.0	15.0	15.0	193.0	74.0	217.0	326.0			3.2										
11	1211-Surfwood	Surfwood MWC	40.0	gpm	80	6.80	20.0	12.0	12.0	4.0	0.0	21.0	2.1													
12	1212	Softening	1,800	gpm	200	7.41	115.5	20.0	20.0	70.2	10.0	10.5	96.0			0.3										
13	1213-300518, Well	Liberty Park Water Association	150	gpm	225	7.70	66.0	20.0	20.0	38.4		143.0	64.0													
14	1214-Potter Valley	Potter Valley School	100	gpm	200	6.50	88.0	15.0	15.0	20.0	0.0	11.0	17.0													
15	Example 1	Mazzie Injector	40.0	gpm	100	6.60	80.0	15.0	15.0	30.0	0.0	28.0	47.0	0.030	1.00	0.3	2.0									
16	1216	Grant Grove - Artesian Well	100	gpm	70	6.80	30.0	15.0	15.0	5.0	1.0	1.0	0.7													
17	1010501-1-001 Grant Grove	Grant Grove - 400 ft Well	100	gpm	50	6.80	10.0	15.0	15.0	2.0	1.0	1.0	0.5													
18	1010501-1-005 Grant Grove	Grant Grove - Artesian Well	80.0	gpm	60	6.80	20.0	15.0	15.0	3.5	0.0	1.0	0.6	0.030	1.00	0.3										
19	1010501-Grant Well Blend	Grant Grove - Artesian Well	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													
20	C-MT 20000122.00	Elmwood Scen #1 8/7/19 Hardness 100-no-ph	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													
21	B - CMT 20000122.00	Elmwood Scen #1 8/7/19 Hardness 100-phos	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													
22	C - CMT 20000122.00	Elmwood Scen #1 8/7/19 Hardness 100-phos	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													
23	D - CMT 20000122.00	Elmwood Scen #2 8/7/19 Hardness 80-no-ph	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													
24	E - CMT 20000122.00	Elmwood Scen #2 8/7/19 Hardness 80-phos	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													
25	F - CMT 20000122.00	Elmwood Scen #2 8/7/19 Hardness 80-phos	224	gpm	226	6.43	36.1	25.0	25.0	10.5	4.3	27.8	91.2													

8. **Pb and Copper Guidance** – This program incorporates the EPA Lead and Copper Guidance Manual for selecting corrosion control treatment strategies based on water characteristics and lead and copper tap results. The program will evaluate data from Water!Pro or the Corrosion Modeling program for suggested corrosion control treatment. The user is provided with one or more suggested treatment options based on the lead and copper issues at hand. The suggested treatment options can then be modeled and further evaluated by using Water!Pro or the Corrosion Control Modeling programs.

**Water!Pro™**

**Guidance for Selecting Lead and Copper Control Strategies<sup>1</sup>**

<p><b>Step 1:</b> Select case that corresponds to system</p> <p>(a) Exceeded Lead and Copper Action Levels  <b>(b) Exceeded Lead Action Level</b>          (c) Exceeded Copper Action Level          (d) Exceeded Lead and/or Copper &amp; remove source Fe and/or Mn          (e) Exceeded Lead and/or Copper &amp; have elevated source Fe &amp; Mn levels</p>	<p><b>Step 2:</b> Activate a button to insert initial water characteristics</p> <p>Select one: <input type="button" value="WaterPro Data"/> <input type="button" value="Corrosion Modeling Data"/></p> <p>Field water pH = 7.35          DIC (mg/L as C) = 10.74          Calcium (mg/L as Ca) = 13.35</p> <p>This data is reproduced and calculated from Steps 1 &amp; 2 in WaterPro worksheet.</p>					
<p><b>Step 3:</b> Recommended Action and Suggested Treatment</p> <table border="1" style="width: 100%;"> <thead> <tr> <th style="width: 50%;">First Suggested Treatment</th> <th style="width: 50%;">Alternate Treatment</th> </tr> </thead> <tbody> <tr> <td>Raise the pH in 0.3 unit increments using: caustic soda or caustic potash or soda ash or potash.</td> <td>Add Orthophosphate, initial dose should be &gt; 0.5 mg/L orthophosphate as P either orthophosphate or blend.</td> </tr> </tbody> </table>			First Suggested Treatment	Alternate Treatment	Raise the pH in 0.3 unit increments using: caustic soda or caustic potash or soda ash or potash.	Add Orthophosphate, initial dose should be > 0.5 mg/L orthophosphate as P either orthophosphate or blend.
First Suggested Treatment	Alternate Treatment					
Raise the pH in 0.3 unit increments using: caustic soda or caustic potash or soda ash or potash.	Add Orthophosphate, initial dose should be > 0.5 mg/L orthophosphate as P either orthophosphate or blend.					

After identifying possible appropriate treatment strategies listed above, the following Water Treatment Checklist should be consulted. The criteria listed under a specific treatment method must be met in order for that treatment to be selected.

Limestone Contactor	Caustic Soda or Potassium Hydroxide	Sodium Bicarbonate (baking soda)	Soda Ash or Potash
pH <= 7.2 Calcium < 60 mg/L Ca Alkalinity < 100 mg/L as CaCO <sub>3</sub>	DIC >= 5 mg/L as C	DIC < 5 mg/L as C pH will not increase above 8.3.	2< DIC < 25 mg/L as C
<b>Aeration</b>	<b>Sodium Silicate</b>	<b>Orthophosphate</b>	<b>Polyphosphate (blended phosphate)</b>
pH <= 7.2 DIC > 10 mg/L as C See Aeration Feasibility Tree	DIC < 10 mg/L as C Iron > 0.20 mg/L or Manganese > 0.05 mg/L or Red or black water complaints	pH in the range of 7.2-7.8 (for all cases) Lead & Copper 5<= DIC < 50 mg/L as C Lead 5<= DIC < 50 mg/L as C	pH 7.0 - 7.8 DIC >= 5 mg/L as C Iron > 0.20 mg/L or Manganese > 0.05 mg/L or Red or black water complaints or Calcium precipitation is a problem

**9. Corrosion Indices and Chemical Treatment** – This program provides the user up to 500 sets of water quality data to be inputted and evaluated for corrosion control and treatment. It allows side-by-side data evaluation and corrosion control treatment.

Corrosion Indices and Chemical Treatment																				
Process Data		Range of Data Sets to Process (max 500):		45		47		(Start/Finish)												
Step 1: Water Quality Data - User Input							Step 2: Indices Water Quality Results													
Data Set #	Site # or Name	Sample Date	TDS mg/L	pH	Alkalinity mg/L CaCO <sub>3</sub>	Calcium mg/L Ca <sup>2+</sup>	Temp. C° for pH Test	Temp. C° for Field Operations	Chloride mg/L Cl <sup>-</sup>	Sulfate mg/L SO <sub>4</sub> <sup>2-</sup>	pH	CO <sub>2</sub> mg/L CO <sub>2(aq)</sub>	DIC mg/L as C	Aggressive Index AI	Ryznar Index RI	Langelier Index LI	CCPP mg/L as CaCO <sub>3</sub>	Buffer Intensity mMpH	Larson's Ratio (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/AIK	CSMR
1	Cal Water Oroville (0410005)		60	7.90	37.0	7.6	15.0	15.0	2.8	1.5	7.80	1.3	9.2	10.6	10.10	-1.15	-4.91	0.071	0.15	1.87
2	SFWP (0410006)		27	6.80	17.2	3.7	15.0	15.0	1.8	3.1	6.80	6.1	5.8	9.0	12.33	-2.76	-15.90	0.228	0.34	0.58
3	Tanks-End Roselawn HS	8/25/16	744	6.90	331.7	79.6	22.8	22.8	171.2	7.2	6.90	74.6	99.9	11.7	7.24	-0.17	-22.20	3.110	1.33	23.78
4	Room 1 S Sink, Roselawn HS	8/12/16	802	7.20	140.0	83.9	27.0	27.0			7.20	14.9	37.6	11.7	7.52	-0.16	-6.97	0.701	N/A	N/A
5	Room 1 E Sink, Roselawn HS	8/25/16	715	7.30	140.0	83.9	27.0	27.0	172.6	1.6	7.30	11.9	36.8	11.8	7.40	-0.05	-1.73	0.576	1.75	107.88
6	Well 1, Roselawn High School	2/24/11	663	7.00	253.1	117.0	20.0	20.0	20.2	100.0	7.00	47.4	73.6	11.8	7.14	-0.07	-6.68	2.050	0.52	0.20
7																				
8	Chamisal WA, Well 1	1/28/16	683	7.10	228.0	106.0	20.0	20.0	160.0	131.0	7.10	34.0	64.2	11.8	7.24	-0.07	-5.41	1.530	0.63	1.22
9	25340 Cammino De Chamisal	1/28/16	706	6.90	223.0	106.0	20.0	20.0	160.0	131.0	6.90	52.4	67.8	11.6	7.46	-0.28	-28.50	2.170	1.62	1.22
10	Chamisal WA, Well 1	8/13/15	720	6.90	228.0	102.0	20.0	20.0	160.0	131.0	6.90	53.5	69.3	11.6	7.48	-0.29	-29.80	2.210	1.59	1.22
11	25340 Cammino De Chamisal	8/13/15	723	7.00	230.0	98.0	20.0	20.0	160.0	131.0	7.00	42.9	66.9	11.7	7.40	-0.20	-18.70	1.860	1.58	1.22
12																				
13	Twain Harte CSD - Ditch-Raw	7/19/16	16	6.33	7.3	2.1	15.0	15.0	0.9	4.1	6.33	7.7	3.9	7.9	14.00	-3.84	-19.70	0.185	1.32	0.21
14	Twain Harte CSD - Well 01	7/31/14	119	6.70	85.0	20.0	15.0	15.0	2.5	3.9	6.70	36.9	30.5	10.3	9.71	-1.51	-65.40	1.290	11.23	0.64
15																				
16	Del Rio - Well 01	7/3/14	300	7.53	169.0	36.8	15.0	15.0	16.3	15.2	7.53	10.5	43.4	11.7	7.91	-0.19	-6.24	0.526	4.35	1.07
17	Del Rio - Well 01		300	7.53	169.0	2.0	15.0	15.0	16.3	15.2	7.53	10.5	43.4	10.4	10.43	-1.45	-20.80	0.526	4.35	1.07
18																				
19	Well 1, Robley Properties MWC	5/28/14	530	7.60	270.0	57.0	15.0	15.0	156.0	250.0	7.60	13.9	68.5	12.1	7.30	0.15	8.32	0.713	0.58	0.62
20	Well 1, Robley Properties MWC	8/11/14	640	7.00	210.0	91.0	15.0	15.0	156.0	250.0	7.00	42.9	62.1	11.6	7.72	-0.36	-31.50	1.830	0.44	0.62
21	Well 1, Robley Properties MWC	5/28/14	530	7.60	270.0	57.0	15.0	15.0	156.0	250.0	7.60	13.9	68.5	12.1	7.30	0.15	8.32	0.713	0.58	0.62
22	Well 1, Robley Properties MWC	8/11/14	640	7.00	210.0	91.0	15.0	15.0	156.0	250.0	7.00	42.9	62.1	11.6	7.72	-0.36	-31.50	1.830	0.44	0.62

Step 3: Chemical Addition Inputs										Step 4: Indices Water Quality Results After Chemical Addition																						
Soda Ash Na <sub>2</sub> CO <sub>3</sub> mg/L	Caustic Soda NaOH mg/L	Hydrated Lime Ca(OH) <sub>2</sub> mg/L	Limestone CaCO <sub>3</sub> mg/L	Sulfuric Acid H <sub>2</sub> SO <sub>4</sub> mg/L	Carbon Dioxide CO <sub>2</sub> ± mg/L	Ortho-phosphate as PO <sub>4</sub> <sup>3-</sup> mg/L	Post Cl <sub>2</sub> mg/L	Post NaOCl mg/L	Fluoride H <sub>2</sub> SIF <sub>6</sub> mg/L	Site # or Name	pH	Alkalinity mg/L CaCO <sub>3</sub>	Calcium mg/L Ca <sup>2+</sup>	CO <sub>2</sub> mg/L CO <sub>2(aq)</sub>	DIC mg/L as C	Aggressive Index AI	Ryznar Index RI	Langelier Index LI	CCPP mg/L as CaCO <sub>3</sub>	Buffer Intensity mMpH												
										1	Cal Water Oroville (0410005)	7.80	37.0	7.6	1.3	9.2	10.6	10.10	-1.15	-4.91	0.071											
										2	SFWP (0410006)	6.80	17.2	3.7	6.1	5.8	9.0	12.33	-2.76	-15.90	0.228											
										3	Tanks-End Roselawn HS	6.90	331.7	79.6	22.8	22.8	171.2	7.2	6.90	74.6	99.9	11.7	7.24	-0.17	-22.20	3.110	1.33	23.78				
										4	Room 1 S Sink, Roselawn HS	7.20	140.0	83.9	27.0	27.0							7.20	14.9	37.6	11.7	7.52	-0.16	-6.97	0.701	N/A	N/A
										5	Room 1 E Sink, Roselawn HS	7.30	140.0	83.9	11.9	36.8	11.8	7.40	-0.05	-1.73	0.576	1.75	107.88									
										6	Well 1, Roselawn High School	7.00	253.1	117.0	20.0	20.0	20.2	100.0	7.00	47.4	73.6	11.8	7.14	-0.07	-6.68	2.050	0.52	0.20				
										7																						
				-22.0						8	Chamisal WA, Well 1	7.54	229.0	106.0	12.3	58.2	12.3	6.81	0.37	22.1	0.626											
				-22.0						9	25340 Cammino De Chamisal	7.13	223.0	106.0	30.5	61.6	11.9	7.22	-0.04	-3.06	1.390											
				-22.0						10	Chamisal WA, Well 1	7.13	228.0	102.0	31.6	63.3	11.8	7.25	-0.06	-4.45	1.440											
				-22.0						11	25340 Cammino De Chamisal	7.31	230.0	98.0	21.0	60.9	12.0	7.10	0.11	8.01	1.010											
										12																						
										13	Twain Harte CSD - Ditch-Raw	6.33	7.3	2.1	7.7	3.9	7.9	14.00	-3.84	-19.68	0.185											
										14	Twain Harte CSD - Well 01	6.70	85.0	20.0	36.9	30.5	10.3	9.71	-1.51	-65.38	1.290											
										15																						
										16	Del Rio - Well 01	7.53	169.0	36.8	10.5	43.4	11.7	7.91	-0.19	-6.24	0.526											
										17	Del Rio - Well 01	7.53	169.0	2.0	10.5	43.4	10.4	10.43	-1.45	-20.78	0.526											
										18																						
										19	Well 1, Robley Properties MWC	7.53	267.3	57.0	16.3	68.5	12.0	7.37	0.08	4.64	0.830											
										20	Well 1, Robley Properties MWC	6.98	207.8	91.0	44.9	62.1	11.6	7.75	-0.39	-34.55	1.900											
										21	Well 1, Robley Properties MWC	8.56	288.8	57.0	1.6	68.5	13.1	6.36	1.10	33.2	0.324											
										22	Well 1, Robley Properties MWC	7.25	228.8	91.0	26.5	62.1	11.9	7.41	-0.08	-5.49	1.230											
										23																						
										24	Bajamont SWTP	8.00	41.2	17.8	0.9	10.1	11.3	8.98	-0.49	-2.07	0.054											

**10. Limestone Contactor** – Limestone treatment is used for dissolving minerals into the water for the purpose of corrosion control. The application of this program is used for determining limestone bed depth for meeting corrosion control parameters. The characteristics of the water to be evaluated along with filter loading rate and limestone particle size design parameters are inputted and the limestone bed depth is calculated plus the new water characteristic. This program has built-in pre-acid treatment to lower the pH for waters with elevated pH. This feature is especially useful for water systems that have desalination where pH is greater than 7 and needs to be lowered for enhancing the limestone treatment process. In addition to this program, the user has the option to have populated in tabular form (see below) the changes in water characteristics, corrosion indices, limestone bed depths and solubility of copper as limestone is dissolved. An example of the tabulated results is given below which the data can be used for graphing illustrations. In this example, the starting pH was 8 with an alkalinity 4.3 mg/L. For limestone to dissolve, 80 mg/L of carbon dioxide was injected to lower the pH to 5.1. The limestone reactor was designed based on the starting pH of 5.1 and alkalinity of 4.3 mg/L. The pre-treatment of carbon dioxide and post treatment of limestone contactor were modeled in the “Limestone Bed Contactor” program. The results in “Step 4” can be automatically exported to

“WaterPro” and “Blend” worksheets for further modeling. The “Limestone Bed Contactor” program is a valuable tool for small to large applications.

### Limestone Bed Contactor

Corrosion Control and Treatment Process Analysis Program - Version 2.4

Step 1: Initial Water Characteristics		Copy Data to WaterPro	
Enter source water characteristics.			
System Name:	Testing Spain	Copy WaterPro Data Here	
TDS =	20.0	mg/L	0.50 mMols/L, Ionic Strength
pH =	8.00	field pH is recommended	
Total Alkalinity =	4.3	mg/L as CaCO <sub>3</sub>	0.09 meq/L
Total Calcium =	2.00	mg/L Ca <sup>2+</sup>	4.99 mg/L as CaCO <sub>3</sub>
Water Temperature =	18.0	°C (temp. at which pH was analyzed)	
Field Water Temperature =	18.0	°C (operating temperature at facility)	
Cl <sup>-</sup> =	4.2	mg/L	5.9 mg/L as CaCO <sub>3</sub>
SO <sub>4</sub> <sup>2-</sup> =	5.0	mg/L	5.2 mg/L as CaCO <sub>3</sub>
CaCO <sub>3</sub> Solubility Product, pKsp =	-8.8100	at 25°C, program default	
Do you want to change the Solubility Product of CaCO <sub>3</sub> ?	<input checked="" type="radio"/> Yes <input type="radio"/> No		
User CaCO <sub>3</sub> Solubility Product, pKsp =	-8.4798	Please enter pKsp and temperature values.	
Relative Temperature for pKsp =	25.0	°C	
Enter Pre-Treatment Dose for Lowering pH.			
Carbon Dioxide (CO <sub>2</sub> ) +/-	25.1	mg/L	57.0 mg/L as CaCO <sub>3</sub>
Hydrochloric Acid (HCl)		mg/L	0.00 mg/L as CaCO <sub>3</sub>
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> )	5.0	mg/L	5.10 mg/L as CaCO <sub>3</sub>

Step 2: Initial Results Before Chemical Addition	
Theoretical initial water characteristics after temperature correction.	
pH =	8.00 field pH 31.3 uS/cm (Electrical Conductivity)
Equilibrium pH =	9.78 maximum pH that can be achieved based on initial TDS
Acidity =	4.41 mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ) =	0.09 mg/L as CO <sub>2(aq)</sub> 0.579 mg/L Atmospheric equilibrium CO <sub>2(aq)</sub>
DIC =	1.05 mg/L C, dissolved inorganic carbon
Langelier Index, Calcite =	-2.40 Tendency to dissolve CaCO <sub>3</sub> (for steel and cast iron piping)
CCPP =	-7.0 mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential at 18 C temperature and 20 mg/L TDS
CaCO <sub>3</sub> pKsp =	-8.341
B <sub>100</sub> + B <sub>CO3</sub> =	0.005 mM/pH, Buffer intensity from water and carbonate species
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk =	2.6 High metal tendency towards mild steel
Copper II =	0.03 mg/L; Cupric Hydroxide, light blue/blue-green
Pre-treatment results of water characteristics if acid is added.	
pH =	4.59 Carbon Dioxide (CO <sub>2</sub> ) = 28.43 mg/L as CO <sub>2(aq)</sub>
Equilibrium pH =	8.11 maximum pH that can be achieved based on initial TDS
Acidity =	66.5 mg/L as CaCO <sub>3</sub> DIC = 7.88 mg/L C
Total Alkalinity =	-0.8 mg/L as CaCO <sub>3</sub> -0.02 meq/L
CCPP =	-65.8 mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential

Step 3: Limestone Bed Contactor Parameters	
Enter parameters for contactor and chemical addition.	
Superficial Velocity =	9.0 gpm/ft <sup>2</sup> 36.67 cm/min
Limestone Particle Diameter =	0.43 cm, (0.1 to 3.2 cm) Include TDS? <input type="checkbox"/>
Limestone Porosity, ε =	0.6 DT: 0.8 0.80 <input type="checkbox"/>
Sphericity (roundness), ψ =	0.80 range: 0.4 - 0.9
Mass % of Limestone Particles =	95 % exposed surface area of CaCO <sub>3</sub>
CaCO <sub>3</sub> (Limestone) =	63.8 mg/L, based on 100% exposed surface area
You may enter "Target pH" to determine Limestone concentration and depth of contactor.	
Target pH =	7.87 <input type="text" value="Target pH"/>

Step 4: Results (After Chemical Addition of Limestone)	
pH =	7.87 pH of water after chemical addition TDS: 86 mg/L
Total Alkalinity =	62.9 mg/L as CaCO <sub>3</sub> 1.26 meq/L
Total Calcium =	27.53 mg/L Ca <sup>2+</sup> 68.7 mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ) =	1.8 mg/L as CO <sub>2(aq)</sub> 0.48 mg/L as C
DIC =	15.5 mg/L C, dissolved inorganic carbon
Langelier Index, Calcite =	-0.27 Tendency to dissolve CaCO <sub>3</sub> (for steel and cast iron piping)
CCPP =	-2.09 mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential
B <sub>100</sub> + B <sub>CO3</sub> =	0.099 mM/pH, Buffer intensity from water and carbonate species
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk =	0.26 Light metal tendency
Copper II =	0.27 mg/L; Cupric Hydroxide, light blue/blue-green
Depth of Contactor =	8.27 feet 99.2 inches 252 cm
Empty Bed Contact Time =	6.87 minutes
Limestone Dissolved =	531 pounds per million gallons of water treated 241 Kg/MG

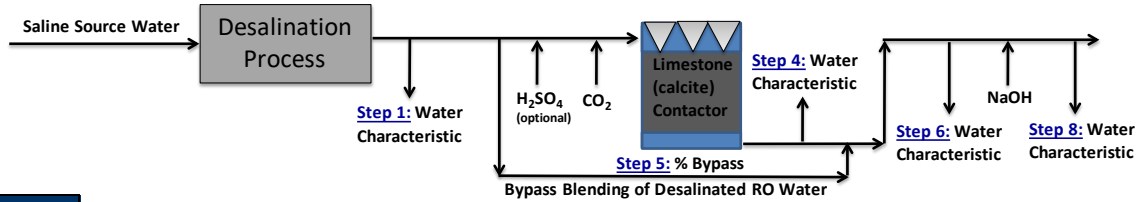
Copy Step 4 results into WaterPro.wks

Enter Limestone dose increment:  mg/L  
 Press "Process Data" to calculate table of limestone bed contactor data from initial characteristics to solubility:

### Process Data Calculated Data from Initial to Equilibrium for Limestone Bed Contactor

CaCO <sub>3</sub> Dose mg/L	pH unit	Total Alk mg/L	CO <sub>2</sub> mg/L	DIC, as C mg/L	Calcium, as Ca <sup>2+</sup> mg/L	B <sub>100</sub> + B <sub>CO3</sub> mM/pH	CCPP mg/L	LI	Copper II mg/L	Depth of Contactor ft	inches	cm	EBCT minutes	Dissolved lbs/MG
0.00	4.59	-0.8	28.4	7.88	2.0	0.145	-65.41	-6.72	>1000	0	0.0	0.0	0.00	0.0
2.00	5.09	1.2	28.3	8.12	2.8	0.110	-63.41	-5.59	>1000	0.07	0.9	2.2	0.06	16.7
4.00	5.42	3.2	27.7	8.36	3.6	0.159	-61.42	-4.83	964.44	0.15	1.8	4.6	0.12	33.3
6.00	5.62	5.2	26.8	8.60	4.4	0.220	-59.45	-4.34	375.62	0.23	2.7	7.0	0.19	50.0
8.00	5.77	7.2	26.0	8.84	5.2	0.277	-57.46	-3.98	191.30	0.31	3.7	9.4	0.26	66.7
10.00	5.89	9.2	25.1	9.08	6.0	0.328	-55.48	-3.70	112.93	0.39	4.7	12.0	0.33	83.4
12.00	5.99	11.2	24.3	9.32	6.8	0.372	-53.51	-3.46	73.10	0.48	5.8	14.6	0.40	100.0
14.00	6.08	13.2	23.4	9.56	7.6	0.411	-51.51	-3.26	50.44	0.57	6.8	17.4	0.47	116.7
16.00	6.16	15.2	22.5	9.80	8.4	0.443	-49.53	-3.08	36.43	0.66	8.0	20.3	0.55	133.4
18.00	6.23	17.2	21.6	10.04	9.2	0.469	-47.55	-2.92	27.25	0.76	9.1	23.2	0.63	150.1
20.00	6.29	19.2	20.8	10.28	10.0	0.490	-45.57	-2.77	20.95	0.86	10.4	26.3	0.72	166.7
22.00	6.35	21.2	19.9	10.52	10.8	0.506	-43.59	-2.64	16.47	0.97	11.6	29.6	0.81	183.4
24.00	6.41	23.2	19.0	10.76	11.6	0.517	-41.59	-2.51	13.18	1.08	13.0	33.0	0.90	200.1
26.00	6.47	25.2	18.1	11.00	12.4	0.524	-39.61	-2.39	10.71	1.20	14.4	36.5	1.00	216.8
28.00	6.52	27.2	17.3	11.24	13.2	0.526	-37.63	-2.28	8.81	1.32	15.8	40.3	1.10	233.4
30.00	6.57	29.2	16.4	11.48	14.0	0.525	-35.64	-2.17	7.32	1.45	17.4	44.2	1.21	250.1
32.00	6.63	31.2	15.5	11.72	14.8	0.520	-33.65	-2.07	6.14	1.59	19.0	48.4	1.32	266.8
34.00	6.68	33.2	14.6	11.96	15.6	0.511	-31.67	-1.97	5.19	1.73	20.8	52.8	1.44	283.5
36.00	6.73	35.2	13.8	12.20	16.4	0.499	-29.68	-1.87	4.41	1.89	22.6	57.5	1.57	300.1
38.00	6.78	37.2	12.9	12.44	17.2	0.485	-27.69	-1.77	3.76	2.05	24.6	62.6	1.71	316.8
40.00	6.84	39.2	12.0	12.68	18.0	0.467	-25.70	-1.68	3.22	2.23	26.8	68.0	1.85	333.5
42.00	6.89	41.2	11.1	12.92	18.8	0.446	-23.72	-1.59	2.76	2.42	29.1	73.8	2.01	350.2
44.00	6.95	43.2	10.3	13.16	19.6	0.423	-21.73	-1.49	2.37	2.63	31.6	80.2	2.19	366.8
46.00	7.00	45.2	9.4	13.40	20.4	0.398	-19.74	-1.40	2.03	2.86	34.3	87.2	2.38	383.5
48.00	7.06	47.2	8.5	13.64	21.2	0.370	-17.75	-1.30	1.73	3.11	37.3	94.9	2.59	400.2
50.00	7.13	49.2	7.6	13.88	22.0	0.341	-15.76	-1.21	1.47	3.40	40.7	103.5	2.82	416.9
52.00	7.20	51.2	6.8	14.12	22.8	0.309	-13.77	-1.11	1.24	3.72	44.6	113.3	3.09	433.5
54.00	7.27	53.2	5.9	14.36	23.6	0.275	-11.78	-1.00	1.03	4.09	49.1	124.7	3.40	450.2
56.00	7.36	55.2	5.0	14.60	24.4	0.240	-9.80	-0.89	0.84	4.53	54.4	138.2	3.77	466.9
58.00	7.46	57.2	4.2	14.84	25.2	0.204	-7.81	-0.76	0.67	5.07	60.9	154.7	4.22	483.5
60.00	7.57	59.2	3.3	15.08	26.0	0.167	-5.82	-0.62	0.52	5.78	69.4	176.3	4.81	500.2
62.00	7.71	61.2	2.5	15.32	26.8	0.130	-3.83	-0.45	0.38	6.79	81.5	207.0	5.64	516.9
64.00	7.89	63.2	1.7	15.56	27.6	0.095	-1.84	-0.25	0.25	8.58	103.0	261.6	7.13	533.6
65.73	8.10	64.9	1.1	15.77	28.3	0.071	-0.12	-0.02	0.16	17.36	208.4	529.4	14.43	548.0

11. **Limestone Target** – This program will determine the Limestone and carbon dioxide dosages for water data in Step 1 to achieve targeted treated water values of Calcium concentration and the Langelier Saturation Index entered in Step 2. After limestone treatment, the user has the option (Step 5) to blend this water with the initial or RO water in Step 1 for corrosion control or go directly to post limestone treatment corrosion control using NaOH. The program allows up to six sets of data input for various scenarios. It is used by companies that design limestone contactors.

