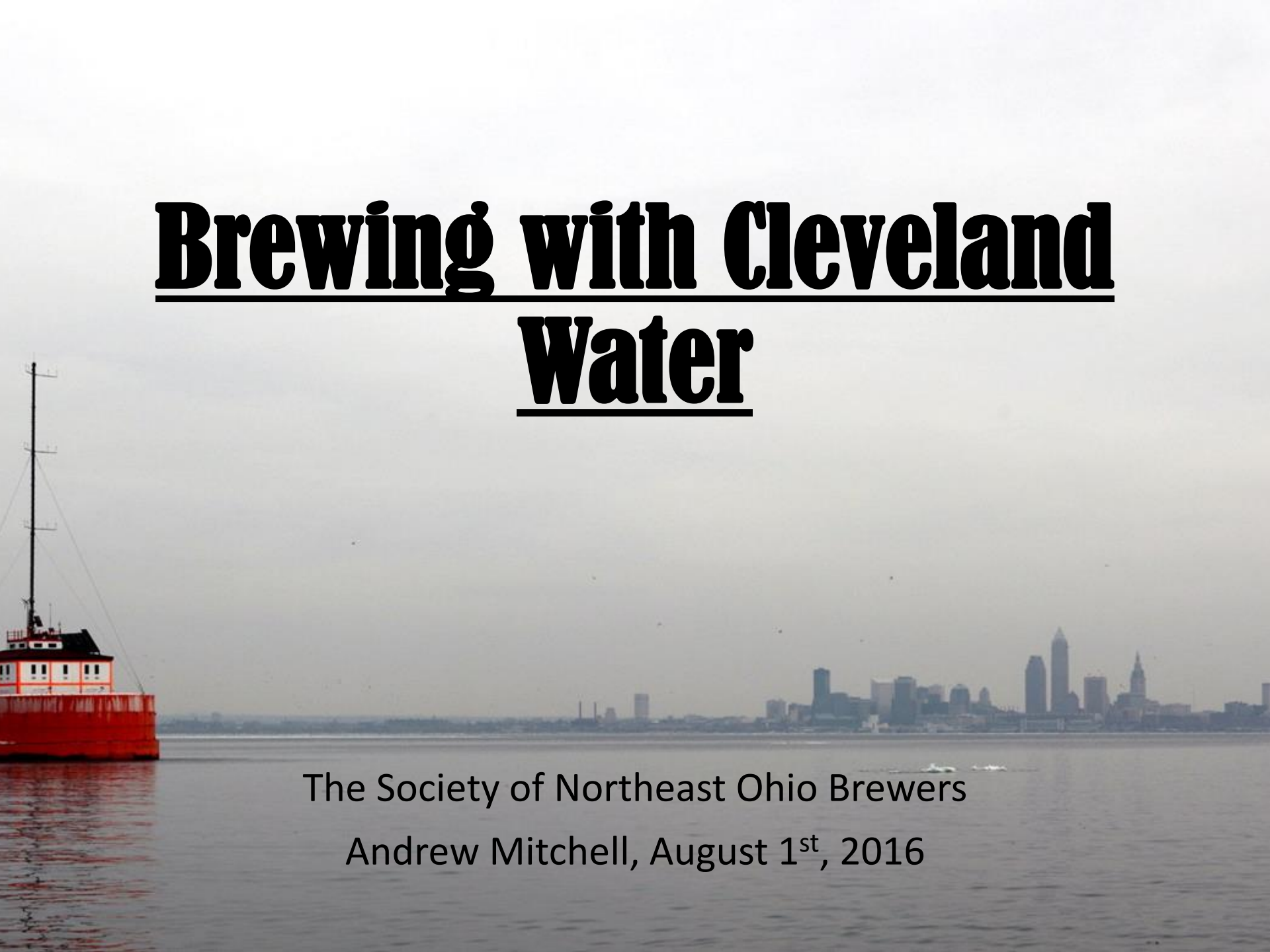
Brewing with Cleveland Water



The Society of Northeast Ohio Brewers

Andrew Mitchell, August 1st, 2016

Why Fuss with Water?

