VERMONT
ENVIRONMENTAL CONSERVATION

GUIDANCE

Drinking Water and Groundwater Protection Division

Developing a Corrosion Control Treatment Recommendation

To determine the proper Corrosion Control Treatment (CCT) recommendation for your system, you'll need to work through this packet. This information is from a 2016 EPA guidance document (https://www.epa.gov/sites/production/files/2016-03/documents/occtmarch2016.pdf). Division staff are available to assist in this process, however, you'll need the following current water chemistry data for finished water (entry point to distribution). It is possible the Division has data available at its website (https://anrweb.vt.gov/DEC/DWGWP/SearchWS.aspx).

Iron and Manganese
pH
Alkalinity (units of mg/L as $CaCO_3$)
estimate of Dissolved Inorganic Carbon (DIC, carbonates and bicarbonates)

Use Appendix B on the next page to estimate DIC using pH and alkalinity. Find where the alkalinity row and pH column meet; if data is between rows or columns, round pH down and round alkalininty to the nearest value.

Answer the questions in the table below, working from left column toward the right. Then follow the numbered flowchart included in this packet.

Identifying the Appropriate Flowchart for Preliminary CCT Selection

Is iron (>0.3mg/L) or manganese (>0.05mg/L) in finished water?	What is the contaminant to be addressed?	What is the finished water pH?	Use This Flowchart
No	Lead only, or Both Lead and Copper	< 7.2	**1**
		7.2 - 7.8	**2**
		7.8 - 9.5	**3**
		> 9.5	**4**
	Copper only	< 7.2	**5**
		7.2 - 7.8	**6**
		> 7.8	**7**
Yes[1]	Lead and/or Copper	< 7.2	**8**
		≥ 7.2	**9**

1. Flowcharts 8 and 9 present several treatment options for lead and copper that also reduce iron and manganese. Systems can also consider removing iron and manganese first, then using flowcharts 1 through 6 to control for lead and/or copper.

Once you have worked through the necessary flowchart, complete the last page of this packet (Corrosion Control Treatment Recommendation) and submit a copy to the Division. This will document the system's formal corrosion control recommendation. Should the water system be required to install CCT, it may affect the class of a system, potentially requiring a certified operator of higher class

*Please note that you are not required to have an engineer to create the recommendation, but may work with one. An engineer's design will be required, as will Division approval or a Permit to Construct, prior to installing treatment.

Appendix B – Estimated Dissolved Inorganic Carbon (mg/L as C) based on Alkalinity and pH (with water temperature of 25 degrees C and TDS of 200)[1, 2]

Total Alkalinity	pH																				
	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4
0	0																				
2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0					
4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0			
6	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	0	0		
8	4	3	3	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	0		
10	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	1	1	0	
12	5	4	4	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	1	1	
14	6	5	4	4	4	4	4	3	3	3	3	3	3	3	3	3	2	2	1	1	0
16	7	6	5	5	4	4	4	4	4	4	4	4	4	4	3	3	3	2	2	1	0
18	8	7	6	5	5	5	5	4	4	4	4	4	4	4	4	4	3	3	2	2	1
20	9	7	6	6	5	5	5	5	5	5	5	5	5	4	4	4	4	3	3	2	1
22	10	8	7	6	6	6	6	5	5	5	5	5	5	5	5	4	4	4	3	2	1
24	11	9	8	7	7	6	6	6	6	6	6	6	5	5	5	5	4	4	3	2	2
26	11	10	8	8	7	7	7	6	6	6	6	6	6	6	6	5	5	4	4	3	2
28	12	10	9	8	8	7	7	7	7	7	7	7	6	6	6	6	5	5	4	3	2
30	13	11	10	9	8	8	8	7	7	7	7	7	7	7	6	6	6	5	4	3	2
35	15	13	11	10	9	9	9	9	9	8	8	8	8	8	8	7	7	6	5	4	3
40	18	15	13	12	11	10	10	10	10	10	10	9	9	9	9	8	8	7	6	5	4
45	20	16	14	13	12	12	11	11	11	11	11	11	10	10	10	9	9	8	7	6	5
50	22	18	16	14	14	13	13	12	12	12	12	12	12	11	11	10	10	9	8	7	5
55	24	20	18	16	15	14	14	14	13	13	13	13	13	12	12	11	11	10	9	8	6
60	26	22	19	17	16	16	15	15	15	14	14	14	14	14	13	12	12	11	10	8	7
65	29	24	21	19	18	17	16	16	16	16	15	15	15	15	14	14	13	12	10	9	8

