Calcite Contactors for Corrosion Control in Small Systems

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Outline

- Lead and copper solubility
- Regulatory overview
- Calcite contactor design, operation, and cost

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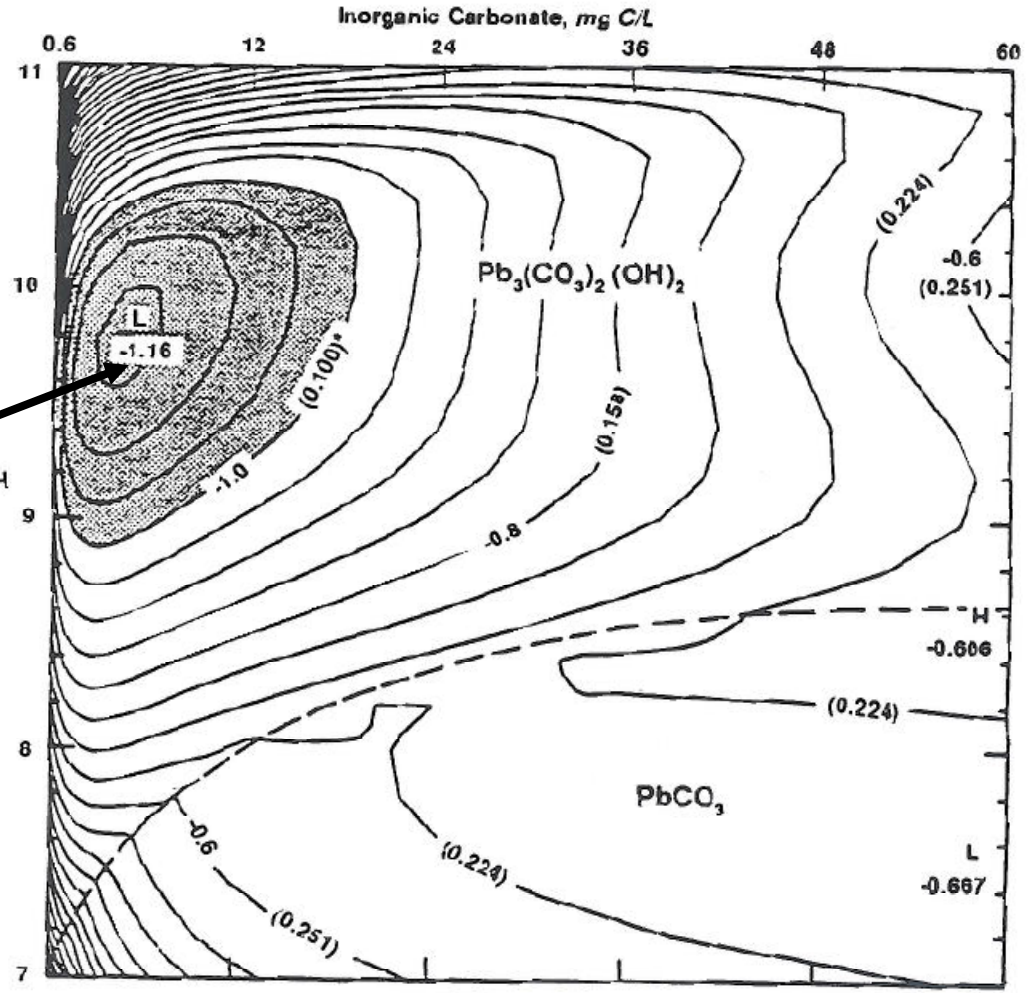
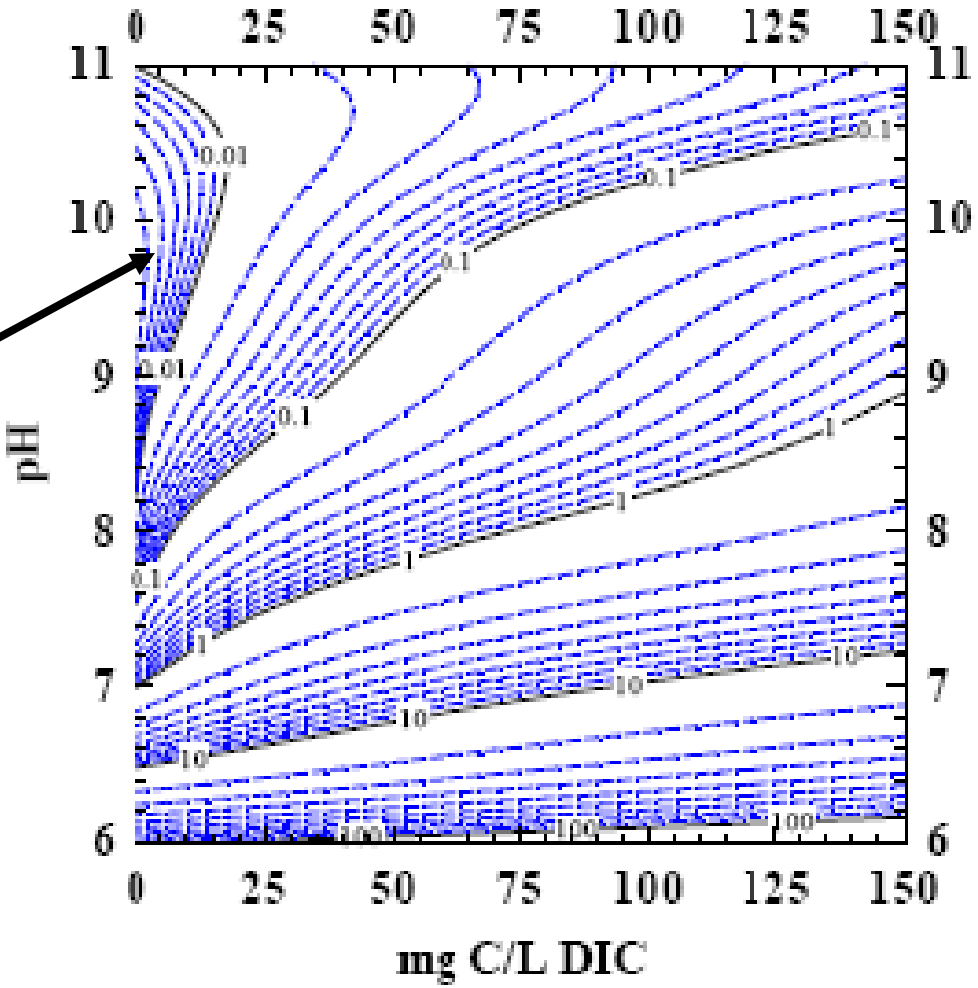
Lead Solubility

