Practical Brewing Water Chemistry

Overview

Why care about water chemistry?

What actually matters?

How do I adjust my water?

Resources to use

Why should I adjust my water?

Beer is 95% water!

Improve mash efficiency

Reduce astringency from incorrect mash and sparge pH

Improve color and clarity

Make hoppy beers hoppier, malty beers maltier

Improve yeast health

Good tasting water can still make bad beer

What to pay attention to

Mash pH – bicarbonate

Flavor ions – sulfate and chloride

What to ignore on water report/calculator:

- Hardness (just pay a little attention to calcium and magnesium)
- Residual Alkalinity (target your mash pH and the rest will follow)
- Starting pH of water (bicarbonate drives mash pH)

Mash pH

Mostly driven by water alkalinity/bicarbonate

- Bicarbonate (HCO_3) is a buffer – resists change in pH. High bicarbonate levels means it will be harder to adjust your pH.
- Alkalinity is a measure of buffering capacity

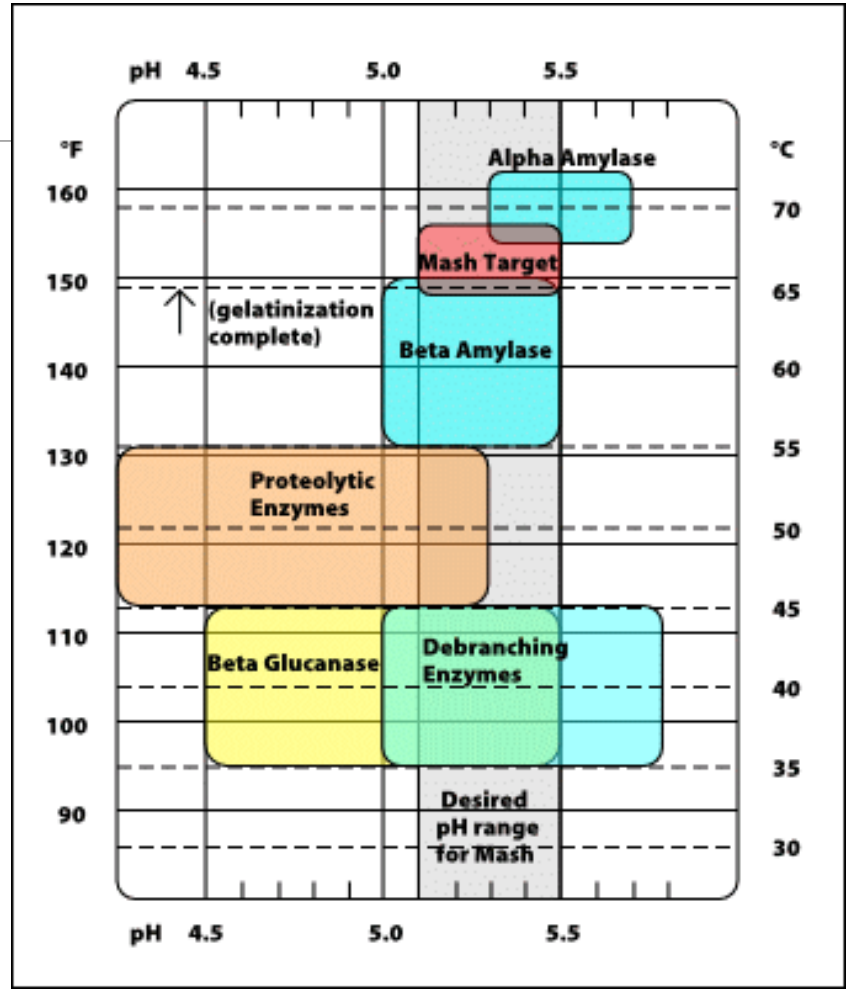
Grain bill also has an effect:

- Color of grain is a good indicator: darker, roasted grains will lower pH more

Calcium and magnesium additions will lower pH slightly

Target 5.3 to 5.5 when measured at room temperature

- Dark beers usually benefit from higher end
- Lighter and crisper beers usually benefit from lower end



Flavor ions

Two most important are Chloride (Cl^-) and Sulfate (SO_4^-)

- Cl^- gives a full, smooth mouthfeel and enhances maltiness
- SO_4^- makes beer feel dryer and enhances hop bitterness
- Often referenced to as a ratio, but absolute values matter too

Magnesium (Mg), calcium (Ca), sodium (Na) are less important to target.