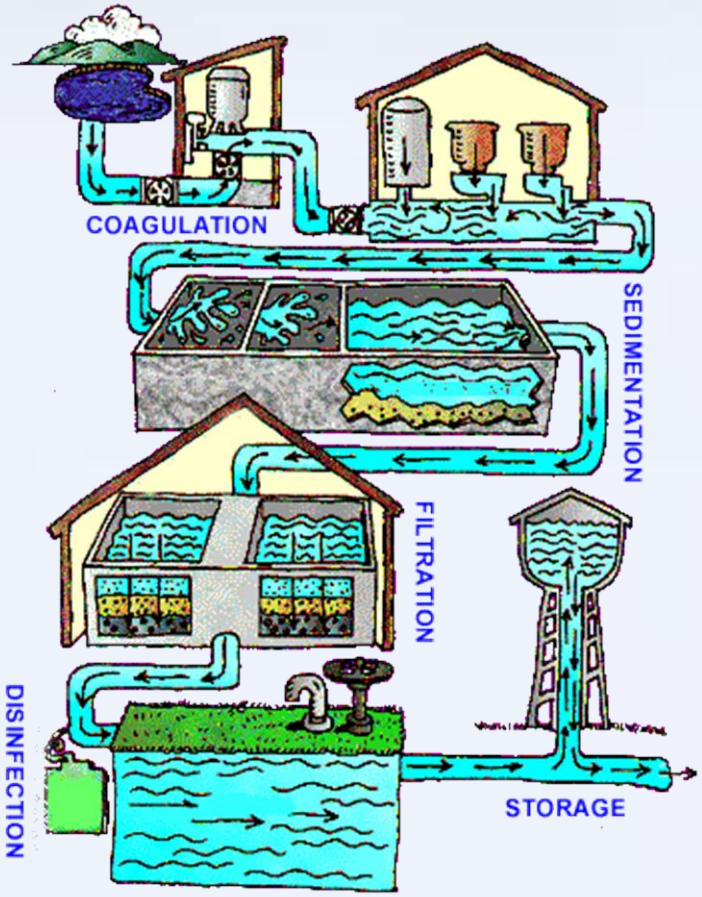
- Colorless, odorless, cheap
- Underestimated, ignored, discarded
- Very little guidance in BJCP guidelines
- Not special ordered or shipped like other ingredients

Cleveland Water

- Abundant
- Single source
- Regionally consistent
- Suitable for many styles
- Easy to treat
- Hardly ever catches on fire

Municipal Treatment

- Coagulation
- Sedimentation
- Sand/charcoal filtration
- Disinfection: CLE uses free chlorine
- Chloramine = difficult to remove
- Chlorine = easy to remove
- We are lucky!