Minimum lead solubility

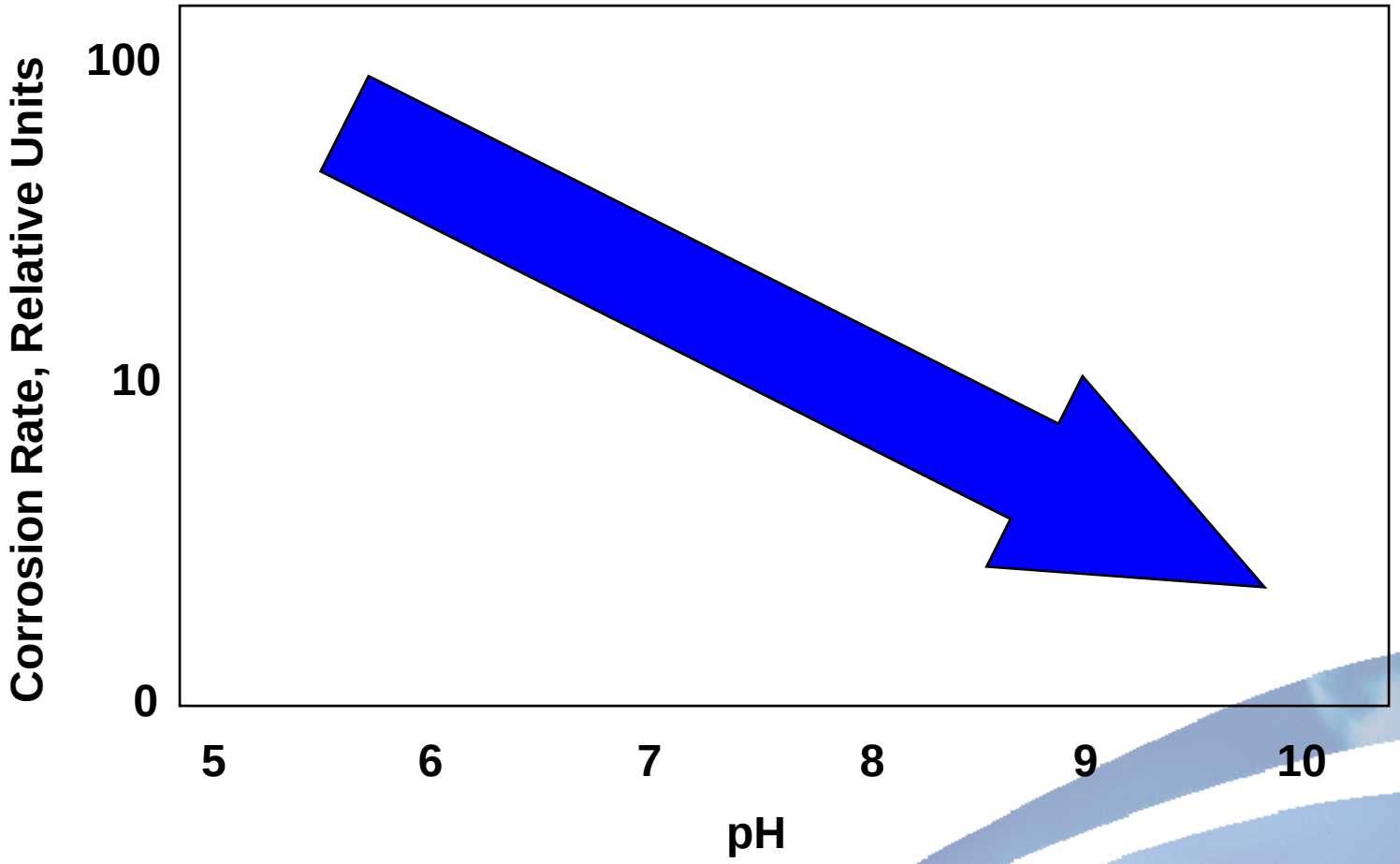


Copper Solubility

Minimum copper solubility



Corrosion vs. pH



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Regulatory Overview

- **US EPA Lead and Copper Rule**
  - First published in 1991
  - Revised most recently in 2004.
  - When action levels are exceeded in more than 10% of sample locations, action must be taken to control corrosion.