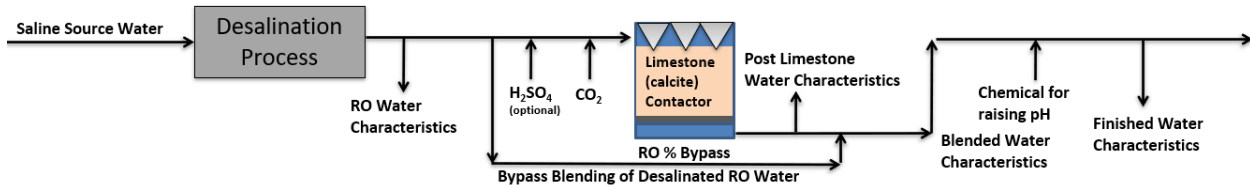


<b>Step 1:</b>		To process all 6 data sets at once, complete data input for each set and press the "Process Sets 1-6" button.		Process Sets 1-6
Enter CaCO <sub>3</sub> Solubility Product, pKsp:	-8.7000			
Relative Temperature (°C) for pKsp:	20.0			

-----Set 1-----			
<b>Step 1: Water Quality Before Limestone Treatment</b>			
<b>Enter Initial or Desalinated RO Water Characteristics</b>			
TDS:	321.0	mg/L	
pH:	5.28	field pH is recommended	
Total Alkalinity:	1.7	mg/L as CaCO <sub>3</sub>	
Total Calcium:	0.90	mg/L Ca <sup>2+</sup>	2.2 mg/L as CaCO <sub>3</sub>
Temperature:	25.0	°C (temp. at which pH was analyzed)	
Field Temperature:	22.0	°C (operating temperature at facility)	
<b>Theoretical Initial Water Characteristics after Temperature Correction.</b>			
Carbon Dioxide (CO <sub>2</sub> ):	19.5	mg/L as CO <sub>2(aq)</sub>	
Langelier Index, Calcite (LSI):	-5.6	Tendency to dissolve CaCO <sub>3</sub>	
CCPP:	-44.6	mg/L as CaCO <sub>3</sub>	
<b>Enter Pre-Limestone Treatment Dosage (H<sub>2</sub>SO<sub>4</sub>) for Lowering pH.</b>			
<b>This is an optional treatment process before the addition of CO<sub>2</sub>.</b>			
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	0.0	mg/L, added before calcite beds	
pH:	5.28	when H <sub>2</sub> SO <sub>4</sub> is added	pH check
<b>Step 2: Enter Limestone Bed Contactor Parameters</b>			
Superficial Velocity:	6.3	gpm/ft <sup>2</sup>	15.4 m/hr 25.7 cm/min
Particle Diameter:	0.43	cm, (0.1 to 3.2 cm)	
Limestone Porosity, ε:	0.6		
Sphericity, ψ:	0.8	range: 0.4 - 0.9, (roundness)	
Mass % of Limestone:	95	% exposed surface area of CaCO <sub>3</sub>	
<b>Step 3: Enter Limestone Treatment Targeted Values</b>			
Calcium:	32	mg/L Ca <sup>2+</sup> targeted value	
Langelier Index, Calcite (LSI):	-0.30	values of -0.05 or less	

<b>Step 4: Limestone Treatment and Water Characteristics Results</b>			
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	0.0	mg/L, added	
Carbon Dioxide (CO <sub>2</sub> ):	19.4	mg/L, added	
pH:	5.03	before limestone contactor	
Limestone (CaCO <sub>3</sub> ):	77.7	mg/L as CaCO <sub>3</sub> , added	
TDS:	398.7	mg/L	
pH:	7.46	post limestone contactor	
Total Alkalinity:	79.4	mg/L as CaCO <sub>3</sub>	
Total Calcium:	32.0	mg/L Ca <sup>2+</sup>	79.9 mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ):	5.2	mg/L as CO <sub>2(aq)</sub>	
Water Temperature:	22	°C	
Langelier Index, Calcite (LSI):	-0.30	Tendency to dissolve CaCO <sub>3</sub>	
CCPP:	-5.0	mg/L as CaCO <sub>3</sub>	
Depth of Contactor:	5.2	feet	62.7 in 159 cm
EBCT:	6.2	minutes	
<b>Step 5: Blending of bypass RO water with Post Limestone Water</b>			
Enter % of bypass RO (Step 1 water) to be blended with treated Limestone water			
% bypass RO water:	60.0	60/40 RO/Limestone Blending Ratio	
<b>Step 6: 60/40 RO/Limestone Blending Ratio Results</b>			
TDS:	352.1	mg/L	
pH:	6.66		
Total Alkalinity:	32.8	mg/L as CaCO <sub>3</sub>	
Total Calcium:	13.3	mg/L Ca <sup>2+</sup>	33.3 mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ):	13.4	mg/L as CO <sub>2(aq)</sub>	
Water Temperature:	22	°C	
Langelier Index, Calcite (LSI):	-2.10	Tendency to dissolve CaCO <sub>3</sub>	
CCPP:	-30.2	mg/L as CaCO <sub>3</sub>	
<b>Step 7: Post Limestone Corrosion Control Targeted Values using NaOH</b>			
Langelier Index, Calcite (LSI):	0.10	Targeted value	
Minimum CCPP:	1.0	mg/L as CaCO <sub>3</sub>	
<b>Step 8: Chemical Stability/Corrosion Control Results applying NaOH</b>			
NaOH Added:	13.65	mg/L	
pH:	8.79	final	
Total Alkalinity:	49.9	mg/L as CaCO <sub>3</sub>	
Total Calcium:	13.3	mg/L Ca <sup>2+</sup>	33.3 mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ):	0.1	mg/L as CO <sub>2(aq)</sub>	
Langelier Index, Calcite (LSI):	0.13	Tendency for deposition of CaCO <sub>3</sub>	
CCPP:	1.1	mg/L as CaCO <sub>3</sub>	

12. **Limestone Scenarios** – This is a continuation of the Limestone Target program that allows the user to model up to 50 sets of data. For each data set, the user inputs the parameters for the limestone contactor, the RO water characteristics, percent by-pass flow and treatment constraints. The user has the option of selecting what set of data to be processed.



Range of Data Sets for complete Processing (max 50)									
Start Set#:	1	Process Data							
End Set#:	1	Set Numbers							
For data inputs, complete <b>Steps 1 - 6</b>									
N°	1	2	3	4	5	6	7	8	By
<b>Step 1: Limestone Bed Contactor Design Parameters</b>									
1	Superficial Velocity (gpm/ft <sup>2</sup> ):	9.0	9.0	9.0	9.0	9.0	6.6	6.6	
2	Particle Diameter (0.1 to 3.2 cm):	0.43	0.43	0.43	0.43	0.43	0.43	0.43	
3	Limestone Porosity, ε:	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
4	Sphericity, ψ: range: 0.4 - 0.9 (roundness):	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
5	Mass % of Limestone (% exposed surface area of CaCO <sub>3</sub> ):	95	95	95	95	95	95	95	
6	CaCO <sub>3</sub> Solubility Product, pKsp:	-8.70	-8.70	-8.70	-8.70	-8.70	-8.48	-8.48	
7	Relative Temperature (°C) for pKsp:	20.0	20.0	20.0	20.0	20.0	25.0	25.0	
<b>Step 2: Initial Desalinated RO Water Characteristics</b>									
9	TDS (mg/L):	320	320	320	320	320	300	300	
10	pH:	7.00	7.00	7.00	7.00	7.00	7.00	7.00	
11	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	20.00	10.00	10.00	10.00	10.00	10.00	10.00	
12	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ): <i>Input only if Alk is not available</i>								
13	Calcium (mg/L as Ca <sup>2+</sup> ):	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
14	Magnesium (mg/L as Mg <sup>2+</sup> ):	3	5	5	5	5	3	3	
15	Sodium (mg/L as Na <sup>+</sup> ):	3	3	3	3	3	3	3	
16	Chloride (mg/L as Cl <sup>-</sup> ):	4.2	5.0	5.0	5.0	5.0	4.2	4.2	
17	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):	5.0	5.0	5.0	5.0	5.0	5.0	5.0	
18	Temperature (°C, at which pH was measured):	10	10	10	10	10	10	10	
19	Field Temperature (°C, operating temperature):	10	10	10	10	10	10	10	
<b>Step 3: Pre-Limestone Acid Addition, Optional</b>									
21	Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> , mg/L, added before calcite beds):	1	2	3	4	5	6	7	8
22									10.0
<b>Step 4: Targeted Values for Limestone Remineralization</b>									
23	Calcium (mg/L as Ca <sup>2+</sup> ):	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
24	Langelier Saturation Index, Calcite (LSI) (values of -0.05 or less):	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30
<b>Step 5: RO/Desalination Bypass</b>									
26	Bypass % of RO water not treated by Limestone filtration:	60	60	60	60	60	60	60	60
<b>Step 6: Finished Water Contraints</b>									
<b>Blend (RO + Limestone Filtrate)</b>									
29	Upper bound pH:	8.30	8.30	8.30	8.30	8.30	8.30	8.30	8.30
30	Upper bound Langelier Saturation Index, Calcite (LSI):	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
31	Upper bound CCPP (mg/L as CaCO <sub>3</sub> ):	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.10
<b>Select Chemical for raising pH</b>									
33	Chemical Dose, mg/L (computer generated):	NaOH	NaOH	CO <sub>2</sub>	Na <sub>2</sub> CO <sub>3</sub>	Ca(OH) <sub>2</sub>	CO <sub>2</sub>	None	NaOH
34	Chemical Dose, mg/L (manually inputted):	10.0	5.0	-5.5	13.1	4.6	-10.0		4.0
<b>Disinfection - Input Dose</b>									
36	Chlorine Gas (Cl <sub>2</sub> , mg/L)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
37	Sodium Hypochlorite (NaOCl, mg/L)								
<b>Step 7: Sodium Adsorption Ratio (SAR)</b>									
<b>Information Adjusted SAR</b>									
40	Soil Water Temperature (°C, in root zone):	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
41	Partial Pressure, P <sub>CO2</sub> , (CO <sub>2</sub> atm of irrigated water):	0.00070	0.00070	0.00070	0.00070	0.00070	0.00070	0.00070	0.00070

38	<b>Step 7: Sodium Adsorption Ratio (SAR)</b>							
39	<b>Information Adjusted SAR</b>							
40	Soil Water Temperature (°C, in root zone):	15.0	15.0	15.0	15.0	15.0	15.0	15.0
41	Partial Pressure, P <sub>CO2</sub> , (CO <sub>2</sub> atm of irrigated water):	0.00070	0.00070	0.00070	0.00070	0.00070	0.00070	0.00070
42	<b>Soil Water Entry for Plant Rhizosphere Root Zone</b>							
43	Partial Pressure, P <sub>CO2</sub> , (CO <sub>2</sub> atm of soil water in rhizosphere):	0.00180	0.00180	0.00180	0.00180	0.00180	0.00180	0.00180
44	<b>Soil Water Entry for Drainage Water below Root Zone</b>							
45	Partial Pressure, P <sub>CO2</sub> , (CO <sub>2</sub> atm of soil water in rhizosphere):	0.00180	0.00180	0.00180	0.00180	0.00180	0.00180	0.00180
46	Leaching Fraction (LF) (fraction of water leached below root zone):	5.000	5.000	5.000	5.000	0.400	0.400	0.400
47	<b>Results - Initial RO Water Characteristics</b>							
48	<b>after Temperature Correction</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
49	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	24.37	12.19	12.19	12.19	12.19	12.19	12.19
50	Carbon Dioxide (mg/L as CO <sub>2aq</sub> ):	4.67	2.34	2.34	2.34	2.34	2.34	2.34
51	Langelier Index, Calcite (LSI):	-3.1	-3.4	-3.4	-3.4	-3.4	-3.4	-3.7
52	CCPP (mg/L as CaCO <sub>3</sub> ):	-13.8	-10.0	-10.0	-10.0	-10.0	-10.0	-12.3
53	[HCO <sub>3</sub> <sup>-</sup> ]/[SO <sub>4</sub> <sup>-2</sup> ] (mol/mol):	7.67	3.84	3.84	3.84	3.84	3.84	3.84
54	Larson's Ratio [Cl <sup>-</sup> + 2SO <sub>4</sub> <sup>-2</sup> ]/[HCO <sub>3</sub> <sup>-</sup> ] (mol/mol):	0.6	1.2	1.2	1.2	1.2	1.1	1.2
55	Larson's Ratio [(Cl <sup>-</sup> + SO <sub>4</sub> <sup>-2</sup> )/Alkalinity] (CaCO <sub>3</sub> /CaCO <sub>3</sub> ):	0.6	1.2	1.2	1.2	1.2	1.1	1.2
56	Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	14.60	22.84	22.84	22.84	22.84	14.60	22.84
57	Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	14.60	10.00	10.00	10.00	10.00	10.00	10.00
58	Non-Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	0.00	12.84	12.84	12.84	12.84	4.61	12.84
59	Cations/Anions Percent Difference:	-19.15%	13.74%	13.74%	13.74%	13.74%	-0.03%	-0.03%
60	<b>Pre-Limestone Treatment Dosage (H<sub>2</sub>SO<sub>4</sub>)</b>							
61	pH (after added H <sub>2</sub> SO <sub>4</sub> ):	7.00	7.00	7.00	7.00	7.00	7.00	4.95
62	<b>Post Limestone Water Characteristics &amp; Design</b>							
63	Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> , mg/L, added before calcite beds):							10.0
64	Carbon Dioxide (CO <sub>2</sub> , mg/L, added before calcite beds):	35.2	36.4	36.4	36.4	36.4	34.2	24.6
65	pH (after H <sub>2</sub> SO <sub>4</sub> and CO <sub>2</sub> additions before calcite beds):	6.07	5.79	5.79	5.79	5.79	5.81	4.73
66	Limestone (mg/L CaCO <sub>3</sub> , dissolved):	77.7	77.7	77.7	77.7	77.7	77.7	77.7
67	TDS (mg/L):	398	398	398	398	398	378	378
68	pH:	7.59	7.63	7.63	7.63	7.63	7.89	7.94
69	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	97.7	87.7	87.7	87.7	87.7	87.7	77.5
70	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	119.1	106.9	106.9	106.9	106.9	106.9	94.5
71	Carbon Dioxide (mg/L as CO <sub>2aq</sub> ):	5.9	4.7	4.7	4.7	4.7	2.6	2.0
72	Calcium (mg/L as Ca <sup>2+</sup> ):	32.0	32.0	32.0	32.0	32.0	32.0	32.0
73	Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	79.9	79.9	79.9	79.9	79.9	79.9	79.9
74	Sulfate (mg/L as SO <sub>4</sub> <sup>-2</sup> ):	5.0	5.0	5.0	5.0	5.0	5.0	14.8
75	Field Water Temperature (°C):	10.0	10.0	10.0	10.0	10.0	10.0	10.0
76	Langelier Saturation Index, Calcite (LSI):	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30
77	CCPP (mg/L as CaCO <sub>3</sub> ):	-5.7	-4.7	-4.7	-4.7	-4.7	-3.2	-2.7
78	[HCO <sub>3</sub> <sup>-</sup> ]/[SO <sub>4</sub> <sup>-2</sup> ] (mol/mol):	37.38	33.54	33.54	33.54	33.54	33.44	9.98
79	Larson's Ratio [Cl <sup>-</sup> + 2SO <sub>4</sub> <sup>-2</sup> ]/[HCO <sub>3</sub> <sup>-</sup> ] (mol/mol):	0.11	0.14	0.14	0.14	0.14	0.13	0.29
80	Larson's Ratio [(Cl <sup>-</sup> + SO <sub>4</sub> <sup>-2</sup> )/Alkalinity] (CaCO <sub>3</sub> /CaCO <sub>3</sub> ):	0.11	0.14	0.14	0.14	0.14	0.13	0.29

81	Depth of Contactor (feet):	7.86	8.34	8.34	8.34	8.34	8.34	8.23	8.70
82	Depth of Contactor (meters):	2.39	2.54	2.54	2.54	2.54	2.54	2.51	2.65
83	Empty Bed Contact Time, EBCT (minutes):	6.53	6.93	6.93	6.93	6.93	6.93	9.33	9.86
84	Superficial Velocity (ft/min):	1.20	1.20	1.20	1.20	1.20	1.20	0.88	0.88
85	<b>Blended Results of RO + Limestone</b>	60/40	60/40	60/40	60/40	60/40	60/40	60/40	60/40
86	TDS (mg/L):	351	351	351	351	351	351	331	331
87	pH:	7.36	7.46	7.46	7.46	7.46	7.46	7.60	7.60
88	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	51.1	41.1	41.1	41.1	41.1	41.1	41.1	37.0
89	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	62.3	50.1	50.1	50.1	50.1	50.1	50.1	45.1
90	Carbon Dioxide (mg/L as CO <sub>2(aq)</sub> ):	5.1	3.3	3.3	3.3	3.3	3.3	2.4	2.2
91	Calcium (mg/L as Ca <sup>2+</sup> ):	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
92	Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
93	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):	5.0	5.0	5.0	5.0	5.0	5.0	5.0	8.9
94	Field Water Temperature (°C):	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
95	Langelier Saturation Index, Calcite (LSI):	-1.39	-1.38	-1.38	-1.38	-1.38	-1.38	-1.25	-1.29
96	CCPP (mg/L as CaCO <sub>3</sub> ):	-12.5	-8.9	-8.9	-8.9	-8.9	-8.9	-7.0	-6.6
97	[HCO <sub>3</sub> <sup>-</sup> ]/[SO <sub>4</sub> <sup>2-</sup> ] (mol/mol):	19.57	15.73	15.73	15.73	15.73	15.73	15.72	7.93
98	Larson's Ratio [Cl <sup>-</sup> + 2SO <sub>4</sub> <sup>2-</sup> ]/[HCO <sub>3</sub> <sup>-</sup> ] (mol/mol):	0.22	0.30	0.30	0.30	0.30	0.27	0.27	0.44
99	Larson's Ratio [(Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alkalinity] (CaCO <sub>3</sub> /CaCO <sub>3</sub> ):	0.22	0.30	0.30	0.30	0.30	0.27	0.27	0.44
100	<b>Final Water Characteristics:</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
101	<b>Results after Chemical Addition</b>	NaOH	NaOH	CO <sub>2</sub>	Na <sub>2</sub> CO <sub>2</sub>	Ca(OH) <sub>2</sub>	CO <sub>2</sub>	None	NaOH
102	Chemical Dose, mg/L (computer generated):		5.0	-5.5	13.1	4.6			4.0
103	Chemical Dose, mg/L (manually inputted):	10.0					-4.9		
104	Chlorine Gas (Cl <sub>2</sub> , mg/L) Added:	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
105	Sodium Hypochlorite (NaOCl, mg/L) Added:								
106	TDS (mg/L):	357	354	351	351	351	351	331	333
107	pH:	9.22	8.32	8.31	8.31	8.30	8.02	7.35	8.32
108	Field Water Temperature (°C):	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
109	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	60.8	44.6	38.4	50.8	44.6	38.4	39.2	39.3
110	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	64.6	53.4	45.9	60.8	53.4	46.4	47.7	47.0
111	Carbon Dioxide (mg/L as CO <sub>2(aq)</sub> ):	0.07	0.49	0.43	0.57	0.51	0.85	4.04	0.43
112	Calcium (mg/L as Ca <sup>2+</sup> ):	13.3	13.3	13.3	13.3	15.8	13.3	13.3	13.3
113	Magnesium (mg/L as Mg <sup>2+</sup> ):	3.0	5.0	5.0	5.0	5.0	3.0	3.0	5.0
114	Sodium (mg/L as Na <sup>+</sup> ):	8.7	5.1	0.7	8.6	5.0	3.0	3.0	4.7
115	Chloride (mg/L as Cl <sup>-</sup> ):	6.2	7.0	7.0	7.0	7.0	6.2	6.2	7.0
116	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):	5.0	5.0	5.0	5.0	5.0	5.0	5.0	8.9
117	<b>Hardness - Final</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
118	Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> ) (mg/L as CaCO <sub>3</sub> ):	45.7	53.9	53.9	53.9	60.1	45.7	45.7	53.9
119	Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	33.3	33.3	33.3	33.3	39.5	33.3	33.3	33.3
120	Magnesium Hardness (mg/L as CaCO <sub>3</sub> ):	12.4	20.6	20.6	20.6	20.6	12.4	12.4	20.6
121	Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> ) (mg/L as CaCO <sub>3</sub> ):	45.7	43.8	37.7	49.9	43.8	38.1	39.1	38.6
122	Non-Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> ) (mg/L as CaCO <sub>3</sub> ):	0.0	10.1	16.2	4.1	16.3	7.6	6.6	15.3
123	Percent Difference of Anion/Cations (Δ%):	-7.02%	4.33%	1.78%	4.88%	8.64%	-0.18%	-0.90%	4.67%

123	Percent Difference of Anion/Cations ( $\Delta\%$ ):	-7.02%	4.33%	1.78%	4.88%	8.64%	-0.18%	-0.90%	4.67%
124	<b>Corrosion Indices -Final</b>								
125	Langelier Saturation Index, Calcite (LSI):	0.45	-0.50	-0.58	-0.46	-0.45	-0.86	-1.51	-0.56
126	CCPP (mg/L as CaCO <sub>3</sub> ):	5.00	-2.4	-2.5	-2.3	-2.0	-3.7	-10.5	-2.4
127	[HCO <sub>3</sub> ]/[SO <sub>4</sub> <sup>2-</sup> ] (mol/mol):	20.35	16.81	14.46	19.14	16.81	14.62	15.02	8.30
128	Larson's Ratio [Cl <sup>-</sup> + 2SO <sub>4</sub> <sup>2-</sup> ]/[HCO <sub>3</sub> <sup>-</sup> ] (mol/mol):	0.21	0.28	0.33	0.25	0.28	0.29	0.28	0.42
129	Larson's Ratio [(Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alkalinity] (CaCO <sub>3</sub> /CaCO <sub>3</sub> ):	0.23	0.34	0.39	0.30	0.34	0.36	0.33	0.49
130	<b>SAR &amp; Irrigated Water Calculations</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
131	Na (total, mg/L):	8.7	5.1	0.7	8.6	5.0	3.0	3.0	4.7
132	Carbon Dioxide (mg/L as CO <sub>2aq</sub> ):	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
133	pH:	7.95	7.82	7.75	7.87	7.82	7.75	7.76	7.76
134	Sodium Adsorption Ratio (simplified method):	0.56	0.30	0.04	0.51	0.28	0.19	0.19	0.28
135	Sodium Adsorption Ratio (adjusted SAR "Rigorous method"):	0.44	0.24	0.03	0.41	0.22	0.14	0.14	0.21
136	<b>SAR &amp; Soil Water Calculations - In Rhizosphere Root Zone</b>								
137	Carbon Dioxide (mg/L as CO <sub>2aq</sub> ):	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
138	pH:	7.54	7.41	7.34	7.47	7.41	7.35	7.36	7.36
139	Sodium Adsorption Ratio (adjusted SAR "Rigorous method"):	0.39	0.21	0.03	0.36	0.19	0.12	0.12	0.19
140	<b>SAR of the Drainage Water when LF is Considered</b>								
141	Sodium Adsorption Ratio (adjusted SAR of the soil water including LF):	0.08	0.05	0.01	0.08	0.43	0.28	0.29	0.41
142	TDS (mg/L):	71	71	70	70	878	878	828	833
143	Electrical Conductivity (EC <sub>dw</sub> ):	112	111	110	110	1,371	1,371	1,293	1,302

#### Adjusted SAR Classification Management Considerations

< 1	Excellent	None
1 - 2	Good	Little concern, add pelletized gypsum periodically
2 - 4	Fair	Aerify soil, sand top-dress, apply pelletized gypsum, monitor soil salinity
4 - 8	Poor	Aerify soil, sand top-dress, apply pelletized gypsum, leach soil regularly, monitor soil salinity closely
8 - 15	Very Poor	Requires special attention; consult water quality specialist
> 15	Unaccept:	Do not use

13. **SAR** – Sodium Adsorption Ration – for evaluating irrigation water quality parameters used in the management of sodium-affected soils.