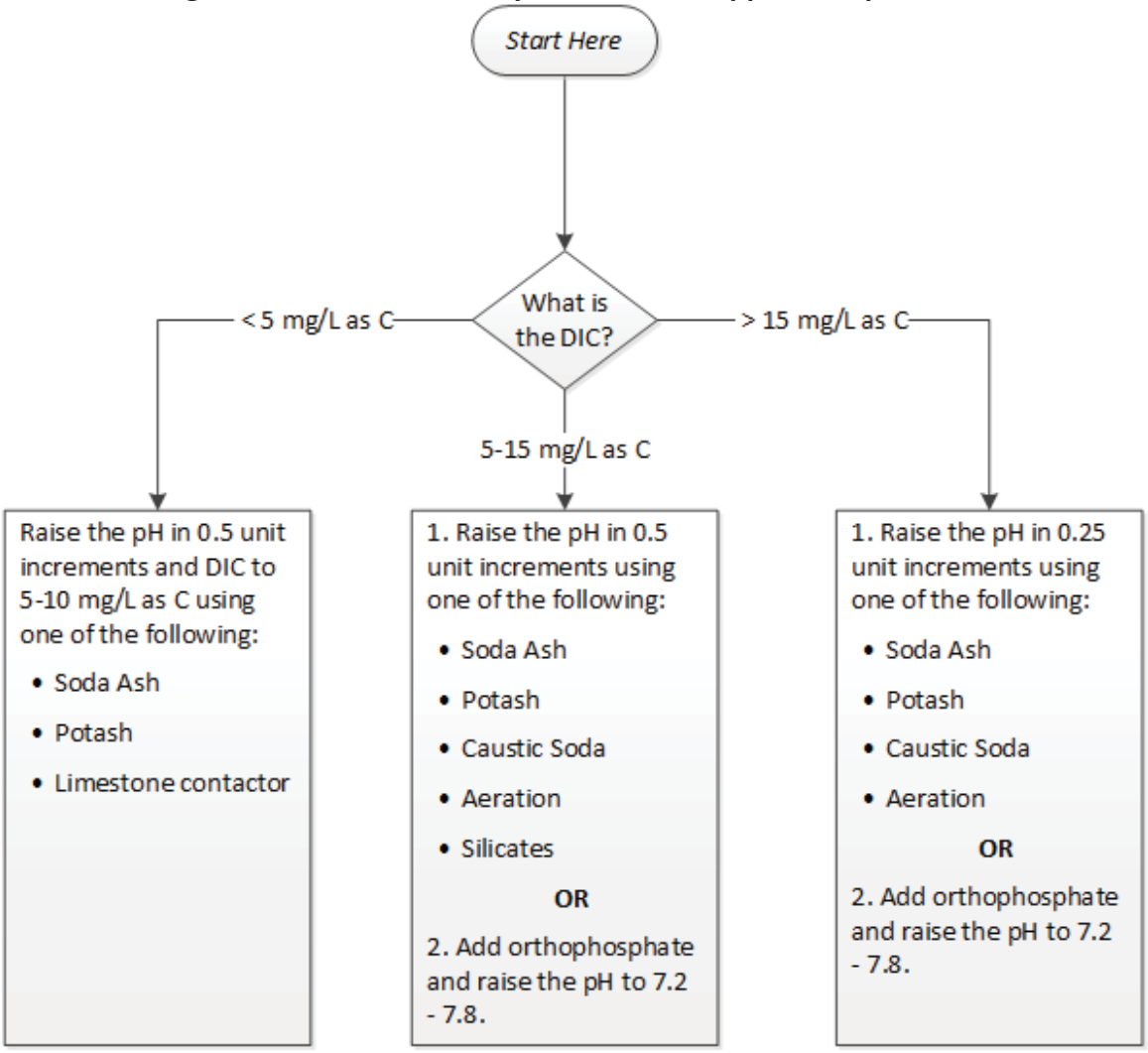
Total Alkalinity	pH																				
	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4
70	31	26	22	20	19	18	18	17	17	17	17	16	16	16	15	15	14	13	11	10	8
75	33	27	24	22	20	19	19	19	18	18	18	18	17	17	16	16	15	14	12	11	9
80	35	29	26	23	22	21	20	20	19	19	19	19	19	18	18	17	16	14	13	12	10
85	37	31	27	25	23	22	21	21	21	20	20	20	20	19	19	18	17	15	14	12	11
90	40	33	29	26	24	23	23	22	22	22	21	21	21	20	20	19	18	16	15	13	11
95	42	35	30	28	26	25	24	23	23	23	23	22	22	22	21	20	19	17	16	14	12
100	44	37	32	29	27	26	25	25	24	24	24	24	23	23	22	21	20	18	17	15	13
125	55	46	40	36	34	32	31	31	30	30	30	29	29	28	27	26	25	23	21	19	17
150	66	55	48	43	41	39	38	37	37	36	36	35	35	34	33	32	30	28	25	23	20
175	77	64	56	51	47	45	44	43	43	42	42	41	41	40	39	37	35	32	30	27	24
200	88	73	64	58	54	52	50	49	49	48	48	47	46	45	44	42	40	37	34	31	28
225	99	82	72	65	61	58	57	56	55	54	54	53	52	51	50	48	45	42	38	35	32
250	110	91	80	72	68	65	63	62	61	60	60	59	58	57	55	53	50	47	43	39	36
275	121	100	88	80	75	71	69	68	67	66	66	65	64	63	61	58	55	51	47	43	39
300	132	110	96	87	81	78	76	74	73	72	72	71	70	68	66	64	60	56	52	47	43
325	143	119	104	94	88	84	82	80	79	78	77	77	75	74	72	69	65	61	56	51	47
350	154	128	112	101	95	91	88	86	85	84	83	82	81	80	77	74	70	65	60	55	51
375	165	137	120	109	102	97	94	93	91	90	89	88	87	85	83	79	75	70	65	59	54
400	176	146	128	116	108	104	101	99	97	96	95	94	93	91	88	85	80	75	69	63	58

[1] Shaded cells indicate chemically impossible condition. May indicate analytical quality or total dissolved solids (TDS) assumption error.