	Action Level
Lead	**0.015 mg/L**
Copper	**1.3 mg/L**

Action level based on 90th percentile of tap water samples.

Samples taken at specified number of taps in distribution system.

Revised Corrosion Control Guidance From USEPA

- **EPA revised rule based on feedback and experience with small systems**
- **New procedure based on type of exceedance (lead only, copper only, or both) and raw water quality**
- **pH and alkalinity are used:**
  - to determine dissolved inorganic carbonate (DIC)
  - Hardness data is used to determine maximum pH increase
  - Decision tree/flowchart is used to determine treatment recommendation
  - Additional restricting factors (i.e. iron and manganese) and cost also impact recommendation

Revised Corrosion Control Guidance From USEPA that Recommends Calcite Contactors

Lead	Copper	pH	Fe & Mn	DIC
Yes	Yes	<7.2	No	<5
Yes	Yes	<7.2	No	<5
Yes	No	<7.2	No	<5
Yes	No	<7.2	No	5-12
Yes	No	<7.2	No	<5
No	Yes	<7.2	No	<5
No	Yes	<7.2	No	5-12
No	Yes	<7.2	No	<5
Either	Either	<7.2	Yes	<5

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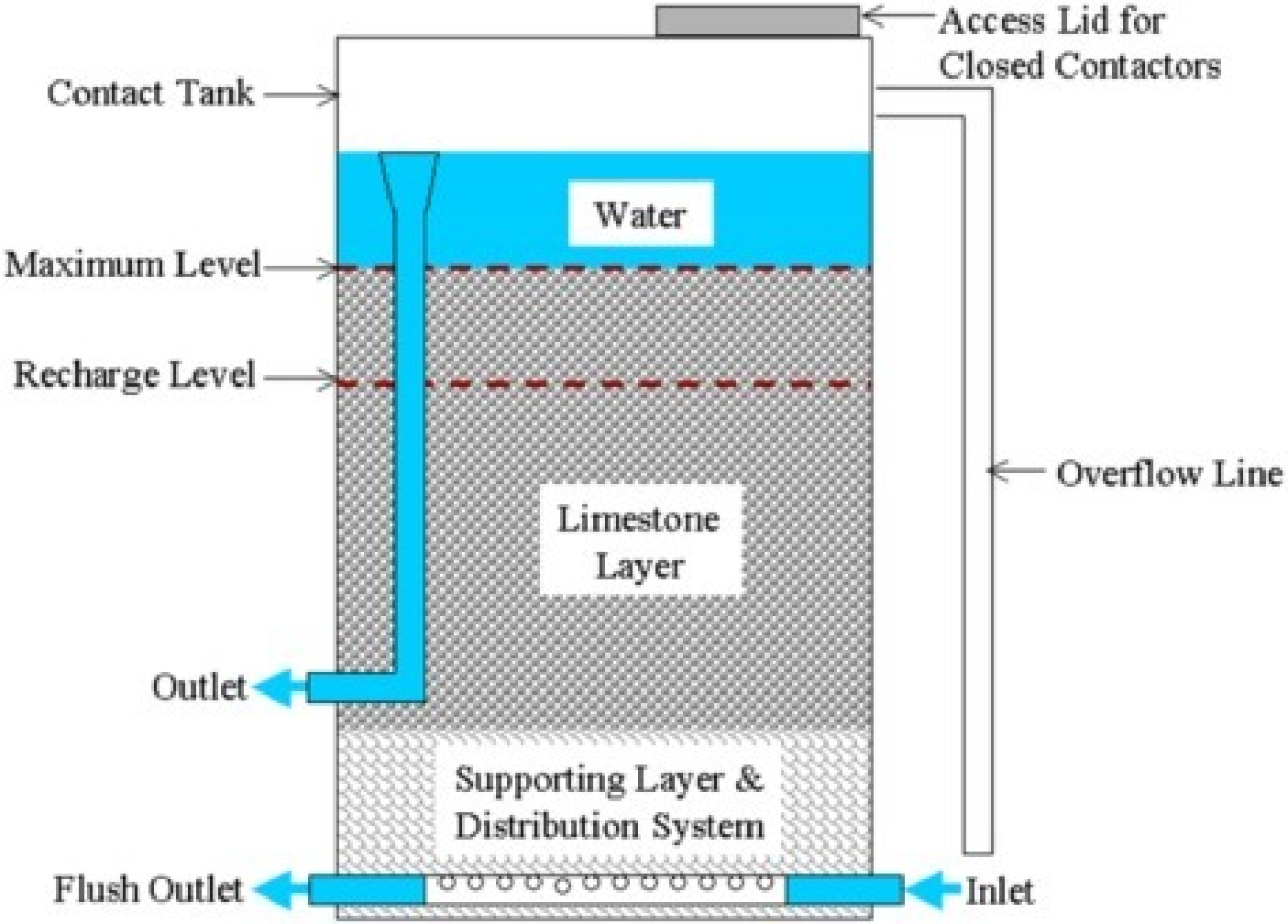
Calcite Contactors