<b>STEP 1: Initial Water Characteristics</b>			
<b>Enter initial water characteristics based on laboratory or field analysis.</b>			
Project:	Plant A		
Source Point:	Canal Water		
Date of Sample:	March 11, 2017		
TDS =	735	mg/L	0.018 mol/L, Ionic Strength
Water Temperature =	12.0	°C (temp. at which pH was analyzed)	
pH =	9.03	field pH is recommended	
Total Alkalinity =	204.0	mg/L as CaCO <sub>3</sub>	4.08 meq/L
Ca <sup>2+</sup> =	46.5	mg/L	2.32 meq/L
Mg <sup>2+</sup> =	17.5	mg/L	1.44 meq/L
Na <sup>+</sup> =	177.6	mg/L	7.73 meq/L
<b>Information for Adjusted SAR</b>			
Soil Water Temperature =	15.0	°C (temperature of water in root zone)	
Partial Pressure, P <sub>CO2</sub> =	0.00070	CO <sub>2</sub> atm of the irrigated water	
<b>Soil Water Entry for Plant Rhizosphere Root Zone</b>			
Partial Pressure, P <sub>CO2</sub> =	0.00180	CO <sub>2</sub> atm of the soil water in rhizosphere	
<b>Soil Water Entry for Drainage Water below Root Zone</b>			
Partial Pressure, P <sub>CO2</sub> =	0.00180	CO <sub>2</sub> atm of the soil water in rhizosphere	
Leaching Fraction (LF) =	0.400	fraction of water leached below root zone	

<b>STEP 2: Theoretical water characteristics &amp; SAR calculations based on irrigated and soil water temperatures.</b>			
<b>General Initial Water Characteristic Calculations at Temperature of 15C</b>			
pH =	8.99	E <sub>cw</sub> = 1,148 uS/cm or 1.15 dS/m	
HCO <sub>3</sub> <sup>-</sup> =	224.3	mg/L	3.68 meq/L
CO <sub>3</sub> <sup>-</sup> =	11.8	mg/L	0.395 meq/L
Carbon Dioxide (CO <sub>2</sub> ) =	0.38	mg/L as CO <sub>2(aq)</sub>	8.63E-06 mol/L
<b>SAR &amp; Irrigated Water Calculations at Temperature of 15C</b>			
Carbon Dioxide (CO <sub>2</sub> ) =	1.41	mg/L as CO <sub>2(aq)</sub>	3.21E-05 mol/L, at 0.0007 atm partial pressure
pH =	8.45	pH of irrigated water if air and water were at carbon dioxide equilibrium	
Sodium Adsorption Ratio =	5.63	simplified method	
Sodium Adsorption Ratio =	6.55	Adjusted SAR "Rigorous method"	
<b>SAR &amp; Soil Water Calculations - In Rhizosphere Root Zone</b>			
Carbon Dioxide (CO <sub>2</sub> ) =	3.64	mg/L as CO <sub>2(aq)</sub>	8.26E-05 mol/L, at 0.0018 atm partial pressure
pH =	8.05	pH of soil water if air and water were at carbon dioxide equilibrium	
Sodium Adsorption Ratio =	6.04	Adjusted SAR "Rigorous method"	
<b>SAR of the Drainage Water when Leaching Fraction is Considered</b>			
Sodium Adsorption Ratio =	11.7	Adjusted SAR of the soil water including leaching fraction.	
TDS of the Drainage Water =	1,838	mg/L	0.046 mol/L, Ionic Strength
Electrical Conductivity (EC <sub>dw</sub> )=	2,871	uS/cm	2.87 dS/m

### **Adjusted SAR Classification Management Considerations**

< 1	Excellent	None
1 - 2	Good	Little concern, add pelletized gypsum periodically
2 - 4	Fair	Aerify soil, sand top-dress, apply pelletized gypsum, monitor soil salinity
4 - 8	Poor	Aerify soil, sand top-dress, apply pelletized gypsum, leach soil regularly, monitor soil salinity closely
8 - 15	Very Poor	Requires special attention; consult water quality specialist
> 15	Unacceptable	Do not use

14. **Corrosion Modeling** – This program was specifically designed for evaluating lead/copper treatment but also provides valuable information on the changes in water characteristics when base chemicals are added or the applied air-stripping of CO<sub>2</sub>. The user inputs the water characteristics and selects a treatment chemical to be modeled. The program calculates the changes in water characteristics, corrosion indices and lead and copper solubility that is populated into a table along with the incremental chemical dosages. The tabulated results make it easy for scanning for appropriate targeted dosage. The data results are also graphically plotted for visual evaluation. The user may also use the data for plotting other graphs of interest.

Below is an example of using caustic soda as a corrosion control chemical based on the starting water characteristics in Step 1 in the worksheet. The treatment results are computer generated in the table below that shows the incremental changes in corrosion indices, lead and copper dissolution and water characteristics as the dosage of caustic soda is increased. Graphs of the results are also plotted for visual evaluation.

**Water!Pro™**

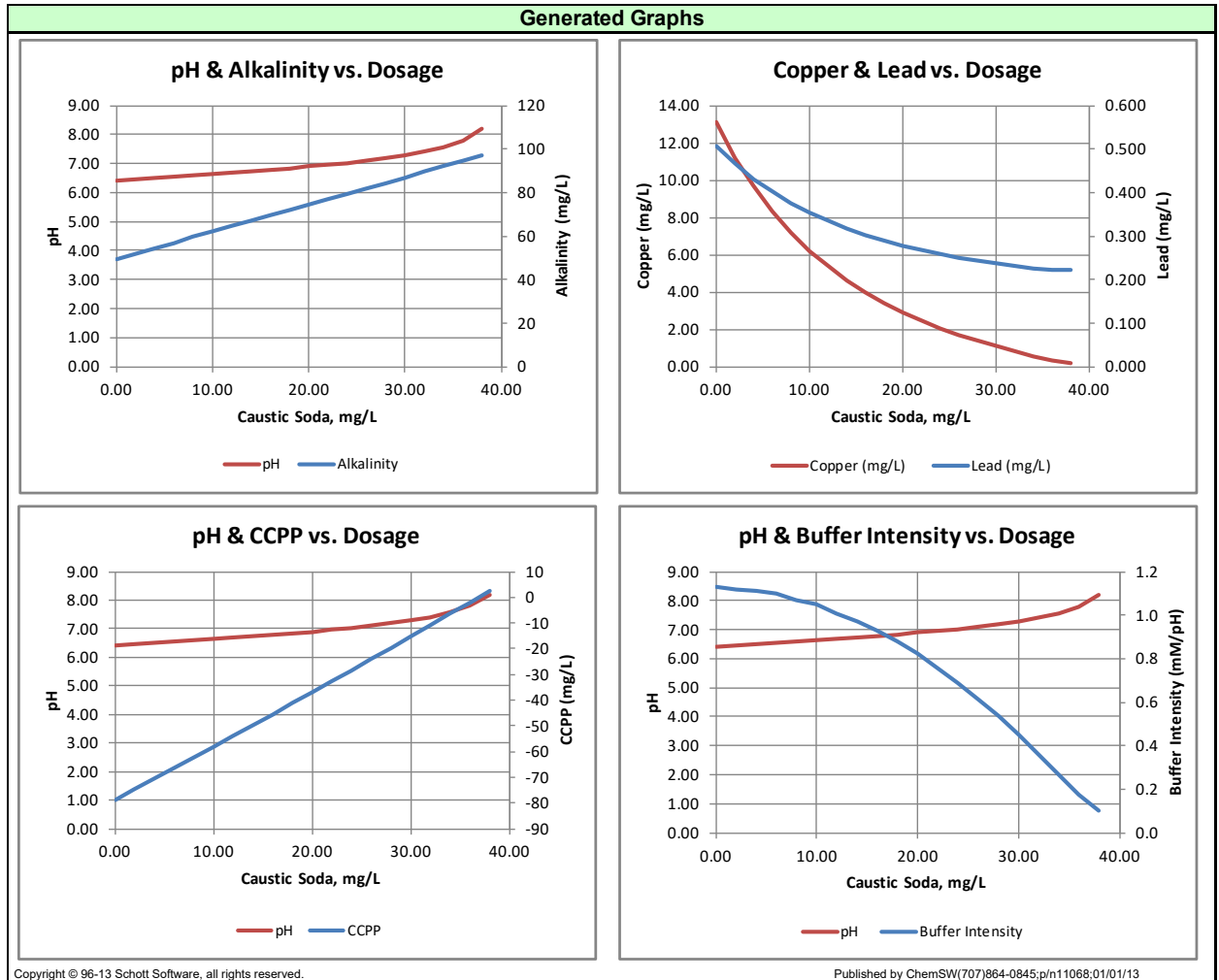
**Corrosion Control Modeling Program**

Step 1 Enter Characteristics of Water to be Treated					Step 2 Chemical Selection & Constraints		
System Name:	Example 5		Copy WaterPro Data Here	Copy Data To WaterPro	Select Corrosion Control Chemical Caustic Soda (NaOH) ▼		
TDS =	151	mg/L	field pH is recommended mg/L as CaCO <sub>3</sub>		Step 3 Enter PO <sub>4</sub> <sup>3-</sup> dose if added with chemical from Step 2		
pH =	6.40				Enter Constraints: Upper limit dose to plot: 100.0 mg/L Upper Bound pH: 8.0		
Total Alkalinity =	49.4	mg/L Ca <sup>2+</sup> 87.41 mg/L as CaCO <sub>3</sub>	Step 4 <b>Plot Data</b>				
Calcium (total) =	35.0	°C (temp. at which pH was analyzed)	Activate button "Plot Data" to plot any new data entered in Steps 1 to 3.				
Water Temperature =	15.0	°C (operating temperature at facility)					
Field Water Temperature =	15.0		Orthophosphate as PO <sub>4</sub> <sup>3-</sup> 0.0 mg/L				
Cl <sup>-</sup> =	37.0	mg/L 52.2 mg/L as CaCO <sub>3</sub>					
SO <sub>4</sub> <sup>2-</sup> =	65.0	mg/L 67.7 mg/L as CaCO <sub>3</sub>					
Mg <sup>2+</sup> =	5.4	mg/L 22.2 mg/L as CaCO <sub>3</sub>					

**Plotting Points for Graphs**

Dose mg/L	Ortho-phosphate mg/L	pH at Field Temp.	Alkalinity as CaCO <sub>3</sub> mg/L	DIC mg/L C	Langelier Index LI	CCPP as CaCO <sub>3</sub> mg/L	Copper II at 25°C mg/L	Lead II at 25°C mg/L	Buffer Intensity mM/pH	CO <sub>2</sub> mg/L	Aggressive Index AI	Ryznar Index RI
0.00	0	6.40	49.40	23.48	-1.84	-78.61	13.100	0.506	1.130	42.60	10.00	10.07
2.00	0	6.44	51.90	23.48	-1.77	-74.55	11.200	0.466	1.120	40.40	10.07	9.99
4.00	0	6.49	54.40	23.48	-1.71	-70.46	9.650	0.431	1.110	38.20	10.13	9.90
6.00	0	6.53	56.91	23.48	-1.64	-66.35	8.320	0.401	1.100	36.00	10.20	9.82
8.00	0	6.58	59.41	23.48	-1.58	-62.22	7.190	0.375	1.070	33.80	10.26	9.74
10.00	0	6.63	61.91	23.48	-1.51	-58.06	6.210	0.353	1.050	31.60	10.33	9.65
12.00	0	6.68	64.41	23.48	-1.45	-53.88	5.360	0.334	1.010	29.40	10.39	9.57
14.00	0	6.73	66.92	23.48	-1.38	-49.68	4.620	0.317	0.973	27.20	10.46	9.49
16.00	0	6.78	69.42	23.48	-1.31	-45.47	3.980	0.302	0.928	25.00	10.53	9.40
18.00	0	6.83	71.92	23.48	-1.24	-41.23	3.410	0.289	0.877	22.80	10.60	9.32
20.00	0	6.89	74.42	23.48	-1.17	-36.97	2.910	0.277	0.821	20.60	10.67	9.23
22.00	0	6.96	76.93	23.48	-1.09	-32.69	2.460	0.267	0.758	18.40	10.75	9.14
24.00	0	7.03	79.43	23.48	-1.01	-28.38	2.060	0.258	0.689	16.20	10.83	9.04
26.00	0	7.10	81.93	23.48	-0.92	-24.06	1.700	0.250	0.615	14.00	10.92	8.94
28.00	0	7.19	84.43	23.48	-0.82	-19.71	1.370	0.243	0.536	11.80	11.02	8.83
30.00	0	7.29	86.94	23.48	-0.71	-15.34	1.080	0.236	0.451	9.63	11.14	8.70
32.00	0	7.41	89.44	23.48	-0.57	-10.95	0.805	0.231	0.361	7.46	11.27	8.56
34.00	0	7.57	91.94	23.48	-0.40	-6.55	0.556	0.226	0.268	5.31	11.44	8.37
36.00	0	7.80	94.44	23.48	-0.16	-2.12	0.333	0.222	0.175	3.21	11.68	8.13
38.00	0	8.18	96.95	23.48	0.22	2.30	0.149	0.222	0.103	1.37	12.07	7.74

The data in Step 1 above is inputted manually or can be imported from the “WaterPro” worksheet. The Step 1 data may also be exported into the “WaterPro” worksheet for evaluation.



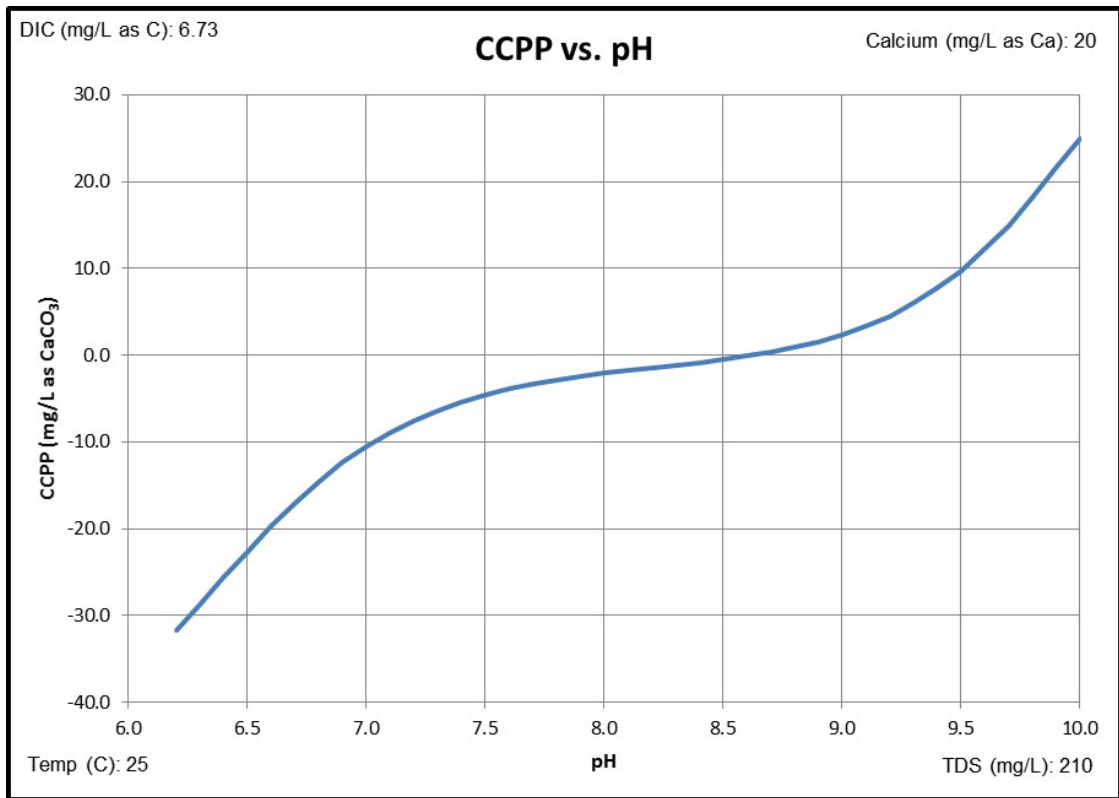
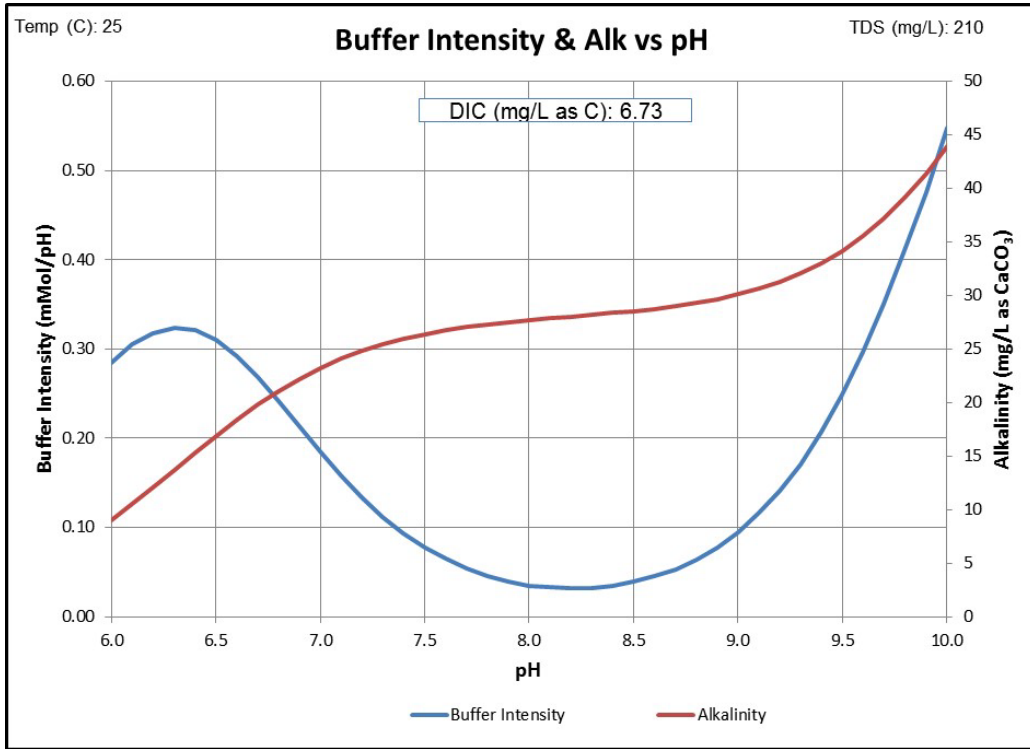
- CCT Scenarios** – This program was designed specifically for lead/copper corrosion control. The program allows up to 50 sets of data to be modeled for corrosion control. The user selects the corrosion control chemical for each data set and input corrosion control constraints that will allow the program to determine the dose based on user inputted constraints. The user also has the option to manually input the corrosion control dose by-passing the corrosion control constraints. The user has the option of selecting what set of data to be processed.

Range of Data Sets for complete Processing (max 50)		Corrosion Control Treatment - Distribution System and Lead/Copper													
Start Set#:	9	Process Data	Set Numbers												
End Set#:	9		1	2	3	4	5	6	7	8	9	10	11	12	
For data inputs, complete		Steps 1 - 3													
N°	<b>Step 1: Initial Water Characteristics Input</b>	Project #:													
1	TDS (mg/L):		147	147	147	147	120	200	320	200	190				
2	pH:		6.80	6.80	6.80	6.80	6.20	7.00	7.20	7.00	7.00				
3	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):		100.0	100.0	100.0	100.0	51.0	50.0	50.0	50.0	50.0				
4	Temperature (°C, at which pH was measured):		22.0	22.0	22.0	22.0	15.0	25.0	25.0	25.0	25.0				
5	Field Temperature (°C, operating temperature):		15.0	15.0	15.0	15.0	15.0	22.0	22.0	22.0	22.0				
6	Calcium (mg/L as Ca <sup>2+</sup> ):		20.0	15.0	15.0	15.0	6.8	5.0	5.0	5.0	5.0				
7	Magnesium (mg/L as Mg <sup>2+</sup> ):		14.0	15.0	15.0	15.0	6.8	5.0	5.0	5.0	5.0				
8	Sodium (mg/L as Na <sup>+</sup> ):		30.0	15.0	15.0	15.0	6.8	5.0	5.0	5.0	5.0				
9	Chloride (mg/L as Cl <sup>-</sup> ):		27.0	27.0	27.0	27.0	15.0	5.0	5.0	5.0	5.0				
10	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):		32.0	32.0	32.0	32.0	21.0	10.0	10.0	10.0	10.0				
11	<b>Step 2: Corrosion Control Constraints</b>														
12	Upper bound pH:		7.30	8.00	8.60	7.20	7.20	8.60	8.60	7.30	8.00				
13	Upper bound Langelier Saturation Index, Calcite (LSI):		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02				
14	Upper bound CAPP (mg/L as CaCO <sub>3</sub> ):		0.50	0.50	2.00	0.50	0.50	0.50	0.50	0.10	0.10				
15	<b>Step 3: Select Chemical for raising pH</b>		KOH	NaOH	CO <sub>2</sub>	NaOH	NaOH	CO <sub>2</sub>	NaOH	CO <sub>2</sub>	CO <sub>2</sub>	Na <sub>2</sub> CO <sub>3</sub>	NaHCO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	
16	Chemical Dose, mg/L (computer generated):			25.7	-30.4	13.4	49.7	-9.5	5.6	-11.2	-8.5				
17	Chemical Dose, mg/L (manually inputted):		17.4												
18	Orthophosphate (as PO <sub>4</sub> <sup>3-</sup> , mg/L) (manually inputted):		2.00							3.00					
19	<b>Disinfection and Fluoridation Entry - Optional</b>														
20	Post Cl <sub>2</sub> (mg/L):														
21	Post NaOCl (mg/L):							3.00	3.00						
22	Fluoride (H <sub>2</sub> SiF <sub>6</sub> , mg/L):									2.00					