[2] References: Butler, J. N. Cogley, D. R. 1998. *Ionic Equilibrium Solubility and pH Calculations*. John Wiley and Sons, New York, NY; Schock, M. R. 1981. "Response of Lead Solubility to Dissolved Carbonate in Drinking Water." *Jour. AWWA*. 73:3: 36.

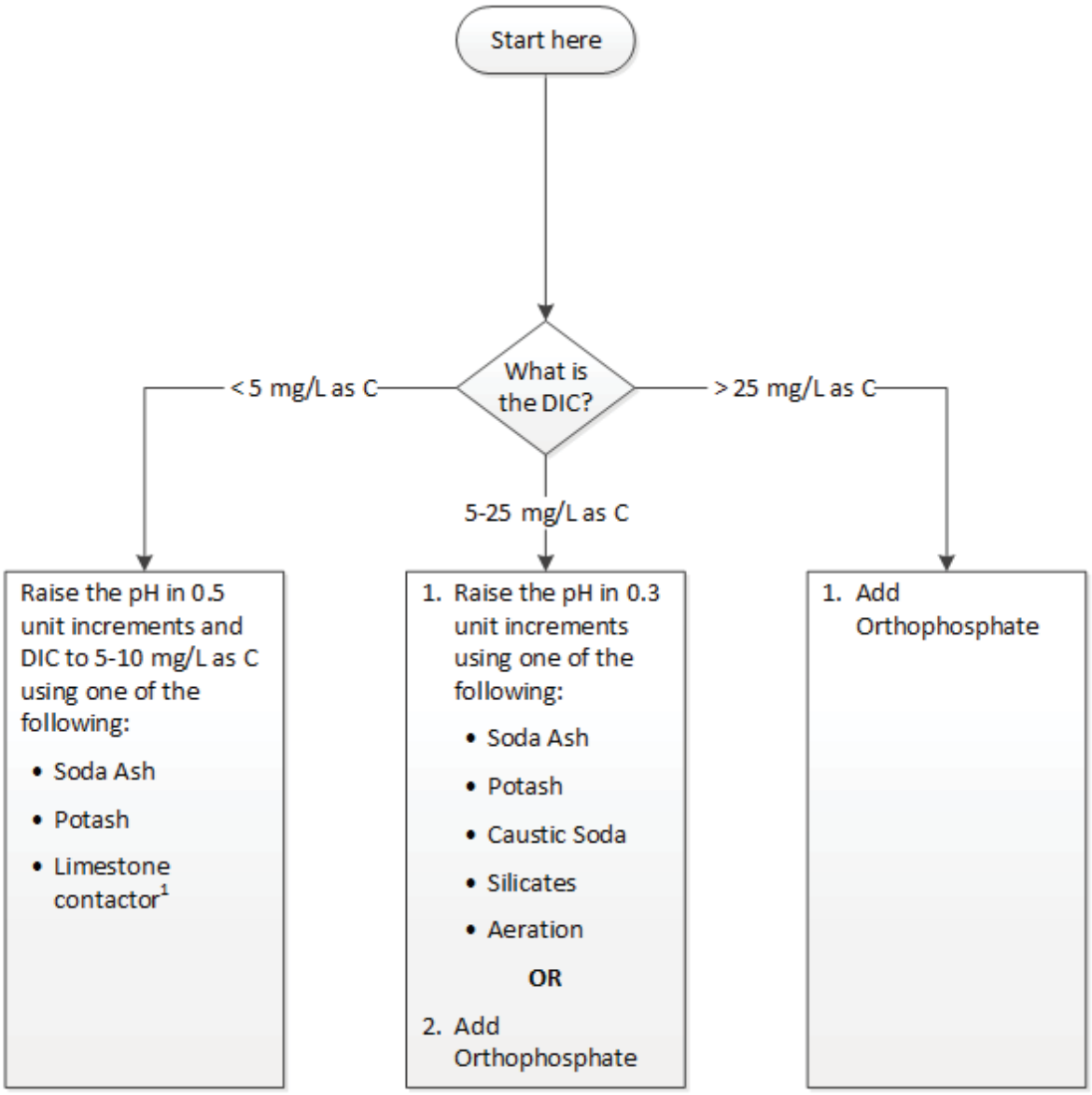
[3] The equilibrium constants are from: Plummer, L. N. and Busenberg, E. 1982. "Solubilities of Calcite Aragonite and Vaterite in CO2-H2O Solutions Between 0 and 90°C, and an Evaluation of the Aqueous Model for the System CaCO3-CO2-H2O". *Geochimica et Cosmochimica Acta (The Journal of The Geochemical Society and The Meteoritical Society)*. 46: 1011.