- **Calcite contactors use limestone to add calcium carbonate to water, which raises pH, and adds alkalinity.**
- **Advantages:**
  - Easy and safe to operate
  - Reduced operating cost
  - Self adjusts the water pH without risk of alkali overdose
  - Increases alkalinity
  - Requires minimal maintenance and operator skill
  - Does not require continuous feed of chemicals
  - Have been used in Europe and Middle East for augmenting iron removal
- **Disadvantages:**
  - Only works on certain water qualities
  - No precise pH control

Calcite Contactors



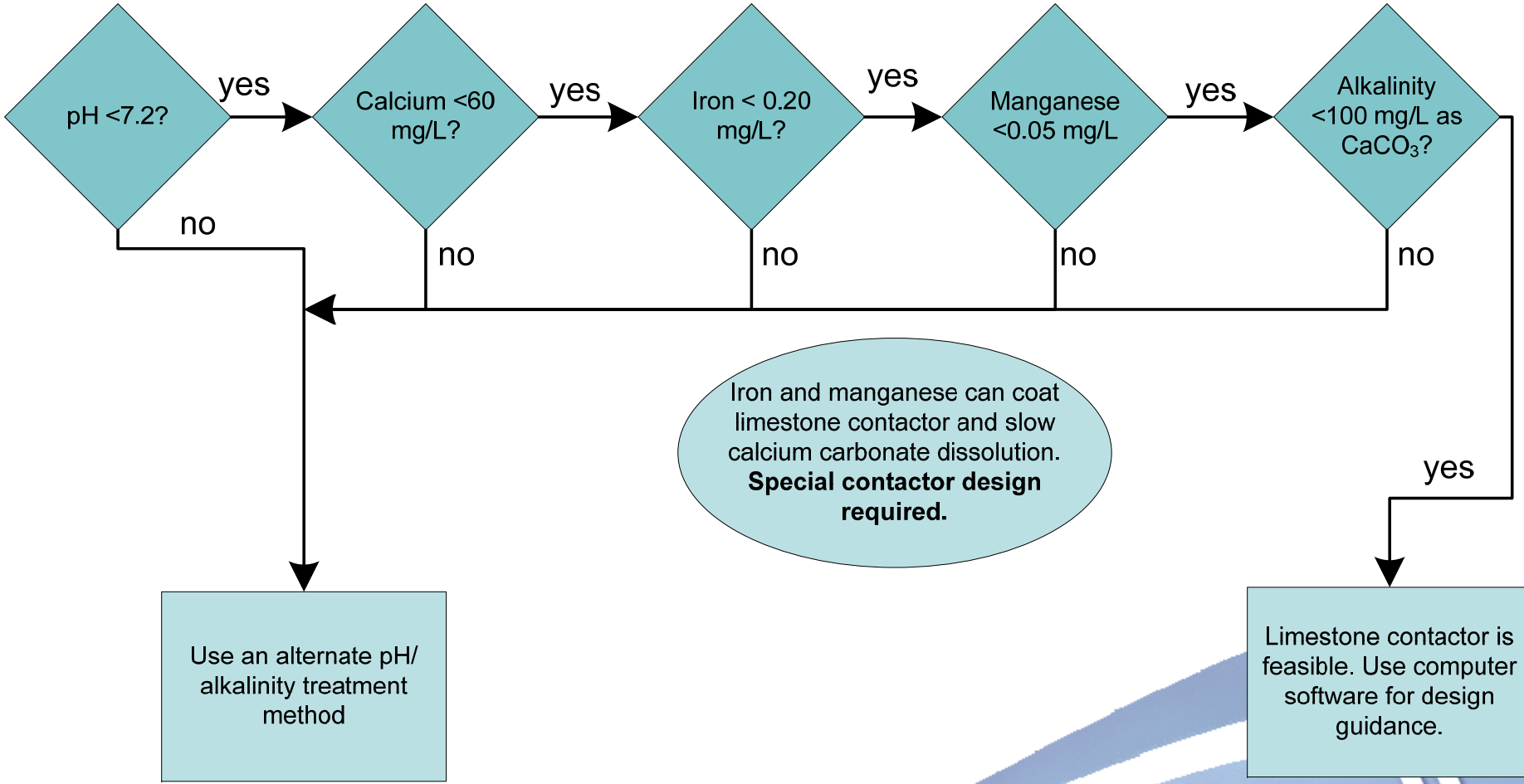
Contactor Design

- **Parameters needed:**
  - pH
  - Alkalinity
  - Dissolved Inorganic Carbon (DIC)
  - Hardness
  - Calcium
  - Iron
  - Manganese
  - Temperature
  - Velocity
  - % Calcium Carbonate
  - Particle Size

} Go into EPA's flowcharts for treatment technology recommendation

} Refine details of contactor design

Contactor Decision Tree



Design Software Used to Size System and Predict Consumption Rate

Limestone Bed Contactor

Corrosion Control and Treatment Process Analysis Program - Version 1.02

Step 1: Initial Water Characteristics

Enter initial water characteristics based on laboratory analysis.