- Mg is a yeast nutrient, but malt usually has enough. Too much creates bitterness & laxative effect…
- Ca aids in clarification. Usually have enough from Cl and SO_4 additions.
- Na accentuates flavor, but best kept at low levels usually. Harmful to yeast health.

Generally, these don’t affect mash/fermentation, only flavor of finished beer.

Water Adjustment Process

Step 1: Get water report (or use 100% RO water)

Step 2: Enter water report and grain bill into a water calculator

Step 3: Guess-and-check mineral additions to meet target profile

Step 4: Add acid or acid malt to calculator as needed to get to target mash pH

Step 5: Brew!

Step 1: Water report

Syracuse city water is available: http://www.syracuse.ny.us/pdfs/Water/WaterNewsletter.pdf and http://www.ocwa.org/2016-annual-water-quality-and-water-supply-statement/

- Likely a mix of Otisco, Ontario, and Skaneateles

Ward Labs W-5A test: $27+postage

Check units! Sulfate as SO_4-S, Bicarbonate as $CaCO_3$. Calculators will help clarify

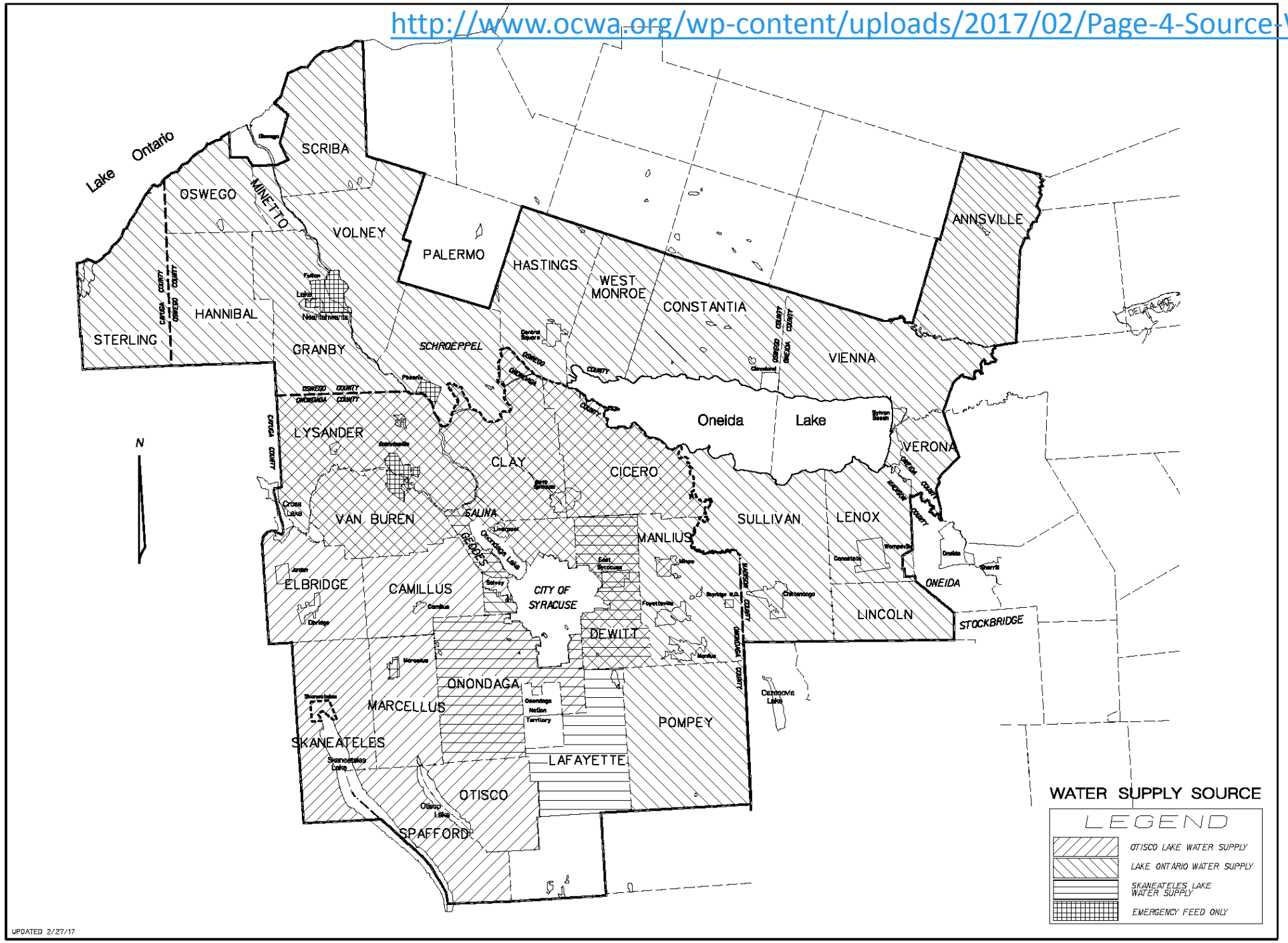
If unsure of your water, using 100% RO water is a cheap and easy way to control your water