23	<b>Step 4: Results for Initial Water Characteristics</b>													
24	Electrical Conductivity (uS/cm):		230	230	230	230	188	313	500	313	297			
25	pH (field water temperature):		6.85	6.85	6.85	6.85	6.20	7.02	7.22	7.02	7.02			
26	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):		100.0	100.0	100.0	100.0	51.00	50.00	50.00	50.00	50.00			
27	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):		121.9	121.9	121.9	121.9	62.21	60.89	60.84	60.89	60.89			
28	Carbonate (mg/L as CO <sub>3</sub> <sup>2-</sup> ):		0.038	0.038	0.038	0.038	0.004	0.034	0.057	0.034	0.034			
29	Acidity (mg/L as CaCO <sub>3</sub> ):		169.4	169.4	169.4	169.4	210.5	70.80	62.82	70.80	70.83			
30	Carbon Dioxide (CO <sub>2</sub> , mg/L):		30.56	30.56	30.56	30.56	70.10	9.17	5.68	9.17	9.18			
31	DIC (dissolved inorganic carbon, mg/L as C):		32.33	32.33	32.33	32.33	31.38	14.50	13.54	14.50	14.50			
32	Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):		107.6	99.2	99.2	99.2	44.98	33.08	33.08	33.08	33.08			
33	Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):		99.9	99.2	99.2	99.2	44.98	33.08	33.08	33.08	33.08			
34	Non-Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):		7.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
35	Cations/Anions Percent Difference, (Σ cations - Σ anions) / (Σ cations + Σ anions):		0.44%	-13.03%	-13.03%	-13.03%	-22.29%	-21.06%	-21.03%	-21.06%	-21.11%			
36	<b>Corrosion Indices</b>	Set#	1	2	3	4	5	6	7	8	9	10	11	12
37	Aggressive Index (AI):		10.5	10.4	10.4	10.4	9.1	9.8	10.0	9.8	9.8			
38	Ryznar Index (RI):		9.47	9.72	9.72	9.72	11.60	10.92	10.79	10.92	10.91			
39	Langelier Index (LI):		-1.31	-1.44	-1.44	-1.44	-2.70	-1.95	-1.79	-1.95	-1.95			
40	CAPP (Calcium Carbonate Precipitation Potential, mg/L as CaCO <sub>3</sub> ):		-53.23	-54.75	-54.75	-54.75	-126.56	-21.58	-15.01	-21.58	-21.58			
41	Buffer Intensity (mM/pH):		1.19	1.19	1.19	1.19	1.43	0.40	0.27	0.40	0.40			
42	Larson's Ratio ((Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk):		0.71	0.71	0.71	0.71	0.84	0.35	0.35	0.35	0.35			
43	CSMR (Chloride to Sulfate Mass Ratio):		0.84	0.84	0.84	0.84	0.71	0.50	0.50	0.50	0.50			
44	<b>Lead and Copper</b>													
45	pH at field water temperature:		6.85	6.85	6.85	6.85	6.20	7.02	7.22	7.02	7.02			
46	Field water temperature (°C):		15.0	15.0	15.0	15.0	15.0	22.0	22.0	22.0	22.0			
47	Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):		6.99	6.99	6.99	6.99	51.83	1.56	0.86	1.56	1.56			
48	Copper II (mg/L), Tenorite, black, CuO(s):		0.64	0.64	0.64	0.64	4.58	0.14	0.08	0.14	0.14			
49	Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):		0.24	0.24	0.24	0.24	1.16	0.12	0.08	0.12	0.12			
50	Lead II (mg/L), Lead Carbonate (PbCO <sub>3(s)</sub> , cerussite):		0.199	0.199	0.199	0.199	0.467	0.258	0.242	0.258	0.257			
51	<b>Lead &amp; Copper and pH Results (at 25°C water temperature):</b>													
52	pH (at 25°C water temperature):		6.78	6.78	6.78	6.78	6.13	7.00	7.20	7.00	7.00			
53	Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):		4.07	4.07	4.07	4.07	28.75	1.31	0.73	1.31	1.31			
54	Copper II (mg/L), Tenorite, black, CuO(s):		0.37	0.37	0.37	0.37	2.62	0.12	0.07	0.12	0.12			
55	Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):		0.18	0.18	0.18	0.18	0.85	0.11	0.08	0.11	0.11			
56	Lead II (mg/L), Lead Carbonate (PbCO <sub>3(s)</sub> , cerussite):		0.258	0.258	0.258	0.258	0.589	0.277	0.261	0.277	0.277			
57	Lead II (mg/L), Basic Lead Carbonate (Pb <sub>3</sub> (CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2(s)</sub> , hydrocerussite):		0.805	0.805	0.805	0.805	2.424	0.580	0.466	0.580	0.579			

<b>Step 5: Results after Chemical Addition</b>														
	Na <sub>2</sub> CO <sub>2</sub>	NaOH	CO <sub>2</sub>	NaOH	NaOH	CO <sub>2</sub>	NaOH	CO <sub>2</sub>	CO <sub>2</sub>					
58	<b>Step 5: Results after Chemical Addition</b>													
59	Chemical Dose, mg/L (computer generated):		25.7	-30.4	13.4	49.7	-9.5	5.6	-11.2	-8.5				
60	Chemical Dose, mg/L (manually inputted):	17.4												
61	Orthophosphate (as PO <sub>4</sub> <sup>3-</sup> , mg/L):	2.00							3.00					
62	pH (field water temperature):	7.00	8.00	8.33	7.20	7.20	8.62	8.62	7.30	8.00				
63	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	115.0	132.2	100.0	116.8	113.2	50.6	57.6	43.1	50.0				
64	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	140.0	159.6	119.6	142.2	137.8	58.8	66.8	52.4	60.2				
65	Carbonate (mg/L as CO <sub>3</sub> <sup>2-</sup> ):	0.063	0.716	1.122	0.100	0.095	1.310	1.571	0.057	0.327				
66	Acidity (mg/L as CaCO <sub>3</sub> ):	170.9	137.3	100.3	152.7	148.3	48.6	55.2	52.3	51.5				
67	Carbon Dioxide (CO <sub>2</sub> , mg/L):	24.66	2.80	1.00	15.87	15.51	0.22	0.25	4.10	0.94				
68	DIC (dissolved inorganic carbon, mg/L as C):	34.3	32.3	24.0	32.3	31.4	11.9	13.5	11.4	12.2				
69	Calcium (mg/L as Ca <sup>2+</sup> ):	20.0	15.0	15.0	15.0	6.8	5.0	5.0	5.0	5.0				
70	Magnesium (mg/L as Mg <sup>2+</sup> ):	14.0	15.0	15.0	15.0	6.8	5.0	5.0	5.0	5.0				
71	Sodium (mg/L as Na <sup>+</sup> ):	37.5	29.8	15.0	22.7	35.4	5.9	9.1	5.0	5.0				
72	Chloride (mg/L as Cl <sup>-</sup> ):	27.0	27.0	27.0	27.0	15.0	6.4	6.4	5.0	5.0				
73	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):	32.0	32.0	32.0	32.0	21.0	10.0	10.0	10.0	10.0				
74	Magnesium Hardness (mg/L as CaCO <sub>3</sub> ):	57.7	61.8	61.8	61.8	28.0	20.6	20.6	20.6	20.6				
75	Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	49.9	37.5	37.5	37.5	17.0	12.5	12.5	12.5	12.5				
76	Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	107.6	99.2	99.2	99.2	45.0	33.1	33.1	33.1	33.1				
77	Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	107.6	99.2	98.1	99.2	45.0	33.1	33.1	33.1	33.1				
78	Non-Carbonate Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> , mg/L as CaCO <sub>3</sub> ):	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0				
79	Cations/Anions Percent Difference, (Σcations-Σanions) / (Σcations+Σanions):	0.81%	-10.47%	-12.49%	-11.70%	-12.27%	-19.14%	-16.75%	-15.78%	-21.07%				
80	<b>Corrosion Indices - Finished Water Characteristics</b>	<b>Set#</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>
81	Aggressive Index (AI):	10.7	11.7	11.9	10.8	10.5	11.4	11.5	10.0	10.8				
82	Ryznar Index (RI):	9.20	8.35	8.28	9.24	9.92	9.37	9.33	10.76	9.94				
83	Langelier Index (LI):	-1.10	-0.17	0.02	-1.02	-1.36	-0.38	-0.36	-1.73	-0.97				
84	CCPP (Calcium Carbonate Precipitation Potential, mg/L as CaCO <sub>3</sub> ):	-41.29	-2.15	0.23	-27.61	-29.62	-2.63	-2.75	-11.72	-5.21				
85	Buffer Intensity (mM/pH):	1.05	0.17	0.10	0.72	0.71	0.07	0.08	0.21	0.06				
86	Larson's Ratio ((Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk):	0.62	0.54	0.71	0.61	0.38	0.35	0.30	0.41	0.35				
87	CSMR (Chloride to Sulfate Mass Ratio):	0.84	0.84	0.84	0.84	0.71	0.64	0.64	0.50	0.50				
88	<b>Lead and Copper</b>													
89	pH at field water temperature:	7.00	8.00	8.33	7.20	7.20	8.62	8.62	7.30	8.00				
90	Field water temperature (°C):	15.0	15.0	15.0	15.0	15.0	22.0	22.0	22.0	22.0				
91	Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):	4.97	0.49	0.18	2.95	2.89	0.03	0.03	0.61	0.12				
92	Copper II (mg/L), Tenorite, black, CuO(s):	0.45	0.04	0.02	0.27	0.27	0.00	0.00	0.06	0.01				
93	Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):	0.19	0.06	0.04	0.14	0.14	0.02	0.02	0.07	0.03				
94	Lead II (mg/L), Lead Carbonate (PbCO <sub>3(s)</sub> , cerussite):	0.184	0.166	0.170	0.176	0.175	0.221	0.219	0.243	0.216				
95	<b>Lead and Copper, and pH Results (at 25°C water temperature) - Finished</b>													
96	pH (at 25°C water temperature):	6.94	7.93	8.23	7.13	7.13	8.58	8.58	7.28	7.98				
97	Copper II (mg/L), Cupric Hydroxide, light blue/blue-green, Cu(OH) <sub>2</sub> (s):	-	0.30	0.11	1.75	1.71	0.03	0.03	-	0.10				
98	Copper II (mg/L), Tenorite, black, CuO(s):	-	0.03	0.01	0.16	0.16	0.00	0.00	-	0.01				
99	Copper II (mg/L), Malachite, blue-green, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s):	-	0.04	0.03	0.11	0.11	0.01	0.02	-	0.03				
100	Copper II (mg/L), Copper Phosphate, Cu <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> *2H <sub>2</sub> O <sub>3</sub> (s):	0.40	-	-	-	-	-	-	0.11	-				
101	Lead II (mg/L), Lead Carbonate, PbCO <sub>3(s)</sub> , cerussite:	-	0.218	0.223	0.229	0.229	0.238	0.236	-	0.233				
102	Lead II (mg/L), Basic Lead Carbonate, Pb <sub>3</sub> (CO <sub>3</sub> ) <sub>2</sub> (OH) <sub>2(s)</sub> , hydrocerussite:	-	0.309	0.227	0.576	0.571	0.146	0.151	-	0.229				
103	Lead II (mg/L), Hydroxy-pyromorphite, Pb <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> (OH) <sub>6(s)</sub> :	0.067	-	-	-	-	-	-	0.019	-				

16. **Buffer Intensity** – For graphically evaluating the changes in buffer intensity versus DIC and alkalinity. Also graphed are CCPP values versus pH based on water DIC, TDS, calcium and temperature.



17. **Blend** – This is an easy program for determining the changes in water characteristic of two blended sources. This has several applications from reducing chemical contaminate concentration to changing the water characteristics for easier treatment to a more desirable outcome before delivery to customers. The initial water characteristics and flow rates for each source are entered. The results are the blended water characteristics along with corrosion indices.

Below is an example of blending two waters. The primary source has very low alkalinity and the other source has much higher alkalinity. The two sources are blended to raise the alkalinity and mineral concentration. The user can adjust the flow for each source to target a water characteristic blend. There is also a drop-down menu for the units of flow (MGD, gpm, ML/day, L/min, L/sec & m<sup>3</sup>/hr.) to select from.

**Water!Pro Blending Modeling Program**

Step 1:	Source Water 1	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>		
Source Point:	Old Well	
Date of Sample:	July 26, 2017	
Plant Flow Rate:	40 gpm	57,600 gal/day
TDS:	398 mg/L	0.0099 mol/L, IS
pH:	7.59	
Total Alkalinity:	97.7 mg/L as CaCO <sub>3</sub>	1.95 meq/L
Water Temperature:	10.0 °C	(temp. at which pH was analyzed)
Field Water Temperature:	10.0 °C	(operating temperature at facility)
Calcium (Ca <sup>2+</sup> ):	32.0 mg/L	79.9 as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	3.0 mg/L	12.4 as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	10.0 mg/L	21.8 as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	4.2 mg/L	5.9 as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	5.0 mg/L	5.2 as CaCO <sub>3</sub>
Nitrate:	15.0 mg/L	as N
UVA-254:	0.03	1/cm, UV Absorption
DOC:	1.0 mg/L	as C (Dissolved Organic Carbon)
Source Water Turbidity:	0.3 NTU	SUVA = 3 L/(m <sup>3</sup> *mg)
Step 2:	Source Water 2	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>		
Source Point:	New Well	
Date of Sample:	July 26, 2017	
Plant Flow Rate:	60 gpm	86,400 gal/day
TDS:	320 mg/L	0.0080 mol/L, IS
pH:	7.00	
Total Alkalinity:	20.0 mg/L as CaCO <sub>3</sub>	0.40 meq/L
Water Temperature:	10.0 °C	(temp. at which pH was analyzed)
Field Water Temperature:	10.0 °C	(operating temperature at facility)
Calcium (Ca <sup>2+</sup> ):	0.9 mg/L as Ca <sup>2+</sup>	2.2 as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	3.0 mg/L	12.4 as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	40.0 mg/L	87.1 as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	4.2 mg/L	5.9 as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	5.0 mg/L	5.2 as CaCO <sub>3</sub>
Nitrate:	4.1 mg/L	as N
UVA-254:	0.03	1/cm, UV Absorption
DOC:	1.0 mg/L	as C (Dissolved Organic Carbon)
Source Water Turbidity:	0.3 NTU	SUVA = 3 L/(m <sup>3</sup> *mg)
Step 3:	Blended Source	
<b>Blended Results Waters 1 and 2</b>		
Source Point:	Old Well & New Well	
Date of Sample:	November 1, 2005	
Combined Plant Flow Rate:	100.0 gpm	144,000 gal/day
TDS:	351 mg/L	0.0088 mol/L, IS
pH:	7.36	
Total Alkalinity:	51.1 mg/L as CaCO <sub>3</sub>	1.021 meq/L
Bicarbonate (HCO <sub>3</sub> <sup>-</sup> ):	62.2 mg/L	1.019 meq/L
Carbonate (CO <sub>3</sub> <sup>2-</sup> ):	0.061 mg/L	0.002 meq/L
Water Temperature:	10.0 °C	Field
Calcium (Ca <sup>2+</sup> ):	13.3 mg/L	33.3 as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	3.0 mg/L	12.4 as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	28.0 mg/L	61.0 as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	4.2 mg/L	5.9 as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	5.0 mg/L	5.2 as CaCO <sub>3</sub>
Nitrate:	8.5 mg/L	as N
DOC:	13.65 mg/L	as C
Acidity:	62.6 mg/L	as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ):	5.13 mg/L	as CO <sub>2(aq)</sub>
UVA-254:	0.030	1/cm, UV Absorption
DOC:	1.0 mg/L	as C (Dissolved Organic Carbon)
Source Water Turbidity:	0.3 NTU	SUVA = 2.07 L/(m <sup>3</sup> *mg)
Hardness		
Total Hardness:	45.7 mg/L	as CaCO <sub>3</sub>
Carbonate Hardness:	45.7 mg/L	as CaCO <sub>3</sub>
Non-Carbonate Hardness:	0.0 mg/L	as CaCO <sub>3</sub>
Cations/Anions % Difference:	26.30%	(Σcations-Σanions)/(Σcations+Σanions)
Corrosion Indices		
Aggressive Index (AI):	10.6	Moderately aggressive conditions
Ryznar Index (RI):	10.14	Tendency to dissolve CaCO <sub>3</sub>
Langelier Saturation Index:	-1.39	Tendency to dissolve CaCO <sub>3</sub>
CCPP:	-12.50	mg/L as CaCO <sub>3</sub>
B <sub>H2O</sub> + B <sub>CO3</sub> :	0.243	mMpH, Buffer intensity
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk:	0.22	Light metal tendency
CSMR:	0.84	Chloride/Sulfate Mass Ratio
Step 4:	Copy Blended Results into other Worksheets	
<div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; background-color: #e0e0e0; text-align: center; width: 150px;">             Copy blended results into <a href="#">WaterPro.wks</a> </div> <div style="border: 1px solid black; border-radius: 10px; padding: 5px; background-color: #e0e0e0; text-align: center; width: 150px;">             Copy blended results into <a href="#">CorrosionModeling.wks</a> </div> </div>		

18. **Indices** – This worksheet is strictly designed for modeling water characteristics for corrosion control treatment. Up to 500 sets of data may be evaluated at once or the user selected set. The user inputs the initial water characteristics and selects treatment and dosage for that set of data. After computer processing, the before and after water characteristics related to corrosion control are calculated.



**Water!Pro Blending Modeling Program (Blend up to Six Sources)**

<b>Step 1:</b>		<b>Source Water 1</b>	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>			
Source Water	SW Treated		
Date of Sample:	November 1, 2014		
Plant Flow Rate:	100.0	gpm	22.7 m <sup>3</sup> /hr
TDS:	300	mg/L	0.0075 mol/L, IS
pH:	7.00		
Total Alkalinity:	80.0	mg/L as CaCO <sub>3</sub>	
Water Temperature:	18.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	18.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	5.0	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):		mg/L	0.0 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	5.5	mg/L	7.8 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	8.0	mg/L	8.3 mg/L as CaCO <sub>3</sub>
Nitrate:	10.0	mg/L	
UVA-254:	0.075	1/cm, UV Absorption	
DOC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3	NTU	SUVA = 1.5 L/(m <sup>2</sup> mg)

<b>Step 4:</b>		<b>Source Water 4</b>	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>			
Source Water	Well 321		
Date of Sample:	November 1, 2014		
Plant Flow Rate:	0	gpm	0.0 m <sup>3</sup> /hr
TDS:	310	mg/L	0.0078 mol/L, IS
pH:	8.00		
Total Alkalinity:	58.0	mg/L as CaCO <sub>3</sub>	
Water Temperature:	15.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	15.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	5.0	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):		mg/L	0.0 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	5.0	mg/L	7.1 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	15.0	mg/L	15.6 mg/L as CaCO <sub>3</sub>
Nitrate:	3.0	mg/L	
UVA-254:	0.075	1/cm, UV Absorption	
DOC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3	NTU	SUVA = 1.5 L/(m <sup>2</sup> mg)

<b>Step 2:</b>		<b>Source Water 2</b>	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>			
Source Water	Well 140		
Date of Sample:	November 1, 2005		
Plant Flow Rate:	0	gpm	0.0 m <sup>3</sup> /hr
TDS:	100	mg/L	0.0025 mol/L, IS
pH:	6.60		
Total Alkalinity:	42.5	mg/L as CaCO <sub>3</sub>	
Water Temperature:	18.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	18.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	5.6	mg/L	14.0 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):		mg/L	0.0 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	12.0	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	8.0	mg/L	32.9 mg/L as CaCO <sub>3</sub>
Nitrate:	1.0	mg/L	
UVA-254:	0.075	1/cm, UV Absorption	
DOC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3	NTU	SUVA = 1.5 L/(m <sup>2</sup> mg)

<b>Step 5:</b>		<b>Source Water 5</b>	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>			
Source Water	Well 151		
Date of Sample:	November 1, 2005		
Plant Flow Rate:	0	gpm	0.0 m <sup>3</sup> /hr
TDS:	200	mg/L	0.0050 mol/L, IS
pH:	6.50		
Total Alkalinity:	5.0	mg/L as CaCO <sub>3</sub>	
Water Temperature:	25.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	22.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	5.0	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):		mg/L	0.0 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	12.0	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	8.0	mg/L	32.9 mg/L as CaCO <sub>3</sub>
Nitrate:	4.0	mg/L	
UVA-254:	0.075	1/cm, UV Absorption	
DOC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3	NTU	SUVA = 1.5 L/(m <sup>2</sup> mg)

<b>Step 3:</b>		<b>Source Water 3</b>	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>			
Source Water	Well 143		
Date of Sample:	November 1, 2005		
Plant Flow Rate:	0	gpm	0.0 m <sup>3</sup> /hr
TDS:	300	mg/L	0.0075 mol/L, IS
pH:	7.00		
Total Alkalinity:	100.0	mg/L as CaCO <sub>3</sub>	
Water Temperature:	12.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	12.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	12.0	mg/L	30.0 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	15.0	mg/L	32.7 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	10.0	mg/L	10.4 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	5.0	mg/L	7.1 mg/L as CaCO <sub>3</sub>
Nitrate:	2.0	mg/L	
UVA-254:	0.075	1/cm, UV Absorption	
DOC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3	NTU	SUVA = 1.5 L/(m <sup>2</sup> mg)

<b>Step 6:</b>		<b>Source Water 6</b>	
<b>Enter Initial Raw Water Characteristics &amp; Parameters</b>			
Source Water	Well 177		
Date of Sample:	November 1, 2005		
Plant Flow Rate:	100.0	gpm	22.7 m <sup>3</sup> /hr
TDS:	200	mg/L	0.0050 mol/L, IS
pH:	7.00		
Total Alkalinity:	60.0	mg/L as CaCO <sub>3</sub>	
Water Temperature:	25.0	°C (temp. at which pH was analyzed)	
Field Water Temperature:	22.0	°C (operating temperature at facility)	
Calcium (Ca <sup>2+</sup> ):	5.0	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	25.0	mg/L	54.4 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	10.0	mg/L	10.4 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	5.0	mg/L	7.1 mg/L as CaCO <sub>3</sub>
Nitrate:	0	mg/L	
UVA-254:	0.075	1/cm, UV Absorption	
DOC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3	NTU	SUVA = 1.5 L/(m <sup>2</sup> mg)

Blended Results			
Blended Sources: Waters 1, 2 and 3			
Combined Plant Flow Rate:	100.0	gpm	22.7 m <sup>3</sup> /hr
TDS:	300	mg/L	0.0075 mol/L, IS
Ph:	7.00		
Total Alkalinity:	80.0	mg/L as CaCO <sub>3</sub>	
Bicarbonate (HCO <sub>3</sub> <sup>-</sup> ):	97.4	mg/L	
Carbonate (CO <sub>3</sub> <sup>2-</sup> ):	0.050	mg/L	
Water Temperature:	18.0	°C, Field	
Calcium (Ca <sup>2+</sup> ):	5.00	mg/L	12.5 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	0.0	mg/L	0.0 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	5.5	mg/L	7.8 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	8.0	mg/L	8.3 mg/L as CaCO <sub>3</sub>
Nitrate:	10.0	mg/L	
DIC:	23.56	mg/L as C	
Acidity:	116.4	mg/L as CaCO <sub>3</sub>	
Carbon Dioxide (CO <sub>2</sub> ):	16.02	mg/L as CO <sub>2(aq)</sub>	
Hardness			
Total Hardness::	53.7	mg/L as CaCO <sub>3</sub>	1.07 meq/L
Carbonate Hardness:	53.7	mg/L as CaCO <sub>3</sub>	1.07 meq/L
Non-Carbonate Hardness:	0.0	mg/L as CaCO <sub>3</sub>	0.00 meq/L
Cations/Anions % Difference:	-28.3%	$(\sum \text{cations} - \sum \text{anions}) / (\sum \text{cations} + \sum \text{anions})$	
Corrosion Indices			
Aggressive Index (AI):	10.0	Extremely aggressive conditions	
Ryznar Index (RI):	10.71	Tendency to dissolve CaCO <sub>3</sub>	
Langelier Saturation Index:	-1.85	Tendency to dissolve CaCO <sub>3</sub>	
CCPP:	-34.16	mg/L as CaCO <sub>3</sub>	
B <sub>H2O</sub> + B <sub>CO3</sub> :	0.684	mM/pH, Buffer intensity	
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk:	0.20	Light metal tendency	
CSMR:	0.69	Chloride/Sulfate Mass Ratio	
UVA-254:	0.075	1/cm, UV Absorption	
DÖC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3.0	NTU SUVA = 1.5 L/(m <sup>3</sup> mg)	

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Blended Results			
Blended Sources: Waters 1, 2, 3, 4, 5 and 6			
Combined Plant Flow Rate:	200.0	gpm	45.4 m <sup>3</sup> /hr
TDS:	250	mg/L	0.0063 mol/L, IS
Ph:	7.00		
Total Alkalinity:	70.0	mg/L as CaCO <sub>3</sub>	
Bicarbonate (HCO <sub>3</sub> <sup>-</sup> ):	85.3	mg/L	
Carbonate (CO <sub>3</sub> <sup>2-</sup> ):	0.046	mg/L	
Water Temperature:	20.0	°C, Field	
Calcium (Ca <sup>2+</sup> ):	5.00	mg/L as Ca <sup>2+</sup>	12.5 mg/L as CaCO <sub>3</sub>
Magnesium (Mg <sup>2+</sup> ):	10.0	mg/L	41.2 mg/L as CaCO <sub>3</sub>
Sodium (Na <sup>+</sup> ):	12.5	mg/L	27.2 mg/L as CaCO <sub>3</sub>
Chloride (Cl <sup>-</sup> ):	7.8	mg/L	10.9 mg/L as CaCO <sub>3</sub>
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	6.5	mg/L	6.8 mg/L as CaCO <sub>3</sub>
Nitrate:	5.0	mg/L	
DIC:	20.48	mg/L as C	
Acidity:	100.7	mg/L as CaCO <sub>3</sub>	
Carbon Dioxide (CO <sub>2</sub> ):	13.51	mg/L as CO <sub>2(aq)</sub>	
Hardness			
Total Hardness::	53.7	mg/L as CaCO <sub>3</sub>	1.07 meq/L
Carbonate Hardness:	53.7	mg/L as CaCO <sub>3</sub>	1.07 meq/L
Non-Carbonate Hardness:	0.0	mg/L as CaCO <sub>3</sub>	0.00 meq/L
Cations/Anions % Difference:	-4.1%	$(\sum \text{cations} - \sum \text{anions}) / (\sum \text{cations} + \sum \text{anions})$	
Corrosion Indices			
Aggressive Index (AI):	9.9	Extremely aggressive conditions	
Ryznar Index (RI):	10.73	Tendency to dissolve CaCO <sub>3</sub>	
Langelier Saturation Index:	-1.86	Tendency to dissolve CaCO <sub>3</sub>	
CCPP:	-29.55	mg/L as CaCO <sub>3</sub>	
B <sub>H2O</sub> + B <sub>CO3</sub> :	0.581	mM/pH, Buffer intensity	
LR: (Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk:	0.25	Light metal tendency	
CSMR:	1.19	Chloride/Sulfate Mass Ratio	
UVA-254:	0.075	1/cm, UV Absorption	
DÖC:	5.0	mg/L as C (Dissolved Organic Carbon)	
Source Water Turbidity:	3.0	NTU SUVA = 1.5 L/(m <sup>3</sup> mg)	

(707)322-2001; ptn1068; June 7, 2023

**Copy Blended Results into other Worksheets: Waters 1, 2 & 3**

Copy blended results into  
[WaterPro.wks](#)

Copy blended results into  
[CorrosionModeling.wks](#)

**Copy Blended Results into other Worksheets: Waters 1, 2, 3, 4, 5 & 6**

Copy blended results into  
[WaterPro.wks](#)

Copy blended results into  
[CorrosionModeling.wks](#)

## 20. Blending Scenarios – This is the last program development that allows the user to compare different blending scenarios.