System Name:	Santa Rosa			
Source Point:	Lake			
Date of Sample:	August 11, 1999			
TDS =	80	mg/L	2.00	mMols/L, Ionic Strength
Total Calcium =	52	mg/L Ca^{2+}	129.86	mg/L as $CaCO_3$
Total Alkalinity =	53.0	mg/L as $CaCO_3$		
pH =	6.50	field pH is recommended		
Water Temperature =	12.5	°C (temp. at which pH was analyzed)		
Field Water Temperature =	12.5	°C (operating temperature at facility)		
$CaCO_3$ Solubility Product, pKsp =	-8.453	at 20°C, program default		
Do you want to change the Solubility Product of $CaCO_3$?	○ Yes	◉ No		
User $CaCO_3$ Solubility Product, pKsp =	-8.721	No data entry is required.		
Relative Temperature for pKsp =	20.0	°C		
Enter Pre -Treatment Dosage for Lowering pH.				
Carbon Dioxide (CO_2) +/-	0.0	mg/L	0.00	mg/L as $CaCO_3$

Step 2: Initial Results (Before Limestone Addition)

Theoretical initial water characteristics after temperature correction.

pH =	6.50		125.0	uS/cm (Electrical Conductivity)
Total Alkalinity =	1.06	meq/L		
Acidity =	141.0	mg/L as $CaCO_3$		
Carbon Dioxide (CO_2) =	38.71	mg/L as $CO_{2(aq)}$	0.688	mg/L, Atmospheric equilibrium $CO_{2(aq)}$
DIC =	194.0	mg/L as $CaCO_3$	23.29	mg/L as C, dissolved inorganic carbon
Langelier Index, Calcite =	-1.50	Tendency to dissolve CaCO3 (for steel and cast iron piping)		
CCPP =	-67.0	mg/L as $CaCO_3$, Calcium Carbonate Precipitation Potential		
$B_{H2B} + B_{CO3}$ =	1.108	mM/pH, Buffer intensity from water and carbonate species		
$CaCO_3$, pKsp =	-8.420	12.5 °C, temperature		
Copper II =	19.61	mg/L; Cupric Hydroxide, light blue/blue-green		

U.S. EPA Guidance recommend that the initial water characteristic meet the following parameters when considering limestone contactor:

pH <= 7.2	**Condition met**
DIC < 10 mg/L as C	**Condition not met**
Calcium < 20 mg/L Ca	**Condition not met**

Step 3: Limestone Bed Contactor Parameters

Enter parameters for contactor and chemical addition.

Superficial Velocity =	5.0	gpm/ft²	20.37	cm/min
Limestone Particle Diameter =	1.0	cm, (0.3 to 3.2 cm)		
Limestone Porosity, ε =	0.42			
Sphericity (roundness), χ =	0.80	range: 0.4 - 0.8		
$CaCO_3$ (Limestone) =	53.0	mg/L		
You may enter "Target pH" to determine Limestone concentration and depth of contactor.				
Target pH =	7.20	Target pH		