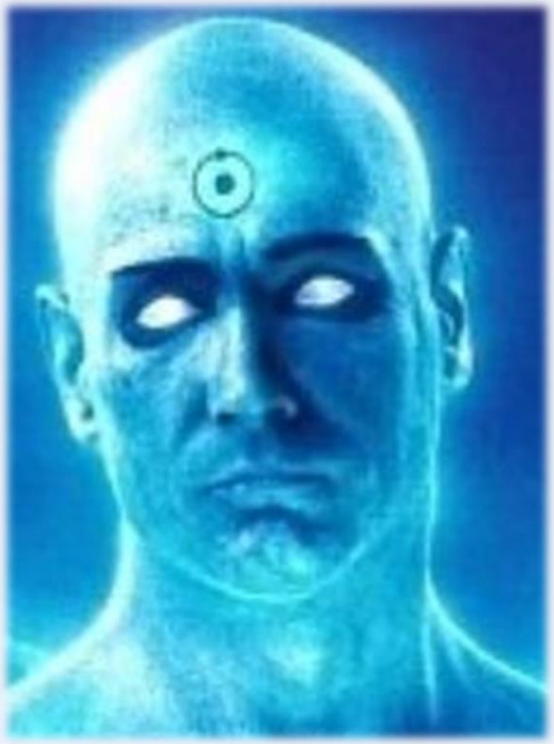


Consumer Treatment

- Open air off-gassing (chlorine)
- Campden tablets (chlorine/chloramine)
- Carbon block filter (chlorine/chloramine/zinc/organics)
- Heating / boiling (chlorine/temporary hardness)
- Distillation (mineral ions, heavy metals, organics)
- Reverse osmosis (most dissolved solids)
- Ion-exchange resins / (mineral ions)
- Multi-stage cartridge filter (carbon + ion-exchange)

pH – Why does it Matter?

- The power of hydrogen
  - Hydronium (H+)= cation (positive)
  - Hydroxide (OH-)= anion (negative)
- High pH = hydronium > hydroxide
- Low pH = hydroxide > hydronium
- Mash conversion & extraction
- Yeast health
- Beer storage, stability, & taste



Measuring pH

- Water analysis reports
- Test strips
- Pen-style meters
- Dual-probe meters
- Photometers
- Why bother?

Controlling pH

- Alkalinity & buffers
  - Bicarbonate (anion) neutralizes hydronium (cation)
- Mineral influences
  - Gypsum & calcium chloride lower pH
  - Chalk & baking soda raise pH
- Chemical acidulation
  - Lactic & phosphoric acid lower pH
- Roasted & dark grains lower pH
- Acidulated malt (sauermalz)

Brewing Mineral Ions

- Charged atoms/compounds
  - Cation = positive (missing electron) metals
  - Anion = negative (extra electron) nonmetals
  - Natural tendency to seek balance
- Water efficient medium for ionizing mineral compounds
- Influences extraction in brewing
- Proper levels required for yeast health
- Dictates pH
- Effects beer aroma, flavor, mouthfeel, and clarity

Brewing Ions - Sulfate

- Recommended concentration: 0-350+ ppm
- Should be <150 ppm unless beer is highly hopped
- >350 ppm can produce sulfury aromas & astringency
- Benefits in beer: accentuates hop bitterness; makes it drier and crisper
- Addition sources:
  - Calcium sulfate (gypsum)
  - Magnesium sulfate (epsom salt)

Brewing Ions - Calcium

- Recommended concentration: 50-100+ ppm
- Effects pH
- Benefits in beer: clarity, stability, and flavor
- Addition sources include:
  - Calcium sulfate (gypsum)
  - Calcium chloride
  - Sodium bicarbonate (baking soda)
  - Calcium carbonate (chalk)

Brewing Ions - Magnesium

- Recommended concentration: 0-30ppm
- Concentrations ≥50 ppm create astringent, sour bitterness taste
- Concentrations >125 ppm have diuretic effect
- Benefits in beer: yeast health, flocculation
- Amount needed for yeast health typically sufficient from the malt itself
- Addition sources:
  - Magnesium sulfate (epsom salt)

Brewing Ions - Chloride

- Recommended concentration: 10-250 ppm
- Keep <100 ppm when sulfate also high to avoid harshness (chloride/sulfate ratio)
- Benefits in beer: accentuates maltiness, adds body
- Most Cl compounds dissolve easily in water
- Addition Sources:
  - Calcium chloride
  - Sodium chloride (kosher table salt)

Brewing Ions - Bicarbonate

- Recommended concentrations:
  - 0-50ppm for light/base malt only beers
  - 50-150 ppm for amber/toasted malt beers
  - 150-250 ppm for dark/roasted malt beers
- Benefits in beer: buffers/raises pH (dark malts lower the pH)
- Cleveland water levels high for most light beers
- Addition Sources:
  - Calcium carbonate (chalk) – difficult to dissolve in water
  - Sodium bicarbonate (baking soda) – not commonly used