Flowchart 1: Selecting Treatment for Lead only or Lead and Copper with pH < 7.2



KEY:
AL = Action Level
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Flowchart 2: Selecting Treatment for Lead only or Lead and Copper with pH from 7.2 to 7.8



KEY:
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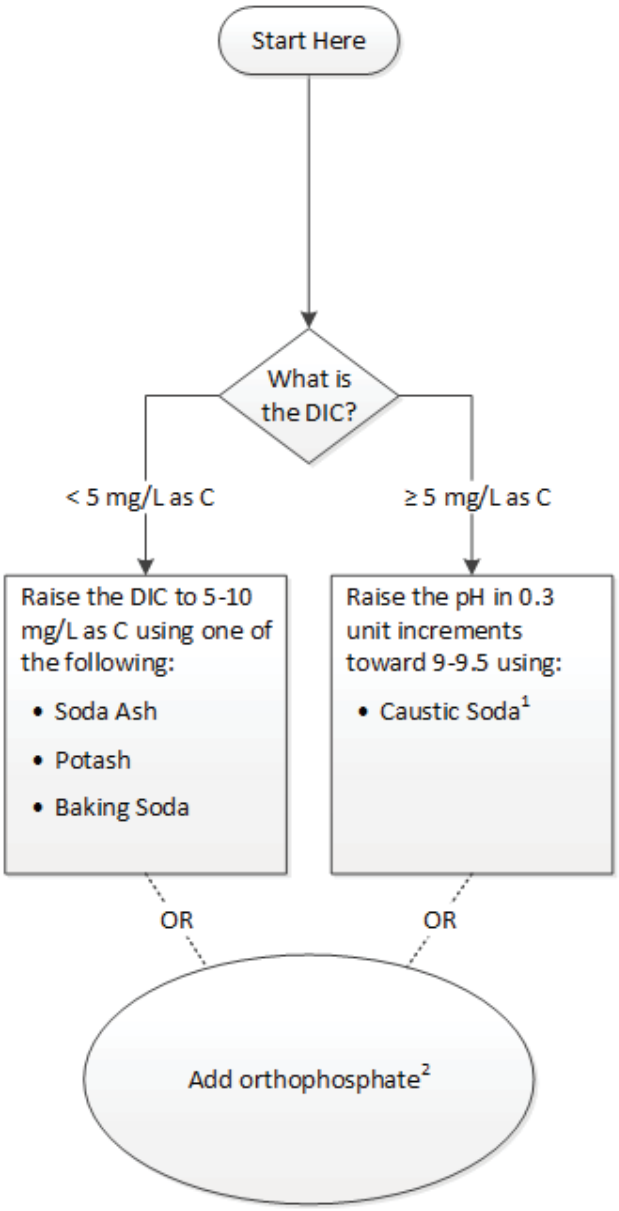
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:

1. Carbon dioxide feed before the limestone contactor may be necessary.

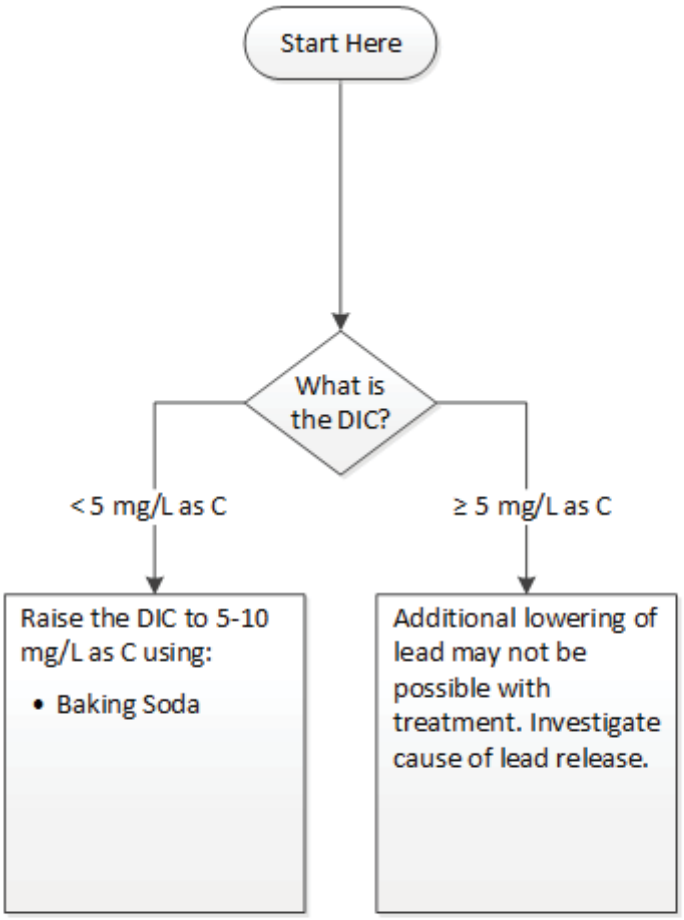
Flowchart 3: Selecting Treatment for Lead only or Lead and Copper with pH > 7.8 to 9.5



KEY:
AL = Action Level
Baking soda = sodium bicarbonate ($NaHCO_3$)
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