### Blending Scenarios - Water Characteristics, Corrosion Indices and Lead/Copper Blend up to 10 Sources & 5 Blended Sets

Up to 10 sets of water characteristics can be inputted.  
The user has the option to blend consecutive sets of data and up to 5 sets of scenarios.

											Process All 5 Scenarios					
											Enter the set numbers to be process for each scenario:					
											Process Set 1	Process Set 2	Process Set 3	Process Set 4	Process Set 5	
											Start Set#	1	7	1	1	2
											End Set#	2	10	10	3	6
											Case 1	Case 2	Case 3	Case 4	Case 5	
											Blend 1-2	Blend 7-10	Blend 1-10	Blend 1-3	Blend 2-6	
Nº	<b>Step 1: Initial Water Characteristics</b>	1	2	3	4	5	6	7	8	9	10	Case 1	Case 2	Case 3	Case 4	Case 5
1	Flow (any units):	100	400	320	300	200	150	300	250	200	150	500	900	2,370	820	1,370
2	TDS (mg/L):	200	100	300	310	200	200	320	200	190	56	120	214	220	202	218
3	pH:	7.00	6.60	7.00	8.00	6.50	7.00	8.00	7.50	7.00	6.50	6.69	7.41	7.03	6.81	6.85
4	Total Alkalinity (mg/L as CaCO <sub>3</sub> ):	80	42.5	100	58	50	60	150	100	50	25	50.0	93.1	74.7	69.5	62.3
5	Temperature (°C, at which pH was measured):	18.0	18.0	12.0	15.0	25.0	25.0	25.0	25.0	25.0	25.0	18.0	25.0	20.5	15.7	17.7
6	Field Temperature (°C, operating temperature):	18.0	18.0	22.0	15.0	22.0	22.0	22.0	22.0	22.0	22.0	18.0	22.0	20.3	19.6	19.3
7	Calcium (mg/L as Ca <sup>2+</sup> ):	5.0	5.6	5.0	5.0	5.0	5.0	25.0	5.0	5.0	5.0	5.5	5.0	7.6	5.3	5.2
8	Magnesium (mg/L as Mg <sup>2+</sup> ):	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
9	Sodium (mg/L as Na <sup>+</sup> ):	5.0	8.0	10.0	12.0	5.0	15.0	20.0	22.0	24.0	12.0	7.4	20.1	13.4	8.4	9.7
10	Chloride (mg/L as Cl <sup>-</sup> ):	5.5	8.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.7	7.5	9.3	10.4	9.8
11	Sulfate (mg/L as SO <sub>4</sub> <sup>2-</sup> ):	8.0	12.0	10.0	15.0	12.0	10.0	10.0	10.0	10.0	10.0	8.0	7.5	7.3	6.8	8.1
12	Nitrate (mg/L as N):	10.0	1.0	2.0	3.0	4.0	0.0	10.0	10.0	10.0	10.0	2.8	10.0	5.4	2.5	2.0

13	Results - Initial Water Characteristics										Blended Results					
	after Temperature Correction										Blend 1-2	Blend 7-10	Blend 1-10	Blend 1-3	Blend 2-6	
14	pH (at field temperature):	7.00	6.60	6.92	8.00	6.52	7.02	8.02	7.52	7.02	6.52	6.69	7.41	7.03	6.81	6.85
15	Acidity (mg/L as CaCO <sub>3</sub> ):	116.9	92.8	150.9	60.2	116.0	85.0	154.1	112.8	70.8	59.1	97.7	107.7	105.4	121.7	102.8
16	Carbon Dioxide (as CO <sub>2(aq)</sub> ):	16.3	22.1	22.4	1.2	29.0	11.0	2.7	5.8	9.2	15.0	21.0	6.6	13.5	23.0	17.8
17	Bicarbonate (mg/L as HCO <sub>3</sub> <sup>-</sup> ):	97.4	51.8	121.8	70.0	61.0	73.1	180.6	121.5	60.9	30.5	60.9	113.1	91.0	84.7	76.0
18	DIC (mg/L as C):	23.6	16.2	30.1	14.2	19.9	17.4	36.5	25.5	14.5	10.1	17.7	24.1	21.6	23.0	19.8
19	Hardness	1	2	3	4	5	6	7	8	9	10	Blend 1-2	Blend 7-10	Blend 1-10	Blend 1-3	Blend 2-6
20	Magnesium Hardness (mg/L as CaCO <sub>3</sub> ):	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.2
21	Calcium Hardness (mg/L as CaCO <sub>3</sub> ):	12.5	14.0	12.5	12.5	12.5	12.5	62.4	12.5	12.5	12.5	13.7	12.5	19.1	13.2	12.9
22	Total Hardness (mg/L as CaCO <sub>3</sub> ):	53.7	55.2	53.7	53.7	53.7	53.7	103.6	53.7	53.7	53.7	54.9	53.7	60.2	54.4	54.1
23	Carbonate Hardness (mg/L as CaCO <sub>3</sub> ):	53.7	42.5	53.7	53.7	50.0	53.7	103.6	53.7	49.9	25.0	50.0	53.7	60.2	54.4	54.1
24	Non-Carbonate Hardness (as CaCO <sub>3</sub> ):	0.0	12.7	0.0	0.0	3.7	0.0	0.0	0.0	3.7	28.7	4.9	0.0	0.0	0.0	0.0
25	Cations/Anions Percent Difference:	-19.6%	4.5%	-21.8%	-0.2%	-3.7%	5.4%	-5.9%	-7.1%	22.2%	30.5%	-1.7%	-6.6%	-3.2%	-11.3%	-5.9%

27	Corrosion Indices	1	2	3	4	5	6	7	8	9	10	Blend 1-2	Blend 7-10	Blend 1-10	Blend 1-3	Blend 2-6
28	Aggressive Index (AI):	9.99	9.36	10.01	10.85	9.30	9.88	11.97	10.60	9.80	9.00	9.52	10.47	10.18	9.76	9.75
29	Ryznar Index (RI):	10.64	11.41	10.48	10.09	11.42	10.76	7.68	9.83	10.91	11.87	11.21	9.91	10.24	10.98	11.00
30	Langelier Saturation Index:	-1.82	-2.40	-1.78	-1.05	-2.45	-1.87	0.17	-1.15	-1.95	-2.68	-2.26	-1.25	-1.61	-2.09	-2.07
31	CCPP (mg/L as CaCO <sub>3</sub> ):	-34.15	-47.43	-44.13	-6.20	-60.29	-24.83	2.91	-13.04	-21.58	-33.89	-44.73	-14.69	-28.50	-47.77	-38.34
32	Buffer Intensity (B <sub>H2O</sub> + B <sub>CO3</sub> , mM/pH):	0.692	0.728	0.937	0.077	0.916	0.478	0.178	0.292	0.399	0.467	0.743	0.324	0.588	0.875	0.704
33	Larson's Ratio ((Cl <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup> )/Alk):	-1.82	-2.40	-1.78	-1.05	-2.45	-1.87	0.17	-1.15	-1.95	-2.68	-2.26	-1.25	-1.61	-2.09	-2.07
34	Chloride Sulfate Mass Ratio (CSMR):	0.69	0.67	0.50	0.33	0.42	0.50	0.50	0.50	0.50	0.50	1.34	1.00	1.27	1.53	1.21
35	Lead and Copper Solubilities at 25°C	1	2	3	4	5	6	7	8	9	10	Blend 1-2	Blend 7-10	Blend 1-10	Blend 1-3	Blend 2-6
36	pH (at 25° temperature):	6.96	6.56	6.91	7.92	6.50	7.00	8.00	7.50	7.00	6.50	6.65	7.41	7.01	6.74	6.81
37	Copper II at 25°C, (mg/L):	2.09	5.20	2.85	0.13	7.08	1.49	0.28	0.60	1.31	5.20	4.07	0.70	1.72	3.61	2.77
38	Lead II at 25°C, (ug/L):	0.252	0.385	0.248	0.230	0.390	0.265	0.218	0.223	0.277	0.528	0.333	0.226	0.252	0.286	0.286

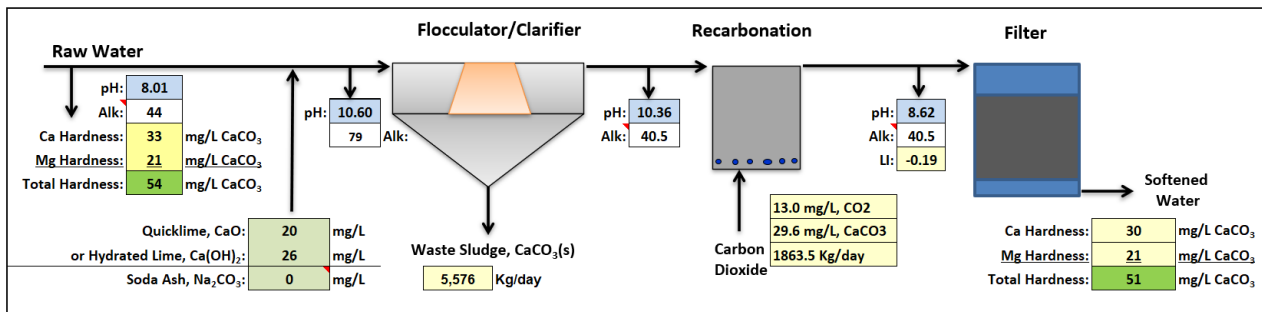
**21. Water Softening** – There are three (3) worksheets for “Single and Two-Stage Lime/Soda-Ash Softening Process.” The programs calculate the amounts of lime/soda ash required based on target hardness and pH. Bar diagrams of the water analysis are displayed for visual understanding of water characteristics before and after treatment which also includes recarbonation. The outcome of the final hardness (Ca/Mg) is inputted by the user. The program will predict the pH, alkalinity, and recarbonation based on the hardness output.

Flow Diagram 1 is for a single-stage lime/soda-ash softening for removal of calcium hardness only. This worksheet should only be used for waters with low magnesium.

**Diagram 1:**

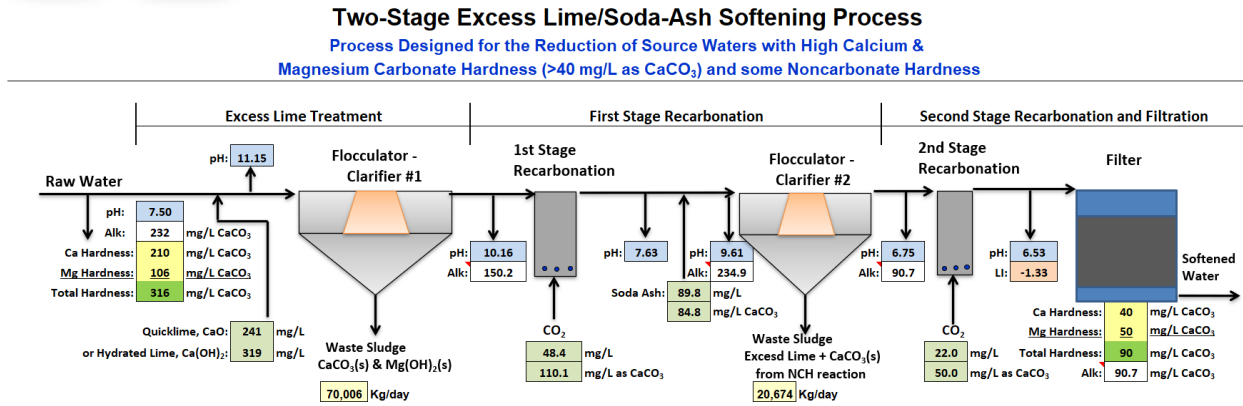
**Single-Stage Lime/Soda-Ash Softening Process  
Selective Calcium Removal Only**

*For waters with high calcium, low magnesium (<= 10 mg/L as Mg<sup>2+</sup>), carbonate hardness and with/without noncarbonate hardness*



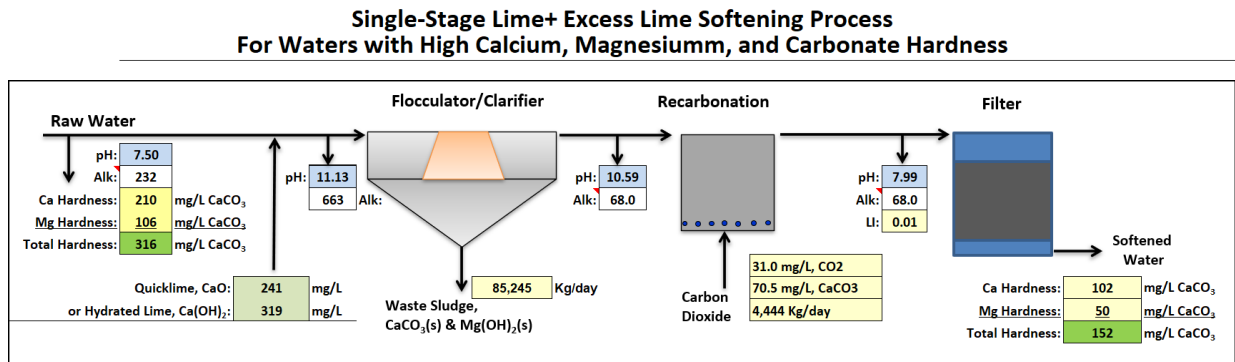
Flow Diagram 2 is for a two-stage lime/soda-ash softening for removal of calcium and magnesium hardness.

Diagram 2:



Flow Diagram 3 is for a single-stage lime softening for removal of calcium and magnesium hardness. No soda ash is added in this model.

Diagram 3:



22. **Counter-Current Packed Tower** – A packed tower is characterized as a cylindrical column filled with packing material. Contaminant water is distributed over the top of the packing material and trickles down through the packing, while air is being simultaneously forced up through the bottom of the packed tower transferring the compound from the water to the air stream. The tower interior and packing material are designed with re-distributors to force the water to flow down over the packing and avoid short circuiting down the walls of the tower. A blower is placed at the bottom of the tower forcing air up through the tower and exiting at the top. The compound in the vapor phase exits the top of the tower with the air as an exhaust stream. This program is to be used as an aid in the design of a “Packed Tower”.

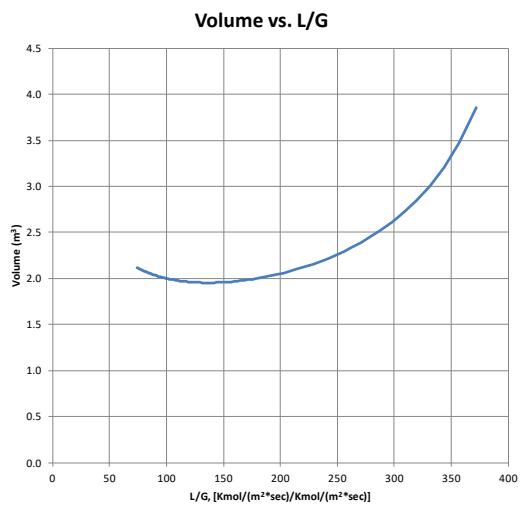
Below is an example how the **Counter-Current Packed Tower Program** can be used in designing a packed tower for the reduction of Trichloroethylene (TCE):

### Counter-Current Packed Tower Air-Stripping Program

Step 1: Target Compound	
Enter characteristics of target compound or select from drop list.	
Target compound:	C <sub>2</sub> HCl <sub>3</sub> Trichloroethylene, TCE
Henry's constant (H <sub>a</sub> ):	427.7 atm 0.325 Dim (L <sub>120</sub> /L <sub>air</sub> )
Molecular weight:	131.39 g/mole
LeBas Molar Volume (V <sub>a</sub> ):	107.1 cm <sup>3</sup> /mole
Atomic Diffusion Volume (D <sub>g</sub> ):	93.5 m <sup>2</sup> /sec
Enter Starting and Ending Compound Concentration:	
Influent concentration:	100 ug/L Source Water
Desired effluent concentration:	5 ug/L Treated Water

Step 2: Reactor Operating Conditions	
Enter operating conditions.	
Design water/air Temperature:	15 °C 59 °F
Total pressure of gas:	1 atm 1.013 Bars
Pressure drop through Packed Tower:	100 N/m <sup>2</sup> 0.402 inches
Flow rate:	1000 m <sup>3</sup> /day 183 gpm
Air-to-Water ratio factor, S:	4.00 Stripping factor (1.2-10): try 3.25
Blower & Pump Power Requirements	
Blower efficiency (Eff <sub>b</sub> ):	35 %
Pump efficiency (Eff <sub>p</sub> ):	80 %
Electrical cost:	15 cent per KW-Hr
Pump/blower in service per day:	24 hours

Step 3: Packing Material	
Enter packing characteristics or select from drop list.	
Type of packing material:	Nor-Pac Nor-Pac (1.5", 38.1 mm)
Nominal diameter size of packing (d <sub>p</sub> ):	38.1 mm 1.50 inches
Nominal surface area of packing (a <sub>s</sub> ):	144.0 m <sup>2</sup> /m <sup>3</sup> (a <sub>s</sub> )
Critical surface tension of packing (σ <sub>c</sub> ):	33 dyne/cm 0.033 N/m
Packing factor for material (C <sub>f</sub> ):	17 dimensionless



Step 4: Air-Stripping Tower - Design	
Results.	
K <sub>a</sub> (applied Safety factor):	0.75 affects tower length
Tower x-Area:	0.251 m <sup>2</sup> 2.7 ft <sup>2</sup>
Tower diameter:	0.565 m 1.85 ft
Tower height:	7.87 m 25.82 ft
Tower volume:	1.98 m <sup>3</sup> 69.8 ft <sup>3</sup>
Calculated Power Requirements:	
P <sub>blower</sub> (brake power):	0.33 KW 0.447 HP
P <sub>pump</sub> (power):	1.12 KW 1.50 HP
P <sub>total</sub> (power):	1.45 KW 1.94 HP
Cost per day:	\$5.22 per 24 hrs of operations per day

Calculated Variables:	
(Q <sub>air</sub> /Q <sub>120</sub> ) <sub>min</sub> :	2.92
(Q <sub>air</sub> /Q <sub>120</sub> ) <sub>mult</sub> :	11.67
Q <sub>airflow</sub> :	0.135 m <sup>3</sup> /sec 4.77 ft <sup>3</sup> /sec
Q <sub>waterflow</sub> :	0.01154 m <sup>3</sup> /sec 0.408 ft <sup>3</sup> /sec
Stripping Factor, S:	4.00
Number of Transfer Units (NTU):	3.633
Height of Transfer Unit (HTU):	2.17

Optimum Tower Design Calculated Values:	
Stripping Factor, R:	3.25
Minimum tower volume:	1.95 m <sup>3</sup> 69.0 ft <sup>3</sup>
Tower height:	8.64 m 28.36 ft
Tower diameter:	0.537 m 1.76 ft
k <sub>L</sub> liquid phase mass transfer coefficient:	3.0764E-04 m/sec Onda model
k <sub>G</sub> gas-phase mass transfer coefficient:	1.1738E-02 m/sec Onda model
K <sub>a</sub> overall liquid phase mass transfer rate constant:	0.02871 1/sec
K <sub>a</sub> (w/Safety factor):	0.02154 1/sec
G <sub>mv</sub> air mass loading rate:	0.6600 Kg/(m <sup>2</sup> -sec) 0.022917 Kmol/(m <sup>2</sup> -sec)
L <sub>mv</sub> water mass loading rate:	46.07 Kg/(m <sup>2</sup> -sec) 2.55963 Kmol/(m <sup>2</sup> -sec)
L/G:	111.69 Kmol/(m <sup>2</sup> -sec)/Kmol/(m <sup>2</sup> -sec)
L <sub>mv</sub> water loading rate:	67.74 gpm/ft <sup>2</sup>
Density of Water:	999.09 Kg/m <sup>3</sup> 62.37 lbs/ft <sup>3</sup>
Density of air:	1.226 Kg/m <sup>3</sup>
(u <sub>L</sub> ) Viscosity of water:	1.145E-03 Kg/m-sec 1.145 cp, 2.77 lb/ft*hr
(u <sub>G</sub> ) Viscosity of air:	1.79E-05 Kg/m-sec 0.018 cp, 0.043 lb/ft*hr
Surface tension of Water:	0.07351 N/m 73.50 dynes/cm
p <sub>L</sub> /(u <sub>L</sub> g):	88,958.5 sec <sup>2</sup> /m <sup>3</sup>
u <sub>L</sub> /(p <sub>L</sub> D <sub>L</sub> ):	1,581.68
u <sub>G</sub> /(p <sub>G</sub> D <sub>G</sub> ):	1.8524
Molecular liquid diffusion coefficient (D <sub>L</sub> ):	7.2448E-06 cm <sup>2</sup> /sec 7.2448E-10 m <sup>2</sup> /sec
Molecular gas diffusion coefficient (D <sub>G</sub> ):	7.8654E-02 cm <sup>2</sup> /sec 7.8654E-06 m <sup>2</sup> /sec
C* <sub>aq</sub> aqueous phase conc. in equilibrium w/air:	25.00 ug/L
a <sub>av</sub> specific surface area for mass transfer:	100.85 m <sup>2</sup> /m <sup>3</sup>
L <sub>mv</sub> /G <sub>m</sub> :	69.8 Kg/(m <sup>2</sup> -sec)/Kg/(m <sup>2</sup> -sec)
F <sub>r</sub> parameter:	2.000
a <sub>2</sub> parameter:	-2.171
a <sub>1</sub> parameter:	-0.7803
a <sub>2</sub> parameter:	-0.249
E <sub>r</sub> parameter:	0.38859
M <sub>r</sub> parameter:	0.003075
y-axis:	0.003075
Air Flow, G <sub>mv</sub> :	0.166 Kg/sec
Delta P losses (blower):	79.71 N/m <sup>2</sup> 0.7971 mbars
P <sub>in</sub> (inlet pressure to packed tower):	102,192 N/m <sup>2</sup> 1.02 Bars

**23. Spray Aeration of TTHMs** – This program is to model total trihalomethanes (TTHM) reduction through spray aeration. Empirical models are used to calculate the percent reduction of each of the THM species. There are two models. **Model 1** calculates the reduction of TTHM for one recirculation cycle. It also provides the power cost based on the recirculation pump operating 24 hours per day. **Model 2** calculates the steady-state concentration of TTHM in a tank after several days of operations. The operational parameter may be based on user constraints or actual tank operations via SCADA.

Below is an example in using Model 1 for calculating the reduction for TTHM for one recirculation treatment path:

<b>Step 1:</b>		<b>TTHM Compounds for Spray Aeration</b>		
<b>Enter influent concentration of TTHM compounds.</b>				
Chloroform, CHCl <sub>3</sub>	78	ug/L	60%	TTHM
Bromodichloromethane, CHBrCl <sub>2</sub>	13	ug/L	10%	TTHM
Dibromochloromethane, Br <sub>2</sub> CiCH	26	ug/L	20%	TTHM
Bromoform, CHBr <sub>3</sub>	13	ug/L	10%	TTHM
Total Trihalomethanes, TTHMs	130	ug/L	100%	
<b>Step 2:</b>		<b>Spray Aeration Operating Conditions</b>		
<b>Enter operating conditions and spray nozzle information.</b>				
Water temperature	22	°C	71.6	°F
Recirculation flow (spray)	75	gpm	284	L/min
Nozzle Sauter Mean Diameter (SMD, D32)	690	µm, 0.069 cm	0.0272	inches
Nozzle angle of spray	60	degrees		
Distance from nozzle to water surface	4.6	ft	1.40	m
Head pressure to nozzle	14.2	psi	10.0	m, 0.99 Bars
<b>Pump Power Requirement:</b>				
Pump efficiency (Eff <sub>p</sub> )	50	%		
Electrical cost	15	Cent per KW-Hr		

<b>Step 3:</b>		<b>Spray Aeration Process - Results</b>		
<b>Treated effluent of TTHM Compounds:</b>		<b>% Reduction of TTHMs Compounds:</b>		
Chloroform, CHCl <sub>3</sub>	26.4	ug/L	66.2%	
Bromodichloromethane, CHBrCl <sub>2</sub>	4.8	ug/L	63.1%	
Dibromochloromethane, Br <sub>2</sub> CiCH	10.3	ug/L	60.4%	
Bromoform, CHBr <sub>3</sub>	5.0	ug/L	61.5%	
Total Trihalomethanes, TTHMs	46.5	ug/L	64.2%	
<b>Calculated Power Requirements:</b>				
P <sub>pump</sub> (power)	0.93	KW	1.24	HP
Cost per day	\$3.33	per 24 hrs of operations per day		
<b>Spray Information:</b>				
A/W, unit air-to-water volumetric ratio	3,156			
h <sub>avg</sub> , average droplet travel distance	4.8	ft	1.45	m

For nozzle selection and Sauter Mean Diameter (SMD, D32), you may go to the website listed below.  
<http://www.bete.com/>

24. **Advanced Oxidation Process (AOP) – H<sub>2</sub>O<sub>2</sub>/UV** – The advanced oxidation process (AOP) Excel program uses hydrogen peroxide and ultraviolet lamps to produce hydroxyl radicals for targeting organic compounds of concern. The first part of the program (**Single Dose Program**) allows the user to evaluate up to two target compounds based on water characteristics, UV lamp specifications, target compound characteristics and hydrogen peroxide dose. The treated compound results are given for four types of reactor flow models (plug flow, tanks-in-series, complete mixed flow and dispersion flow).

The second part of the AOP Excel program (**H<sub>2</sub>O<sub>2</sub> Dosage and Flow Range Program**) allows the user to view the results for a dose range of hydrogen peroxide and for a reactor flow range for a set dosage of hydrogen peroxide for one of the four selected reactor flow models.