Brewing Ions - Sodium

- Recommended concentration: 0-150 ppm
- 70-150 ppm can round out flavors and accentuate malt sweetness
- >200 ppm creates salty taste
- High sodium + high sulfate = harsh bitterness
- Low sodium typically desired for most styles
- Addition sources:
  - Sodium chloride (kosher table salt)
  - Sodium Bicarbonate (baking soda)

Measuring Ions

- Water analysis report
- Test strips
- Photometer/colorimeter
- Converting polyatomic ionic measurements:
  - Must be factored for use in brewing water calculators
  - Calcium reported as CaCO3: multiply by 0.4
  - Sulfate reported as SO4-S: multiply by 3
  - Chloride reported as NaCl: multiply by 0.6
  - Sodium reported as NaCl: multiply by 0.4

Cleveland Levels - Observed

- pH: 7.0-7.6
- Total Alkalinity: 70-100 ppm
- Total Hardness: 100-130 ppm
- Bicarbonate (HCO3): 85-120 ppm (typically ~90)
- Calcium (Ca): 30-35 ppm
- Sulfate (SO4): 25-40 ppm
- Chloride (Cl): 15-30 ppm
- Magnesium (Mg): ~9 ppm
- Sodium (Na): 10-20 ppm

Cleveland Levels - Assumed

- pH: 7.3
- Total Alkalinity: 77 ppm
- Total Hardness: 119 ppm
- Bicarbonate (HCO3): 94 ppm
- Calcium (Ca): 33 ppm
- Sulfate (SO4): 35 ppm
- Chloride (Cl): 24 ppm
- Magnesium (Mg): 9 ppm
- Sodium (Na): 13 ppm

*Assumed levels approximated for Cleveland water recipes. Adjustments may be necessary based on observed levels at specific location.

Calculators and Spreadsheets

- Bru'n Water
- EZ Water Calculator
- Probrewer.com water chemistry calculator
- The Brewer's Friend online calculator
- A.J. deLange's NUBWS (Nearly Universal Brewing Water Spreadsheet)
- Greg Noonan's Water Witch spreadsheet

Example Spreadsheet

Bru'n Water

Link to Bru'n Water website for updates and to donate

Water Report Input

Hover cursor over cells w/ red triangles to display helpful com

Cations	Enter Ion Concentrations from Water Report (mg/L or ppm)		Anions
Calcium (Ca)	33.0	94.0	Bicarbonate (HCO_3)
Magnesium (Mg)	9.0	0.0	Carbonate (CO_3)
Sodium (Na)	13.0	35.0	Sulfate (SO_4)
Potassium (K)	0.0	24.0	Chloride (Cl)
Iron (Fe)	0.0	0.0	Nitrate (NO_3)
		0.0	Nitrite (NO_2)
		0.0	Fluoride (F)