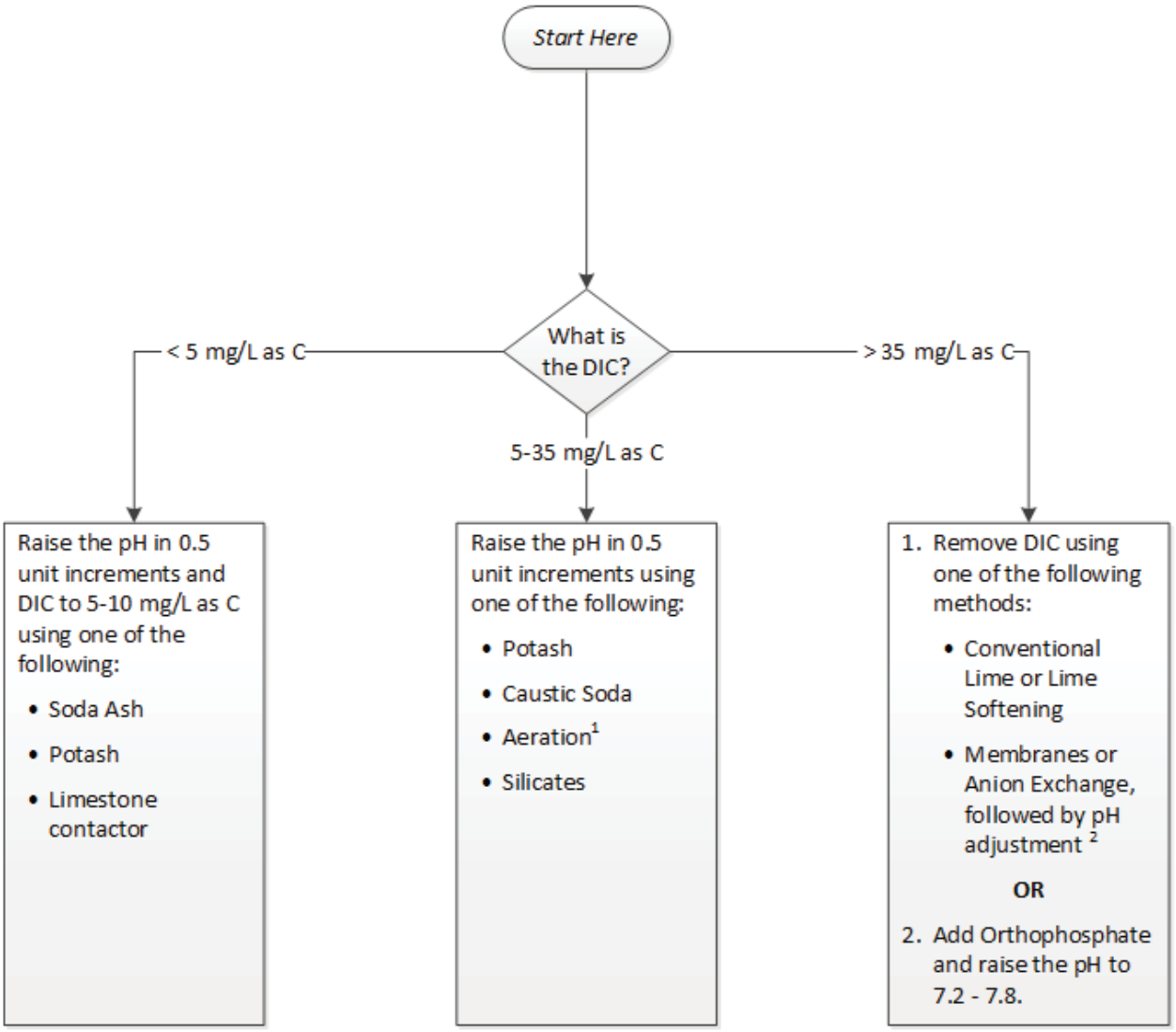
Footnotes:
1. Systems with copper plumbing may experience copper pitting problems when operating at pH 9 – 9.5 and DIC of 5 – 15. Orthophosphate may be a better option for these systems.
2. Optimal pH range for orthophosphate is 7.2 - 7.8 but phosphate may be effective at higher pH depending on dose. Orthophosphate effectiveness is lowest in the pH range of 8 – 8.5. Systems should also avoid this range because of inadequate buffering in the distribution system.

Flowchart 4: Selecting Treatment for Lead only or Lead and Copper with pH > 9.5



KEY:
AL = Action Level
Baking soda = sodium bicarbonate ($NaHCO_3$)
DIC = Dissolved Inorganic Carbon