Below is an example how the **Single Dose Program** can be used in targeting Geosmin and MIB taste and odor compounds:

**Advanced Oxidation Process (AOP) - H<sub>2</sub>O<sub>2</sub>/UV Program**  
**Single Dose H<sub>2</sub>O<sub>2</sub> Modeling Program**

Step 1: Reactor and Water Characteristics				Step 2: Targeted Compound				
Enter reactor volume/flow and water parameters.				Enter characteristics of target compounds or select from drop list.				
Project Name:	Water Treatment Plant			1	Target Compound (1):	Geosmin	Geosmin	
Sample Point:	After filtration, before UV Reactor				Molecular Weight:	182.3	g/mol	
Reactor Flow Rate:	400	gpm	0.025 m <sup>3</sup> /sec	25 L/sec	k HO• with target compound:	1.40E+10	L/(mol-sec)	
Reactor Volume:	50	gallons	0.189 m <sup>3</sup>	189.3 L	Compound Concentration:	122	ng/L 6.69E-10 Moles	
pH:	8.00	field pH is recommended		2	Target Compound (2):	MIB	2-Methylisoborneol (MIB)	
Total Alkalinity:	170	mg/L as CaCO <sub>3</sub>			Molecular Weight:	168.28	g/mol	
Iron:	0.00	mg/L as Fe (II)		0.000	mMol/L	k HO• with target compound:	8.20E+09	L/(mol-sec)
Manganese:	0.00	mg/L as Mn (II)		0.000	mMol/L	Compound Concentration:	54	ng/L 3.21E-10 Moles
UVA-254:	0.040	1/cm, UV Absorption for cell path length of 1 cm		91.2%	UVT			
TOC:	2.90	mg/L as C		0.241	mMol/L			
Step 3: UV System Specification and H <sub>2</sub> O <sub>2</sub> Dosage				Step 4: Results of Target Compounds				
Enter UV specifications and H <sub>2</sub> O <sub>2</sub> dosage.				Initial Concentration:				
Number of UV lamps:	8	lamps in operation		122 ng/L	54 ng/L	H <sub>2</sub> O <sub>2</sub> ent	EE/O	
UV Wavelength of light:	254	nm UV light absorbed by H <sub>2</sub> O <sub>2</sub> : 5.5%		Reactor Models: T = 0.13 min	Geosmin	MIB	mg/L	
Nominal Lamp Power:	9	KW per lamp		Plug Flow Reactor	5.3 ng/L	8.6 ng/L	3.50	
Ballast Power:	75%	(20 - 100%)		4 Tanks-In-Series; TIS = 4	12 ng/L	11.9 ng/L	3.51	
Lamp efficiency:	12%	(5 - 50%); 10 - 20% for MPUV and 25 - 40% for LPUV lamps		Completely Mix Flow Reactor	29.5 ng/L	19 ng/L	3.53	
H <sub>2</sub> O <sub>2</sub> dosage:	4	mg/L 0.118 mMol/L		Dispersed Flow Reactor; Pe = 35	6.7 ng/L	9.3 ng/L	3.51	
				UV light absorbed by H <sub>2</sub> O <sub>2</sub> : 5.46% H <sub>2</sub> O <sub>2</sub> dosage: 4 mg/L				
Save input data in Steps 1 - 4:				1	2	3	4	
Retrieve input data in Steps 1 - 4:				1	2	3	4	
				Last Retrieve #1				

The example above is based on a conventional surface water treatment plant with membrane filtration that has AOP treatment after its membrane filters for the reduction of taste and odor compounds. The water characteristics of the permeated water are entered into Step 1. In Step 2, the user selects up to two target compounds from drop-down menus that will automatically fill in the characteristics of that compound. If the targeted compound is not part of the list, the user may enter the name of the compound and associated characteristic. In Step 3, the user inputs the specifications of the UV reactor and target H<sub>2</sub>O<sub>2</sub> dosage. Step 4 displays the results based on 4 types of reactors. To better predict the results, it is recommended that before and after treatment samples be taken so that the model can be calibrated (adjust lamp efficiency) to improve predicted results.

25. **pH Targeting** – This program calculates the volume (mL) of an acid, coagulant or base chemical for user targeted pH. Plotting points and graphs are automatically generated. The

sample volume (i.e., 200 mL) and water characteristics (pH, alkalinity, temperature and TDS) are inputted. The user selects a chemical (acid, coagulant or base) and inputs the % strength and specific gravity of chemical to be titrated. A targeted pH is entered. With a click of a button, the volume (mL) of chemical titrated and associated dosage (mg/L) is calculated along with the amount of alkalinity consumed or added. In addition to this program, the information may be used to determine chemical feed rate for plant flow rate. Another section of the program calculates the amount of alkalinity consumed or added with user inputs of sample volume, selected chemical, % strength, specific gravity and volume titrated. The pH Targeting program has two separate sections for acid/coagulant and base chemical computations.

Applications: (Jar testing, Titration for endpoint pH, Chemical feed rate and chemical usage)

Below is an example how the program can be used in targeting pH using acid and base chemicals.

### pH Targeting Program for Acid/Coagulants and Base Chemicals

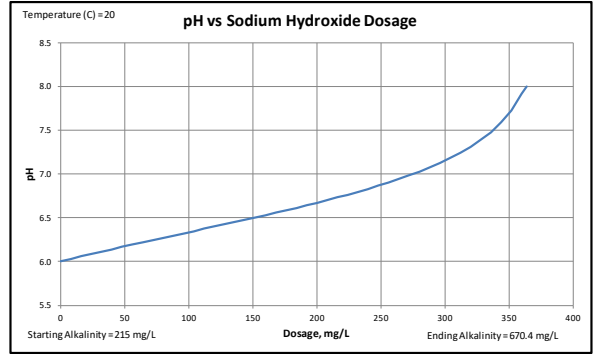
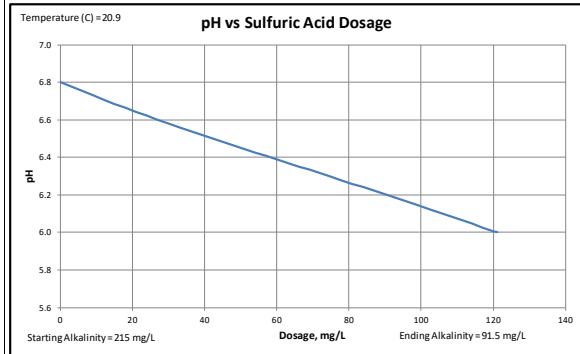
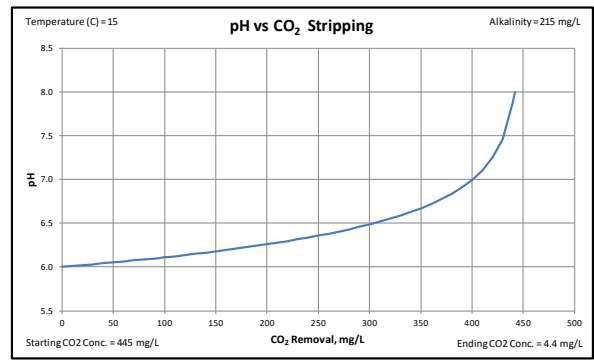
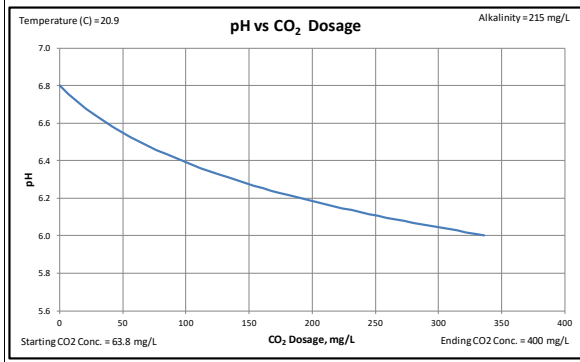
pH Acid/Coagulant Targeting Titrating Program			
<b>Step 1: Sample Volume and Water Characteristics</b>			
Enter volume and water characteristics of sample to be titrated			
Sample Volume =	1,000.0	mL	
TDS =	100	mg/L	0.00250 mol/L, Ionic Strength
Total Alkalinity =	66.0	mg/L as CaCO <sub>3</sub>	
pH =	7.00	field pH is recommended	
Water Temperature =	15.0	°C (temp. at which pH was analyzed)	
<b>Step 2: Acid/Coagulant Titration for Target pH</b>			
Select Acid or Coagulant Chemical and Enter S.G., % Strength and Target pH			
Select Chemical	Sp. G.	% Strength	
Acetic Acid (White Vinegar)	1.00	0.600	
Enter target pH =	4.80	target pH for Acetic Acid (White Vinegar) addition	
Activate button to process data	Apply	Note: Activate button anytime there is a change in Steps 1 or 2.	
<b>Step 3: Titration Results</b>			
Calculated volume of acid titrated required for target pH			
pH =	4.80	pH after Acetic Acid (White Vinegar) addition	
Total Alkalinity =	1.20	mg/L as CaCO <sub>3</sub>	
Total Alkalinity Consumed =	64.80	mg/L as CaCO <sub>3</sub>	
Acetic Acid (White Vinegar) =	24.862	mL per 1000 mL sample volume	
Acetic Acid (White Vinegar) =	149.17	mg/L	
<b>Step 4: Chemical Feed Rate (vol/time) Calculation</b>			
Enter plant flow rate and operating hours and select appropriate units			
Flow Rate =	1,000.0	gallons/min	
Operating Hours per Day =	11	Hours	
Chemical Feed Rate =	94,103.4	mL/min	
Chemical Usage per Day =	62,108.3	Liters for a 11 hour operating period per day	
<b>Step 5: Alkalinity Consumed based on Volume Titrated</b>			
Ferric Chloride	Input Values	Acetic Acid (CH <sub>3</sub> COOH); pH = 4.6 - 4.9	
Specific Gravity	1.460	Ending pH:	4.80
% Strength:	1.000	% Strength:	0.600
Sample Volume (mL):	1,000	Sample Volume (mL):	1000
Volume Titrated (mL):	7.942	Volume Titrated (mL):	24.862
Consumed Alkalinity (mg/L):	107.26	Consumed Alkalinity (mg/L):	64.73

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pH Base Targeting Titrating Program			
<b>Step 1: Sample Volume and Water Characteristics</b>			
Enter volume and water characteristics of sample to be titrated			
Sample Volume =	1,000.0	mL	
TDS =	100	mg/L	0.00250 mol/L, Ionic Strength
Total Alkalinity =	30.0	mg/L as CaCO <sub>3</sub>	
pH =	6.00	field pH is recommended	
Water Temperature =	15.0	°C (temp. at which pH was analyzed)	
<b>Step 2: Base Titration for Target pH</b>			
Select Base Chemical and Enter S.G., % Strength and Target pH			
Select Chemical	Sp. G.	% Strength	
Sodium Bicarbonate	1.84	50.000	
Enter target pH =	9.00	target pH for Sodium Bicarbonate addition	
Activate button to process data	Apply	Note: Activate button anytime there is a change in Steps 1 or 2.	
<b>Step 3: Titration Results</b>			
Calculated volume of base titrated required for target pH			
pH =	9.00	pH after Sodium Bicarbonate addition	
Total Alkalinity =	109.16	mg/L as CaCO <sub>3</sub>	
Total Alkalinity Added =	79.16	mg/L as CaCO <sub>3</sub>	
Sodium Bicarbonate =	0.144	mL per 1000 mL sample volume	
Sodium Bicarbonate =	132.82	mg/L	
<b>Step 4: Chemical Feed Rate (vol/time) Calculation</b>			
Enter plant flow rate and operating hours and select appropriate units			
Flow Rate =	1,000.0	Liters/min	
Operating Hours per Day =	24	Hours	
Chemical Feed Rate =	2.3	Gal/hr	
Chemical Usage per Day =	54.9	Gallons for a 24 hour operating period per day	
<b>Step 5: Alkalinity Added based on Volume Titrated</b>			
Sodium Hydroxide	Input Values		
Specific Gravity	1.100		
% Strength:	5.000		
Sample Volume (mL):	1,000		
Volume Titrated (mL):	0.328		
Added Alkalinity (mg/L):	22.57		

Below are examples of generated graphs and plotting points from Steps 1 and 2:

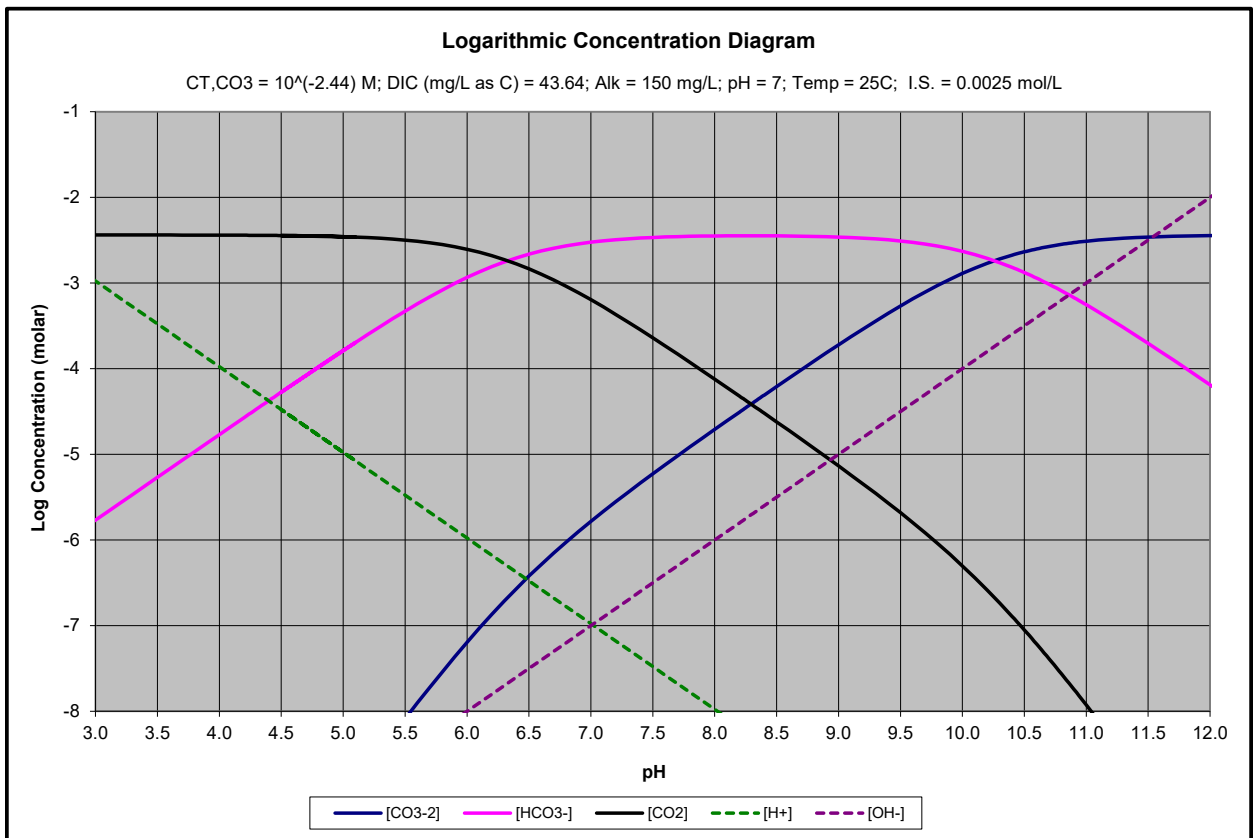


Acid Chemicals - Plotting Points for Graphs								CO <sub>2</sub> Stripping and Base Chemicals - Plotting Points for Graphs											
This section is dedicated to Carbon Dioxide treatment				This section is rotated among selected acid/coagulant treatments				This section is dedicated to Carbon Dioxide removal				This section is rotated among selected base treatments							
CO <sub>2</sub> Dosage	Alkalinity	CO <sub>2</sub>	DIC	Sulfuric Acid Dosage	Alkalinity	CO <sub>2</sub>	DIC	CO <sub>2</sub> Stripping	pH	Alkalinity	CO <sub>2</sub>	DIC	NaOH Dosage	pH	Alkalinity	CO <sub>2</sub>	DIC		
mg/L	mg/L	mg/L	mg/L C	mg/L	mg/L	mg/L	mg/L C	mg/L		mg/L	mg/L	mg/L C	mg/L		mg/L	mg/L	mg/L C		
0	6.80	215.0	63.8	69.0	0	6.80	215.0	63.8	69.0	0	6.00	215.0	444.9	173.0	0	6.00	215.0	408.7	163.1
7	6.75	215.0	70.8	70.9	3	6.78	211.9	66.5	69.0	10	6.01	215.0	434.9	170.3	8	6.03	225.0	399.9	163.1
14	6.71	215.0	77.8	72.8	6	6.75	208.9	69.2	69.0	20	6.02	215.0	424.9	167.6	16	6.06	238.0	391.0	163.1
21	6.68	215.0	84.8	74.7	9	6.73	205.8	71.9	69.0	30	6.03	215.0	414.9	164.9	24	6.09	245.0	382.2	163.1
28	6.64	215.0	91.8	76.6	12	6.71	202.7	74.6	69.0	40	6.04	215.0	404.9	162.1	32	6.11	255.0	373.4	163.1
35	6.61	215.0	98.8	78.6	15	6.68	199.7	77.3	69.0	50	6.05	215.0	394.9	159.4	40	6.14	265.0	364.7	163.1
42	6.58	215.0	105.8	80.5	18	6.66	196.6	80.0	69.0	60	6.06	215.0	384.9	156.7	48	6.17	275.1	355.9	163.1
49	6.55	215.0	112.8	82.4	21	6.64	193.6	82.6	69.0	70	6.07	215.0	375.0	153.9	56	6.19	285.1	347.1	163.1
56	6.53	215.0	119.8	84.3	24	6.62	190.5	85.3	69.0	80	6.09	215.0	364.9	151.2	64	6.22	295.1	338.3	163.1
63	6.50	215.0	126.8	86.2	27	6.60	187.4	88.0	69.0	90	6.10	215.0	355.0	148.5	72	6.25	305.1	329.4	163.1
70	6.48	215.0	133.8	88.1	30	6.58	184.4	90.7	69.0	100	6.11	215.0	345.0	145.8	80	6.27	315.1	320.7	163.1
77	6.46	215.0	140.8	90.0	33	6.56	181.3	93.4	69.0	110	6.12	215.0	334.9	143.0	88	6.30	325.1	311.8	163.1
84	6.44	215.0	147.8	91.9	36	6.54	178.2	96.1	69.0	120	6.14	215.0	324.9	140.3	96	6.32	335.1	303.0	163.1
91	6.42	215.0	154.8	93.8	39	6.52	175.2	98.8	69.0	130	6.15	215.0	315.0	137.6	104	6.35	345.1	294.3	163.1
98	6.40	215.0	161.8	95.8	42	6.50	172.1	101.5	69.0	140	6.16	215.0	305.0	134.8	112	6.37	355.1	285.5	163.1
105	6.38	215.0	168.8	97.7	45	6.48	169.1	104.2	69.0	150	6.18	215.0	294.9	132.1	120	6.40	365.1	276.7	163.1
112	6.36	215.0	175.8	99.6	48	6.46	166.0	106.9	69.0	160	6.19	215.0	284.9	129.4	128	6.43	375.2	267.9	163.1
119	6.34	215.0	182.8	101.5	51	6.45	162.9	109.6	69.0	170	6.21	215.0	274.9	126.6	136	6.45	385.2	259.1	163.1
126	6.33	215.0	189.8	103.4	54	6.43	159.9	112.2	69.0	180	6.23	215.0	264.9	123.9	144	6.48	395.2	250.3	163.1
133	6.31	215.0	196.8	105.3	57	6.41	156.8	114.9	69.0	190	6.24	215.0	255.0	121.2	152	6.50	405.2	241.5	163.1
140	6.30	215.0	203.8	107.2	60	6.39	153.7	117.6	69.0	200	6.26	215.0	245.0	118.5	160	6.53	415.2	232.7	163.1
147	6.28	215.0	210.8	109.1	63	6.37	150.7	120.3	69.0	210	6.28	215.0	235.0	115.7	168	6.56	425.2	223.9	163.1
154	6.27	215.0	217.8	111.0	66	6.35	147.6	123.0	69.0	220	6.30	215.0	225.0	113.0	176	6.58	435.2	215.1	163.1
161	6.25	215.0	224.8	113.0	69	6.33	144.6	125.7	69.0	230	6.32	215.0	215.0	110.3	184	6.61	445.2	206.3	163.1
168	6.24	215.0	231.8	114.9	72	6.31	141.5	128.4	69.0	240	6.34	215.0	205.0	107.5	192	6.64	455.2	197.5	163.1
175	6.23	215.0	238.8	116.8	75	6.30	138.4	131.1	69.0	250	6.36	215.0	195.0	104.8	200	6.67	465.2	188.7	163.1
182	6.21	215.0	245.7	118.7	78	6.28	135.4	133.8	69.0	260	6.38	215.0	185.0	102.1	208	6.70	475.2	179.9	163.1
189	6.20	215.0	252.8	120.6	81	6.26	132.3	136.5	69.0	270	6.41	215.0	175.0	99.4	216	6.73	485.3	171.2	163.1
196	6.19	215.0	259.8	122.5	84	6.24	129.2	139.2	69.0	280	6.43	215.0	165.0	96.6	224	6.76	495.3	162.3	163.1
203	6.18	215.0	266.8	124.4	87	6.22	126.2	141.9	69.0	290	6.46	215.0	155.0	93.9	232	6.80	505.3	153.6	163.1
210	6.17	215.0	273.8	126.3	90	6.20	123.1	144.5	69.0	300	6.49	215.0	145.0	91.2	240	6.83	515.3	144.8	163.1
217	6.16	215.0	280.7	128.2	93	6.18	120.0	147.3	69.0	310	6.52	215.0	135.0	88.4	248	6.87	525.3	136.0	163.1
224	6.15	215.0	287.8	130.1	96	6.17	117.0	149.9	69.0	320	6.55	215.0	125.0	85.7	256	6.90	535.3	127.2	163.1
231	6.14	215.0	294.7	132.0	99	6.15	113.9	152.6	69.0	330	6.59	215.0	115.0	83.0	264	6.94	545.3	118.5	163.1
238	6.13	215.0	301.7	134.0	102	6.13	110.9	155.3	69.0	340	6.63	215.0	105.0	80.3	272	6.98	555.3	109.7	163.1
245	6.12	215.0	308.8	135.9	105	6.11	107.8	158.0	69.0	350	6.67	215.0	95.0	77.5	280	7.01	565.3	100.9	163.1
252	6.11	215.0	315.7	137.8	108	6.09	104.7	160.7	69.0	360	6.72	215.0	85.1	74.8	288	7.07	575.3	92.2	163.1
259	6.10	215.0	322.7	139.7	111	6.07	101.7	163.4	69.0	370	6.77	215.0	75.1	72.1	296	7.12	585.4	83.4	163.1
266	6.09	215.0	329.8	141.6	114	6.05	98.6	166.1	69.0	380	6.83	215.0	65.1	69.3	304	7.18	595.4	74.7	163.1
273	6.08	215.0	336.8	143.5	117	6.03	95.5	168.8	69.0	390	6.91	215.0	55.1	66.6	312	7.24	605.4	65.9	163.1
280	6.07	215.0	343.8	145.4	120	6.00	92.5	171.5	69.0	400	6.99	215.0	45.1	63.9	320	7.31	615.4	57.2	163.1
287	6.06	215.0	350.8	147.3	121	6.00	91.5	171.5	68.8	410	7.10	215.0	35.1	61.2	328	7.39	625.4	48.6	163.1
294	6.05	215.0	357.7	149.2	124	6.00	90.5	171.5	68.8	420	7.25	215.0	25.2	58.4	336	7.48	635.4	40.0	163.1
301	6.04	215.0	364.7	151.1	127	6.00	89.5	171.5	68.8	430	7.46	215.0	15.3	55.7	344	7.59	645.4	31.5	163.1
308	6.03	215.0	371.8	153.1	130	6.00	88.5	171.5	68.8	440	7.88	215.0	5.8	53.0	352	7.73	655.4	23.2	163.1
315	6.03	215.0	378.8	155.0	133	6.00	87.5	171.5	68.8	442	8.00	215.0	4.4	52.5	360	7.91	665.4	15.4	163.1
322	6.02	215.0	385.8	156.9	136	6.00	86.5	171.5	68.8	444	8.00	215.0	3.0	52.0	364	8.00	670.4	12.6	163.4
329	6.01	215.0	392.8	158.8	139	6.00	85.5	171.5	68.8										
336	6.00	215.0	399.7	160.7	142	6.00	84.5	171.5	68.8										

26. **Carbonate System** – Alkalinity and the Carbonate System – The carbonate system components are calculated based on alkalinity, pH, water temperature and TDS. The carbonate species are graphed, and the quantity of acid and base are calculated for defined pH values. Listed below are the forms of alkalinity and acidity:

- Caustic alkalinity: the amount of strong acid (mmol/L) required to lower the pH of a sample to  $\text{pH}(\text{CO}_3^{2-})$ .
- Total acidity: the amount of strong base (mmol/L) required to raise the pH of a sample to  $\text{pH}(\text{CO}_3^{2-})$ .
- Carbonate alkalinity: the amount of strong acid (mmol/L) required to lower the pH of a sample to  $\text{pH}(\text{HCO}_3^-)$ .
- Carbon dioxide acidity: the amount of strong base (mmol/L) required to raise the pH of a sample to  $\text{pH}(\text{HCO}_3^-)$ .
- Total alkalinity: the amount of strong acid (mmol/L) required to lower the pH of a sample to  $\text{pH}(\text{CO}_2)$ .
- Mineral acidity: the amount of strong base (mmol/L) required to raise the pH of a sample to  $\text{pH}(\text{CO}_2)$ .