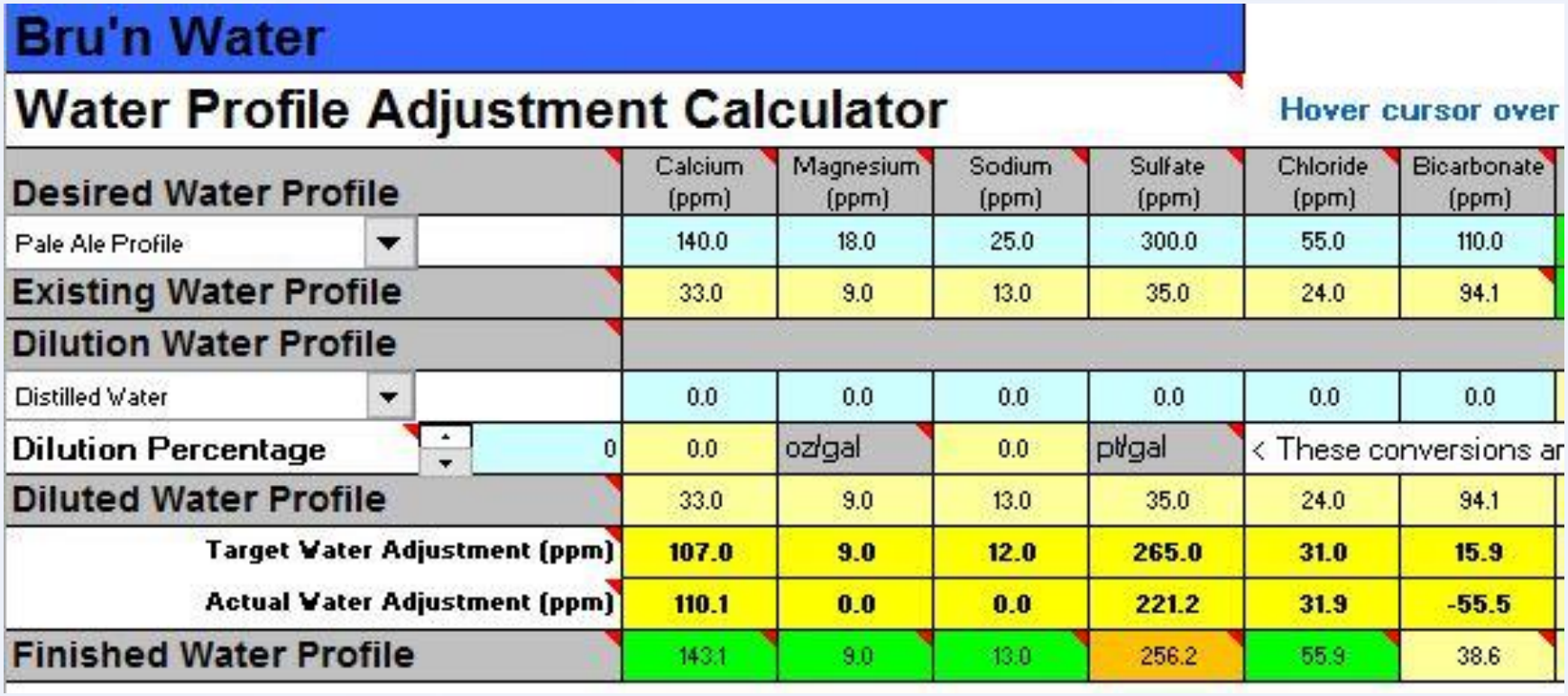
If water report provides only Total Alkalinity (as $CaCO_3$), use the calculator below to estimate the Bicarbonate and Carbonate concentrations. Insert the estimated results in the table above.

Reported Total Alkalinity (as CaCO3) (mg/L or ppm)	Reported or Measured Water pH	Estimated Bicarbonate Concentration (ppm)	Estimated Carbonate Concentration (ppm)
77.0	7.3	93.8	0.1

Ion Balance Results			
Total Cations (meq/L)	2.95	0.00	Cation/Anion Difference
Total Anions (meq/L)	2.95		

Hardness and Alkalinity Results

Example Spreadsheet



Bru'n Water

Water Profile Adjustment Calculator

Hover cursor over

	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Desired Water Profile						
Pale Ale Profile	140.0	18.0	25.0	300.0	55.0	110.0
Existing Water Profile	33.0	9.0	13.0	35.0	24.0	94.1
Dilution Water Profile						
Distilled Water	0.0	0.0	0.0	0.0	0.0	0.0
Dilution Percentage 0	0.0	oz/gal	0.0	pt/gal	< These conversions ar	
Diluted Water Profile	33.0	9.0	13.0	35.0	24.0	94.1
Target Water Adjustment (ppm)	**107.0**	**9.0**	**12.0**	**265.0**	**31.0**	**15.9**
Actual Water Adjustment (ppm)	**110.1**	**0.0**	**0.0**	**221.2**	**31.9**	**-55.5**
Finished Water Profile	143.1	9.0	13.0	256.2	55.9	38.6

Example Spreadsheet

Mash Parameters					
Batch Volume (gal)	5.00	Hardness (ppm as $CaCO_3$)	395	RA (ppm as $CaCO_3$)	-76
Estimated Mash pH	5.4	Alkalinity (ppm as $CaCO_3$)	32	SO_4/Cl Ratio	4.58