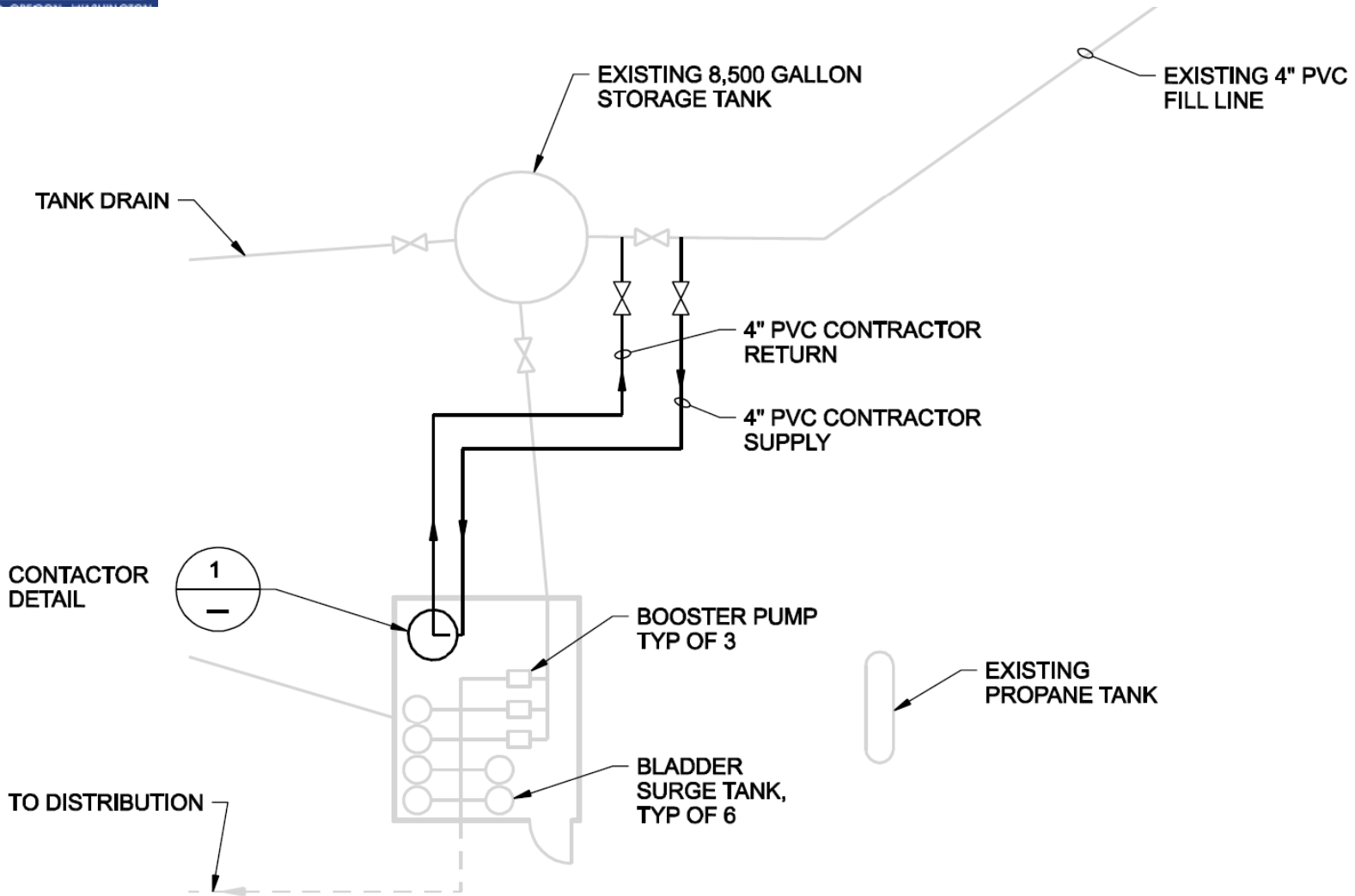
Program Overview

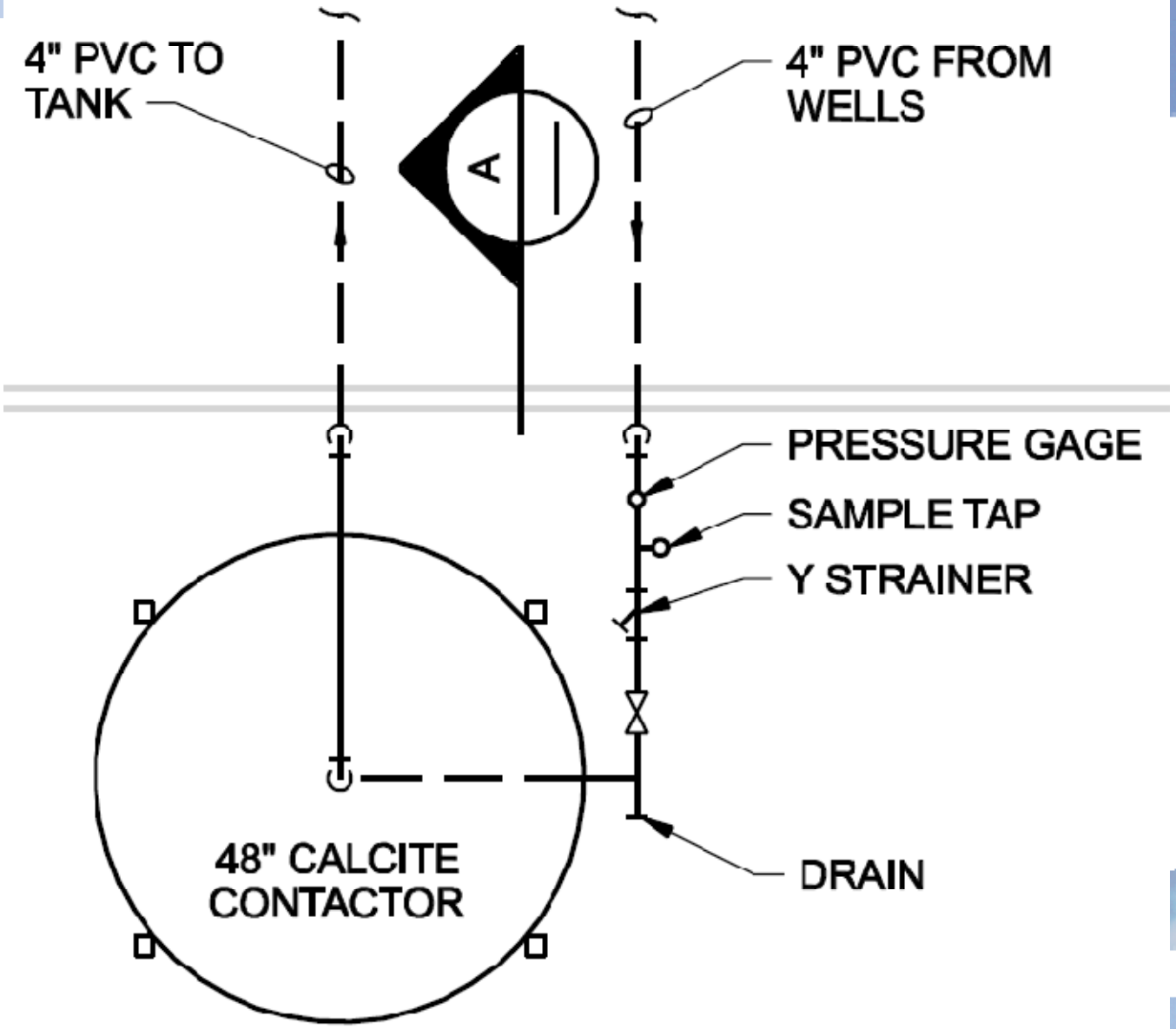
Step 4: Results (After Chemical Addition of Limestone)