Water Report Input

Cations	Enter Ion Concentrations from Water Report (mg/L or ppm)		Anions
Calcium (Ca)	34.0	121.4	Bicarbonate (HCO_3)
Magnesium (Mg)	13.0	0.3	Carbonate (CO_3)
Sodium (Na)	10.0	14.0	Sulfate (SO_4)
		20.0	Chloride (Cl)
Optional Inputs (not required, but may improve ion balance)		0.5	Nitrate (NO_3)
Potassium (K)	0.0	0.0	Nitrite (NO_2)
Iron (Fe)	0.1	0.7	Fluoride (F)

Syracuse city water 2015

http://www.ocwa.org/wp-content/uploads/2017/02/Page-4-Source-Water-Map.pdf



Step 2: Use a brewing water calculator

[Bru’n Water]

Beersmith

[Brewer’s Friend]

[EZ Water]

Water Profile Adjustment Calculator

Desired Water Profile		Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
NE Hoppy		125	10	10	125	125	85
Existing Water Profile		55	13	17	18	4	226
Dilution Water Profile							
RO Water		1	0	8	1	4	16
Percent Dilution Water	71	91	oz/gal	6	pt/gal	< These conversions are	
Diluted Water Profile		17	4	11	6	4	77
Target Finished Water Adjustment (ppm)		**108**	**6**	**-1**	**119**	**121**	**8**
Actual Finished Water Adjustment (ppm)		**126**	**0**	**0**	**118**	**135**	**0**
Mashing Water Profile		142	4	11	124	139	77
Overall Finished Water Profile		142	4	11	124	139	NA

Bru’n Water

Step 2: Enter grain bill, determine target

Grain bill will help determine mash pH adjustments

- Grain type and color determine affect on pH

Target profile is mostly driven by sulfate & chloride values

- Most calculators have preset profiles based on color/balance
- Yellow full – 55:70 ppm
- Yellow dry – 105:45 ppm
- NEIPA – 150:150 ppm

Generally keep sulfate <350ppm and chloride <150ppm

Targeting a specific city may not be useful – brewers often treated and/or pre-boiled water

Grain Bill Input

Grains	Grain Type	Quantity (lb)	Quantity (oz)	Color (L)	Percentage of Grain Bill
Weyermann Pilsner	Base Malt	7.0	0.0	2	54.5
Weyermann Munich	Base Malt	4.0	0.0	7	31.1
Weyermann Caramunich II	Crystal Malt	0.8	0.0	46	5.8
Carafa Special II	Roast Malt	0.4	0.0	430	3.1
Crystal 80	Crystal Malt	0.4	0.0	80	3.1
Acid Malt	Acid Malt	0.3	0.0	2	2.3

Desired Water Profile	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Brown Balanced	50	10	27	70	55	90
Yellow Balanced	50	7	5	75	60	0
NE Hoppy	125	10	10	125	125	85
Pale Ale Profile	113	20	25	300	55	35

Step 3: Calculating mineral additions

Calcium Chloride (CaCl)

- Chloride gives a full, smooth mouthfeel and enhances maltiness

Gypsum (Calcium Sulfate, $CaSO_4$)

- Sulfate makes beer feel dryer and enhances hop bitterness

For Bru'N Water it's a guess-and-check approach until finished profile is close to desired target profile

Mineral additions will affect mash pH slightly

Desired Water Profile	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
NE Hoppy	125	10	10	125	125	85
Existing Water Profile	55	13	17	18	4	226

Mashing Water Profile	134	4	11	124	124	77
Overall Finished Water Profile	134	4	11	124	124	NA