This is a great program for learning and understanding the carbonate system. A graphically example of the carbonate system is given below:



27.

28. **Acid-Irrigation Program** – This program models three different acids (Sulfurous Acid, Sulfuric Acid and Carbon Dioxide) for irrigation water pH adjustment to improve crop yield. The user has the option to input feed rate in pounds/hour and the program will calculate the pH of the irrigation water. Or, the user can input the irrigation water targeted pH, and the program will automatically calculate the chemical dose by clicking on the “process” button. Chemical cost per acre-ft is determined for each chemical based on user input cost for chemical. The user can also model the combination of chemicals such as sulfuric acid and carbon dioxide. The treated water results for each chemical and combination thereof is alkalinity, pH, acidity, dose in mg/L and the CCPP along with field application and cost.

# Acid-Irrig!Pro Version 1.3

Program for modeling water pH and alkalinity changes based on the addition of dry sulfur, sulfuric acid, and carbon dioxide

Step 1: Source Water Characteristics - Blue Entries				
TDS:	500	mg/L	0.0125	mol/L 781 uS/cm
pH:	8.50	Must be > 2		
Total Alkalinity:	170.67	mg/L as CaCO <sub>3</sub>	3.410	meq/L
Water Temperature:	23.0	°C (temperature at which pH was analyzed)		
Water Temperature:	23.0	°C (irrigation water temperature)		
If alkalinity is unknown, then enter the reported laboratory HCO <sub>3</sub> <sup>-</sup> and click "Find Alk." button <b>Find Alk</b>				
Target Bicarbonate, HCO <sub>3</sub> <sup>-</sup> :	66.50	mg/L as HCO <sub>3</sub> <sup>-</sup>	1.030	meq/L 13.1 mg/L as C
Cation/Anions:		meq/L	CaCO <sub>3</sub>	lbs/ac-in lbs/ac-ft
Calcium (Ca <sup>2+</sup> ):	35.66	1.78	89.06	8.08 96.96
Magnesium (Mg <sup>2+</sup> ):	80.83	6.65	332.86	18.32 219.78
Sodium (Na <sup>+</sup> ):	68.14	2.96	148.33	15.44 185.28
Chloride (Cl <sup>-</sup> ):	97.02	2.74	136.95	21.98 263.80
Sulfate (SO <sub>4</sub> <sup>2-</sup> ):	110.05	2.29	114.69	24.94 293.23
Total Hardness (Ca <sup>2+</sup> + Mg <sup>2+</sup> ):	-	8.43	421.9	- -
Carbonate Hardness:	-	3.28	164.0	- -
Non-Carbonate Hardness:	-	5.15	257.9	- -
Cation/Anions Ratio:	1.35	meq/L/meq/L		

Step 3: Product Chemical Strength		
Elemental Sulfur (S):	99.9	% Strength or Purity
Carbon Dioxide (CO <sub>2</sub> ):	100.0	% Strength
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	93.0	% Strength

## Step 4: Source Water Applied Chemical Modeling (1, 2, 3, 4)

1. CO <sub>2</sub> : Operational Flow and Carbon Dioxide (CO <sub>2</sub> ) Addition				
Pump Flow:	600	gpm	36,000	gal/hr. 0.86 MGD
Carbon Dioxide, 100%:	30.10	pounds/hour	722.4	lbs/day 327.7 Kg/day
Chemical product cost (\$ per lb)	0.60	\$/pound	1,200	\$/lb. -Ton 1,323 \$/Metric-Ton
Optional: For program to calculate carbon dioxide dose based on target treated water pH:				
Target pH:	6.50	<b>Process</b>		
Treated Water Results after CO <sub>2</sub> Addition				
pH:	6.50	unit		
Total Alkalinity:	170.7	mg/L as CaCO <sub>3</sub>	3.41	meq/L
Carbon Dioxide, CO <sub>2</sub> :	98.15	mg/L	4.46	meq/L
Acidity:	393.9	mg/L as CaCO <sub>3</sub>	7.87	meq/L
CCPP:	-138.9	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential		
Treated Water:	2.652	Acre-ft	31.82	Acre-in
Carbon Dioxide (CO <sub>2</sub> ):	272.45	lbs/ac-ft	22.70	lbs/ac-in
Carbon Dioxide (CO <sub>2</sub> ):	100.2	mg/L	227.8	mg/L as CaCO <sub>3</sub>
Carbon Dioxide, CO <sub>2</sub> cost, \$:	163.47	\$ per Acre-ft per day		183.25 \$ per Ha-day

2. Sulfur: Operational Flow and Elemental Sulfur (S) Addition				
Pump Flow:	600	gpm	36,000	gal/hr. 0.86 MGD
Elemental Sulfur (S), 99.9%:	10.75	pounds/hour	258.0	lbs/day 117.0 Kg/day
Chemical product cost (\$ per lb)	0.32	\$/pound	640	\$/lb. -Ton 705 \$/Metric-Ton
Optional: For program to calculate sulfur (dry) dose based on treated water pH:				
Target pH:	6.50	<b>Process</b>		
Treated Water Results after Sulfur Addition (H <sub>2</sub> SO <sub>4</sub> , Sulfurous Acid)				
pH:	6.50	unit		
Total Alkalinity:	101.8	mg/L as CaCO <sub>3</sub>	2.03	meq/L
Carbon Dioxide, CO <sub>2</sub> :	58.53	mg/L	2.66	meq/L
Acidity:	234.9	mg/L as CaCO <sub>3</sub>	4.69	meq/L
CCPP:	-119.0	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential		
Hydrogen Sulfite (HSO <sub>3</sub> <sup>-</sup> ):	76.59	% ion in solution		
Sulfite (SO <sub>3</sub> <sup>2-</sup> ):	23.40	% ion in solution		
Treated Water:	2.652	Acre-ft	31.82	Acre-in
Sulfur (dry):	97.31	lbs/ac-ft	8.11	lbs/ac-in
Sulfur Dioxide (SO <sub>2</sub> ):	21.46	pounds/hour	515.0	lbs/day 194.2 lbs/ac-ft
Sulfurous Acid (H <sub>2</sub> SO <sub>3</sub> ):	91.53	mg/L	68.9	mg/L as CaCO <sub>3</sub>
Sulfur (dry) cost, \$:	31.14	\$ per Acre-ft per day		34.91 \$ per Ha-day

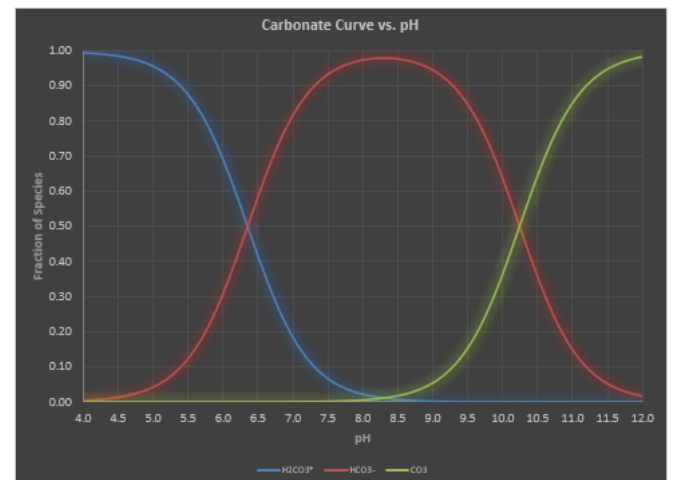
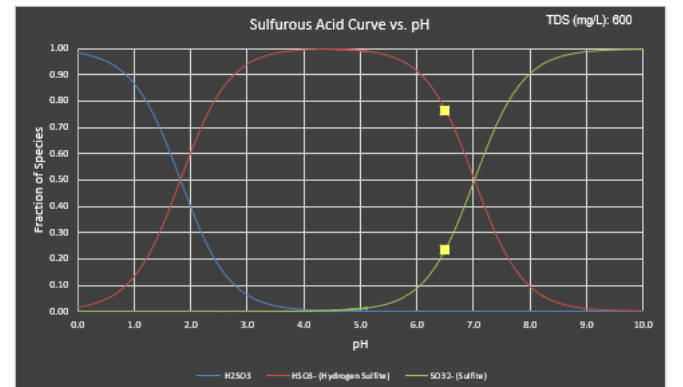
3. H <sub>2</sub> SO <sub>4</sub> : Operational Flow and Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ) Addition				
Pump Flow:	600	gpm	36,000	gal/hr. 0.86 MGD
Sulfuric Acid, 93%:	21.79	pounds/hour	523.0	lbs/day 237.2 Kg/day
Chemical product cost (\$ per lb)	0.60	\$/pound	1,200	\$/lb. -Ton 1,323 \$/Metric-Ton
Optional: For program to calculate sulfuric acid dose based on target treated water pH:				
Target pH:	6.50	<b>Process</b>		
Treated Water Results after H <sub>2</sub> SO <sub>4</sub> Addition				
pH:	6.50	unit		
Total Alkalinity:	101.8	mg/L as CaCO <sub>3</sub>	2.03	meq/L
Carbon Dioxide, CO <sub>2</sub> :	58.53	mg/L	2.66	meq/L
Acidity:	234.9	mg/L as CaCO <sub>3</sub>	4.69	meq/L
CCPP:	-119.0	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Potential		
Treated Water:	2.652	Acre-ft	31.82	Acre-in
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	197.23	lbs/ac-ft	16.44	lbs/ac-in
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	67.5	mg/L	68.9	mg/L as CaCO <sub>3</sub>
Sulfuric Acid, H <sub>2</sub> SO <sub>4</sub> cost, \$:	118.34	\$ per Acre-ft per day		132.66 \$ per Ha-day

**Forms of Alkalinity and Acidity based on initial water characteristics:**  
**Caustic alkalinity:** the amount of strong acid (mMoles/L) required to lower the pH of a sample to pH(CO<sub>3</sub><sup>2-</sup>) = **10.86** = [OH<sup>-</sup>] - [H<sup>+</sup>] - [HCO<sub>3</sub><sup>-</sup>] - 2[H<sub>2</sub>CO<sub>3</sub><sup>\*</sup>] = **0.000** mMol/L (0 mg/L as HCl)  
**Total acidity:** the amount of strong base (mMoles/L) required to raise the pH of a sample to pH(CO<sub>3</sub><sup>2-</sup>) = **10.86** = 2[H<sub>2</sub>CO<sub>3</sub><sup>\*</sup>] + [HCO<sub>3</sub><sup>-</sup>] + [H<sup>+</sup>] - [OH<sup>-</sup>] = **3.318** mMol/L (132.7 mg/L as NaOH)  
**Carbonate alkalinity:** the amount of strong acid (mMoles/L) required to lower the pH of a sample to

Step 2: Results of Carbonate Speciation			
pH:	8.50	Irrigation water based on water temperature	
CCPP:	-5.6	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Poter	
Bicarbonate, HCO <sub>3</sub> <sup>-</sup> :	200.00	mg/L	3.278 meq/L 39.37 mg/L
Carbonate, CO <sub>3</sub> <sup>2-</sup> :	3.89	mg/L	1.296E-01 meq/L 0.78 mg/L
Hydroxide, OH <sup>-</sup> :	5.238E-02	mg/L	3.080E-03 meq/L
Hydrogen Ion, H <sup>+</sup> :	3.187E-06	mg/L	3.162E-06 meq/L
Carbonic Acid, H <sub>2</sub> CO <sub>3</sub> <sup>*</sup> :	1.33	mg/L	4.286E-02 meq/L 0.257 mg/L
Carbon Dioxide, CO <sub>2</sub> :	9.433E-01	mg/L	4.287E-02 meq/L 0.257 mg/L
Sum of Alkalinity (OH <sup>-</sup> + HCO <sub>3</sub> <sup>-</sup> + CO <sub>3</sub> <sup>2-</sup> - H <sup>+</sup> ): 3.4105 meq/L			
Bicarbonate, HCO <sub>3</sub> <sup>-</sup> :	164.04	mg/L as CaCO <sub>3</sub>	3.28 mMol/L
Carbonate, CO <sub>3</sub> <sup>2-</sup> :	6.48	mg/L as CaCO <sub>3</sub>	6.478E-02 mMol/L
Hydroxide, OH <sup>-</sup> :	1.541E-01	mg/L as CaCO <sub>3</sub>	3.080E-03 mMol/L
Hydrogen Ion, H <sup>+</sup> :	1.583E-04	mg/L as CaCO <sub>3</sub>	3.162E-06 mMol/L
CO <sub>2</sub> or H <sub>2</sub> CO <sub>3</sub> <sup>*</sup> :	2.15	mg/L as CaCO <sub>3</sub>	2.143E-02 mMol/L
Dissolved Inorganic Carbon (DIC):	40.40	mg/L as C	3.36 mMol/L
Alkalinity (OH <sup>-</sup> + HCO <sub>3</sub> <sup>-</sup> + CO <sub>3</sub> <sup>2-</sup> - H <sup>+</sup> ):	170.68	mg/L as CaCO <sub>3</sub>	1.705 mMol/L
Acidity (HCO <sub>3</sub> <sup>-</sup> + H <sub>2</sub> CO <sub>3</sub> <sup>*</sup> + H <sup>+</sup> - OH <sup>-</sup> ):	166.0	mg/L as CaCO <sub>3</sub>	3.32 meq/L

4. Multi-Acids: Operational Flow and addition of Multi-Acids				
Pump Flow:	600	gpm	36,000	gal/hr. 0.86 MGD
Elemental Sulfur (S), 99.9%:	10.75	pounds/hour	258.0	lbs/day 117.0 Kg/d
Carbon Dioxide, 100%:	0.00	pounds/hour	0.0	lbs/day 0.0 Kg/d
Sulfuric Acid, 93%:	0.00	pounds/hour	0.0	lbs/day 0.0 Kg/d
Sulfur (dry) product cost (\$ per lb):	0.60	\$/pound	1,200	\$/lb. -Ton 1,323 \$/Metric-Ton
Carbon Dioxide product cost (\$ per lb):	0.60	\$/pound	1,200	\$/lb. -Ton 1,323 \$/Metric-Ton
Sulfuric Acid product cost (\$ per lb):	0.60	\$/pound	1,200	\$/lb. -Ton 1,323 \$/Metric-Ton

Treated Water Results after Chemical Addition(s)				
pH:	6.50	unit		
Total Alkalinity:	101.8	mg/L as CaCO <sub>3</sub>	2.03	meq/L
Carbon Dioxide, CO <sub>2</sub> :	58.52	mg/L	2.66	meq/L
Acidity:	234.9	mg/L as CaCO <sub>3</sub>	4.69	meq/L
CCPP:	-119.0	mg/L as CaCO <sub>3</sub> , Calcium Carbonate Precipitation Poter		
Treated Water:	2.652	Acre-ft	31.82	acre-in
Sulfur (dry):	97.30	lbs/ac-ft	8.11	lbs/ac-in
Sulfurous Acid (H <sub>2</sub> SO <sub>3</sub> ):	91.53	mg/L	68.9	mg/L as CaCO <sub>3</sub>
Carbon Dioxide (CO <sub>2</sub> ):	0.00	lbs/ac-ft	0.00	lbs/ac-in
Carbon Dioxide (CO <sub>2</sub> ):	0.0	mg/L	0.0	mg/L as CaCO <sub>3</sub>
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	0.00	lbs/ac-ft	0.00	lbs/ac-in
Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> ):	0.0	mg/L	0.0	mg/L as CaCO <sub>3</sub>
Sulfur (dry) cost, \$:	58.38	\$ per Acre-ft per day		65.45 \$ per Ha-day
Carbon Dioxide, CO <sub>2</sub> cost, \$:	0.00	\$ per Acre-ft per day		0.00 \$ per Ha-day
Sulfuric Acid, H <sub>2</sub> SO <sub>4</sub> cost, \$:	0.00	\$ per Acre-ft per day		0.00 \$ per Ha-day
Total Cost, \$:	58.38	\$ per Acre-ft per day		65.45 \$ per Ha-day



29. **Super Chlorination/Acid Cleaning Program** – This program was developed to assist water professionals in determining the volume of liquid chlorine and acetic acid (5% white vinegar) for disinfecting groundwater wells. The user has the option of selecting a strong acid (HCl or H<sub>2</sub>SO<sub>4</sub>) for other applications. When sodium hypochlorite (NaOCl) is added to water, it dissociates into HOCl and OCl<sup>-</sup> products. HOCl has approximately 80 to 100 times more disinfecting power than OCl<sup>-</sup>. The lower the pH, the more HOCl is present and less OCl<sup>-</sup> formation. When NaOCl is added alone, the pH of the water will increase and greater formation of OCl<sup>-</sup> will occur. Adding an acid directly into the well (don't mix directly with chlorine) plus the addition of NaOCl will provide better disinfection than adding NaOCl alone. The user inputs the desire pH and chlorine concentration, and the program will calculate the volume of acid and NaOCl to be added to the well source.

30. **CT Calculator** – CT (mg/L x min) is the nomenclature for chlorine residual (mg/L) multiplied by disinfection contact time (minutes). The CT value is used to determine log inactivation of the pathogen *Giardia cyst*. The log inactivation for *Giardia cyst* is calculated based on the following parameters:

Chlorine Residual	pH	Working volume of reactor
Water Temperature	Flow through reactor	Reactor baffling factor

Up to 31 operating scenarios can be calculated. CT compliance is required for all public drinking water facilities throughout the U.S. that treats surface water and/or ground waters under the direct influent of surface water. The baffling factor of a reactor is determined through a tracer study or is assigned by the regulatory agency. A partial display of the worksheet is given below:

### CT Calculator for Giardia Lamblia Cysts by Free Chlorine

Reactor Type or Description	Reactor Data for Peak Hourly Flow							CT Results				
	Baffling Factor t <sub>10</sub> /T	Required Log Inactivation	Flow Rate, gpm	Working Volume, gallons	Temp, °C	pH	Chlorine Residual, mg/L	Effective Contact Time, minutes	Required Ct <sub>10</sub>	Calculated Ct <sub>10</sub>	CT Ratio (Ct <sub>calc</sub> /Ct <sub>req</sub> )	Calculated Log Inactivation
Clearwell, no baffling	0.10	1.0	500	189,446	17.4	7.7	0.80	38	28	30	1.08	1.1
Clearwell, 3 baffles	0.40	0.5	500	189,446	17.4	7.7	0.20	152	13	30	2.33	1.2
Pipeline	0.90	0.5	2,500	35,000	30.0	7.7	1.00	13	9	13	1.40	0.7

31. **LRV - Membranes** – The log removal value (LRV) membrane program is used to verify that the membrane filtration system is achieving the required or desired pathogen log removal of *Cryptosporidium* and *Giardia cyst*. This program uses a rigorous computational approach (Darcy) that calculates separately the air and water flows through a cut fiber. In addition to calculating the LRV, the by-pass flow (leakage) and number of broken fibers are determined. The following information in the table below is required:

**User Input:**

Membrane Information	Membrane Integrity Test (MIT) Data	Membrane Operating Data
Volume of Pressurized Membrane	Start/Ending Pressure	Flow Rate
Lumen Diameter	Pressure Hold Time	Transmembrane Pressure (TMP)
Potting depth or defect length	Back Pressure	Volumetric Concentration Factor (VCF)
Capillary Constant	Air Temperature	Water Temperature
Contact Angle	Membrane Integrity Test (MIT) Data	

After data is entered, the following results are calculated:

**Output Results:**

1.	Filter Flux Rate, GFD (gallons per day per square-foot)
2.	ALCR, Air-to-Liquid Conversion Ratio (the flow of air to the flow of water through one cut fiber)
3.	PDR, Pressure Decay Rate from MIT results (psig/min and mbar/min)
4.	Number of Broken Fibers
5.	Defect Size, ug (resolution size opening based on MIT end pressure)
6.	Water Bypass, mg/L (the flow of water bypassed during membrane operation)
7.	LRV (log removal value of <i>Cryptosporidium</i> and <i>Giardia cyst</i> based MIT and membrane operating results); $LRV = -\log(\text{water bypass}/\text{plant flow})$

32. **Cyanotoxins** –This program calculates the log and % oxidation of Microcystin-LR (MC-LR) and Cylindrospermopsin (CYN) based on free chlorine residual for various pH, temperature, working volume, and tank baffling factor.

Below are examples of the oxidation program for MC-LR and CYN using free chlorine residual. Each constituent program has three models depending on the initial water quality parameters.

**Microcystin-LR Reduction via Free Chlorine Residual**

Model 1 CT Calculation for Microcystin-LR (MC-LR)					
Enter water quality parameters:					
pH	8.0	unit	Results:		
Temperature	22	°C	CT	1.21E-01	mol · sec
Initial MC-LR	70	ug/L	CT	143	mg/L · min
Final MC-LR	1	ug/L	Log (%) Reduction	1.8, (98.6%)	unit

Model 2 Initial Microcystin-LR (MC-LR) Calculation					
Enter water quality parameters:					
pH	8.0	unit	Results:		
Temperature	22	°C	CT	1.21E-01	mol · sec
Operating CT	143	mg/L · min	Initial MC-LR	70	ug/L
Final MC-LR	1	ug/L	Log (%) Reduction	1.8, (98.6%)	unit

Model 3 Initial Microcystin-LR (MC-LR) Calculation					
Enter water quality parameters:					
pH	8.0	unit	Results:		
Temperature	22	°C	CT	1.37E-01	mol · sec
Chlorine Residual	1.18	mg/L	Operating CT	162.3	mg/L · min
HRT	275	minutes	Initial MC-LR	37	ug/L
Baffling Factor	0.5	t <sub>10</sub> /T	Final MC-LR	0.3	ug/L
Final MC-LR	0.3	ug/L	Log (%) Reduction	2.1, (99.2%)	unit

**Cylindrospermopsin (CYN) Reduction via Free Chlorine Residual**

Model 1 CT Calculation for Cylindrospermopsin (CYN)					
Enter water quality parameters:					
pH	8.5	unit	Results:		
Temperature	10	°C	CT	6.14E-02	mol · sec
Initial CYN	500	ug/L	CT	72.5	mg/L · min
Final CYN	0.7	ug/L	Log (%) Reduction	2.9, (99.9%)	unit

Model 2 Initial Cylindrospermopsin (CYN) Calculation					
Enter water quality parameters:					
pH	8.7	unit	Results:		
Temperature	20	°C	CT	2.96E-02	mol · sec
Operating CT	35.0	mg/L · min	Initial CYN	15	ug/L
Final CYN	0.7	ug/L	Log (%) Reduction	1.3, (95.5%)	unit

Model 3 Initial Cylindrospermopsin (CYN) Calculation					
Enter water quality parameters:					
pH	8.8	unit	Results:		
Temperature	15	°C	CT	5.92E-02	mol · sec
Chlorine Residual	1.00	mg/L	Operating CT	70.0	mg/L · min
HRT	140.0	minutes	Initial CYN	33	ug/L
Baffling Factor	0.5	t <sub>10</sub> /T	Final CYN	0.7	ug/L
Final CYN	0.7	ug/L	Log (%) Reduction	1.7, (97.9%)	unit

33. **ChemDose** –This program is used for calculating chemical dosages. Based on the characteristics of the chemical solution, the dosage is calculated based on chemical feed and plant flow rates. The user may choose from a drop-down list of units for volumes and flow rates. This program is ideal for water professionals for doing quick dosage calculations or to check hand calculations.

The second dose program (ChemDose(PS)) will calculate chemical dosages based on chemical specification and chemical feed pump settlings (% stroke/speed). The third dose program is primarily for mixing dry chemicals such as alum, soda ash, NaF, etc.