Flowchart 5: Selecting Treatment for Copper Only with pH < 7.2

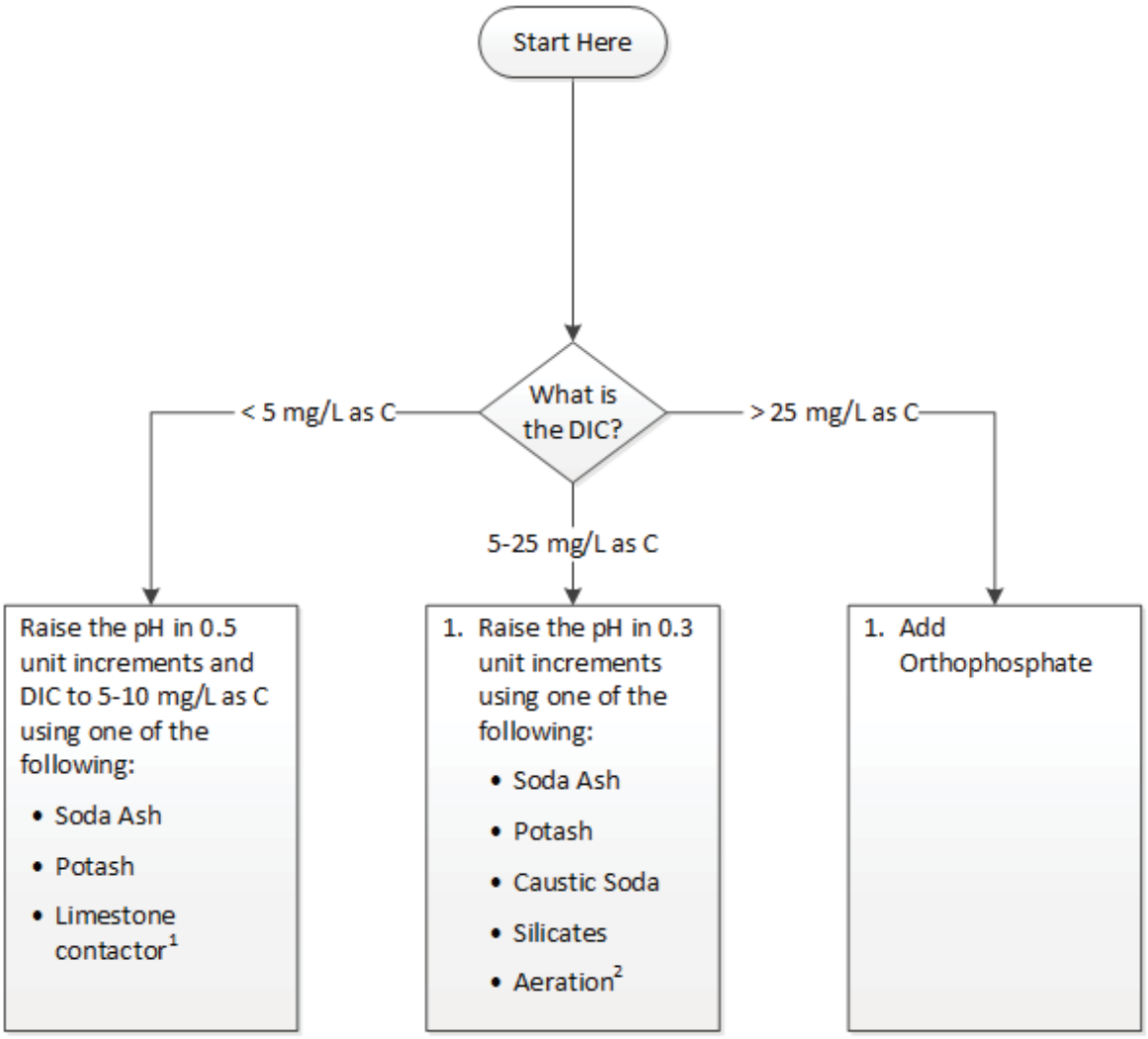


KEY:
AL = Action Level
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:

1. May be most appropriate at higher end of DIC range
2. To achieve optimal levels, consider treating less than 100 percent of the water (i.e., split stream).