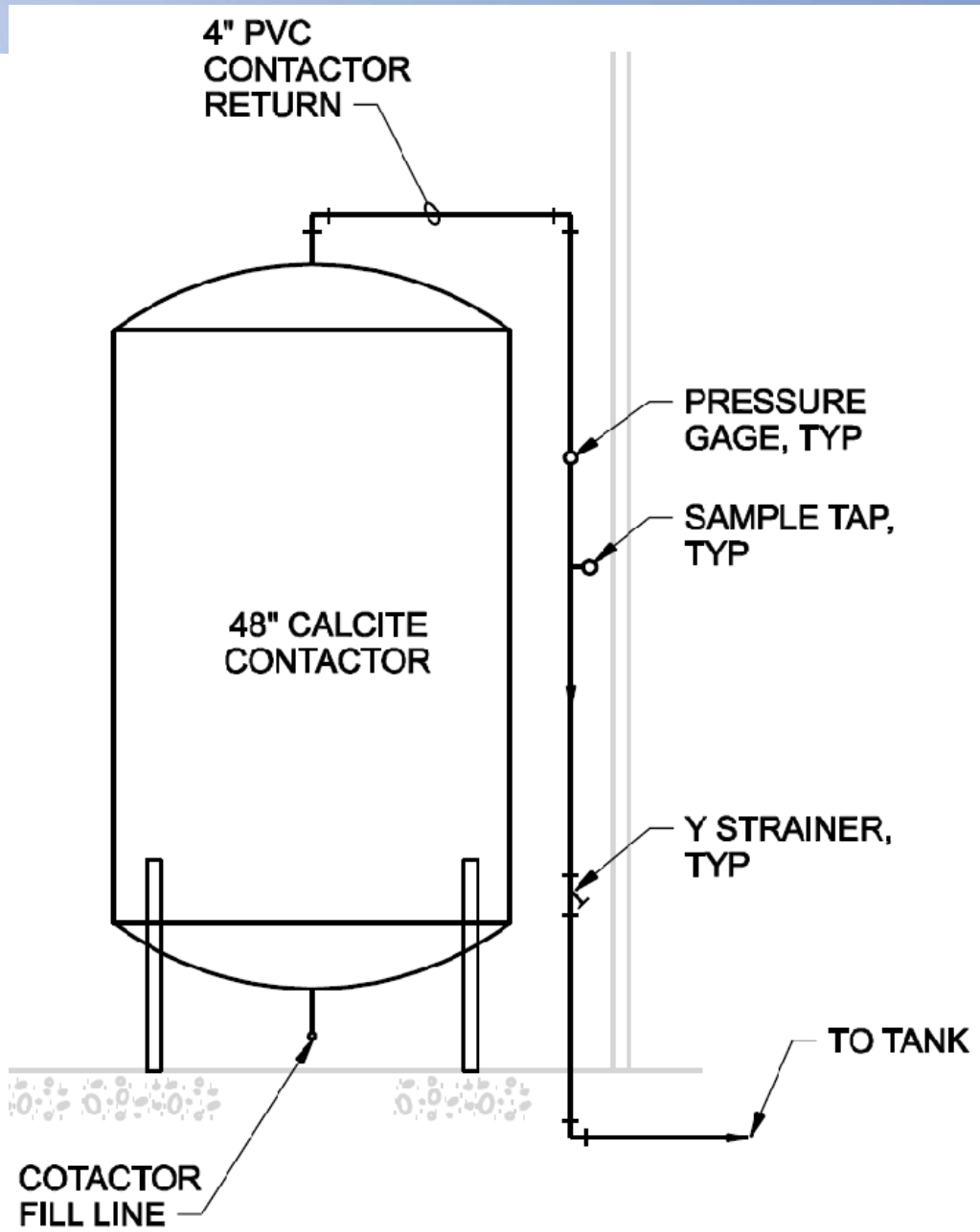
pH =	7.20	pH of water after chemical addition			
Total Alkalinity =	106.0	mg/L as $CaCO_3$	2.12	meq/L	
Total Calcium =	73.22	mg/L Ca^{2+}	182.9	mg/L as $CaCO_3$	
Carbon Dioxide (CO_2) =	15.47	mg/L as $CO_{2(aq)}$	4.22	mg/L as C	
DIC =	247.0	mg/L as $CaCO_3$	29.65	mg/L C, dissolved inorganic carbon	
Langelier Index, Calcite =	-0.36	Tendency to dissolve CaCO3 (for steel and cast iron piping)			
CCPP =	-14.0	mg/L as $CaCO_3$, Calcium Carbonate Precipitation Potential			
$B_{H2B} + B_{CO3}$ =	0.697	mM/pH, Buffer intensity from water and carbonate species			
Copper II =	3.30	mg/L; Cupric Hydroxide, light blue/blue-green			
Depth of Contactor =	4.37	feet	52.4	inches	133 cm
Empty Bed Contact Time =	6.5	minutes			
Limestone Dissolved =	441.9	pounds per million gallons of water treated			200.6 Kg/MG