Additions	Total Mash Water Vol (gal)	3.50	Total Sparge Water Vol (gal)	6.30
	Mash Dilution Vol (gal)	0.00	Sparge Dilution Vol (gal)	0.00
	Mash Water Additions		Sparge Water Additions	
Mineral	(grams)		(grams)	
Gypsum ($CaSO_4$)	5.3		9.5	
Epsom Salt ($MgSO_4$)	0.0		0.0	
Canning Salt (NaCl)	0.0		0.0	
Baking Soda ($NaHCO_3$)	0.0		Not Recommended	
Calcium Chloride ($CaCl_2$)	0.9		1.6	

Style Example: American IPA

- Very bitter, hop-forward
- SO4/Cl ratio of at least 4:1
- Low SRM (base malt only)
- Brilliant clarity
- Mitigate hop astringency

IPA: Cleveland Water Recipe

Target Levels

- Mash pH: 5.3 – 5.5
- HCO3: 39 - 94 ppm
- Ca: 150 ppm
- Mg: 9 ppm
- SO4: 278 ppm
- Cl: 56 ppm
- Na: 13 ppm

Recipe

- Distilled/RO: 0%
- *Lactic Acid: 0 - 0.3ml/gal
- Gypsum: 1.65 gram/gal
- Calcium Chloride: 0.25 gram/gal

*** pH meter recommended if using lactic acid**

Style Example: Burton Ale

- English Pale Ale
- Historical Burtonized interpretation
- High mineral content
- Absurdly high sulfate
- Mineral taste acceptable
- Some crystal malt character
  - Target for this recipe is ~10 SRM
- Accentuated hop bitterness

Burton Ale: Cleveland Water Recipe

Target Levels

- Mash pH: 5.5
- HCO3: 255 ppm
- Ca: 306 ppm
- Mg: 9 ppm
- SO4: 477 ppm
- Cl: 88 ppm
- Na: 13 ppm

Recipe

- Distilled/RO: 0%
- *Chalk: 0.5 gram/gal
- Gypsum: 3 gram/gal
- Calcium Chloride: 0.5 gram/gal

***Chalk should be added directly to mash, not sparge**

Style Example: Cream Ale

- Clean, balanced
- SO4/Cl ratio ~1:1
- Low SRM (base malt only)
  - 24% flaked corn used in this example
  - 4-5 SRM targeted in this recipe
- Brilliant clarity
- Mitigate mineral harshness

Cream Ale: Cleveland Water Recipe

Target Levels

- Mash pH: 5.5
- HCO3: 1 ppm
- Ca: 53 ppm
- Mg: 5 ppm
- SO4: 54 ppm
- Cl: 50 ppm
- Na: 7 ppm

Recipe

- Distilled/RO: 50%
- *Lactic Acid: 0.25ml/gal
- Gypsum: 0.25 gram/gal
- Calcium Chloride: 0.3 gram/gal

*** pH meter recommended if using lactic acid**

Style Example: English Porter

- Less hoppy or roasty than U.S. versions
- More malty, chocolaty, softer than U.S. versions
- Copious use of dark roasted & brown malt
- High SRM & malt-driven acidity
  - This recipe assumes 30 SRM
- Buffers needed to maintain proper mash pH
- Traditionally hard water profile
  - 0.6-0.8 SO4/Cl ratio