Flowchart 6: Selecting Treatment for Copper Only with pH from 7.2 to 7.8

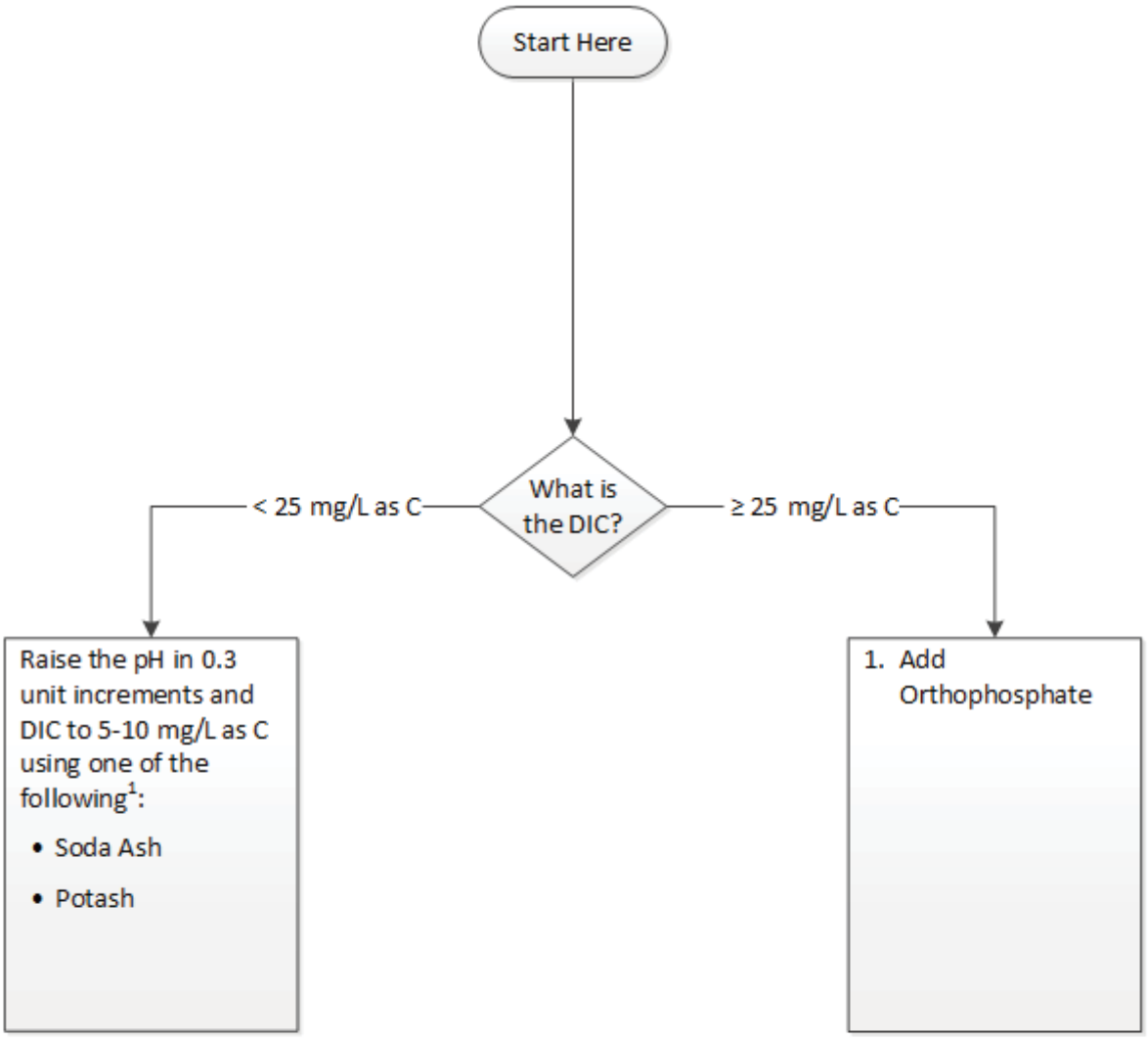


KEY:
AL = Action Level
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:

1. Carbon dioxide feed before the limestone contactor may be necessary.
2. May be most appropriate at higher end of DIC range

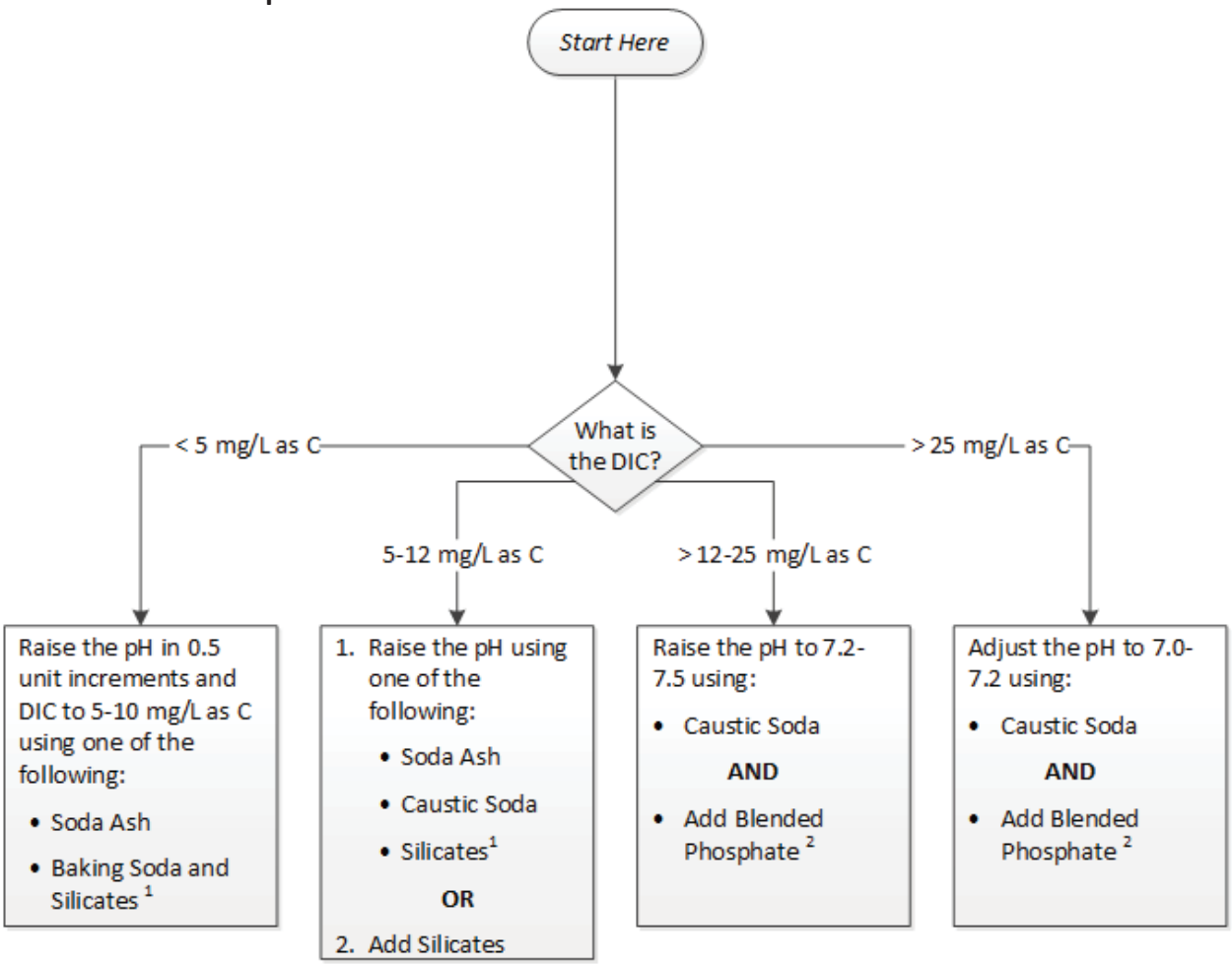
Flowchart 7: Selecting Treatment for Copper Only with pH > 7.8



KEY:
AL = Action Level
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Potash = potassium carbonate (K_2CO_3)
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:
1. Carbon dioxide feed before the limestone contactor may be necessary.