Contactors

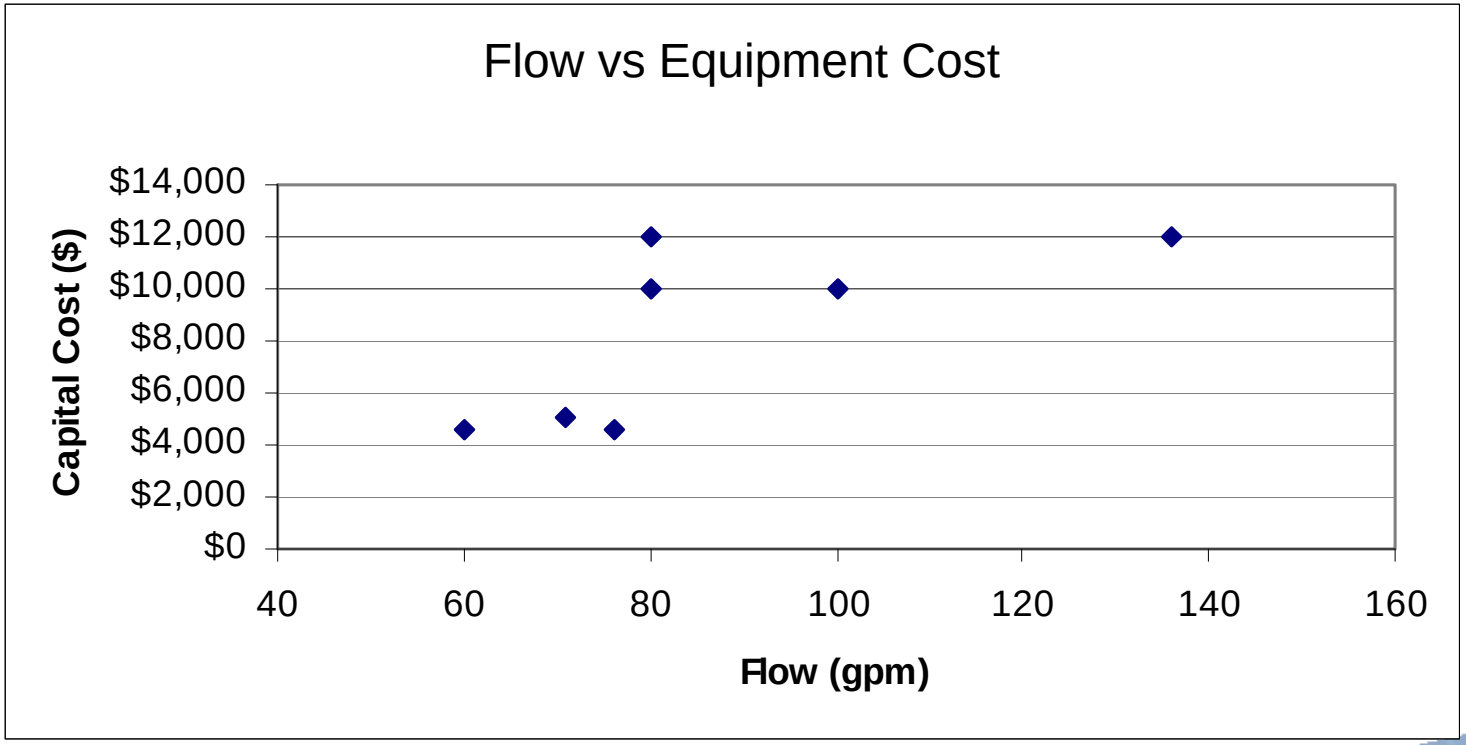
Example Project Layout & Design




4" PVC TO TANK
A
4" PVC FROM WELLS
PRESSURE GAGE
SAMPLE TAP
Y STRAINER
48" CALCITE CONTACTOR
DRAIN


4" PVC
CONTACTOR
RETURN
PRESSURE
GAGE, TYP
SAMPLE TAP,
TYP
48" CALCITE
CONTACTOR
Y STRAINER,
TYP
TO TANK
COTACTOR
FILL LINE

Capital Cost



- **"Jump" in price occurs with increase in number of tanks installed**

Operations & Maintenance

Procedure	Frequency
Inspection of the tank	Weekly
pH monitoring to ensure target pH values are met	Periodically
Flow adjustment to maintain constant contact time	Periodically
Limestone bed scraping/cleaning and refilling	6-8 weeks
Complete media replacement	Once in 10 years
Monitor flow to ensure it is within permissible values	Regularly
Headloss inspection	Weekly
Monitor height of limestone media	Monthly
Ensure no precipitates on media surface	Regularly

Operation and Maintenance Cost

- **Typically very low**
  - Includes regular pH monitoring
  - Limestone addition when pH decreases

Additional Resources

- **USEPA Revised Guidance Manual for Selecting Lead and Copper Control Strategies, March 2003.**

Questions?