English Porter: Cleveland Water Recipe

Target Levels

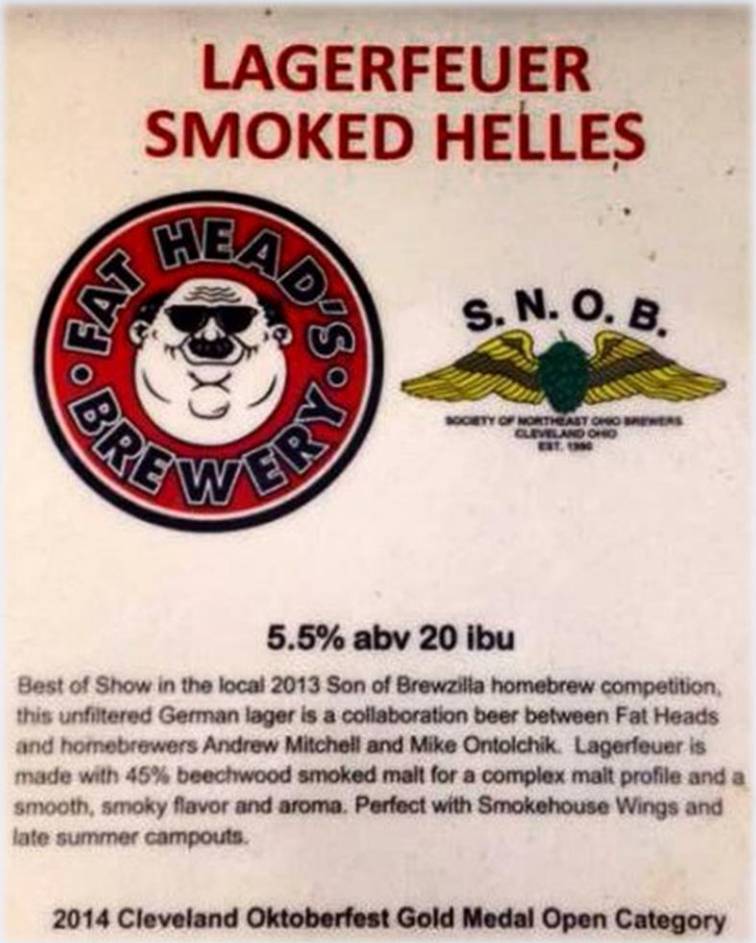
- Mash pH: 5.3
- HCO3: 94 ppm
- Ca: 81 ppm
- Mg: 9 ppm
- SO4: 64 ppm
- Cl: 88 ppm
- Na: 13 ppm

Recipe

- Distilled/RO: 0%
- *Chalk: not recommended
- Gypsum: 0.2 gram/gal
- Calcium Chloride: 0.5 gram/gal

*** If recreating London water profile, use 0.2 g/gal chalk, 0.15 g/gal calcium chloride, no gypsum**

Style Example: Helles Lager



- Light, malt-driven lager
- Low-Moderate mineral content
- Predominantly pilsner malt
  - This recipe assumes 100%
- Clean, well attentuated
- Low-acidity grain bill
  - Target for this recipe is ~6 SRM
- Low bicarbonate (contradicts Munich water profile)

Helles Lager: Cleveland Water Recipe

Target Levels

- Mash pH: 5.3
- HCO3: -51 ppm
- Ca: 67 ppm
- Mg: 2 ppm
- SO4: 54 ppm
- Cl: 76 ppm
- Na: 3 ppm