Flowchart 8: Selecting Treatment for Lead and/or Copper with Iron and Manganese in Finished Water and pH < 7.2

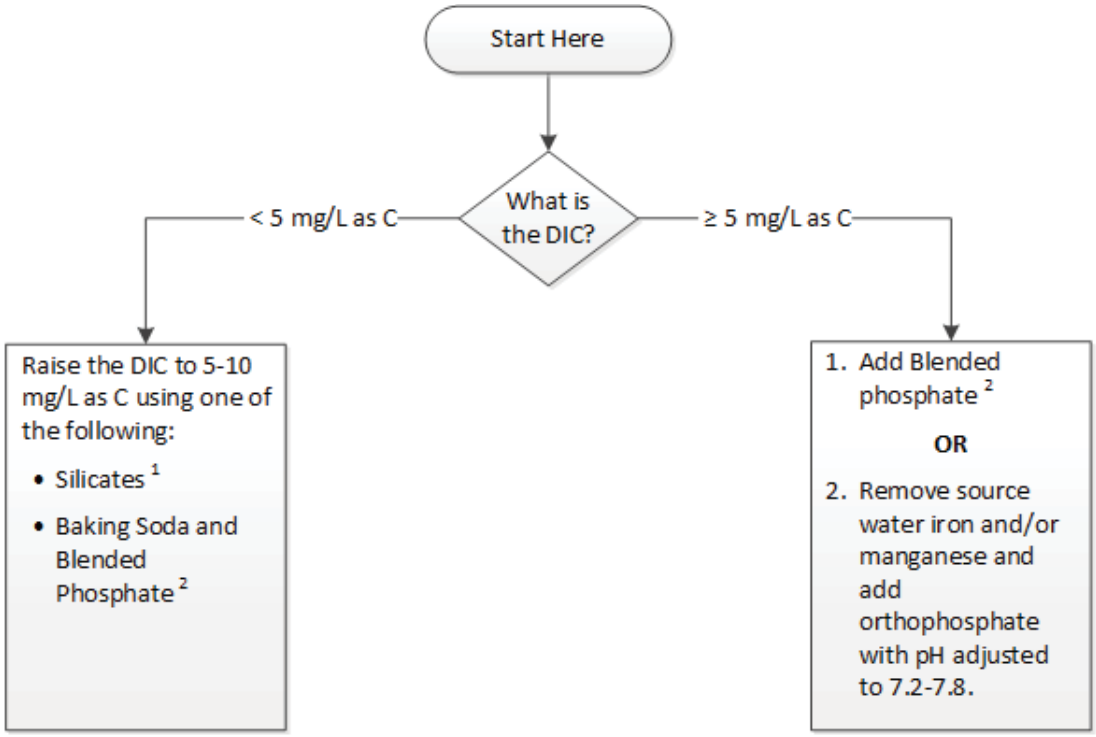


KEY:
AL = Action Level
Caustic soda = sodium hydroxide (NaOH)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon
Soda ash = sodium carbonate (Na_2CO_3)

Footnotes:

1. Silicates are most effective when combined iron and manganese concentrations are less than 1.0 mg/L.
2. The effectiveness of blended phosphate varies based on the formulation. Additional evaluation and/or monitoring is recommended. See Section 3.3.2 for additional discussion.

Flowchart 9: Selecting Treatment for Lead and/or Copper with Iron and Manganese in Finished Water and pH ≥ 7.2



KEY:
AL = Action Level
Baking soda = sodium bicarbonate ($NaHCO_3$)
DIC = Dissolved Inorganic Carbon
mg/L as C = milligrams per liter as carbon

Footnotes:

1. Silicates are most effective when combined iron and manganese concentrations are less than 1.0 mg/L.
2. The effectiveness of blended phosphate varies based on the formulation. Additional evaluation and/or monitoring is recommended. See Section 3.3.2 for additional discussion. Blended phosphates are less effective for controlling copper at DIC greater than 25 mg/L as C.

VERMONT
ENVIRONMENTAL CONSERVATION

FORM

Drinking Water and Groundwater Protection Division

CORROSION CONTROL TREATMENT RECOMMENDATION

WATER SYSTEM NAME _____ WSID _____

Upon being required to install corrosion control, the water system identified above will pursue the following treatment:

Treatment Recommendation

Check box or explain as needed:

- ☐ pH increase with sodium carbonate (soda ash)
- ☐ pH increase with sodium hydroxide (caustic soda)
- ☐ Orthophosphate addition
- ☐ Orthophosphate/polyphosphate blend (to also address Manganese/Iron)
- ☐ Aeration
- ☐ Other:

Reason/Rationale behind Recommendation

Summarize and/or attach relevant water quality data (e.g., pH, alkalinity, calcium, hardness, conductivity, lead and copper results history):

Other treatment present at the system (e.g., chlorination):

Certification

Name: _____ Signature: _____Date: _____

I certify that I am the person authorized to fill out this form and that the information contained herein is true, accurate, and complete to the best of my knowledge and ability at the time the assessment was performed.

Title (check one): ☐ Operator ☐ Administrative Contact

This guidance sheet and related environmental information are available electronically via the internet. For information visit us through the Vermont Homepage at http://www.vermont.gov or visit VT DWGWPD directly at http://dec.vermont.gov/water

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