Main Menu

**ChemDose!Pro**

**Chemical Feed Dose Calculator (pump rate) for the Water and Wastewater Industry**

Solution Crock Mixing (1)			
Solution Strength, Specific Gravity and Chemical Dose Calculations			
Enter Characteristics of Solution & Mixing Parameters			
Name of liquid product:	Polymer Blend 960		
Specific gravity of product:	1.29		
Product solution strength:	100	%	
Chemical product cost (\$) per pound:	2.00	\$/lb	
Volume of liquid product mixed:	10.00	gal	
Volume of water mixed with liquid product:	10.00	gal	
Mixing Results			
Total solution volume:	20.00	gal	
Specific gravity of solution mix:	1.15		
Chemical solution strength of mix:	56.33	%	
Enter Feed Pump Rate, Plant Production and Hrs. Operated			
Chemical feed pump rate or usage:	14	mL/min	
Plant flow rate or production:	24.0	gpm	
Hours operated:	20.0	hours	
Results - Chemical Dose Calculations for Polymer Blend 960			
Chemical Feed Dose:	99.40	mg/L	
Chemical Feed Dose:	829.4	lbs/MG	
Solution Used (56.33% Strength):	4.44	gal/day	
Solution Used (56.33% Strength):	31.1	gal/week	
Liquid Product Used (Polymer Blend 960):	2.22	gal/day	
Liquid Product Used (Polymer Blend 960):	15.53	gal/week	
Plant production per day:	28,800	gal/day	
Chemical cost per day (Polymer Blend 960):	47.78	\$/day	
Cost per gallon of treated water:	0.166	cent/gal	

Solution Crock Mixing (2)			
Solution Strength, Specific Gravity and Chemical Dose Calculations			
Enter Characteristics of Solution & Mixing Parameters			
Name of liquid product:	Zeta Flocc 20, pDADMAC		
Specific gravity of product:	1.03		
Product solution strength:	100	%	
Chemical product cost (\$) per pound:	2.00	\$/lb	
Volume of liquid product mixed:	1.00	gal	
Volume of water mixed with liquid product:	4.00	gal	
Mixing Results			
Total solution volume:	5.00	gal	
Specific gravity of solution mix:	1.006		
Chemical solution strength of mix:	20.48	%	
Enter Feed Pump Rate, Plant Production and Hrs. Operated			
Chemical feed pump rate or usage:	2	mL/min	
Plant flow rate or production:	24.0	gpm	
Hours operated:	20.0	hours	
Results - Chemical Dose Calculations for Zeta Flocc 20, pDADMAC			
Chemical Feed Dose:	4.54	mg/L	
Chemical Feed Dose:	37.9	lbs/MG	
Solution Used (20.48% Strength):	0.63	gal/day	
Solution Used (20.48% Strength):	4.44	gal/week	
Liquid Product Used (Zeta Flocc 20, pDADMAC):	0.13	gal/day	
Liquid Product Used (Zeta Flocc 20, pDADMAC):	0.89	gal/week	
Plant production per day:	28,800	gal/day	
Chemical cost per day (Zeta Flocc 20, pDADMAC):	2.18	\$/day	
Cost per gallon of treated water:	0.008	cent/gal	

Main Menu

## ChemDose!Pro

### Chemical Feed Dose Calculator (pump settings) for the Water and Wastewater Industry

#### Solution Crock Mixing (1)

Solution Strength, Specific Gravity and Chemical Dose Calculations			
Enter Characteristics of Solution & Mixing Parameters			
Name of liquid product:	Polymer Blend 960		
Specific gravity of product:	1.29		
Product solution strength:	100.00	%	
Chemical product cost (\$) per pound:	2.00	\$/lb	
Volume of liquid product mixed:	1.00	gal	
Volume of water mixed with liquid product:	0.00	gal	
Mixing Results			
Total solution volume:	1.00	gal	
Specific gravity of solution mix:	1.29		
Chemical solution strength of mix:	100	%	
Enter Feed Pump Settings, Plant Production and Hrs. Operated			
Chemical feed pump capacity rating:	30.00	gal/day	
Chemical feed pump stroke setting:	29.6	%	
Chemical feed pump speed setting:	30	%	
Plant flow rate or production:	24.0	gpm	
Hours operated:	15.0	hours	
Results - Chemical Dose Calculations for Polymer Blend 960			
Chemical feed pump rate (calculated):	7.00	mL/min	
Chemical Feed Dose:	99.44	mg/L	
Chemical Feed Dose:	829.7	lbs/MG	
Solution Used (100% Strength):	1.67	gal/day	
Solution Used (100% Strength):	11.66	gal/week	
Liquid Product Used (Polymer Blend 960):	1.67	gal/day	
Liquid Product Used (Polymer Blend 960):	11.67	gal/week	
Plant production per day:	21,600	gal/day	
Chemical cost per day (Polymer Blend 960):	35.88	\$/day	
Cost per gallon of treated water:	0.166	cent/gal	

#### Solution Crock Mixing (2)

Solution Strength, Specific Gravity and Chemical Dose Calculations			
Enter Characteristics of Solution & Mixing Parameters			
Name of liquid product:	Zeta Flocc 20, pDADMAC		
Specific gravity of product:	1.03		
Product solution strength:	100.00	%	
Chemical product cost (\$) per pound:	2.00	\$/lb	
Volume of liquid product mixed:	1.00	gal	
Volume of water mixed with liquid product:	4.00	gal	
Mixing Results			
Total solution volume:	5.00	gal	
Specific gravity of solution mix:	1.006		
Chemical solution strength of mix:	20.48	%	
Enter Feed Pump Settings, Plant Production and Hrs. Operated			
Chemical feed pump capacity rating:	15.00	gal/day	
Chemical feed pump stroke setting:	20	%	
Chemical feed pump speed setting:	20	%	
Plant flow rate or production:	24.0	gpm	
Hours operated:	20.0	hours	
Results - Chemical Dose Calculations for Zeta Flocc 20, pDADMAC			
Chemical feed pump rate or usage:	1.58	mL/min	
Chemical Feed Dose:	3.58	mg/L	
Chemical Feed Dose:	29.8	lbs/MG	
Solution Used (20.48% Strength):	0.50	gal/day	
Solution Used (20.48% Strength):	3.50	gal/week	
Liquid Product Used (Zeta Flocc 20, pDADMAC):	0.10	gal/day	
Liquid Product Used (Zeta Flocc 20, pDADMAC):	0.70	gal/week	
Plant production per day:	28,800	gal/day	
Chemical cost per day (Zeta Flocc 20, pDADMAC):	1.72	\$/day	
Cost per gallon of treated water:	0.006	cent/gal	

Main Menu

## ChemDose!Pro

### Chemical Feed Dose Calculator for Dry Chemical Mixing #1

Solution Strength, Specific Gravity and Chemical Dose Calculations			Hydrated Chemical
			Anhydrous Chemical
Enter Characteristics of Solution & Mixing Parameters			
Name of Dry Chemical:	Alum *14.3H <sub>2</sub> O		
Commercial purity of dry chemical:	100	%	
Percent ion (100% pure material):	98	%	
Weight of dry chemical added to water:	100	Kg	
Volume of water mixed with dry chemical:	500	L	
Chemical/Physical Mixing Results:			
Total solution volume:	542.95	L	
Specific gravity of solution:	1.105		
Chemical solution strength:	16.35	%	
Enter Chemical Feed Rate, Plant Production and Hrs. Operated			
Chemical feed rate or usage:	420	mL/min	
Plant flow rate:	110	gpm	
Hours operated:	24.0	hours	
Solution Used:	732.4	gal/day	
Results - Chemical Dose Calculations			
Chemical Feed Dose:	182.2	mg/L	
Chemical Feed Dose:	1,520.6	lbs/MG	

Modifying Existing Solution Strength and Specific Gravity			Hydrated Chemical
			Anhydrous Chemical
Enter Characteristics of Solution & Mixing Parameters			
Name of Dry Chemical:	Alum *14.3H <sub>2</sub> O		
Commercial purity of dry chemical:	100	%	
Percent ion (100% pure material):	98	%	
Weight of dry chemical added:	10.8	Kg	
Volume of water mixed with dry chemical:	200	gal	
Chemical/Physical Mixing Results:			
Total solution volume:	201.23	gal	
Specific gravity of solution:	1.008		
Chemical solution strength:	1.38	%	
Enter characteristics of solution remaining:			
Specific gravity of solution:	1.105		
Chemical solution strength:	16.35	%	
Volume of solution remaining:	20	gal	
Results - Chemical/Physical Blend			
Total solution volume:	221.2	gal	
Specific gravity of solution mix:	1.017		
Chemical solution strength of mix:	2.85	%	

34. **Jar Testing** –This worksheet is designed to assist operators in preparation of stock solution for coagulant jar test or any other chemical of interest. Based on desired dose for each jar testing, the volume of milliliters injected is automatically calculated based on percent solution. Below is an example of the spreadsheet output:

### Jar Testing Stock Solution Preparation Program

#### Jar Test Stock Solution Preparation (1)

<b>1. Enter Product Characteristics</b>	
Name of Liquid Chemical:	ACH
Specific gravity of liquid chemical:	1.3
Chemical solution strength:	50 %
<b>2. Preparation of Stock Solution</b>	
Enter Volume of <b>stock solution</b> :	500.00 mL
Enter Targeted % Strength of <b>stock solution</b> :	1.000
<b>3. Stock Solution Results</b>	
Add 7.73 mL of product solution (Step 1) to 492.27 mL of water (Step 2) to make a 1%, 500 mL stock solution	

#### Jar Test Dosage Results (1)

<b>1. Stock Solution Characteristics</b>						
Specific Gravity of Stock Solution:	1.0046	1 mL = 10.05 mg/L				
% Strength of Stock Solution:	1.0000	10,000 mg/L, ACH				
<b>2. Enter in blue the Jar volume and desired dosage for each jar</b>						
Jar Vol (mL)	2000	2 Liter				
	<b>Jar 1</b>	<b>Jar 2</b>	<b>Jar 3</b>	<b>Jar 4</b>	<b>Jar 5</b>	<b>Jar 6</b>
	Dose	Dose	Dose	Dose	Dose	Dose
Dose, mg/L	5	10	15	20	25	30
Delivered Vol (mL)	1	2	3	3.99	4.99	6

35. **TTHMs, HAAs, CH** – The theoretical disinfectant by-product concentration for total trihalomethanes, haloacetic acids and chloral hydrates are calculated based on chlorine and bromide ion concentrations, water age, pH, temperature, and dissolved organic carbon (DOC). The user can learn what changes in the disinfectant by-products may occur when one or more of the water parameters are changed. Below is an example of the model:

#### **TTHMs/HAA6/CH Modeling Program** *Predictive Raw-Water Models for TTHM, THAA, CH and Respective Species*

<b>Step 1: Enter Information for Predicted TTHMs, HAA6, CH formations</b>		
Sample Point	Raw Water	
Raw Water DOC =	4.50	mg/L as C
Applied Chlorine dose (Cl <sub>2</sub> ) =	2.2	mg/L
Contact time (t) =	100.0	hour
Bromide ion concentration (Br) =	0.10	mg/L
pH =	7.50	
Water Temperature =	20.0	°C

<b>Step 2: Results - Predicted TTHMs, HAA6 &amp; CH</b>			
<b>Trihalomethanes (TTHMs)</b>			
CHCl <sub>3</sub> (chloroform); R <sup>2</sup> = 0.87	125.5	ug/L	1.051 umol/L
CHCl <sub>2</sub> Br (bromodichloromethane); R <sup>2</sup> = 0.90	35.9	ug/L	0.219 umol/L
CHClBr <sub>2</sub> (dibromochloromethane); R <sup>2</sup> = 0.89	5.7	ug/L	0.027 umol/L
CHBr <sub>3</sub> (bromoform); R <sup>2</sup> = 0.61	0.2	ug/L	0.001 umol/L
TTHM (total trihalomethane); R <sup>2</sup> = 0.90	173.6	ug/L	1.298 umol/L
<b>Haloacetic Acids (HAAs)</b>			
CHCl <sub>2</sub> -CO <sub>2</sub> H (dichloroacetic acid); R <sup>2</sup> = 0.83	27.3	ug/L	0.212 umol/L
CCl <sub>3</sub> -CO <sub>2</sub> H (trichloroacetic acid); R <sup>2</sup> = 0.87	50.1	ug/L	0.307 umol/L
CH <sub>2</sub> Cl-CO <sub>2</sub> H (monochloroacetic acid); R <sup>2</sup> = 0.14	2.8	ug/L	0.029 umol/L
CH <sub>2</sub> Br-CO <sub>2</sub> H (monobromoacetic acid); R <sup>2</sup> = 0.43	0.3	ug/L	0.002 umol/L
CHBr <sub>2</sub> -CO <sub>2</sub> H (dibromoacetic acid); R <sup>2</sup> = 0.77	0.7	ug/L	0.003 umol/L
BrCl-CO <sub>2</sub> H (Bromochloroacetic Acid); R <sup>2</sup> = 0.76	10.0	ug/L	0.062 umol/L
Total HAAs; R <sup>2</sup> = 0.87	96.8	ug/L	0.616 umol/L
<b>Chloral Hydrate (CH)</b>			
C <sub>2</sub> HCl <sub>3</sub> (OH) <sub>2</sub> (chloral hydrate); R <sup>2</sup> = 0.81	17.5	ug/L	0.106 umol/L

#### **TTHMs/HAA6/CH Modeling Program** *Predictive Coagulated-Water Models for TTHM, THAA, CH and Respective Species*

<b>Step 1: Enter Information for Predicted TTHMs, HAA6, and CH formations</b>		
Sample Point	Settled Water	
DOC =	4.08	mg/L as C
Applied Chlorine dose (Cl <sub>2</sub> ) =	2.0	mg/L
Contact time (t) =	100.0	hour
Bromide ion concentration (Br) =	0.10	mg/L
pH =	7.50	
Water Temperature =	20.0	°C
Models were based on the adjacent parameters		

<b>Step 2: Results - Predicted TTHMs, HAA6 &amp; CH</b>			
<b>Trihalomethanes (TTHMs)</b>			
CHCl <sub>3</sub> (chloroform); R <sup>2</sup> = 0.91	49.9	ug/L	0.418 umol/L
CHCl <sub>2</sub> Br (bromodichloromethane); R <sup>2</sup> = 0.83	29.3	ug/L	0.179 umol/L
CHClBr <sub>2</sub> (dibromochloromethane); R <sup>2</sup> = 0.32	4.8	ug/L	0.023 umol/L
CHBr <sub>3</sub> (bromoform); R <sup>2</sup> = 0.72	0.6	ug/L	0.002 umol/L
TTHM (total trihalomethane); R <sup>2</sup> = 0.89	114.7	ug/L	0.623 umol/L
<b>Haloacetic Acids (HAAs)</b>			
CHCl <sub>2</sub> -CO <sub>2</sub> H (dichloroacetic acid); R <sup>2</sup> = 0.88	13.6	ug/L	0.106 umol/L
CCl <sub>3</sub> -CO <sub>2</sub> H (trichloroacetic acid); R <sup>2</sup> = 0.93	22.5	ug/L	0.138 umol/L
CH <sub>2</sub> Cl-CO <sub>2</sub> H (monochloroacetic acid); R <sup>2</sup> = 0.36	1.7	ug/L	0.010 umol/L
CH <sub>2</sub> Br-CO <sub>2</sub> H (monobromoacetic acid); R <sup>2</sup> = 0.35	0.5	ug/L	0.004 umol/L
CHBr <sub>2</sub> -CO <sub>2</sub> H (dibromoacetic acid); R <sup>2</sup> = 0.84	1.4	ug/L	0.006 umol/L
BrCl-CO <sub>2</sub> H (Bromochloroacetic Acid); R <sup>2</sup> = 0.87	12.9	ug/L	0.081 umol/L
Total HAAs; R <sup>2</sup> = 0.92	41.0	ug/L	0.344 umol/L
<b>Chloral Hydrate (CH)</b>			
C <sub>2</sub> HCl <sub>3</sub> (OH) <sub>2</sub> (chloral hydrate); R <sup>2</sup> = 0.87	9.6	ug/L	0.058 umol/L

36. **Br & O3** – There are two programs in this worksheet. The first model predicts the formation of bromate based on input parameters of DOC, ozone concentration, contact time, bromide ion concentration and pH and with or without ammonia. The second program is an ozone decay

model. Based on water quality parameters of DOC, applied ozone, bromide ion concentration, pH and alkalinity, the ozone concentration is predicted after a given contact time. Below is an example of the bromate and ozone modeling programs:

**Bromate Modeling Program**  
**Predictive Models for Bromate Formation**  
**with & without Ammonia**

<b>Step 1: Enter Information for Predicted Bromate Formations</b>			
DOC =	4.10	mg/L as C	
Transferred/Utilized Ozone (O <sub>3</sub> ) =	1.1	mg/L	
Contact time (t) =	20.0	minutes	
Bromide ion concentration (Br) =	0.09	mg/L	
pH =	7.50		
Ammonia (NH <sub>3</sub> -N) =	0.40	mg/L	

<b>Step 2: Results - Predicted Bromate</b>			
<b>Bromate without Ammonia</b>			
BrO <sub>3</sub> (bromate ); R <sup>2</sup> = 0.73	3.1	ug/L	0.024 umol/L
<b>Bromate with Ammonia</b>			
BrO <sub>3</sub> (bromate ); R <sup>2</sup> = 0.78	3.5	ug/L	0.028 umol/L

**Ozone Modeling Program**  
**Predictive Model for Ozone Decay**

<b>Step 1: Enter Information for Predicted Ozone Decay</b>			
DOC =	4.50	mg/L as C	
Transferred/Utilized Ozone (O <sub>3</sub> ) =	2.0	mg/L	
Contact time (t) =	2.0	minutes	
Bromide ion concentration (Br) =	0.10	mg/L	
pH =	7.00		
Alkalinity =	100	mg/L as CaCO <sub>3</sub>	

<b>Step 2: Results - Dissolved Ozone</b>			
<b>Dissolved Ozone</b>			
DO <sub>3</sub> ; R <sup>2</sup> = 0.66	0.19	mg/L	

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37. **Arsenate Removal** – This is a simple program that predicts the amount of iron coagulant needed for the reduction of As(V) through filtration.

**Predicted Arsenate Removal Program using Iron Coagulant for pH range 6.5 - 8.**

A simplified isotherm equation predicts arsenate removal using iron coagulant (FeCl<sub>3</sub>). Model predicts arsenate removal to within +/- 13 percent (90% confidence) at pH 6.5-8.

Data Set 1:

<b>Step 1: Enter Source Water Parameter</b>		
Arsenate, As(V)	200	ug/L

<b>Step 2: Enter Fe (Iron) Dosage</b>		
Fe (Iron)	5.00	mg/L
FeCl <sub>3</sub> :- calculated	14.52	mg/L

<b>Step 3: Arsenate Results</b>		
Fe:As(V)	25	wt/wt
% As(V) Removed	87.5	%
As(V) Removed	174.9	ug/L
As(V) (treated water)	25.1	ug/L

<b>Step 4: Chemical Feed Rate for FeCl<sub>3</sub></b>		
Specific gravity of liquid chemical	1.37	wt/wt
Chemical solution strength	34	% wt/wt
Treatment Flow	150	gpm
Calculated chemical feed rate	17.7	mL/min

Data Set 2:

<b>Step 1: Enter Source Water Parameter</b>		
Arsenate, As(V)	25	ug/L

<b>Step 2: Enter Fe (Iron) Dosage</b>		
Fe (Iron)	2.00	mg/L
FeCl <sub>3</sub> :- calculated	5.81	mg/L

<b>Step 3: Arsenate Results</b>		
Fe:As(V)	80	wt/wt
% As(V) Removed	73.6	%
As(V) Removed	18.4	ug/L
As(V) (treated water)	6.6	ug/L

<b>Step 4: Chemical Feed Rate for FeCl<sub>3</sub></b>		
Specific gravity of liquid chemical	1.37	wt/wt
Chemical solution strength	34	% wt/wt
Treatment Flow	1,500	gpm
Calculated chemical feed rate	70.8	mL/min

38. **IronMag** - The stoichiometric oxidation for iron and/or manganese are predicted based on the oxidants of chlorine, ozone, oxygen, chlorine dioxide and potassium permanganate. The user inputs the concentration of iron and/or manganese that are dissolved in water and the oxidant chemical concentrations are calculated along with predictive changes in pH and

alkalinity. An example of user input of water characteristics with high levels of iron and manganese (Step 1) and the stoichiometry calculations of iron and manganese oxidation (Step 2) is given below:

<b>Step 1: Initial Water Characteristics</b>	
<b>Enter initial water characteristics based on laboratory and field analysis.</b>	
System Name:	Santa Rosa
Source Point:	Well 01
Date of Sample:	12/12/2014
Plant Flow Rate =	50.0 gpm 72,000 gallons/day 0.072 MGD
TDS =	200 mg/L 312.5 uS/cm (Electrical Conductivity)
pH =	7.00 field pH is recommended
Total Alkalinity =	364 mg/L as CaCO <sub>3</sub> 7.27 meq/L
Water Temperature =	25.0 °C (temperature at which pH was analyzed)
Field Water Temperature =	25.0 °C (operating temperature at facility) Adj. pH = 7.00
Iron(II) =	1.0 mg/L
Manganese(II) =	1.00 mg/L
For determining the HOCl concentration based on the above water characteristics and liquid/gas dosages:	
NaOCl or Cl <sub>2</sub> , mg/L =	3.3 mg/L 2.56 mg/L as HOCl 0.74 mg/L as OCl <sup>-</sup>

<b>Step 2: Results</b>					<b>Predicted Change in Water Characteristics</b>	
<b>Stoichiometry of Iron and Manganese Oxidation</b>					<b>Alkalinity</b>	<b>pH</b>
<b>Oxidant</b>	<b>Fe<sup>2+</sup></b>	<b>Mn<sup>2+</sup></b>	<b>(Fe<sup>2+</sup> + Mn<sup>2+</sup>)</b>	<b>Ibs/MG</b>		
1 Chlorine required, mg/L as HOCl =	0.63	1.29	1.93	16.1	358	6.96
2 Ozone required, mg/L as O <sub>3</sub> =	0.42	0.87	1.29	10.8	360	6.98
3 Oxygen required, mg/L as O <sub>2</sub> =	0.14	0.29	0.43	3.6	360	6.98
4 Chlorine dioxide required, mg/L as ClO <sub>2</sub> =	0.24	2.46	2.70	22.5	358	6.96
5 Permanganate required, mg/L as KMnO <sub>4</sub> =	0.94	1.92	2.86	23.9	361	6.98

<b>Step 3: Operating Cost - Enter associated cost for Iron and Manganese</b>				
<b>Oxidant</b>	<b>Chemical</b>	<b>Energy</b>	<b>Miscellaneous</b>	<b>Total Cost</b>
	<b>\$/lb</b>	<b>\$/MG</b>	<b>\$/MG</b>	<b>\$/MG</b>
1 Chlorine as Cl <sub>2</sub>	\$3.00	\$7.00	\$1.50	\$56.70
2 Ozone as O <sub>3</sub>	\$5.00	\$12.00	\$2.00	\$67.82
3 Oxygen as O <sub>2</sub>	\$5.00	\$9.00	\$2.00	\$29.12
4 Chlorine dioxide as ClO <sub>2</sub>	\$6.00	\$5.00	\$3.00	\$143.04
5 Permanganate as KMnO <sub>4</sub>	\$4.00	\$4.00	\$4.00	\$103.49

39. **Anion-Cation Balance!Pro** – This worksheet calculates the total anion and cations (Meq/L) based on the input individual measured ions. The results of the anion/cations are compared for quality control. The results are automatically entered into a laboratory form for printout. A partial view of the program is given below:

## Anion-Cation Balance!Pro™

Anions	Concentration mg/L	Calc. Meq/L	Cations	Concentration mg/L	Calc. Meq/L
BO <sub>2</sub> <sup>-</sup>		-	Al <sup>3+</sup>		-
Br <sup>-</sup>		-	B <sup>3+</sup>		-
Cl <sup>-</sup>	15	0.42310	Ba <sup>2+</sup>		-
CO <sub>3</sub> <sup>-2</sup>		-	Ca <sup>2+</sup>	35	1.74659
CrO <sub>4</sub> <sup>2-</sup>		-	Cr <sup>3+</sup>		-
F <sup>-</sup>		-	Cu <sup>2+</sup>		-
HCO <sub>3</sub> <sup>-</sup>	122	1.99944	Fe <sup>2+</sup>		-
HPO <sub>4</sub> <sup>2-</sup>		-	Fe <sup>3+</sup>		-
H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>		-	H <sup>+</sup>		-
HS <sup>-</sup>		-	K <sup>+</sup>		-
HSO <sub>3</sub> <sup>-</sup>		-	Li <sup>+</sup>		-
HSO <sub>4</sub> <sup>-</sup>		-	Mg <sup>2+</sup>	10	0.82288
I <sup>-</sup>		-	Mn <sup>2+</sup>		-
NO <sub>2</sub> <sup>-</sup>		-	Mn <sup>4+</sup>		-
NO <sub>3</sub> <sup>-</sup>		-	Na <sup>+</sup>	10	0.43498
OH <sup>-</sup>		-	NH <sub>4</sub> <sup>+</sup>		-
PO <sub>4</sub> <sup>3-</sup>		-	Pb <sup>2+</sup>		-
S <sup>2-</sup>		-	Sr <sup>2+</sup>		-
SiO <sub>3</sub> <sup>2-</sup>		-	Zn <sup>2+</sup>		-
SO <sub>3</sub> <sup>2-</sup>		-			
SO <sub>4</sub> <sup>2-</sup>	25	0.52049			

Total Anions 2.94303 Total Cations 3.00445

Calculated TDS, mg/L = 155.0 Calculated IS, mol/L = 0.00452

The acceptance ion balance criteria has been set at: 2.0%

The percent difference is: -1.03% Acceptable

40. **Anion-Cation Balance!Pro Lab Sheet** – results from the “Anion-Cation Balance” worksheet are copied into this worksheet for printout.

## About the Author:

Guy Schott has over 31 years of technical, regulatory, and training experience in the drinking water industry working with utilities, consulting engineers, and regulatory agencies. He is a registered Professional Engineer and holds California T5 water treatment and D2 distribution operator certificates. Mr. Schott has Bachelor and Master of Science degrees in Civil Engineering from California State University of Fresno.

Mr. Schott has over 36 years of experience in developing software applications, compliance and operational forms related to the drinking water industry. His work has been used worldwide to assist water utilities, engineers, scholastics, and chemists in drinking water treatment. Mr. Schott has presented papers and presentations at Water Quality Technical Conferences (WQTC), CA-NV American Water Works Association (AWWA) conferences, and has provided training to regulatory agencies, utilities, and consulting engineers on the following:

WQTC	CA-NV AWWA	Training/Presentations	Articles
WaterPro – Lead/Copper Corrosion Control – Modeling Program	Tracer Studies (various topics)	Tracer Studies (various topics) (California/Alaska)*	Opflow – Jar Testing Made Easy, August 2020 <a href="https://doi.org/10.1002/opfl.1411">https://doi.org/10.1002/opfl.1411</a>
Enhanced Coagulation – Modeling Program	Filter Surveillance Techniques*	Filter Surveillance Techniques*	Opflow – Coming to Terms With CT Values, October 2022 <a href="https://doi.org/10.1002/opfl.tk">https://doi.org/10.1002/opfl.tk</a>
	Lead/Copper Corrosion Control	Lead/Copper Corrosion Control	
	UV Disinfection – plus Modeling Program	Membrane Filtration – plus Modeling Program	
	Chemical Dosing*	UV Disinfection	
	Storage Tank Aeration to Reduce Trihalomethanes	CT – Compliance/Concepts	
	Jar Testing	Federal and State Regulations	
		Jar Testing	
		Geosmin/MIB Work – Clear Lake	
		Storage Tank Aeration to Reduce Trihalomethanes	

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