Water Additions							
Minerals	Addition (gram/gal)	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Gypsum ($CaSO_4 \times 2H_2O$)	0.80	49.2			117.9		
Calcium Chloride ($CaCl_2$)	0.71	67.7				119.8	
Epsom Salt ($MgSO_4 \times 7H_2O$)	0.00		0.0		0.0		
Magnesium Chloride ($MgCl_2 \times 6H_2O$	0.00		0.0			0.0	
Canning Salt (NaCl)	0.00			0.0		0.0	
Baking Soda ($NaHCO_3$)	0.00			0.0			0.0
Chalk ($CaCO_3$)	0.00	0.0					0.0
Pickling Lime ($Ca(OH)_2$)	0.00	0.0					0.0

Step 4: Adjusting Mash pH

Acid (Lactic, Phosphoric)

- Up to ~5mL Lactic

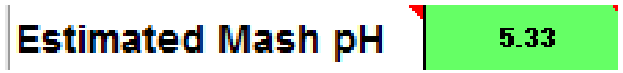
Acid malt

- Up to ~5% of grain bill

Dilute with RO if your mash pH can't get low enough due to your water's alkalinity

- Will likely need to dilute if your bicarbonate is above 150 ppm unless you're making a dark beer

Target pH of 5.3 to 5.5



Step 5: Brew!

Add minerals/acid to strike water and sparge water as necessary

Mash pH is difficult to adjust on the fly, so measure and make adjustments on the next brew day if needed

Water Adjustment Summary

Hover cursor over cells w/ red corner marks to display helpful information

NE Hoppy	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Existing Water Profile	55	13	17	18	4	226
Mashing Water Profile	142	4	11	124	139	77
Finished Water Profile	142	4	11	124	139	NA
Recommended Ranges	20 to 150	0 to 30	0 to 150	0 to 350	0 to 100	as needed

Mash Parameters					
Batch Volume (gallons)	5.50	Hardness (ppm as $CaCO_3$)	371	RA (ppm as $CaCO_3$)	-41
Estimated Mash pH	5.33	Alkalinity (ppm as $CaCO_3$)	63	SO_4/Cl Ratio	0.9

Additions		Total Mash Water Vol (gal)	7.90	Total Sparge Water Vol (gal)	0.00
		Mash Dilution Vol (gal)	5.61	Sparge Dilution Vol (gal)	0.00
		Mash Water Additions		Sparge Water Additions	
Minerals		(grams)		(grams)	
Gypsum ($CaSO_4 \times 2H_2O$)		6.3		0.0	
Calcium Chloride ($CaCl_2$)	Anhydrous	6.3		0.0	
Epsom Salt ($MgSO_4 \times 7H_2O$)		0.0		0.0	
Magnesium Chloride ($MgCl_2$)		0.0		0.0	
Canning Salt (NaCl)		0.0		0.0	
Baking Soda ($NaHCO_3$)		0.0		Not Recommended	
Chalk ($CaCO_3$)		0.0		Not Recommended	
Pickling Lime ($Ca(OH)_2$)		0.0		Not Recommended	
Acids					
		0.0	(ml)		
		0.0	(ml)		
Lactic	88.00 %			0.0	(ml)
				0.0	(ml)

118 (ppm) Lactate added to water Expected to be under taste threshold

Other Notes

Sparge water acidification: lower pH to 5.5 to 6.0 to prevent tannin extraction

Chlorine/Chloramines – aerate, add metabisulfate (campden), or carbon filter

Water softeners replaces calcium and magnesium with sodium or potassium – avoid

A precise scale able to measure at least 0.1g is better than volume-based measurements (like tsp)

Rare case you need to increase pH:

- Chalk doesn't dissolve well, so it's difficult to use
- Add pickling lime after grain to reduce large swings. Handle with care.
- Baking soda adds sodium, so limit additions

Flavor ions don't affect fermentation/mash much – you can add them in your glass!

Conclusions

Adjust mash pH with acid or acid malt, dilute with RO water if necessary

Add gypsum and calcium chloride to hit sulfate and chloride targets

You don’t need to know the chemistry/math behind it! Just like an IBU formula – the calculators exist for a reason

Resources

Bru'N Water "Water Knowledge" https://sites.google.com/site/brunwater/water-knowledge

- In the spreadsheet, hover over cells to learn info on acceptable ranges of minerals and how concepts apply

http://brulosophy.com/projects/exbeeriments/ search water chemistry, that's been one area they've consistently seen significant difference

For more technical information, see Kaminski and Palmer book: *Water: A Comprehensive Guide for Brewers* and Chapter 15 of How to Brew by Palmer (http://howtobrew.com/book/section-3/understanding-the-mash-ph/)

Questions?