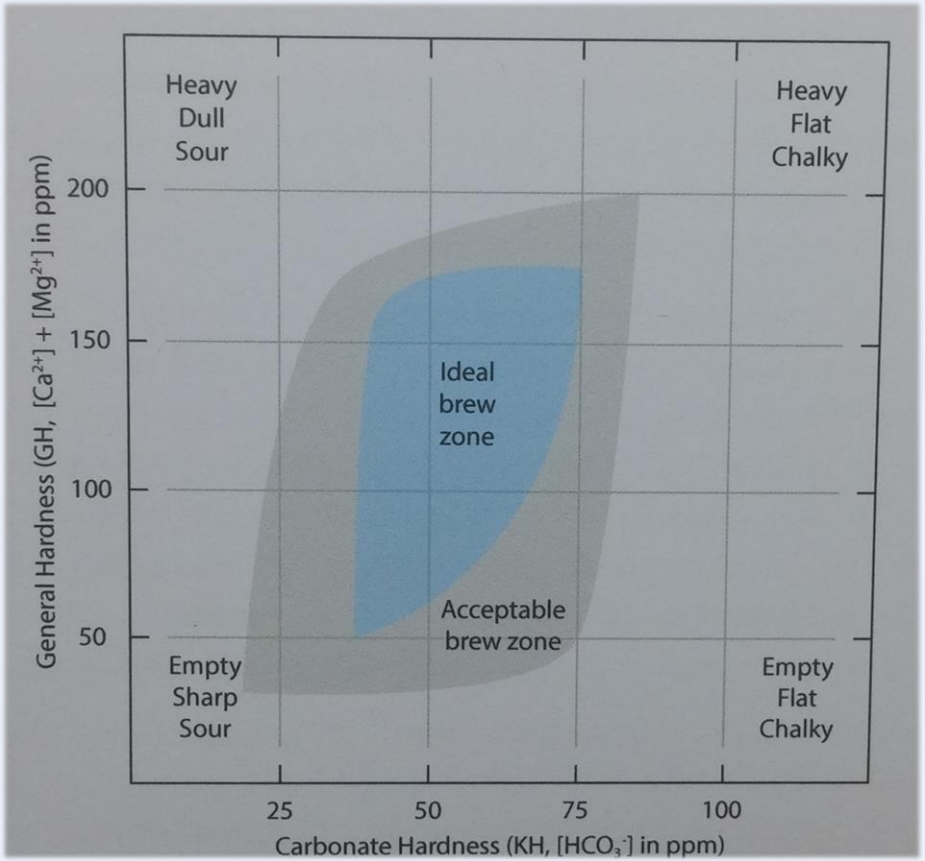
Recipe

- Distilled/RO: 75%
- *Lactic Acid: 0.4 ml/gal
- Gypsum: 0.31 gram/gal
- Calcium Chloride: 0.55 gram/gal

*** pH meter recommended if using lactic acid**

Style Example: Coffee

- Brewed coffee ~ 5 pH
- High pH water = more acid extraction
- Narrow window for bicarbonate
- Magnesium & calcium have same effect – body & flavor



Coffee: Cleveland Water Recipe

Target Levels

- Coffee pH: 5
- HCO3: 65 ppm
- Ca: 94 ppm
- Mg: 32 ppm

Recipe

- Distilled/RO: 33%
- *Epsom salt: 1 gram/gal
- Calcium chloride: 1 gram/gal

*** Epsom used to increase Mg, as it is a more efficient flavor extractor than Ca. Excessive Mg and/or sensitive systems may prove this recipe to be diuretic. If so, increase CaCl and decrease Mg to maintain 125 ppm GH.**

Future Water Experiments

- High pH coffee water
  - Others have achieved 5pH coffee using base water as high as 11.5pH
- Chlorine removal tests with iDip
  - Standing water time
  - Campden tablet effectiveness
  - Carbon filter lifespans
- Low calcium Northeast IPA w/higher flocculent yeast
- Tea & Kombucha water profiles

Don't Believe Me!

Learn from the real experts using these sources:

1. "Water; A Comprehensive Guide for Brewers", John Palmer & Colin Kaminski (2013)
2. "Dave Miller's Homebrewing Guide", Dave Miller (1995)
3. "Water for Coffee", Maxwell Colonna-Dashwood & Christopher H. Hendon (2015)
4. "How to Brew", John Palmer (1999-2015): howtobrew.com
5. "Removing Chloramines from Brewing Water" Brewing Techniques, Vol. 9, No. 1 , A.J. deLange (1999)
6. "Water Knowledge", Martin Brungard (2015): https://sites.google.com/site/brunwater/
7. "A Guide to Drinking Water Treatment Technologies for Household Use", Centers for Disease Control and PRevention (2014): http://www.cdc.gov/healthywater/drinking/home-water-treatment/household_water_treatment.html

A compilation of Cleveland area brewing water reports can be found here:
https://docs.google.com/spreadsheets/d/17sEYvSaFsX1TEc8JsDvgqaqwbw3fJSu1YuXkLfJOE-A/